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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	12628977
Filing Date	2009-12-01
First Named Inventor	Ron Hadar
Art Unit	1795
Examiner Name	Matthew Martin
Attorney Docket Number	108144-202701/US

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	4	6031736		2000-02-29	Takehara et al.	
	5	6448489		2002-09-10	Kimura et al.	
	6	6844739		2005-01-18	Kasai et al.	
	7	6894911		2005-05-17	Telefus et al.	
	8	6897370		2005-05-24	Kondo et al.	

SMA Solar Technology America LLC v. Tigo Energy Inc.
IPR2023-01184 Patent No. 8,823,218 Ex. 1016 (Part 2 of 2)

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	9	7248946		2007-07-24	Bashaw et al.	
	10	7256566		2007-08-14	Bhavaraju et al.	
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Signature	/John P. Ward/	Date (YYYY-MM-DD)	2010-08-10
Name/Print	John P. Ward	Registration Number	40216

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PAT-NO: JP02003134661A

DOCUMENT-IDENTIFIER: **JP 2003134661 A**

TITLE: LOAD INTERRUPTION DETECTING DEVICE AND **PHOTOVOLTAIC** POWER GENERATOR

PUBN-DATE: May 9, 2003

INVENTOR-INFORMATION:

NAME	COUNTRY
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APPL-NO: JP2001319571

APPL-DATE: October 17, 2001

INT-CL (IPC): H02H007/122 , G05F001/67 , H01L031/04 , H02J003/38

ABSTRACT:

PROBLEM TO BE SOLVED: To provide a load interruption detecting device for **photovoltaic** power generator in which voltage rise can be minimized even if a load interruption occurs.

SOLUTION: A **load** interruption **detecting** system in a **photovoltaic** power generator performing linkage operation with a power system comprises means for **detecting** the instantaneous output voltage from the **photovoltaic** power generator, and means for **detecting** deviation of a current of the **photovoltaic** power generator from a command value, wherein occurrence of **load** interruption of the **photovoltaic** power generator is determined when the instantaneous value of the output voltage exceeds a predetermined value and/or the deviation of the electric current from the command for exceeds a predetermined value, and when a state of **load** interruption takes place, an **inverter** is suspended by a gate blocking means.

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CLAIMS

[Claim(s)]
[Claim 1]An output voltage instantaneous value detection means to be a load shutdown sensing device in a photovoltaic power generation apparatus which performs electric power system and link operation, and to detect an instantaneous value of output voltage of a photovoltaic power generation apparatus, A load shutdown sensing device possessing a current deviation detection means to detect a deviation to a command value of current of said photovoltaic power generation apparatus.
[Claim 2]The load shutdown sensing device according to claim 1 characterized by presuming load shutdown of said photovoltaic power generation apparatus when an instantaneous value of said output voltage exceeds a predetermined level or a deviation to a command value of said current exceeds a predetermined level.
[Claim 3]The load shutdown sensing device according to claim 1 characterized by presuming load shutdown of said photovoltaic power generation apparatus when an instantaneous value of said output voltage exceeds a predetermined level and a deviation to a command value of said current exceeds a predetermined level.
[Claim 4]The load shutdown sensing device according to claim 1 providing a detection means to presume load shutdown of said photovoltaic power generation apparatus when current which flows although an instantaneous value of said output voltage exceeds a predetermined level and a command value of said current is not zero is zero.
[Claim 5]4 either from Claim 1 When the state where provide a load shutdown sensing device of a description and a gate block means to intercept a gate control signal of an inverter which transforms a solar cell output inversely to alternating current power, and said load shutdown is presumed happens, A photovoltaic power generation apparatus suspending said inverter by said gate block means.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the art of detecting the load shutdown in the photovoltaic power generation apparatus which performs electric power system and link operation.
[0002]
[Description of the Prior Art]Since unlike the power generation method of other utilization of natural energy it can install in the roof and wall surface of a building easily and there are also no worries about noise and other public nuisances in them, the photovoltaics by a solar cell is increasingly expected as a pollution-free power generation system. In recent years, it becomes possible to perform electric power system and link operation, and when performing photovoltaics in an ordinary home, it gains popularity that the inverter for system interconnections performs commercial alternating current power and a system interconnection.
[0003]While the photovoltaic power generation apparatus is performing electric power system and link operation, the state of what is called load shutdown which turns into a break state suddenly at the place of a distribution board or others, and becomes no-load [a photovoltaic power generation apparatus] may happen. Since the current which was flowing until now becomes zero suddenly and there is a possibility of the output voltage of a photovoltaic power generation apparatus carrying out an abnormal rise, and having an adverse effect on a device when load shutdown happens, In order to avoid this, the current of a link point is supervised, or a power surge is detected, abnormalities are detected, and the method of suspending an inverter with a gate block is put in practical use.
[0004]
[Problem(s) to be Solved by the Invention]However, in the above-mentioned method, the detection means for supervising the current of a link point was needed, and SUBJECT that it will be the hindrance of the miniaturization of a device and low-cost-izing occurred. In the method of detecting a power surge, since a power surge value became large by a detection delay, the voltage resistance value of the inner component needed to be enlarged and SUBJECT that it will be a cost hike of a device occurred.

[0005]This invention was made under such a background and an object of this invention is to provide the load shutdown sensing device which can suppress a power surge to the minimum even if load shutdown occurs, and a photovoltaic power generation apparatus provided with it.
[0006]
[Means for Solving the Problem]An output voltage instantaneous value detection means for the invention according to claim 1 to be a load shutdown sensing device in a photovoltaic power generation apparatus which performs electric power system and link operation, and to detect an instantaneous value of output voltage of a photovoltaic power generation apparatus, A load shutdown sensing device of a photovoltaic power generation apparatus possessing a current deviation detection means to detect a deviation to a command value of current of said photovoltaic power generation apparatus is provided.
[0007]A means according to this invention to detect abnormalities when an instantaneous value of output voltage of a photovoltaic power generation apparatus is supervised and it goes up to rated voltage more than a predetermined ratio, Since it has a means to detect abnormalities and load shutdown is detected when a deviation of actual current over a command value of current becomes a size more than predetermined, no matter load shutdown may occur to what timing, it is detectable at high speed.
[0008]In the load shutdown sensing device according to claim 1, the invention according to claim 2 presumes load shutdown of said photovoltaic power generation apparatus, when an instantaneous value of said output voltage exceeds a predetermined level or a deviation to a command value of said current exceeds a predetermined level.
[0009]Since according to this invention a deviation of a command value of current and inverter output current is detected, load shutdown is presumed in both [when this deviation exceeds a predetermined value] cases and device protection is performed when an instantaneous value of output voltage exceeds a predetermined level and, A peak of output voltage can be suppressed below to a certain value, and safety can be improved.
[0010]In the load shutdown sensing device according to claim 1, the invention according to claim 3 presumes load shutdown of said photovoltaic power generation apparatus, when an instantaneous value of said output voltage exceeds a predetermined level and a deviation to a command value of said current exceeds a predetermined level.
[0011]According to this invention, since load shutdown is presumed and device protection is performed when an instantaneous value of output voltage exceeds a predetermined level and a detection deviation of a command value of current and inverter output current exceeds a predetermined value, reliability can be improved.
[0012]In the load shutdown sensing device according to claim 1 the invention according to claim 4, An instantaneous value of said output voltage exceeds a predetermined level, and when current which flows although a command value of said current is not zero is zero, a detection means to presume load shutdown of said photovoltaic power generation apparatus is provided.
[0013]According to this invention, an instantaneous value of output voltage exceeds a predetermined

level, and since load shutdown is presumed and device protection is performed when current which flows although a command value of current is not zero is zero, reliability can be improved.
[0014]4 the invention according to claim 5 either from Claim 1 A load shutdown sensing device of a description, A gate block means to intercept a gate control signal of an inverter which transforms a solar cell output inversely to alternating current power is provided, and when the state where said load shutdown is presumed happens, a photovoltaic power generation apparatus suspending said inverter by said gate block means is provided.
[0015]According to this invention, since an inverter is stopped with a gate block when the state where provide a gate block means to intercept a gate control signal of an inverter, and load shutdown is presumed happens, safe and reliable photovoltaics can be carried out.
[0016]
[Embodiment of the Invention]Hereafter, it explains, referring to a figure for this embodiment of the invention.
[0017]<1st embodiment> drawing 1 is a block diagram showing the composition of the photovoltaic power generation apparatus by a 1st embodiment of this invention. In this figure, the numerals 1 are solar cell outputs and output direct current power including a solar panel, a joint box, a boost chopper, etc. After the inverter 2 transforms inversely the direct current power of the solar cell output 1 to alternating current power, it removes waveform distortion with the sine-ized filter 4, and performs the electric power system 5 and link operation to which the load 6 was connected.
[0018]In order to link the inverter 2 with the electric power system 5, it is necessary to control output current. The signal which the current command value creating means 12 outputs is compared with the current signal of the current sensor 3 in the current deviation detection means 13, in the inverter gate control means 14, a gate control signal is generated so that a deviation may become zero, and the inverter 2 is driven. Since the current which was flowing until now will become zero suddenly if what is called load shutdown from which suddenly [the photovoltaic power generation apparatus by such composition] becomes that link with the electric power system 5 severed near a link point no-load occurs, The output voltage of a photovoltaic power generation apparatus carries out an abnormal rise, there is a possibility of having an adverse effect on a device, and it is necessary to suspend the inverter 2 promptly.
[0019]For this reason, if the state where the instantaneous value of the voltage of a link point is monitored continuously, and the instantaneous value of voltage exceeds 120% of the peak values of rated voltage by the output voltage instantaneous value detection means 11 happens, The gate control signal which sends out a signal to the gate block means 15, and is promptly outputted to it from the inverter gate control means 14 is blocked, and the inverter 2 is stopped.
[0020]In the current deviation detection means 13, detect the deviation of the current command value of the current command value creating means 12, and the current signal of the current sensor 3, set inverter gate control means 14, output a gating signal, and are driving the inverter 2 so that this deviation may become small, but. Since said deviation will become large if load shutdown occurs, the gate control signal which sends out a signal to the gate block means 15, and is outputted

to it from the inverter gate control means 14 at this time is blocked, and the inverter 2 is stopped.
[0021]According to this embodiment, since either when a current deviation with a command value becomes large suspends an inverter when output voltage rises and, the peak value of output voltage can be held down to 150% or less, and it can be extremely considered as the high protection method of the degree of safe.
[0022]<2nd embodiment> drawing 2 is a block diagram showing the composition of the photovoltaic power generation apparatus by a 2nd embodiment of this invention. In this figure, the numerals 1 are solar cell outputs and output direct current power including a solar panel, a joint box, a boost chopper, etc. After the inverter 2 transforms inversely the direct current power of the solar cell output 1 to alternating current power, it removes waveform distortion with the sine-ized filter 4, and performs the electric power system 5 and link operation to which the load 6 was connected.
[0023]In order to link the inverter 2 with the electric power system 5, it is necessary to control output current. The signal which the current command value creating means 12 outputs is compared with the current signal of the current sensor 3 in the current deviation detection means 13, in the inverter gate control means 14, a gate control signal is generated so that a deviation may become zero, and the inverter 2 is driven. Since the current which was flowing until now will become zero suddenly if what is called load shutdown from which suddenly [the photovoltaic power generation apparatus by such composition] becomes that link with the electric power system 5 severed near a link point no-load occurs, The output voltage of a photovoltaic power generation apparatus carries out an abnormal rise, there is a possibility of having an adverse effect on a device, and it is necessary to suspend the inverter 2 promptly.
[0024]For this reason, the instantaneous value of the voltage of a link point is continuously monitored by the output voltage instantaneous value detection means 11, and shortly after the state where the instantaneous value of voltage exceeds 120% of the peak values of rated voltage happens, a signal is sent out to AND gate 16. In the current deviation detection means 13, detect the deviation of the current command value of the current command value creating means 12, and the current signal of the current sensor 3, set inverter gate control means 14, output a gating signal, and are driving the inverter 2 so that this deviation may become small, but. Since said deviation will become large if load shutdown occurs, a signal is sent out to AND gate 16 at this time.
[0025]When the signal of both the signal of the output voltage instantaneous value detection means 11 and the signal of the deviation score size from the current deviation detection means 13 is given to AND gate 16, The gate control signal which sends out a signal to the gate block means 15, and is outputted to it from the inverter gate control means 14 is blocked, and the inverter 2 is stopped. According to this embodiment, output voltage rises, and since an inverter is suspended when a current deviation with a current command value becomes large, it can be extremely considered as the high protection method of reliability.
[0026]<3rd embodiment> drawing 2 is a block diagram showing the composition of the photovoltaic power generation apparatus by a 3rd embodiment of this invention, and is the same composition as a 2nd above-mentioned embodiment. Since the current which was flowing until now will become

zero suddenly if what is called load shutdown from which suddenly [the photovoltaic power generation apparatus by composition like drawing 2] becomes that link with the electric power system 5 severed near a link point no-load occurs, The output voltage of a photovoltaic power generation apparatus carries out an abnormal rise, there is a possibility of having an adverse effect on a device, and it is necessary to suspend the inverter 2 promptly.

[0027]For this reason, the instantaneous value of the voltage of a link point is continuously monitored by the output voltage instantaneous value detection means 11, and shortly after the state where the instantaneous value of voltage exceeds 120% of the peak values of rated voltage happens, a signal is sent out to AND gate 16. In the current deviation detection means 13, detect the deviation of the current command value of the current command value creating means 12, and the current signal of the current sensor 3, set inverter gate control means 14, output a gating signal, and are driving the inverter 2 so that this deviation may become small, but. Although a current command value is not zero, when the signal of the current sensor 3 becomes zero, it is judged as load shutdown and a signal is sent out to AND gate 16.

[0028]When the signal of both the signal of the output voltage instantaneous value detection means 11 and the signal of the deviation score size from the current deviation detection means 13 is given to AND gate 16, The gate control signal which sends out a signal to the gate block means 15, and is outputted to it from the inverter gate control means 14 is blocked, and the inverter 2 is stopped. According to this embodiment, since output voltage rises, and an inverter is suspended when a actual current value is zero, although a current command value is not zero, it can be extremely considered as the high protection method of reliability.

[0029]As mentioned above, although operation of an embodiment of the invention has been explained in full detail with reference to Drawings, this invention is not restricted to this embodiment, and even if the design variation etc. of the range which does not deviate from the gist of this invention occur, it is contained in this invention.

[0030]

[Effect of the Invention]As explained so far, according to this invention, the effect taken below is acquired. A means according to the invention of Claim 1 to detect abnormalities when the instantaneous value of the output voltage of a photovoltaic power generation apparatus is supervised and it goes up to rated voltage more than a predetermined ratio, Since it has a means to detect abnormalities and load shutdown is detected when the deviation of the actual current over the command value of current becomes a size more than predetermined, no matter load shutdown may occur to what timing, it is detectable at high speed.

[0031]When the instantaneous value of output voltage exceeds a predetermined level according to the invention of Claim 2, And since the deviation of the command value of current and inverter output current is detected, load shutdown is presumed in both [when this deviation exceeds a predetermined value] cases and device protection is performed, the peak of output voltage can be suppressed below to a certain value, and safety can be improved.

[0032]According to the invention of Claim 3, since load shutdown is presumed and device protection

is performed when the instantaneous value of output voltage exceeds a predetermined level and the detection deviation of the command value of current and inverter output current exceeds a predetermined value, reliability can be improved.

[0033]According to the invention of Claim 4, the instantaneous value of output voltage exceeds a predetermined level, and since load shutdown is presumed and device protection is performed when the current which flows although the command value of current is not zero is zero, reliability can be improved.

[0034]According to the invention of Claim 5, since an inverter is stopped with a gate block when the state where provide a gate block means to intercept the gate control signal of an inverter, and load shutdown is presumed happens, safe and reliable photovoltaics can be carried out.

[Translation done.]

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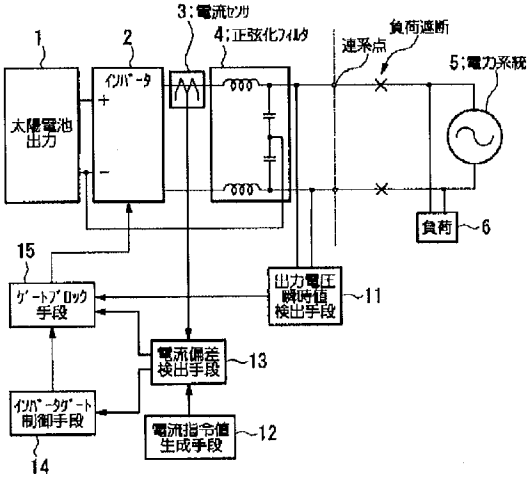
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最終頁に続く

(54)【発明の名称】　負荷遮断検出装置および太陽光発電装置

(57)【要約】
【課題】　負荷遮断が発生しても電圧上昇を最小限に抑えることができる太陽光発電装置の負荷遮断検出装置を提供する。
【解決手段】　電力系統と連系運転を行う太陽光発電装置における負荷遮断検出方式であって、太陽光発電装置の出力電圧の瞬時値を検出する出力電圧瞬時値検出手段と、前記太陽光発電装置の電流の指令値に対する偏差を検出する電流偏差検出手段とを具備し、前記出力電圧の瞬時値が所定のレベルを超えるか、または／および前記電流の指令値に対する偏差が所定のレベルを超えたとき、前記太陽光発電装置の負荷遮断と認定することを特徴とし、負荷遮断と認定される状態が起こったとき、ゲートブロック手段によってインバータを停止することを特徴とする。



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【特許請求の範囲】

【請求項１】　電力系統と連系運転を行う太陽光発電装置における負荷遮断検出装置であって、
太陽光発電装置の出力電圧の瞬時値を検出する出力電圧瞬時値検出手段と、
前記太陽光発電装置の電流の指令値に対する偏差を検出する電流偏差検出手段とを具備することを特徴とする負荷遮断検出装置。

【請求項２】　前記出力電圧の瞬時値が所定のレベルを超えるか、または前記電流の指令値に対する偏差が所定のレベルを超えたとき、前記太陽光発電装置の負荷遮断と認定することを特徴とする請求項１記載の負荷遮断検出装置。

【請求項３】　前記出力電圧の瞬時値が所定のレベルを超え、且つ、前記電流の指令値に対する偏差が所定のレベルを超えたとき、前記太陽光発電装置の負荷遮断と認定することを特徴とする請求項１記載の負荷遮断検出装置。

【請求項４】　前記出力電圧の瞬時値が所定のレベルを超え、且つ、前記電流の指令値がゼロでないにもかかわらず流れる電流がゼロであったとき、前記太陽光発電装置の負荷遮断と認定する検出手段を具備することを特徴とする請求項１記載の負荷遮断検出装置。

【請求項５】　請求項１から４のいずれか記載の負荷遮断検出装置と、太陽電池出力を交流電力に逆変換するインバータのゲート制御信号を遮断するゲートブロック手段とを具備し、
前記負荷遮断と認定される状態が起こったとき、前記ゲートブロック手段によって前記インバータを停止することを特徴とする太陽光発電装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】この発明は、電力系統と連系運転を行う太陽光発電装置における負荷遮断を検出する技術に関する。

【０００２】

【従来の技術】太陽電池による太陽光発電は、他の自然エネルギー利用の発電方式と異なり、建築物の屋根や壁面に容易に設置することができ、騒音その他の公害の心配もないため、無公害発電システムとして期待されるようになってきている。近年、電力系統と連系運転を行うことが可能となり、一般家庭で太陽光発電を行うときは系統連系用インバータによって商用交流電源と系統連系を行うのが一般的になっている。

【０００３】太陽光発電装置が電力系統と連系運転を行っているとき、分電盤やその他の場所で突然断線状態となり太陽光発電装置が無負荷となる、いわゆる負荷遮断の状態が起こることがある。負荷遮断が起こると、今まで流れていた電流が突然ゼロになるため、太陽光発電装置の出力電圧が異常上昇してしまい、装置に悪影響を与える虞があるので、これを回避するため、連系点の電流を監視したり、電圧上昇を検出して異常を検出し、ゲートブロックによってインバータを停止する方法が実用化されている。

【０００４】

【発明が解決しようとする課題】ところが上述の方法では、連系点の電流を監視するための検出手段が必要となり、装置の小型化、低コスト化の妨げになってしまうという課題があった。また、電圧上昇を検出する方法では、検出遅れによって電圧上昇値が大きくなるため、内部部品の耐電圧値を大きくする必要があり、装置のコストアップとなってしまうという課題があった。

【０００５】本発明はこのような背景の下になされたもので、負荷遮断が発生しても電圧上昇を最小限に抑えることができる負荷遮断検出装置、およびそれを備える太陽光発電装置を提供することを目的とする。

【０００６】

【課題を解決するための手段】請求項１に記載の発明は、電力系統と連系運転を行う太陽光発電装置における負荷遮断検出装置であって、太陽光発電装置の出力電圧の瞬時値を検出する出力電圧瞬時値検出手段と、前記太陽光発電装置の電流の指令値に対する偏差を検出する電流偏差検出手段とを具備することを特徴とする太陽光発電装置の負荷遮断検出装置を提供する。

【０００７】この発明によれば、太陽光発電装置の出力電圧の瞬時値を監視し、定格電圧に対して所定の比率以上に上昇したとき異常を検出する手段と、電流の指令値に対する実際の電流の偏差が所定以上の大きさになったとき異常を検出する手段とを備えて負荷遮断の検出を行うので、どのようなタイミングで負荷遮断が発生しても高速で検出を行うことができる。

【０００８】請求項２に記載の発明は、請求項１記載の負荷遮断検出装置において、前記出力電圧の瞬時値が所定のレベルを超えるか、または前記電流の指令値に対する偏差が所定のレベルを超えたとき、前記太陽光発電装置の負荷遮断と認定することを特徴とする。

【０００９】この発明によれば、出力電圧の瞬時値が所定のレベルを超えたとき、および、電流の指令値とインバータ出力電流との偏差を検出し、この偏差が所定値を超えたときのどちらの場合も負荷遮断と認定して装置保護を行うので、出力電圧のピークをある値以下に抑えることができ、安全性を高めることができる。

【００１０】請求項３に記載の発明は、請求項１記載の負荷遮断検出装置において、前記出力電圧の瞬時値が所定のレベルを超え、且つ、前記電流の指令値に対する偏差が所定のレベルを超えたとき、前記太陽光発電装置の負荷遮断と認定することを特徴とする。

【００１１】この発明によれば、出力電圧の瞬時値が所定レベルを超え、且つ、電流の指令値とインバータ出力電流との検出偏差が所定値を超えたとき、負荷遮断と認

定して装置保護を行うので、信頼性を高めることができる。

【００１２】請求項４に記載の発明は、請求項１記載の負荷遮断検出装置において、前記出力電圧の瞬時値が所定のレベルを超え、且つ、前記電流の指令値がゼロでないにもかかわらず流れる電流がゼロであったとき、前記太陽光発電装置の負荷遮断と認定する検出手段を具備することを特徴とする。

【００１３】この発明によれば、出力電圧の瞬時値が所定レベルを超え、且つ、電流の指令値がゼロでないにもかかわらず流れる電流がゼロであったとき、負荷遮断と認定して装置保護を行うので、信頼性を高めることができる。

【００１４】請求項５に記載の発明は、請求項１から４のいずれか記載の負荷遮断検出装置と、太陽電池出力を交流電力に逆変換するインバータのゲート制御信号を遮断するゲートブロック手段とを具備し、前記負荷遮断と認定される状態が起こったとき、前記ゲートブロック手段によって前記インバータを停止することを特徴とする太陽光発電装置を提供する。

【００１５】この発明によれば、インバータのゲート制御信号を遮断するゲートブロック手段を具備して負荷遮断と認定される状態が起こったとき、ゲートブロックによってインバータを停止させるので、安全でかつ信頼性の高い太陽光発電を実施することができる。

【００１６】

【発明の実施の形態】以下、この発明の実施の形態について図を参照しながら説明する。

【００１７】＜第１の実施の形態＞図１は、この発明の第１の実施の形態による太陽光発電装置の構成を示すブロック図である。この図において、符号１は太陽電池出力であり、太陽電池パネル、接続箱および昇圧チョッパ等を含み、直流電力を出力する。インバータ２は、太陽電池出力１の直流電力を交流電力に逆変換した後、正弦化フィルタ４によって波形歪を除去し、負荷６の接続された電力系統５と連系運転を行う。

【００１８】インバータ２は、電力系統５と連系を行うために出力電流を制御する必要があり、電流指令値生成手段１２の出力する信号と電流センサ３の電流信号とを電流偏差検出手段１３において比較し、偏差がゼロになるようにインバータゲート制御手段１４においてゲート制御信号を生成し、インバータ２を駆動する。このような構成による太陽光発電装置が連系点付近で電力系統５との連系が突然絶たれ無負荷となる、いわゆる負荷遮断が発生すると、今まで流れていた電流が突然ゼロになるため、太陽光発電装置の出力電圧が異常上昇してしまい、装置に悪影響を与える虞があり、速やかにインバータ２を停止する必要がある。

【００１９】このため、出力電圧瞬時値検出手段１１によって連系点の電圧の瞬時値を常時監視しており、電圧の瞬時値が定格電圧のピーク値の１２０％を超える状態が起こると、直ちにゲートブロック手段１５に信号を送出してインバータゲート制御手段１４から出力されているゲート制御信号をブロックしてインバータ２を停止させる。

【００２０】さらに、電流偏差検出手段１３において電流指令値生成手段１２の電流指令値と電流センサ３の電流信号との偏差を検出し、この偏差が小さくなるようにインバータゲート制御手段１４おいてゲート信号を出力してインバータ２を駆動しているが、負荷遮断が発生すると前記偏差が大きくなるので、このときゲートブロック手段１５に信号を送出してインバータゲート制御手段１４から出力されているゲート制御信号をブロックしてインバータ２を停止させる。

【００２１】この実施の形態では、出力電圧が上昇した場合、および指令値との電流偏差が大きくなった場合のどちらでもインバータを停止するので、出力電圧のピーク値を１５０％以下に抑えることができ、きわめて安全度の高い保護方式とすることができる。

【００２２】＜第２の実施の形態＞図２は、この発明の第２の実施の形態による太陽光発電装置の構成を示すブロック図である。この図において、符号１は太陽電池出力であり、太陽電池パネル、接続箱および昇圧チョッパ等を含み、直流電力を出力する。インバータ２は、太陽電池出力１の直流電力を交流電力に逆変換した後、正弦化フィルタ４によって波形歪を除去し、負荷６の接続された電力系統５と連系運転を行う。

【００２３】インバータ２は、電力系統５と連系を行うために出力電流を制御する必要があり、電流指令値生成手段１２の出力する信号と電流センサ３の電流信号とを電流偏差検出手段１３において比較し、偏差がゼロになるようにインバータゲート制御手段１４においてゲート制御信号を生成し、インバータ２を駆動する。このような構成による太陽光発電装置が連系点付近で電力系統５との連系が突然絶たれ無負荷となる、いわゆる負荷遮断が発生すると、今まで流れていた電流が突然ゼロになるため、太陽光発電装置の出力電圧が異常上昇してしまい、装置に悪影響を与える虞があり、速やかにインバータ２を停止する必要がある。

【００２４】このため、出力電圧瞬時値検出手段１１によって連系点の電圧の瞬時値を常時監視しており、電圧の瞬時値が定格電圧のピーク値の１２０％を超える状態が起こると、直ちに論理積回路１６に信号を送出する。さらに、電流偏差検出手段１３において電流指令値生成手段１２の電流指令値と電流センサ３の電流信号との偏差を検出し、この偏差が小さくなるようにインバータゲート制御手段１４おいてゲート信号を出力してインバータ２を駆動しているが、負荷遮断が発生すると前記偏差が大きくなるので、このとき論理積回路１６に信号を送出する。

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【００２５】出力電圧瞬時値検出手段１１の信号、および電流偏差検出手段１３からの偏差値大の信号の両方の信号が論理積回路１６に与えられたとき、ゲートブロック手段１５に信号を送出してインバータゲート制御手段１４から出力されているゲート制御信号をブロックしてインバータ２を停止させる。この実施の形態では、出力電圧が上昇し、且つ、電流指令値との電流偏差が大きくなった場合にインバータを停止するのできわめて信頼度の高い保護方式とすることができる。

【００２６】<第３の実施の形態>図２は、この発明の第３の実施の形態による太陽光発電装置の構成を示すブロック図であり、上述の第２の実施の形態と同一の構成である。図２のような構成による太陽光発電装置が連系点付近で電力系統５との連系が突然絶たれ無負荷となる、いわゆる負荷遮断が発生すると、今まで流れていた電流が突然ゼロになるため、太陽光発電装置の出力電圧が異常上昇してしまい、装置に悪影響を与える虞があり、速やかにインバータ２を停止する必要がある。

【００２７】このため、出力電圧瞬時値検出手段１１によって連系点の電圧の瞬時値を常時監視しており、電圧の瞬時値が定格電圧のピーク値の１２０％を超える状態が起こると、直ちに論理積回路１６に信号を送出する。さらに、電流偏差検出手段１３において電流指令値生成手段１２の電流指令値と電流センサ３の電流信号との偏差を検出し、この偏差が小さくなるようにインバータゲート制御手段１４おいてゲート信号を出力してインバータ２を駆動しているが、電流指令値がゼロでないのに電流センサ３の信号がゼロになったとき負荷遮断と判断して論理積回路１６に信号を送出する。

【００２８】出力電圧瞬時値検出手段１１の信号、および電流偏差検出手段１３からの偏差値大の信号の両方の信号が論理積回路１６に与えられたとき、ゲートブロック手段１５に信号を送出してインバータゲート制御手段１４から出力されているゲート制御信号をブロックしてインバータ２を停止させる。この実施の形態では、出力電圧が上昇し、且つ、電流指令値がゼロでないのに実際の電流値がゼロであった場合にインバータを停止するので、きわめて信頼度の高い保護方式とすることができる。

【００２９】以上、本発明の実施の形態の動作を図面を参照して詳述してきたが、本発明はこの実施の形態に限られるものではなく、本発明の要旨を逸脱しない範囲の設計変更等があっても本発明に含まれる。

【００３０】

【発明の効果】これまでに説明したように、本発明によれば以下に示す効果が得られる。請求項１の発明によれば、太陽光発電装置の出力電圧の瞬時値を監視し、定格電圧に対して所定の比率以上に上昇したとき異常を検出する手段と、電流の指令値に対する実際の電流の偏差が所定以上の大きさになったとき異常を検出する手段とを備えて負荷遮断の検出を行うので、どのようなタイミングで負荷遮断が発生しても高速で検出を行うことができる。

【００３１】請求項２の発明によれば、出力電圧の瞬時値が所定レベルを超えたとき、および、電流の指令値とインバータ出力電流との偏差を検出し、この偏差が所定値を超えたときのどちらの場合も負荷遮断と認定して装置保護を行うので、出力電圧のピークをある値以下に抑えることができ、安全性を高めることができる。

【００３２】請求項３の発明によれば、出力電圧の瞬時値が所定レベルを超え、且つ、電流の指令値とインバータ出力電流との検出偏差が所定値を超えたとき、負荷遮断と認定して装置保護を行うので、信頼性を高めることができる。

【００３３】請求項４の発明によれば、出力電圧の瞬時値が所定レベルを超え、且つ、電流の指令値がゼロでないにもかかわらず流れる電流がゼロであったとき、負荷遮断と認定して装置保護を行うので、信頼性を高めることができる。

【００３４】請求項５の発明によれば、インバータのゲート制御信号を遮断するゲートブロック手段を具備して負荷遮断と認定される状態が起こったとき、ゲートブロックによってインバータを停止させるので、安全でかつ信頼性の高い太陽光発電を実施することができる。

【図面の簡単な説明】

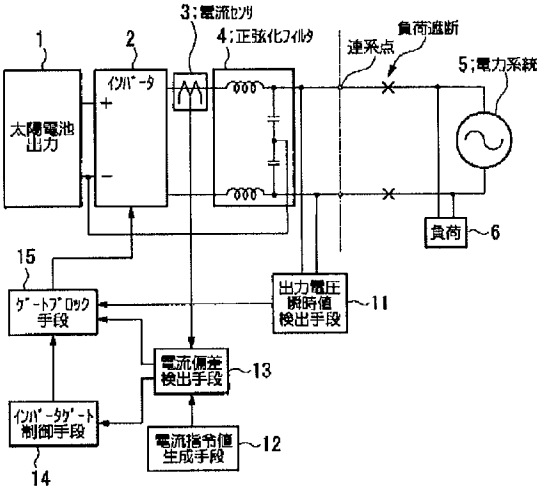
【図１】　本発明の第１の実施の形態による太陽光発電装置の構成を示すブロック図。

【図２】　本発明の第２または第３の実施の形態による太陽光発電装置の構成を示すブロック図。

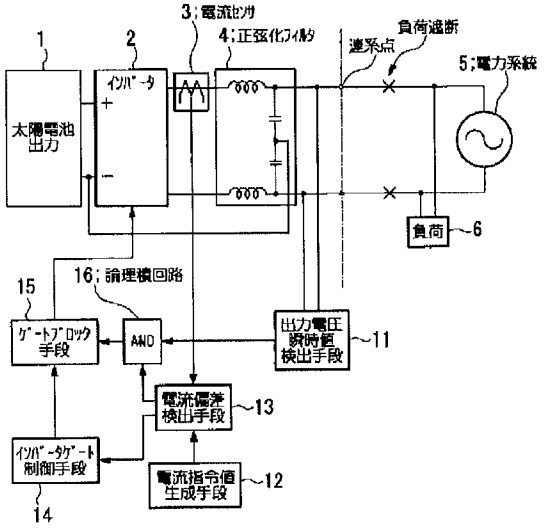
【符号の説明】

１…太陽電池出力
２…インバータ
３…電流センサ
４…正弦化フィルタ
５…電力系統
６…負荷
１１…出力電圧瞬時値検出手段
１２…電流指令値生成手段
１３…電流偏差検出手段
１４…インバータゲート制御手段
１５…ゲートブロック手段
１６…論理積回路

【図1】



【図2】



フロントページの続き

Fターム(参考) 5F051 KA05 KA08 KA10
5G053 AA07 AA09 BA01 BA04 CA02
EB01 FA01
5G066 HA13 HB06
5H420 BB13 CC03 DD03 DD09 DD10
FF03 FF04 FF25 LL02 LL05

Electronic Acknowledgement Receipt

EFS ID:	8192290
Application Number:	12628977
International Application Number:	
Confirmation Number:	6958
Title of Invention:	Systems and Methods for an Enhanced Watchdog in Solar Module Installations
First Named Inventor/Applicant Name:	Ron HADAR
Customer Number:	64494
Filer:	John Patrick Ward/Patricia Caldwell
Filer Authorized By:	John Patrick Ward
Attorney Docket Number:	108144-202701/US (TGY027)
Receipt Date:	10-AUG-2010
Filing Date:	01-DEC-2009
Time Stamp:	17:51:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed (SB/08)	108144-202701_IDS.pdf	612117 0f3d2c2d644c3a2a33e3002e06ce33034fe79327	no	5

Warnings:	
Information:	

2	Foreign Reference	JP_2003134661.pdf	559269 fd7108f25e791d5484ab460d3d9aee8921506e99	no	13

Warnings:	
Information:	
Total Files Size (in bytes):	1171386

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/628,977	12/01/2009	Ron HADAR	108144-202701/US (TGY027)	6958

64494 7590 06/14/2010

GREENBERG TRAURIG, LLP (SV)
IP DOCKETING
2450 COLORADO AVENUE
SUITE 400E
SANTA MONICA, CA 90404

EXAMINER	
MARTIN, MATTHEW T	
ART UNIT	PAPER NUMBER
1795	

NOTIFICATION DATE	DELIVERY MODE
06/14/2010	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

LAIPMAIL@GTLAW.COM
allenr@gtlaw.com
santosv@gtlaw.com

Office Action Summary	Application No.	Applicant(s)	
	12/628,977	HADAR ET AL.	
	Examiner	Art Unit	
	MATTHEW T. MARTIN	1795	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-20* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-20* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *5/10/2010, 12/23/2009*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Status of Claims

1. Claims 1-20 are pending and are examined below.

Claim Rejections - 35 USC § 103

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

3. The factual inquiries set forth in *Graham* v. *John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

4. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

5. Claims 1-10 and 13-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dorn et al., U.S. Publication No. 2008/0142071 in view of Wiles, "Photovoltaic Power Systems and the National Electrical Code: Suggested Practices" Sandia, 1999.

Regarding Claim 1, Dorn et al. teaches a photovoltaic system. The system taught by Dorn includes a solar module (see paragraph 21), a controller (see paragraph 21) that may reconfigure the configuration of the module, and a power bus connecting the system.

Dorn et al. further teaches that the device taught may be automatically be reconfigured through a switching system, which may be any switching device, and may be switched automatically by a controller (see paragraph 22). This system is interpreted understood by the examiner as a watchdog system. As, when configured automatically, the switching device will disconnect the plurality for cells for, among other things, safety reasons (see paragraph 17).

Although Dorn et al. does mention potential configurations for its switching system, such as diverting power, charging a battery, and disconnecting individual cells, Dorn et al. is silent on the exact configuration of the switching device/controller watchdog unit.

Wiles teaches that a photovoltaic power system must have a disconnect system. The Wiles circuit includes multiple power switching circuits, each controlling a load. The power switching circuits taught by Wiles monitor communication from a central controller and are required to disconnect the PV array under certain operating conditions.

Therefore, it would be obvious to one of ordinary skill in the art to modify the photovoltaic system taught by Dorn et al. by including a disconnect system, as taught by Wiles to be industry standard, because the PV system must respond to voltage interrupts for safety purposes (see Dorn et al. at paragraph 17 and Wiles at page 34).

Regarding Claim 2, Dorn et al. teaches a switchable connection (see paragraph 22). Furthermore, Dorn et al. teaches that this connection may be used to disconnect the solar module or parts thereof from the power bus (see paragraphs 17 and 22).

Regarding Claim 3, Dorn et al. teaches that the switchable connection is configured by a controller (see paragraph 22).

Regarding Claim 4, Wiles et al. teaches that PV output circuits, which can be considered a feed line, are directly connected to the power controller (see page 29, branch circuits section).

Regarding Claim 5, Dorn et al. teaches that the device may include a bypass circuit (see paragraph 24).

Regarding Claims 6 and 18, Wiles teaches incorporating a backup generator into a photovoltaic power system (see fig. 18). Additionally, Wiles teaches that the backup generator is connected to the charge controller, and therefore would provide power to the controller (see fig. 18).

Regarding Claim 7, Wiles teaches that the disconnect needs to be effective when the system is subject to too much voltage (i.e. the threshold of irregularity has been surpassed; see page 35 at "Equipment Disconnects" section). It is the examiner's interpretation that the threshold of irregularity refers to the conventionally known "interrupt rating", the maximum amount of current a protective device can cut off safely.

Regarding Claim 8, Dorn et al. and Wiles et al. teach that the communication is dependant on the signal of a central controller, because the signal can be interpreted as any electrical communication.

Regarding Claim 9, Wiles teaches that a junction box is often used in photovoltaic power systems because the junction box provides for weatherproofing of circuit components.

Regarding Claim 10, Dorn et al. teaches that the PV module is disconnected from the bus when the automatic switching system (watchdog unit) receives a signal from the controller.

Regarding Claim 13, Dorn and Wiles teach disconnecting the photovoltaic device in response to controller commands.

Regarding Claim 16, Dorn disconnects the solar module in response to controller signals. It is the examiner's position that the shutdown of the solar module corresponds to disconnecting the module.

6. Claims 12, 19 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dorn et al. in view of Wiles et al., and further in view of Takahara et al., U.S. Patent No. 6,101,073.

Regarding Claim 12, modified Dorn et al. teaches a solar power generation system as discussed above. Modified Dorn et al. does not teach that a challenge/response system is used.

Takahara et al. teaches a protection system for a solar power generation.

In one of the methods taught by Takahara, an output process (challenge) is sent to a controller to detect a ground fault (see claim 21). The controller is then sent another signal (response) based on the detection (see claim 21).

Therefore, it would be obvious to one of ordinary skill in the art to modify the control connection and disconnection steps in the method taught by Dorn et al. with the steps of Takahara because the Takahara system maintains safety in the system (see Dorn et al and paragraph 17).

Regarding Claim 19, modified Dorn et al. teaches a solar power system as discussed above. Furthermore, Dorn et al. teaches that a computer may be used to reconfigure (i.e. connect and disconnect) the photovoltaic cells based on information (signal) provided by a detection circuit (see paragraph 21).

Modified Dorn et al. does not teach the specific method steps used to monitor the system.

Takahara teaches a protection system for a solar power generation.

Takahara teaches using a control unit (computing device) to monitor signal from a solar cell. If a ground fault is detected in the system, which can occur when either no signal is sent of to the control unit, the system is disconnected (see column, line). Furthermore, it can be interpreted that the occurrence of a ground fault can constitute the loss of signal.

Therefore, it would be obvious to one of ordinary skill in the art to modify the control connection and disconnection steps in the method taught by Dorn et al. with the steps of Takahara because the Takahara system maintains safety in the system (see Dorn et al and paragraph 17).

Regarding Claim 5, Dorn et al. teaches that the device may include a bypass circuit (see paragraph 24).

7. Claim 11 is rejected under 35 U.S.C. 103(a) as being unpatentable over Dorn et al. in view of Wiles et al., as applied to Claims 1-10 and 13-18 above, and further in view of Choe, U.S. Publication No. 2005/0051209.

Regarding Claim 11, modified Dorn et al. teaches a photovoltaic power system as discussed above.

Modified Dorn et al. does not teach a controller in wireless communication.

Choe et al. teaches a power regulation system for a solar cell using a controller in wireless communication (see abstract).

Therefore, it would be obvious to one of ordinary skill in the art to modify the controller taught by Dorn et al. by including the wireless controller taught by Choe because the wireless controller allows for remote data detection in the system (see abstract).

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MATTHEW T. MARTIN whose telephone number is (571)270-7871. The examiner can normally be reached on 8:30 to 5:00 EST Monday through Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jennifer Michener can be reached on (571)272-1424. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Jennifer K. Michener/
Supervisory Patent Examiner, Art Unit 1795

/MATTHEW T MARTIN/
Examiner, Art Unit 1795
2 June 2010

Notice of References Cited	Application/Control No. 12/628,977	Applicant(s)/Patent Under Reexamination HADAR ET AL.	
	Examiner MATTHEW T. MARTIN	Art Unit 1795	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2008/0142071	06-2008	Dorn et al.	136/245
*	B	US-6,101,073	08-2000	Takehara, Nobuyoshi	361/42
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Wiles et al., "Photovoltaic Power Systems and the National Electrical Code", Sandia, 1999
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	12628977
Filing Date	2009-12-01
First Named Inventor	Ron Hadar
Art Unit	1795
Examiner Name	Matthew T. Martin
Attorney Docket Number	108144-202701/US

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	5143556		1992-09-01	Matlin	
	2	5280133		1994-01-18	Nath	
	3	5604430		1997-02-18	Decker et al.	
	4	6093885		2000-07-25	Takehara et al.	
	5	6275016		2001-08-14	Ivanov	
	6	6396239		2002-05-28	Benn et al.	
	7	6515215		2003-02-04	Mimura	
	8	6545211		2003-04-08	Mimura	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.M./

Receipt date: 05/10/2010	Application Number	12628977 12628977 - GAU: 1795
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2009-12-01
	First Named Inventor	Ron Hadar
	Art Unit	1795
	Examiner Name	Matthew T. Martin
	Attorney Docket Number	108144-202701/US

	9	6593520		2003-07-15	Kondo et al.	
	10	6650031		2003-11-18	Goldack	
	11	6653549		2003-11-25	Matsushita et al.	
	12	6837739		2005-01-04	Gorringe et al.	
	13	6984970		2006-01-10	Capel	
	14	7061214		2006-06-13	Mayega	
	15	7150938		2006-12-19	Munshi et al.	
	16	7276886		2007-10-02	Kinder	
	17	7518346		2009-04-14	Prexl	
	18	7595616		2009-09-29	Prexl	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	12628977 12628977 - GAU: 1795
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Attorney Docket Number	108144-202701/US

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20050057214		2005-03-17	Matan	
	2	20050057215		2005-03-17	Matan	
	3	20060001406		2006-01-05	Matan	
	4	20060174939		2006-08-10	Matan	
	5	20060185727		2006-08-24	Matan	
	6	20060231132		2006-10-19	Neussner	
	7	20070273351		2007-11-29	Matan	
	8	20080121272		2008-05-29	Besser et al.	
	9	20080122449		2008-05-29	Besser et al.	
	10	20080122518		2008-05-29	Besser et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.M./

Receipt date: 05/10/2010	Application Number	12628977 12628977 - GAU: 1795
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2009-12-01
(Not for submission under 37 CFR 1.99)	First Named Inventor	Ron Hadar
	Art Unit	1795
	Examiner Name	Matthew T. Martin
	Attorney Docket Number	108144-202701/US

	11	20080142071		2008-06-19	Dorn et al.	
	12	20080179949		2008-07-31	Besser et al.	
	13	20080191560		2008-08-14	Besser et al.	
	14	20080191675		2008-08-14	Besser et al.	
	15	20080303503		2008-12-11	Wolfs	
	16	20090114263		2009-05-07	Powell et al.	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	2005262278	AU		2005-07-12	Central Queensland University et al.		☐
	2	4232356	DE		1994-03-31	Inst Solare Energieversorgungs		☐
	3	19961705	DE		2001-07-05	SMA Regelsysteme GmbH		☐

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.M./

Receipt date: 05/10/2010	Application Number	12628977 12628977 - GAU: 1795
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2009-12-01
	First Named Inventor	Ron Hadar
	Art Unit	1795
	Examiner Name	Matthew T. Martin
	Attorney Docket Number	108144-202701/US

	4	1388774	EP		2004-02-11	CIT Alcatel		☐
	5	2249147	ES		2006-03-16	Fundacion Robotiker		☐
	6	4219982	JP		1992-08-11	Sanyo Electric Co.		☐
	7	8097460	JP		1996-04-12	Nissan Electric Co. Ltd.		☐
	8	8116628	JP		1996-05-07	Nitto Kogyo KK		☐
	9	8316517	JP		1996-11-29	Sanyo Electric Co.		☐
	10	9148611	JP		1997-06-06	Sanyo Electric Co. Ltd.		☐
	11	2000358330	JP		2000-12-26	Nissan Electric Co. Ltd.		☐
	12	2003012569	WO		2003-02-13	Stichting Energie et al.		☐

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T5

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Receipt date: 05/10/2010	Application Number	12628977 12628977 - GAU: 1795
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2009-12-01
	First Named Inventor	Ron Hadar
	Art Unit	1795
	Examiner Name	Matthew T. Martin
	Attorney Docket Number	108144-202701/US

	1	Advanced Energy Group, "The Basics of Solar Power Systems," located at http://web.archive.org/web/20010331044156/http://www.solar4power.com/solar-power-basics.html, March 31, 2001.	☐
	2	Definition of "removable" from Webster's Third New International Dictionary, Unabridged, 1993.	☐
	3	Definition of "remove" from Webster's Third New International Dictionary, Unabridged, 1993.	☐
	4	HEWES, J. "Relays," located at http://web.archive.org/web/20030816010159/www.kpsec.freeuk.com/components/relay.htm, August 16, 2003.	☐
	5	International Patent Application No. PCT/US2008/081827, International Search Report and Written Opinion, June 24, 2009.	☐
	6	PALMA, L. et al., "A Modular Fuel Cell, Modular DC-DC Converter Concept for High Performance and Enhanced Reliability," 38th IEEE Power Electronics Specialists Conference (PESC'07), pp. 2633-2638, June 17, 2007.	☐
	7	QUASCHNING, V. et al., "Cost Effectiveness of Shadow Tolerant Photovoltaic Systems," Euronsun 96, pp. 819-824, September 16, 1996.	☐
	8	URIARTE, S. et al., "Energy Integrated Management System for PV Applications," 20th European Photovoltaic Solar Energy Conference, June 6, 2005.	☐
	9	WALKER, G. R. et al., "Cascaded DC-DC Converter Connection of Photovoltaic Modules," 33rd IEEE Power Electronics Specialists Conference (PESC'02), Vol. 1, pp. 24-29, 2002.	☐

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12628977	HADAR ET AL.
	Examiner	Art Unit
	MATTHEW T MARTIN	1795

SEARCHED			
Class	Subclass	Date	Examiner
136	243, 244, 251	5/24/2010	mtm
307	19, 20, 64-66	5/24/2010	mtm

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor Search	6/2/2010	mtm
NPL Search	5/24/2010, 6/2/2010	mtm
EAST Search	5/24/2010, 6/2/2010	mtm

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	447	challenge same response same controller	US-PGPUB; USPAT	OR	OFF	2010/06/02 14:02
L2	49	l1 and (power near2 system or photovoltaic or solar adj cell)	US-PGPUB; USPAT	OR	OFF	2010/06/02 14:04
L3	1	"6101073".pn.	US-PGPUB; USPAT	OR	OFF	2010/06/02 14:11
L4	14387	"136".clas. and restart or reconnect	US-PGPUB; USPAT	OR	OFF	2010/06/02 14:19
L5	41	"136".clas. and (restart or reconnect)	US-PGPUB; USPAT	OR	OFF	2010/06/02 14:19
L6	1	"20080142071".pn.	US-PGPUB; USPAT	OR	OFF	2010/06/02 14:23
L7	15	((RON) near2 (HADAR)).INV.	US-PGPUB; USPAT	OR	OFF	2010/06/02 14:40
L8	15	((SHMUEL) near2 (ARDITI)).INV.	US-PGPUB; USPAT	OR	OFF	2010/06/02 14:40
S1	6	"136".clas. and watchdog	US-PGPUB; USPAT	OR	OFF	2010/03/12 11:12
S2	1	"136".clas. and power near4 bus same disconnect	US-PGPUB; USPAT	OR	OFF	2010/05/18 13:43
S3	1	"3740636".pn.	US-PGPUB; USPAT	OR	OFF	2010/05/24 10:43

S4	33	("5143556" "5280133" "5604430" "6093885" "6275016" "6396239" "6515215" "6545211" "6593520" "6650031" "6653549" "6837739" "6984970" "7061214" "7150938" "7276886" "7518346" "7595616" "20050057214" "20050057215" "20060001406" "20060174939" "20060232232" "20070273351" "20080121272" "20080122449" "20080122518" "20080142071" "20080179949" "20080191560" "20080191675" "20080303503" "20090114263").pn.	US-PGPUB; USPAT	OR	OFF	2010/05/24 10:50
S5	8378	"136".clas. and (solar adj (cell or module) or photovoltaic)	US-PGPUB; USPAT	OR	OFF	2010/05/24 10:59
S6	44	"136".clas. and (solar adj (cell or module) or photovoltaic) and power adj bus	US-PGPUB; USPAT	OR	OFF	2010/05/24 10:59
S7	0	S6 and monitor same disconnect	US-PGPUB; USPAT	OR	OFF	2010/05/24 10:59
S8	12	tigo near4 energy.as.	US-PGPUB; USPAT	OR	OFF	2010/05/24 11:10
S9	5944	(307/19.ccls. 307/20. ccls. 307/64-66.ccls. 136/244.ccls. 136/243. ccls. 136/251.ccls. 136/206.ccls.)	US-PGPUB; USPAT	OR	OFF	2010/05/24 11:12
S10	0	"136".clas. and monitor same controller and disconnect same interrupt	US-PGPUB; USPAT	OR	OFF	2010/05/24 11:17
S11	73	"136".clas. and monitor same controller	US-PGPUB; USPAT	OR	OFF	2010/05/24 11:17

S12	9	"136".clas. and monitor same controller and disconnect	US-PGPUB; USPAT	OR	OFF	2010/05/24 11:18
S13	102	monitor same communication and communication same interrupt$4 same disconnect	US-PGPUB; USPAT	OR	OFF	2010/05/24 11:32
S14	12335	monitor same controller and controller same interrupt$4	US-PGPUB; USPAT	OR	OFF	2010/05/24 11:34
S15	129	monitor same controller and controller same interrupt$4 same disconnect	US-PGPUB; USPAT	OR	OFF	2010/05/24 11:34
S16	0	"136.cla.s" and disconnect$4 same interrupt$4 same signal	US-PGPUB; USPAT	OR	OFF	2010/05/24 11:46
S17	5	"136".clas. and disconnect$4 same interrupt$4 same signal	US-PGPUB; USPAT	OR	OFF	2010/05/24 11:47
S18	5	"136".clas. and controller same interrupt $4 same signal	US-PGPUB; USPAT	OR	OFF	2010/05/24 14:28
S19	0	"136".clas. and threshold same irrgeularity	US-PGPUB; USPAT	OR	OFF	2010/05/24 14:45
S20	0	"136".clas. and threshold same irrgeularity	US-PGPUB; USPAT	OR	OFF	2010/05/24 14:45
S21	2	"136".clas. and threshold same irregularity	US-PGPUB; USPAT	OR	OFF	2010/05/24 14:45
S22	22	"136".clas. and wireless near10 controller	US-PGPUB; USPAT	OR	OFF	2010/05/24 14:53
S23	0	"136".clas. and challenge same controller	US-PGPUB; USPAT	OR	OFF	2010/05/24 15:00

EAST Search History (Interference)

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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12628977	HADAR ET AL.
	Examiner	Art Unit
	MATTHEW T MARTIN	1795

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/02/2010								
	1	✓								
	2	✓								
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	4	✓								
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	16	✓								
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	18	✓								
	19	✓								
	20	✓								

PTO/SB/08a (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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Application Number	12628977
Filing Date	2009-12-01
First Named Inventor	Ron Hadar
Art Unit	1795
Examiner Name	
Attorney Docket Number	108144-202701/US(TGY027)

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/M.M./	1	4580090		1986-04-01	Bailey et al.	
/M.M./	2	4604567		1986-08-05	Chetty	
/M.M./	3	4873480		1989-10-10	Lafferty	
/M.M./	4	5027051		1991-06-25	Lafferty	
/M.M./	5	5504418		1996-04-02	Ashley	
/M.M./	6	5648731		1997-07-15	Decker et al.	
/M.M./	7	5747967		1998-05-05	Muljadi et al.	
/M.M./	8	5932994		1999-08-03	Jo et al.	

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/M.M./	9	7259474		2007-08-21	Blanc	
/M.M./	10	7336004		2008-02-26	Lai	
/M.M./	11	7394237		2008-07-01	Chou et al.	
/M.M./	12	7462955		2008-12-09	McNamara	
/M.M./	13	7518266		2009-04-14	Eckroad	
/M.M./	14	7538451		2009-05-26	Nomoto	
/M.M./	15	7545053		2009-06-09	Yoshikawa	
/M.M./	16	7602080		2009-10-13	Hadar et al.	

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/M.M./	1	20050172995		2005-08-11	Rohrig et al.	

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	Attorney Docket Number	108144-202701/US(TGY027)

/M.M./	2	20080036440		2008-02-14	Garmer	

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/M.M./	1	0178757	EP		1986-04-23	TRW Inc.		☐
/M.M./	2	11103538	JP		1999-04-13	My Way Giken KK		☐
/M.M./	3	2005069096	WO		2005-07-28	Koninklijke Philips Electronics		☐
/M.M./	4	2005112551	WO		2005-12-01	Hansung Engineering Co. LTD		☐

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
/M.M./	1	ALONSO, R. et al., "A New Distributed Converter Interface for PV Panels," 20th European Photovoltaic Solar Energy Conference, Barcelona, Spain, pp. 2288-2291, June 6-10, 2005.	☐
/M.M./	2	ALONSO, R. et al., "Experimental Results of Intelligent PV Module for Grid-Connected PV Systems," 21st European Photovoltaic Solar Energy Conference, Dresden, Germany, pp. 2297-2300, September 4-8, 2006.	☐

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	Attorney Docket Number	108144-202701/US(TGY027)

/M.M./	3	BASSO, Tim, "IEEE Standard for Interrconnecting Distributed Resources With the Electric Power System," IEEE PES Meeting, June 9, 2004.	☐
/M.M./	4	Boostbuck.com, "The Four Boostbuck Topologies," located at http://www.boostbuck.com/TheFourTopologies.html, 2003.	☐
/M.M./	5	ENSLIN, Johan H.R., et al., "Integrated Photovoltaic Maximum Power Point Tracking Converter," IEEE Transactions on Industrial Electronices, Vol. 44, No. 6, pp. 769-773, December 1997.	☐
/M.M./	6	GAUTAM, Nalin K. et al., "An Efficient Algorithm to Simulate the Electrical Performance of Solar Photovoltaic Arrays," Energy, Vol. 27, No. 4, pp. 347-361, 2002.	☐
/M.M./	7	LINARES, Leonor et al., "Improved Energy Capture in Series String Photovoltaics via Smart Distributed Power Electronics," 24th Annual IEEE Applied Power Electronics Conference and Exposition, pp. 904-910, February 15, 2009.	☐
/M.M./	8	NORDMANN, T. et al., "Performance of PV Systems Under Real Conditions," European Workshop on Life Cycle Analysis and Recycling of Solar Modules, The "Waste" Challenge, Brussels, Belgium, March 18-19, 2004.	☐
/M.M./	9	ROMAN, Eduardo, et al., "Intelligent PV Module for Grid-Connectred PV Systems," IEEE Transactions on Industrial Electronics, Vol. 53, No. 4, pp. 1066-1073, August 2006.	☐
/M.M./	10	WALKER, Jeffrey R. et al., "Cascaded DC-DC Converter Connection of Photovoltaic Modules," IEEE Transactions on Power Electronics, Vol. 19, No. 4, pp. 1130-1139, July 2004.	☐

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/628,977	12/01/2009	Ron HADAR	108144-202701/US (TGY027)

CONFIRMATION NO. 6958

64494
GREENBERG TRAURIG, LLP (SV)
IP DOCKETING
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SUITE 400E
SANTA MONICA, CA 90404

PUBLICATION NOTICE

OC000000042025944

Title: Systems and Methods for an Enhanced Watchdog in Solar Module Installations

Publication No.US-2010-0139734-A1
Publication Date:06/10/2010

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The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

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	1	5143556		1992-09-01	Matlin	
	2	5280133		1994-01-18	Nath	
	3	5604430		1997-02-18	Decker et al.	
	4	6093885		2000-07-25	Takehara et al.	
	5	6275016		2001-08-14	Ivanov	
	6	6396239		2002-05-28	Benn et al.	
	7	6515215		2003-02-04	Mimura	
	8	6545211		2003-04-08	Mimura	

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	9	6593520		2003-07-15	Kondo et al.	
	10	6650031		2003-11-18	Goldack	
	11	6653549		2003-11-25	Matsushita et al.	
	12	6837739		2005-01-04	Gorringe et al.	
	13	6984970		2006-01-10	Capel	
	14	7061214		2006-06-13	Mayega	
	15	7150938		2006-12-19	Munshi et al.	
	16	7276886		2007-10-02	Kinder	
	17	7518346		2009-04-14	Prexl	
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	1	20050057214		2005-03-17	Matan	
	2	20050057215		2005-03-17	Matan	
	3	20060001406		2006-01-05	Matan	
	4	20060174939		2006-08-10	Matan	
	5	20060185727		2006-08-24	Matan	
	6	20060231132		2006-10-19	Neussner	
	7	20070273351		2007-11-29	Matan	
	8	20080121272		2008-05-29	Besser et al.	
	9	20080122449		2008-05-29	Besser et al.	
	10	20080122518		2008-05-29	Besser et al.	

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	11	20080142071		2008-06-19	Dorn et al.	
	12	20080179949		2008-07-31	Besser et al.	
	13	20080191560		2008-08-14	Besser et al.	
	14	20080191675		2008-08-14	Besser et al.	
	15	20080303503		2008-12-11	Wolfs	
	16	20090114263		2009-05-07	Powell et al.	

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	1	2005262278	AU		2005-07-12	Central Queensland University et al.		☐
	2	4232356	DE		1994-03-31	Inst Solare Energieversorgungs		☐
	3	19961705	DE		2001-07-05	SMA Regelsysteme GmbH		☐

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	4	1388774	EP		2004-02-11	CIT Alcatel		☐
	5	2249147	ES		2006-03-16	Fundacion Robotiker		☐
	6	4219982	JP		1992-08-11	Sanyo Electric Co.		☐
	7	8097460	JP		1996-04-12	Nissan Electric Co. Ltd.		☐
	8	8116628	JP		1996-05-07	Nitto Kogyo KK		☐
	9	8316517	JP		1996-11-29	Sanyo Electric Co.		☐
	10	9148611	JP		1997-06-06	Sanyo Electric Co. Ltd.		☐
	11	2000358330	JP		2000-12-26	Nissan Electric Co. Ltd.		☐
	12	2003012569	WO		2003-02-13	Stichting Energie et al.		☐

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	12628977
	Filing Date	2009-12-01
	First Named Inventor	Ron Hadar
	Art Unit	1795
	Examiner Name	Matthew T. Martin
	Attorney Docket Number	108144-202701/US

	1	Advanced Energy Group, "The Basics of Solar Power Systems," located at http://web.archive.org/web/20010331044156/http://www.solar4power.com/solar-power-basics.html, March 31, 2001.	☐
	2	Definition of "removable" from Webster's Third New International Dictionary, Unabridged, 1993.	☐
	3	Definition of "remove" from Webster's Third New International Dictionary, Unabridged, 1993.	☐
	4	HEWES, J. "Relays," located at http://web.archive.org/web/20030816010159/www.kpsec.freeuk.com/components/relay.htm, August 16, 2003.	☐
	5	International Patent Application No. PCT/US2008/081827, International Search Report and Written Opinion, June 24, 2009.	☐
	6	PALMA, L. et al., "A Modular Fuel Cell, Modular DC-DC Converter Concept for High Performance and Enhanced Reliability," 38th IEEE Power Electronics Specialists Conference (PESC'07), pp. 2633-2638, June 17, 2007.	☐
	7	QUASCHNING, V. et al., "Cost Effectiveness of Shadow Tolerant Photovoltaic Systems," Euronsun 96, pp. 819-824, September 16, 1996.	☐
	8	URIARTE, S. et al., "Energy Integrated Management System for PV Applications," 20th European Photovoltaic Solar Energy Conference, June 6, 2005.	☐
	9	WALKER, G. R. et al., "Cascaded DC-DC Converter Connection of Photovoltaic Modules," 33rd IEEE Power Electronics Specialists Conference (PESC'02), Vol. 1, pp. 24-29, 2002.	☐

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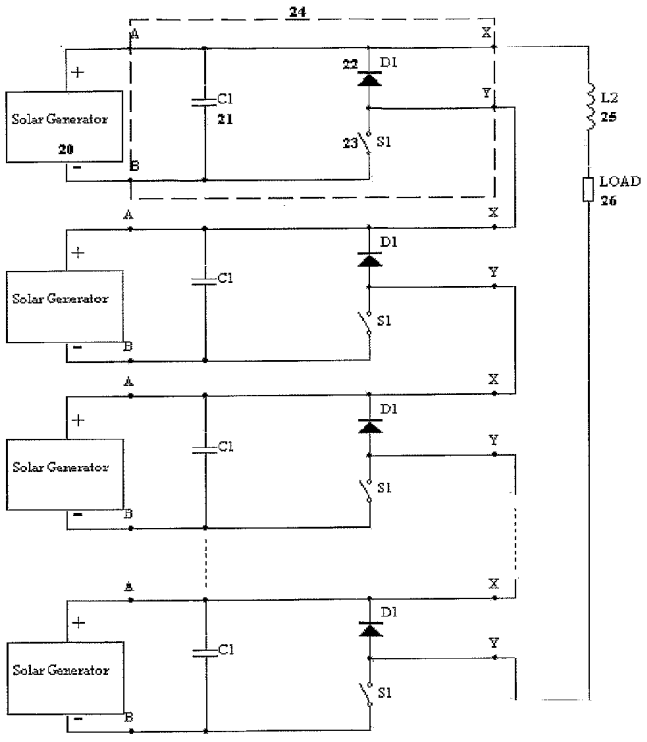
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(54) Title: A DEVICE FOR DISTRIBUTED MAXIMUM POWER TRACKING FOR SOLAR ARRAYS



(57) Abstract: The present invention is a system for providing power from solar cells whereby each cell or cell array is allowed to produce its maximum available power and converted by an operatively connected DC/DC converter. Each cell or cell array has its own DC/DC converter. In one form the system for providing power from solar cells includes one or more solar generators wherein each of said solar generators has one to nine solar cells; a maximum power tracker operatively associated with each solar generator, each of said maximum power tracker includes a buck type DC/DC converter without an output inductor, each of said maximum power trackers are operatively connected in series with each other; an inductor operatively connected to the series connected maximum power trackers; and means for providing electrical power from the inductor to load means, wherein each of said maximum power trackers is controlled so that the operatively associated solar generator operates at its maximum power point to extract maximum available power.

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A DEVICE FOR DISTRIBUTED MAXIMUM POWER TRACKING FOR SOLAR ARRAYS

FIELD OF INVENTION

The present invention relates to solar cell technology and in particular to maximum power tracking converters. The present invention has particular but not exclusive application for use in vehicles that are at least in part electrically powered by solar cells. Reference to solar powered vehicles is by means of example only and the present invention has application in other areas.

BACKGROUND OF THE INVENTION

A solar cell is a device able to convert incident light to electrical power. Many solar cells are typically grouped to form an array of solar cells. To collect the electrical power from the solar cells, groups of cells are either directly connected in series or in parallel. Where the cells are connected in series, they must have identical currents but if the cells are connected in parallel they must operate with identical voltages. An individual cell will produce maximum power at a unique cell voltage and current which will vary from cell to cell. The combination of voltage and current that allows a cell to produce its maximum power is termed the maximum power point. The maximum power point varies with cell illumination and temperature. Connection of the cells in series forces cells to have identical current while connection in parallel forces cells to have identical voltage. Direct connection in series or parallel results in failure to collect all the available electrical power from the solar cells in the array and at least some of the cells will operate at a condition other than at their maximum power points.

To obtain the maximum available power from a group of solar cells connected in an array or sub-array, a maximum power tracking device is used. Maximum power tracking devices are DC to DC power converters that allow an array or sub-array to operate at their maximum power point. A DC to DC converter can transform a power input at a certain voltage and current to be transformed to a DC power output at a differing voltage and current. A key feature of all maximum power trackers is a control device that determines the point of maximum power for the connected solar cells and acts to adjust the DC to DC converter performance to adjust the cell voltage or current to extract the maximum available power.

However there are a number of problems or disadvantages associated with the use of a single maximum power device to control the voltage or current of an array or sub-array of solar cells.

Where solar cells are used to power vehicles, the vehicles are usually aerodynamically designed with curved surfaces and also have limited surface area in which to mount the solar cells. Consequently arrays of cells are mounted on the curved surfaces but the variation of the angle of incidence of light on the different cells within the array on the curved surface causes variation in the available optical power. Furthermore, cells in an array may be subjected to variable light levels due to shadowing by foreign objects such as trees and buildings between the cell and the source of illumination.

Because of differences in optical illumination, cell temperatures may vary within arrays causing some cells to be hotter than other cells. Arrays may be cooled partially by air flow or by the use of a cooling fluid in an illumination concentrator system. These mechanisms however may not provide uniform cooling to all cells.

The available power from each cell within an array will vary due to the variations in illumination and temperature. In these cases, the maximum power conditions of different cells within the array will differ at any one point of time. Furthermore the maximum power conditions of some cells within the array will vary differently over time compared with others. As well these variations are not predictable. In addition changes to the maximum power conditions of cells can vary rapidly thereby requiring a relatively quick response time.

Currently maximum power tracking devices are directly electrically connected to an array of solar cells. A single maximum power tracking device is currently used to control the available power from an array of between ten to several hundred cells.

OBJECT OF THE INVENTION

It is an object of the present invention to provide an alternate maximum power tracking device that overcomes at least in part one or more of the above mentioned problems or disadvantages.

SUMMARY OF THE INVENTION

The present invention arises from the realization that each cell at any one particular time point will have a unique maximum power point defined by a specific cell voltage and specific current at which the cell will produce its maximum available power. Furthermore the invention was developed from the realization that it is not possible for every cell in an array to operate at its maximum power point if the array is formed by the direct electrical interconnection of cells. With this in mind and taking advantage of recent advances in low voltage electronics, maximum power tracking

devices for very small groups of directly connected cells or for single solar cells were developed to provide a solution to optimizing the electrical power from the array.

In one aspect the present invention broadly resides in a system for providing power from solar cells including

one or more solar generators wherein each of said solar generators has one to nine solar cells;

a maximum power tracker operatively associated with each solar generator, each of said maximum power tracker includes a buck type DC/DC converter without an output inductor, each of said maximum power trackers are operatively connected in series with each other;

an inductor operatively connected to the series connected maximum power trackers; and

means for providing electrical power from the inductor to load means, wherein each of said maximum power trackers is controlled so that the operatively associated solar generator operates at its maximum power point to extract maximum available power.

The maximum power tracker preferably includes an energy storage capacitor and a control means for adjusting the buck type DC/DC converter duty cycle so that a connected solar generator operates at its maximum power point.

Preferably the control means makes observations of solar generator voltage, and observations of the change in energy storage capacitor voltage during the buck converter switch off time and observations of the duration of the buck converter switch off time to infer solar generator power to adjust the buck converter duty cycle to extract maximum power from the connected solar generator.

In one preferred embodiment, the switching operations of the DC/DC converter are synchronized in frequency by the use of a synchronizing signal.

Preferably each solar generator includes one solar cell. Preferably each solar generator includes one solar cell and each solar cell is connected to its own dedicated maximum power tracker so that the tracker responds to its connected solar cell.

Preferably the system uses a single inductor.

Load means includes devices that use or store the electrical power.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the present invention can be more readily understood and put into practical effect, reference will now be made to the accompanying drawings wherein:

Figure 1 is a diagrammatic view of a simplified Buck type DC/DC converter with solar generator and load;

Figure 2 is a diagrammatic view of an alternative embodiment of a simplified Buck type DC/DC converter with solar generator and load;

Figure 3 is a diagrammatic view of a solar generator with a Buck type DC/DC converter without an inductor;

Figure 4 is a diagrammatic view of an alternative embodiment of a solar generator with a Buck type DC/DC converter without an inductor;

Figure 5 is a diagrammatic view of the interconnection of a plurality of Buck type DC/DC converters without inductors, corresponding plurality of solar generators, one inductor and a load; and

Figure 6 is a diagrammatic view of a preferred embodiment of the single cell MPPT converter;

Figure 7 is a graphical representation of the control signals and gate signals for MOSFETs;

Figure 8 is a graphical representation of a no load 2kHz waveforms, top MOSFET gate waveform; top MOSFET gate drive referred to ground, bottom MOSFET gate waveform to ground, output terminal to ground (from top to bottom);

Figure 9 is a graphical representation of an unloaded 20kHz waveforms, Traces top to bottom, output terminal, bottom MOSFET gate, top MOSFET gate, all referred to ground;

Figure 10 is a graphical representation of a loaded 20kHz waveforms, traces top to bottom, output terminal, bottom MOSFET gate, top MOSFET gate, all referred to ground;

Figure 11 is a graphical representation of input voltage, current and power at 10kHz (from top to bottom);

Figure 12 is a graphical representation of output current, voltage and power at 10kHz (from top to bottom);

Figure 13 is a table of equipment for efficiency measurement; and

Figure 14 is a table of converter efficiency at different frequencies.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to Figure 1 there is shown a simplified buck type DC/DC converter 10 connected to a solar generator 11 and load 12. The solar generator 11 can be a solar cell or several cells. The buck type DC/DC converter 10 includes a capacitor 13 which serves as an energy storage element, a controlled switching

device 14, a diode or a controlled device acting as a synchronous rectifier 15 and an output inductor 16. An alternative arrangement for the buck type DC/DC converter 10 is shown in Figure 2.

A buck type DC/DC converter can be controlled to operate the solar generator at its maximum power point while producing an adjustable level of output current. The solar generator and maximum power tracker will be referred to as a solar generator /MPPT. Many solar generators/MPPT can be series connected. Each DC/DC converter will then have an identical output current but they can be individually controlled to allow each solar generator to operate at their maximum power point.

A conventional buck converter uses an output inductor to provide energy storage that is necessary for current filtering. An important feature of this invention is that the many inductors would normally be required, one for each solar generator/MPPT, and this can be replaced by a single inductor which will perform the energy storage and filtering function for many series connected solar generator/MPPT. The MPPT device can be produced as an inductor free device.

Figure 3 shows an inductorless DC/DC buck converter with a solar generator while Figure 4 shows an alternate embodiment.

Many solar generators/MPPT devices that utilize inductor free DC/DC buck converters can be series connected with a single inductor to supply power to an electrical load. The series connection of the solar generators/MPPT devices forces each inductorless DC/DC buck converter to supply an identical output current. Each converter operates with a constant current load.

The controlled switching device operates alternates between an open and closed state. The average portion of time that the switch is closed is the switch duty

cycle. Closure of the controlled switching device causes the load current to be supplied from the solar generator and the energy storage capacitor. When the controlled switch is open, the load current transfers to the diode or synchronous rectifier device while the solar generator current replenishes the charge within energy storage capacitor.

The duty cycle of the controlled switching device will determine the average current withdrawn from the energy storage capacitor. The energy storage capacitor will adjust its voltage in response to the difference in the current supplied by the solar generator and the current withdrawn to by the controlled switch. The switching device will be controlled by a device that adjusts the controlled switch duty cycle to maintain the solar generator voltage at the maximum power point.

With respect to Figure 5 there is shown a solar generator 20 connected to a capacitor 21, diode 22 and control switch 23. The capacitor 21, diode 22 and control switch 23 forms the inductorless DC/DC converter 24. Several solar generators 20 are connected in series via their dedicated inductorless DC/DC converters 24. Each solar generator 20 has its own inductorless DC/DC converters 24. After the last inductorless DC/DC converters 24, there is an inductor 25 to filter the current prior to reaching the load 26. The inductor 25 can be smaller in terms of magnetic energy shortage measured as $\frac{1}{2} LI^2$,where L is the inductance value in Henry and I is the inductor current, in Amperes, than the total combined set of inductors that are normally used with each buck DC/DC converter. The use of a smaller inductor and only one inductor reduces cost and weight and increases the efficiency in providing maximum power from the solar cells. In the preferred embodiment the solar generator consists of a solar generator which is a single high performance solar cell.

With reference to Figure 6, there is shown a DC to DC converter 30 in the formed by MOSFETs Q1 and Q2 (31 and 32 respectively), and the energy storage capacitor 33. No filter inductor is required. In this preferred embodiment MOSFET Q1 (31) is a synchronous rectifier implementation of the diode device and MOSFET Q2 (32) is the buck converter controlled switch element. In the preferred embodiment the output terminals of the solar generator/MPPT device are the the drain terminal of Q1, point X and the junction of the source terminal of Q1 and the drain terminal of Q2, point Y.

The control element of the maximum power device is a microprocessor. In this preferred embodiment, an ultra-low power Texas Instruments MSP430 microprocessor 34 which is capable of operation at a supply voltage of 1.8V. This allows direct operation from a dual junction cell which typically produces 2V. If other cell types are used with lower cell voltages, a power conditioning device may be required to develop a higher voltage supply to allow the control element to be operated from a single cell. For example, silicon cells typically produce 0.4V and a voltage boosting converter would be required to generate a voltage high enough to operate a microprocessor control element.

An alternate embodiment is possible where the solar generator/MPPT device output terminals are the junction of Q1 and Q2, point Y, and the source of Q2. In this case Q1 is the controlled switch element and Q2 is the diode element implemented as a synchronous rectifier.

The gate drive voltage for the MOSFETS Q1 and Q2 is derived by charge pump circuit. In the preferred implementation a multiple stage charge pump circuit formed by diodes D_1 to D_4 , devices 35-38, and their associated capacitors 39-42.

The MOSFETS Q1 and Q2 are driven by a gate driver circuit. In the preferred embodiment a comparator, 43, forms the driver circuit. As this circuit delivers a higher gate to source voltage to device Q2 than Q1, Q2 achieves a lower turn on resistance. In the preferred embodiment Q2 is the controlled switching device as this arrangement minimises power losses.

Resistors 44 and 45 form a voltage divider network which is used to perform voltage observations of solar generator voltage using a analogue to digital converter within the microprocessor 34. An important feature of the maximum power tracking method is the measurement of cell voltage magnitude, the and measurement of the change in cell voltage during periods when the controlled switch, 32, is open and the measurement of the time that the controlled switch is open to infer cell power. This may be used as an input to a maximum power tracking method that will control the DC-DC converter duty cycle to allow the solar generator to operate at maximum power.

In order to secure high efficiency in the solar generator/MPPT, low switching frequencies are preferred. In the preferred embodiment switching frequencies will be below 20 kHz. At very low switching frequencies the ripple voltage on capacitor C1 will increase. The voltage ripple will cause the cell to deviate from its maximum power point. An optimum switching frequency range will exist. In the preferred embodiments the switching frequency will be adjusted to maximise the energy delivered by the solar generator/MPPT.

A plurality of solar generator/MPPT may be configured within a large array to switch at the same frequency and with a relative phase relationship that provides improved cancellation of switching frequency voltage components in the output voltage waveforms of the solar generator/MPPT combinations. This allows a smaller

inductor to provide filtering of the load current. Such synchronisation may be provided by auxiliary timing signals that are distributed within an array or by other means.

In some embodiments the solar generator/MPPT devices within an array may not switch at the same frequency. The combined output voltage of large number of asynchronously switching series connected buck converters will follow a binomial distribution. The average output voltage of the group of n solar generator/MPPT devices, with an input voltage V_{in} and a duty cycle d, increases linearly with n while the switching ripple or the distortion voltage, V_{dist}, rises as $\sqrt{n}$.

$$V_{dist} = V_{in}\sqrt{n(d - d^2)} \qquad (1)$$

Likewise the average volt second area, A, for a shared filter inductor follows an $\sqrt{n}$ relationship.

$$A = \sqrt{n}\frac{V_{in}}{f}(d - d^2) \qquad (2)$$

In a non synchronized embodiment, a larger inductor is required than in an optimally synchronized embodiment. The required inductor is still significantly smaller than the combined plurality of inductors that would be required for conventional buck converters.

A prototype converter was developed to first examine the conversion efficiency of the DC to DC converter stage and its suitability for use with a dual junction single solar cell, with an approximate maximum power point at 2V and

300mA. For these tests the MSP340 was programmed to drive the charge pump circuitry and to operate the buck converter stage at a fixed 50% duty ratio. The experimental circuit is as in Figure 6. A fixed 2V input source voltage was applied and a load consisting of a 2 500μH inductor and a 1.6 Ω resistor was applied. A dead-time of 0.8μS is inserted in each turn-on and turn-off transient to prevent MOSFETs shoot through conduction events.

As gate charging loss was a significant loss contributor, a range of operating frequencies was trialled. Figure 7 shows the control waveforms at 20kHz. The waveforms show the dead times between the top and bottom signals at turn-on and turn-off. All waveforms in this figure are ground referred. The measured no load loss in this condition was 6mW which is approximately twice the expected figure. The gate drive loss is fully developed at no load and we may have additional loss in the charge pump circuitry. Figure 8 shows gate waveforms at 2kHz but a differential measurement is made of V_{gs1} to show the lowering of the gate source voltage to approximately 4V due to elevation of the source at the device turn-on.

The waveforms at 20 kHz without load are shown in Figure 9. Note that the load connection is across terminals X and Y. The lower MOSFET has the higher gate drive voltage and a lower R_{dson}. Figure 10 shows the loaded waveforms. Note the conduction of the MOSFET inverse diodes in the dead time as seen by the 2 μS wide peaks on the leading and trailing pulse top edges on the top trace. The transfer of current to these diodes generates an additional conduction loss of 24mW which reduces efficiency at higher frequencies.

Given circuit losses are around a few percentage points of rating, precise voltage and current measurements are needed if power measurements are used to determine efficiency. A complication is that the output is inductorless and both the

output voltage and current contain significant switching frequency components. It is likely that a significant amount of power is transferred to the combined R-L load at frequencies other than DC.

In order to determine the efficiency of this converter, a new high end oscilloscope was used to measure the input and output power. The internal math function was employed to obtain the instantaneous power from the current and voltage, the mean value of which indicates the average power. The current probe was carefully calibrated before each current measurement, to minimise measurement errors. Figure 13 shows the details of the equipment used in a table format. Figures 11 and 12 show the input and output voltages, current and power. The mean value of measured power is displayed at the right column of the figures.

The efficiencies of the converter obtained are shown in a table in Figure 14. It is seen that the measured efficiency is slightly lower than estimated especially at higher frequencies. One reason is the loss during the dead-time. The on-state voltage drop of the diode is much higher than the MOSFET, and therefore reduces the efficiency of the converter. At 10kHz the dead time loss accounts for 12mW of the observed 30mW. The results do confirm that the circuit is capable of achieving high efficiencies especially if the switching frequency is low.

VARIATIONS

It will of course be realised that while the foregoing has been given by way of illustrative example of this invention, all such and other modifications and variations thereto as would be apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of this invention as is herein set forth.

Throughout the description and claims this specification the word "comprise" and variations of that word such as "comprises" and "comprising", are not intended to exclude other additives, components, integers or steps.

CLAIMS

1. A system for providing power from solar cells including

one or more solar generators wherein each of said solar generators has one to nine solar cells;

a maximum power tracker operatively associated with each solar generator, each of said maximum power tracker includes a buck type DC/DC converter without an output inductor, each of said maximum power trackers are operatively connected in series with each other;

an inductor operatively connected to the series connected maximum power trackers; and

means for providing electrical power from the inductor to load means, wherein each of said maximum power trackers is controlled so that the operatively associated solar generator operates at its maximum power point to extract maximum available power.

2. A system as claimed in claim 1 wherein the maximum power tracker includes an energy storage capacitor and a control means for adjusting the buck type DC/DC converter duty cycle so that a connected solar generator operates at its maximum power point.

3. A system as claimed in claim 1 wherein the maximum power tracker includes an energy storage capacitor and a control means for adjusting the buck type DC/DC converter duty cycle so that a connected solar generator operates at its maximum power point; said control means makes observations of solar generator voltage, and observations of the change in energy storage capacitor voltage during the buck

converter switch off time and observations of the duration of the buck converter switch off time to infer solar generator power to adjust the buck converter duty cycle to extract maximum power from the connected solar generator.

4. A system as claimed in any one of the above mentioned claims wherein the switching operations of the DC/DC converter are synchronized in frequency by the use of a synchronizing signal.

5. A system as claimed in any one of the above mentioned claims wherein each solar generator includes one solar cell.

6. A system as claimed in any one of the above mentioned claims wherein each solar generator includes one solar cell and each solar cell is connected to its own dedicated maximum power tracker so that the tracker responds to its connected solar cell.

7. A system as claimed in any one of the above mentioned claims wherein the system uses a single inductor.

8. A system as claimed in any one of the above mentioned claims wherein load means includes devices that use or store the electrical power.

9. A system as substantially described herein with reference to and as illustrated by the accompanying drawings.

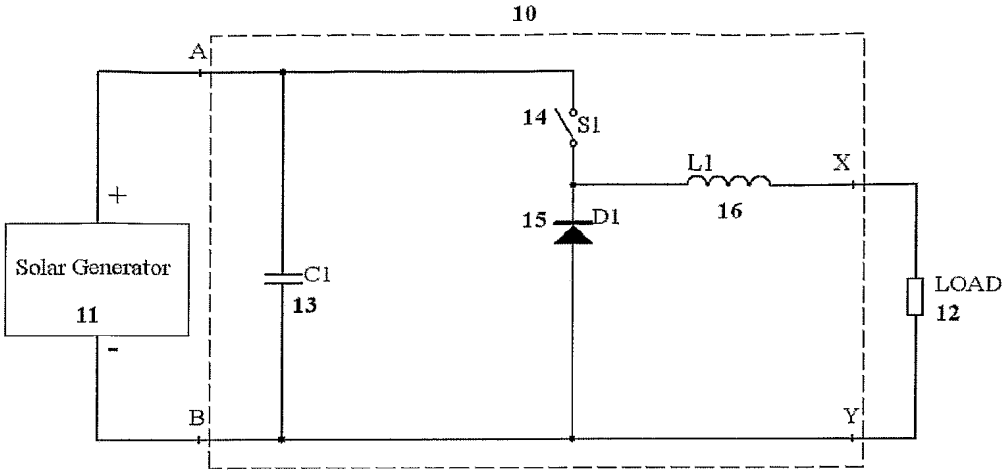


FIGURE 1

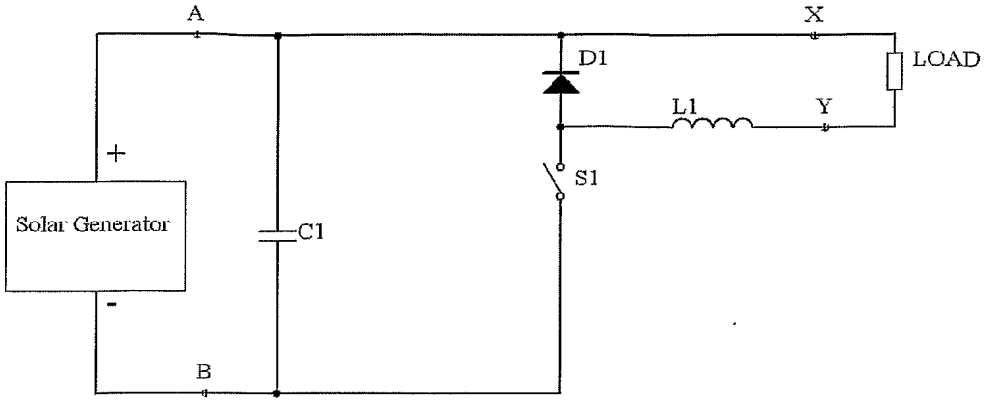


FIGURE 2

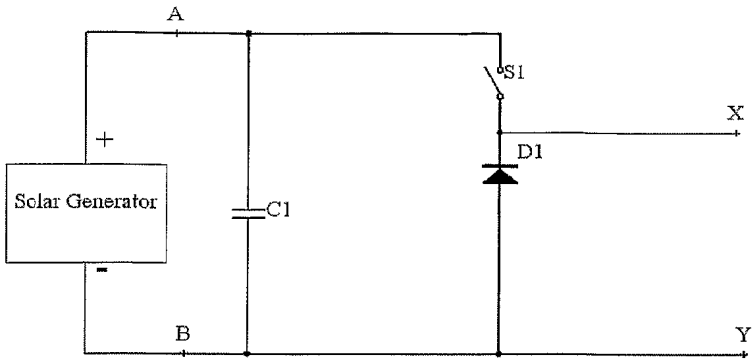


FIGURE 3

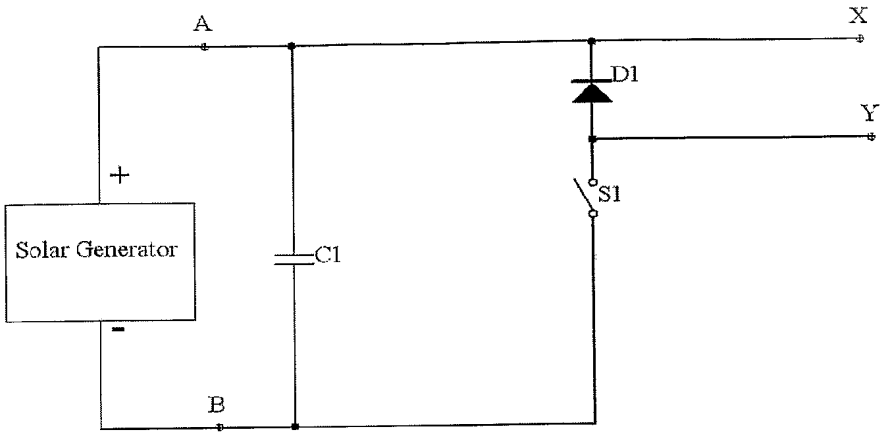


FIGURE 4

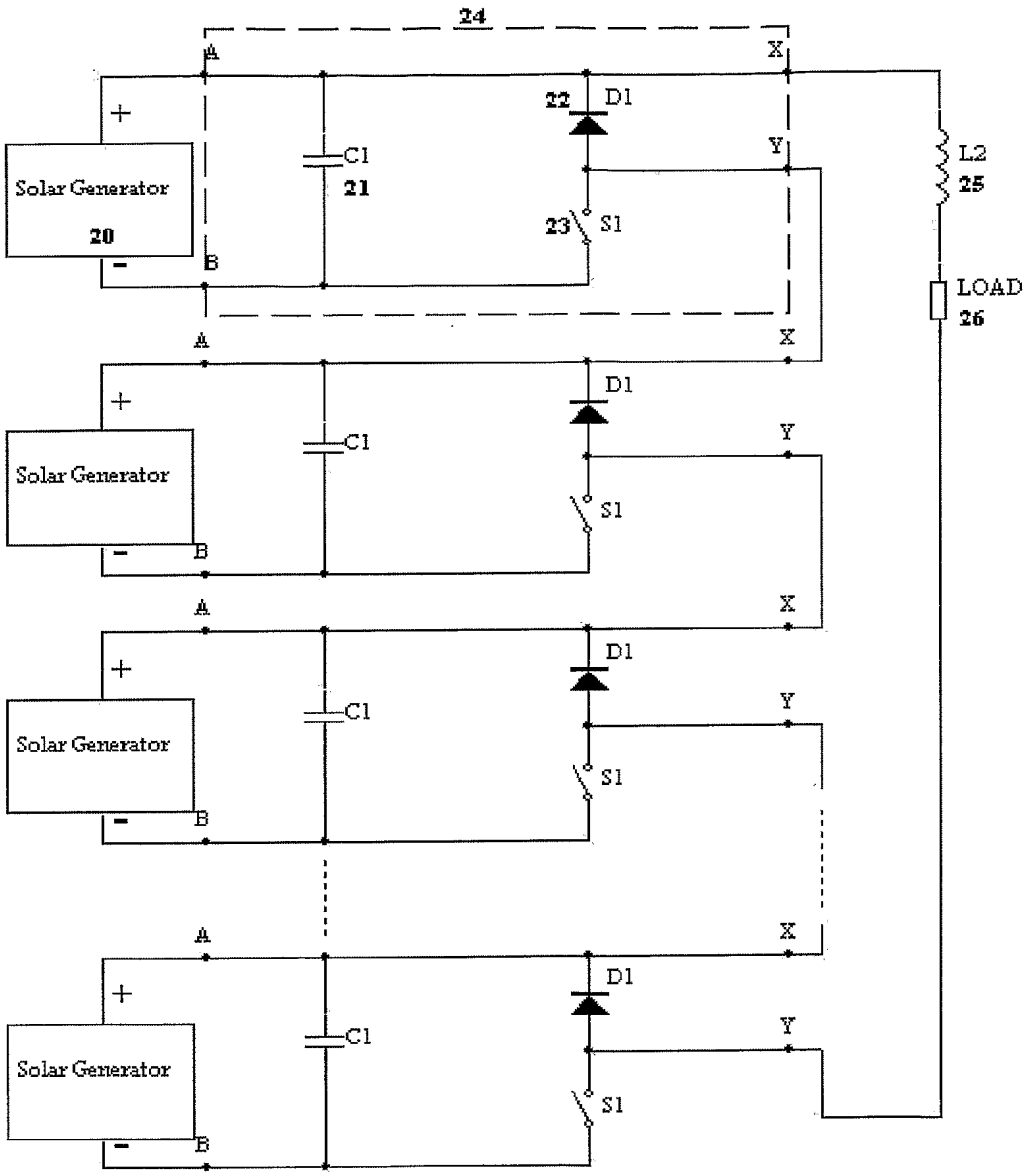

24
A
X
22
D1
+
C1
21
Y
L2
25
Solar Generator
20
23
S1
-
B
LOAD
26
A
X
D1
+
C1
Y
Solar Generator
S1
-
B
A
X
D1
+
C1
Y
Solar Generator
S1
-
B
A
X
D1
+
C1
Y
Solar Generator
S1
-
B

FIGURE 5

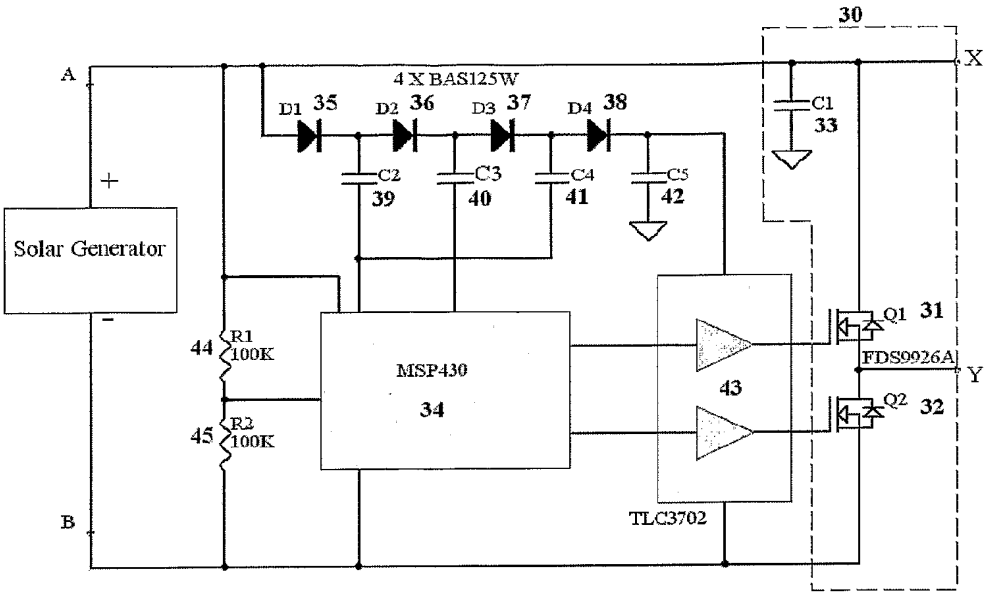

30
A
4 X BAS125W
D1 35
D2 36
D3 37
D4 38
C1
33
X
+
Solar Generator
–
C2
39
C3
40
C4
41
C5
42
Q1 31
FDS9926A
Y
Q2 32
R1
100K
44
R2
100K
45
MSP430
34
43
TLC3702
B

FIGURE 6

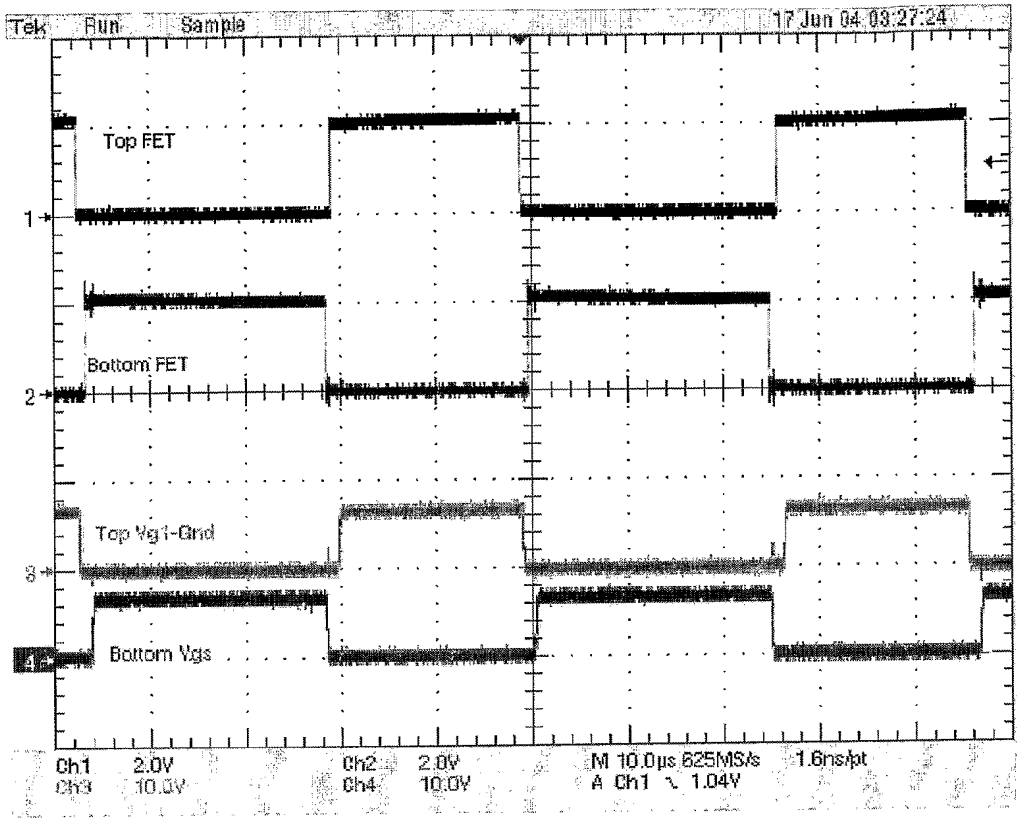

Tek Run Sample 17 Jun 04 03:27:24
Top FET
Bottom FET
Top Vg1-Gnd
Bottom Vgs
Ch1 2.0V
Ch3 10.0V
Ch2 2.0V
Ch4 10.0V
M 10.0µs 625MS/s 1.6ns/pt
A Ch1 ∖ 1.04V

FIGURE 7

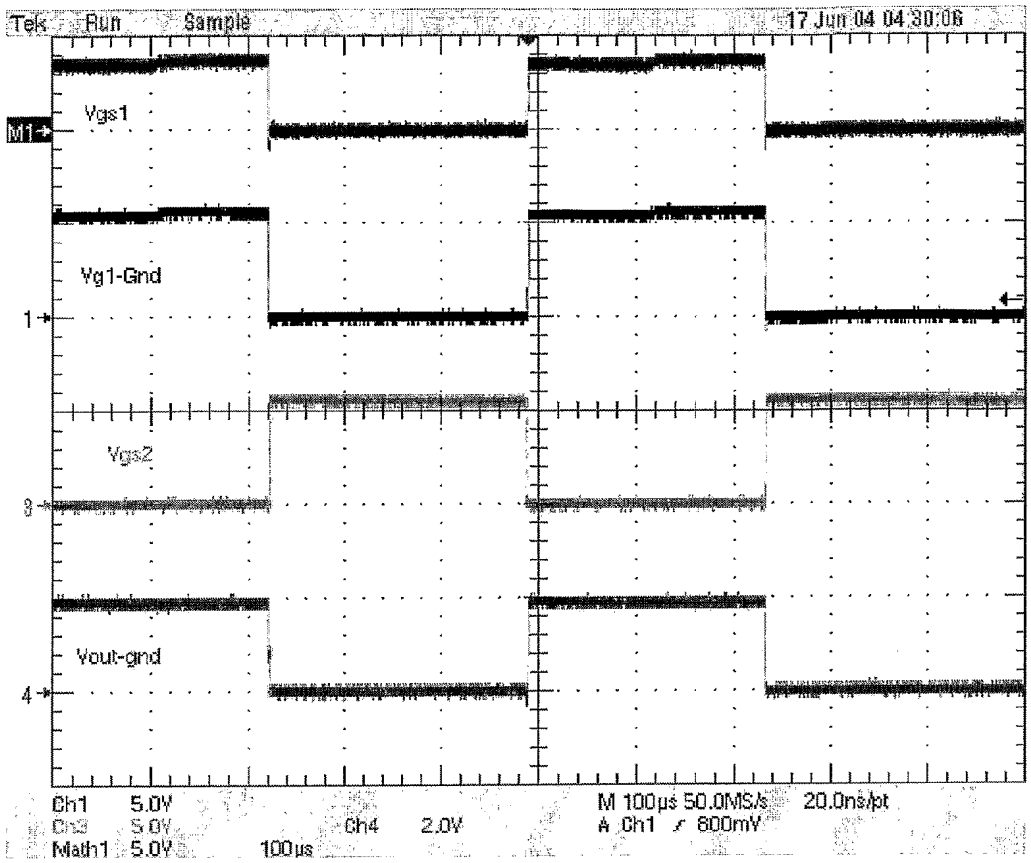

Tek Run Sample 17 Jun 04 04:30:06
Vgs1
Vg1-Gnd
Vgs2
Vout-gnd
Ch1 5.0V
Ch3 5.0V
Math1 5.0V
100µs
Ch4 2.0V
M 100µs 50.0MS/s 20.0ns/pt
A Ch1 ∕ 800mV

FIGURE 8

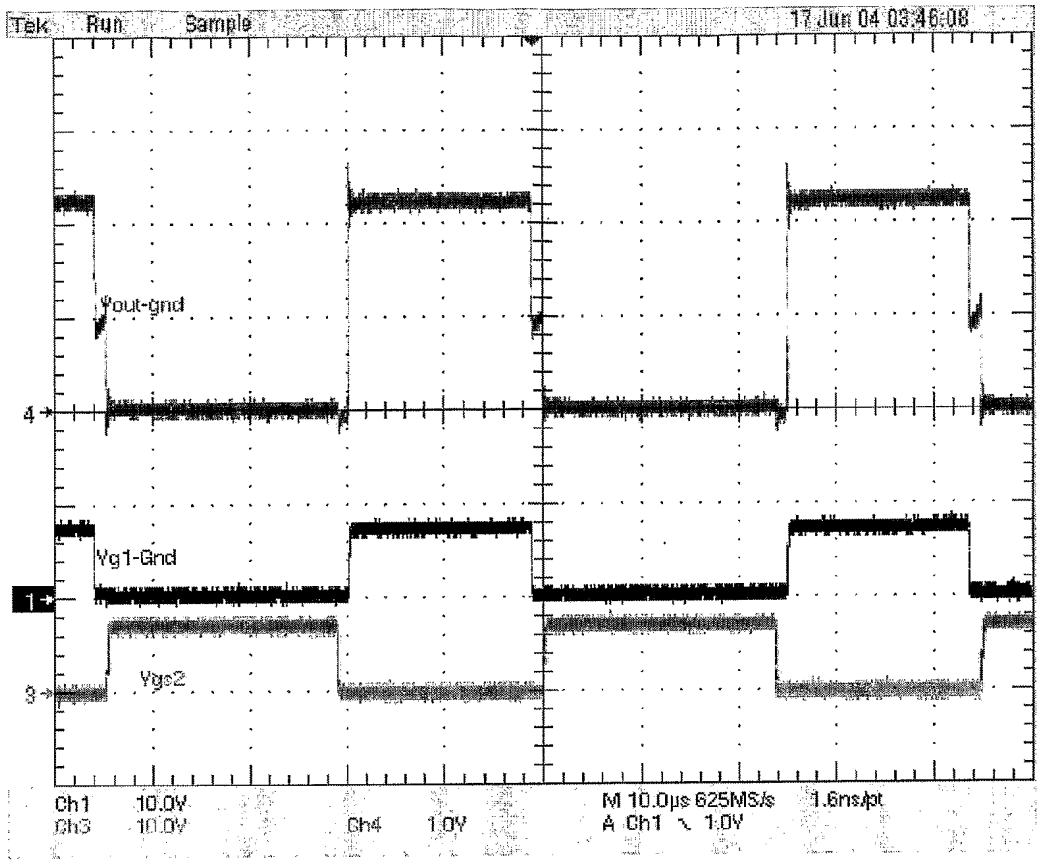

Tek Run Sample
17 Jun 04 03:46:08
Vout-gnd
Vg1-Gnd
Vgs2
4
1
3
Ch1 10.0V
Ch3 10.0V
Ch4 1.0V
M 10.0µs 625MS/s
A Ch1 ∖ 1.0V
1.6ns/pt

FIGURE 9

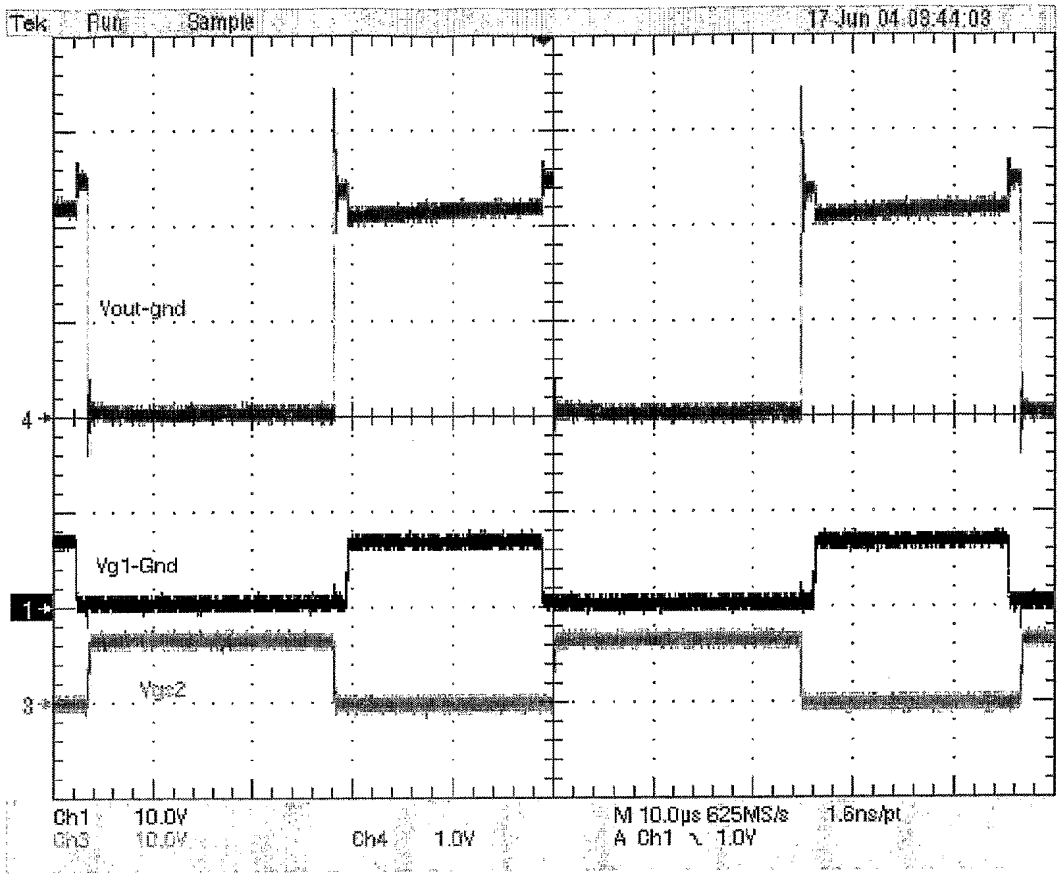

Tek Run: Sample
17 Jun 04 08:44:03
Vout-gnd
Vg1-Gnd
Vgs2
4
1
3
Ch1 10.0V
Ch3 10.0V
Ch4 1.0V
M 10.0µs 625MS/s 1.6ns/pt
A Ch1 ∖ 1.0V

FIGURE 10

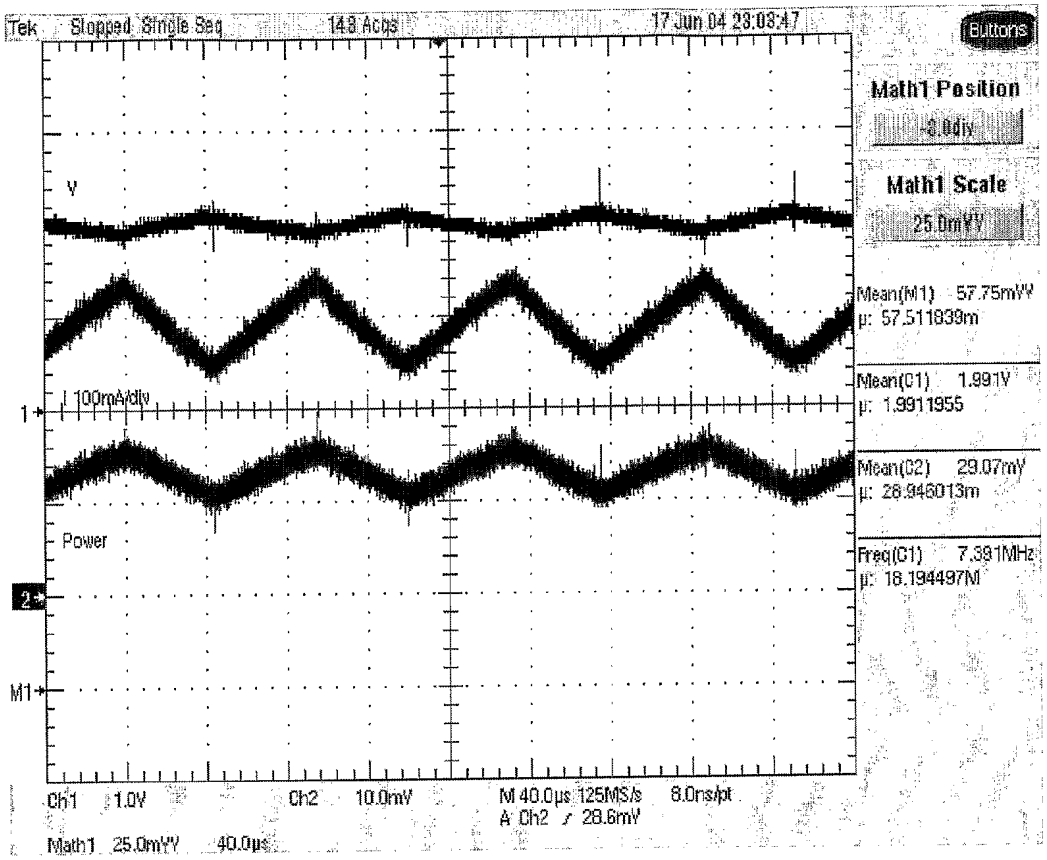

Tek Stopped Single Seq 148 Acqs 17 Jun 04 23:03:47
Buttons
Math1 Position
-3.0div
Math1 Scale
25.0mV/V
V
100mA/div
Power
M1
Mean(M1) 57.75mV/V
μ: 57.511839m
Mean(C1) 1.991V
μ: 1.9911955
Mean(C2) 29.07mV
μ: 28.946013m
Freq(C1) 7.381MHz
μ: 18.194497M
Ch1 1.0V Ch2 10.0mV M 40.0μs 125MS/s 8.0ns/pt
A Ch2 28.6mV
Math1 25.0mV/V 40.0μs

FIGURE 11

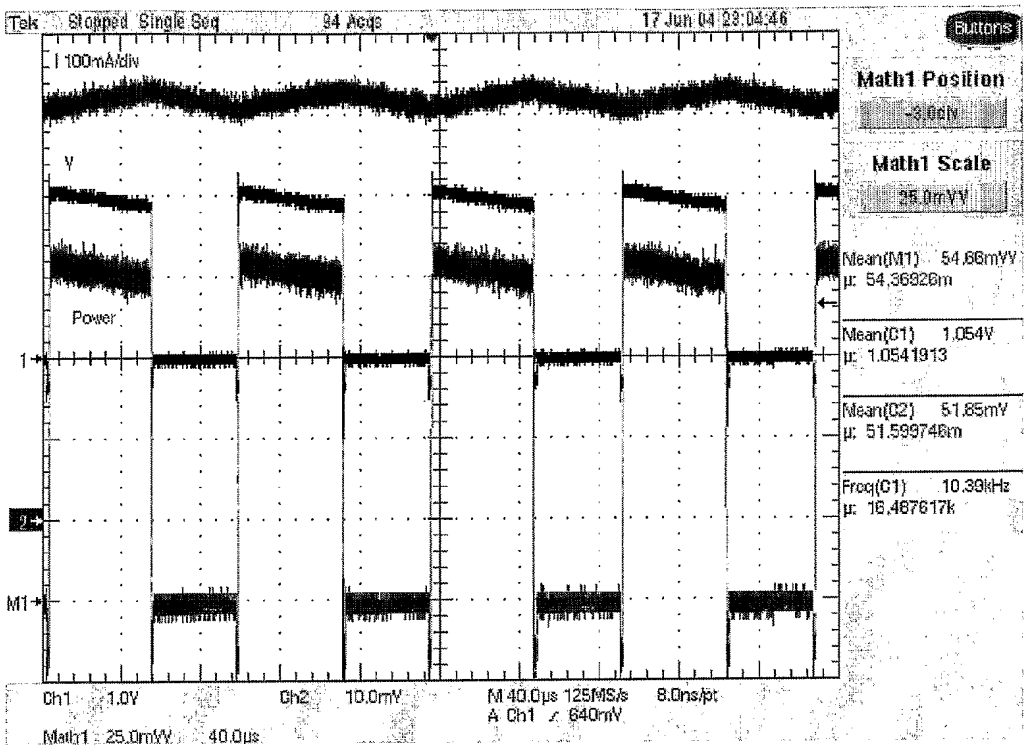

Tek Stopped Single Seq 94 Acqs 17 Jun 04 23:04:46
Buttons
I 100mA/div
V
Power
1
2
M1
Math1 Position
Math1 Scale
Mean(M1) 54.66mVV
Mean(C1) 1.054V
Mean(C2) 51.85mV
Freq(C1) 10.39kHz
Ch1 1.0V Ch2 10.0mV M 40.0µs 125MS/s 8.0ns/pt
A Ch1 640mV
Math1 25.0mVV 40.0µs

FIGURE 12

Name of equipment	Model	Quantity
Current probe	Tektronix AM503B+TM502A	1
Voltage probe	Tektronix P5050	1
Oscilloscope	Tektronics DPO5034	1

FIGURE 13

Frequency (kHz)	Input Power (mW)	Output Power (mW)	Efficiency
2	520	510	98%
10	577	547	95%
20	506	471	93%

FIGURE 14

Power supply system with at least two rectifier-inverter pairs - has voltage from one pair phase-shifted with respect to other pair thus eliminating unwanted harmonics

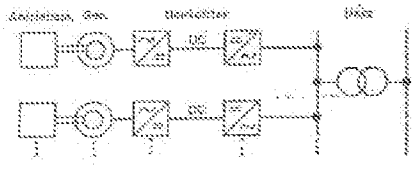
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Publication date: 1994-03-31
Inventor(s): HEIER SIEGFRIED DIPL ING [DE]; KLEINKAUF WERNER PROF DR ING [DE] +
Applicant(s): INST SOLARE ENERGIEVERSORGUNGS [DE] +
Classification:
- international: ***F03D9/00; H02J3/01; H02J3/38; H02J5/00; H02P9/48;*** **F03D9/00; H02J3/01; H02J3/38; H02J5/00; H02P9/00;** (IPC1-7): H02J3/01; H02J3/38; H02N6/00; H02P9/48
- European: F03D9/00C2B; H02J3/01; H02J3/38; H02J5/00; H02P9/48
Application number: DE19924232356 19920926
Priority number(s): DE19924232356 19920926

Also published as:
DE4232356 (C2)

Cited documents:
DE3023195 (A1)
DE2911342 (A1)
DE2317068 (A1)
EP0473257 (A2)
EP0353715 (A2)

Abstract of **DE 4232356 (A1)**

The power source with at least two rectifier-inverter pairs (used as a controllable DC link), typically a wind power plant or photovoltaic plant, has the voltage from one pair phase-shifted with respect to the other pair so as to eliminate totally or partially the harmonics generated. There is a step-up transformer between the output voltage and the Grid. To eliminate or reduce harmonics, the half period of the critical harmonic number is chosen as the displacement in the firing angles. The critical harmonic number lies near the grid frequency. ADVANTAGE - Reduces unwanted harmonics being fed into Grid.



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H 02 P 9/48

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DE 42 32 356 C 2

Innerhalb von 3 Monaten nach Veröffentlichung der Erteilung kann Einspruch erhoben werden

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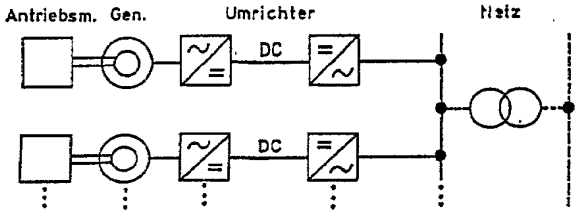
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(56) Für die Beurteilung der Patentfähigkeit in Betracht gezogene Druckschriften:

DE 30 23 195 A1
DE-OS 29 11 342
DE-OS 23 17 068
EP 04 73 257 A2
EP 03 53 715 A2
H. PRINZ: Einführung in die Starkstromtechnik, München 1961, S.144-149;

(54) Stromversorgungseinrichtung mit mindestens zwei Stromquellen

(57) Stromversorgungseinrichtung mit mindestens zwei Stromquellen, wobei jede Stromquelle über einen zugeordneten Stromrichter in ein Wechselstromnetz einspeist, dadurch gekennzeichnet, daß zur Herabsetzung der Amplitude einer bestimmten vorhandenen Oberschwingung die Spannung von mindestens einem der Stromrichter mit Hilfe eines Steuerwinkels phasenverschoben zu mindestens einem anderen Stromrichter in das Netz einspeisbar ist.



Systeme mit gemeinsamer Netzkopplung

DE 42 32 356 C 2

BUNDESDRUCKEREI 11. 96 602 162/99

Beschreibung

Die Erfindung betrifft eine Stromversorgungseinrichtung mit mindestens zwei Stromquellen gemäß dem Oberbegriff des Anspruchs 1.

Stromversorgungseinrichtungen der eingangs genannten Art sind bekannt. Häufig werden Windkraftanlagen in Form von sogenannten Windparks eingesetzt, wobei der Aufbau derartiger Windparks von den herrschenden Windverhältnissen und der Art der Einzelanlagen abhängt. Bei Windkraftanlagen mit Asynchron-Generatoren wird eine direkte Netzkopplung bevorzugt, während bei Synchron-Generatoren meist eine Netzkopplung über einen Frequenzumrichter, bestehend aus einem Gleichrichter mit Gleichstrom-Zwischenkreis und netzgeführtem Wechselrichter, erfolgt. Es werden auch Windkraftanlagen mit Generatoren eingesetzt, die mehrere parallel zueinander angeordnete Statorwicklungen mit entsprechenden Stromrichtern aufweisen. Ein derartiger Generator kann im vorliegenden Fall auch als ein System bestehend aus zwei Maschinen bzw. zwei Einheiten betrachtet werden.

Eine Umrichterspeisung ist dann von Vorteil, wenn das Energieangebot vergleichmäßigt werden soll. So kann z. B. bei böigem Wind über variable Drehzahl mit Hilfe der Schwungmassen als Speicher ein Ausgleich geschaffen werden. Bei einem Windrad mit Umrichter wird die Drehzahl bei schwankender Windgeschwindigkeit derart verändert, daß die vom Wind angebotene Energie besser genutzt, mechanische Anlagenteile entlastet und eine gleichmäßigere Ausgangsleistung abgegeben wird. Das heißt, die Schwungmasse des Windrades wird zur Vergleichmäßigung der Abgabeleistung herangezogen.

Bei Netzeinspeisung über Umrichtersysteme besteht die Gefahr von Netzeinwirkungen. U.a. können Oberschwingungen in das Netz eingebracht werden und Netzresonanzen entstehen. Die Folge ist, daß sich Strom- oder Spannungsüberhöhungen im Netz ergeben, die sich bis zu einzelnen Verbrauchern fortpflanzen und dort zu Beeinträchtigungen führen.

Photovoltaikanlagen oder Batteriespeicher, die Gleichstrom liefern, sind ebenfalls häufig über netzgeführte Wechselrichter mit dem Wechsel- oder Drehstromnetz verbunden und verursachen entsprechende Oberschwingungsprobleme.

Wird ein Netz am Anschlußpunkt eines oder mehrerer Einspeise- oder Verbrauchersysteme betrachtet, so ist für das Verhalten die Gesamtimpedanz der Konfiguration maßgebend, die sich anhand der gegebenen Kombination von ohmschen Widerständen, Induktivitäten und Kapazitäten im Einspeise-, Verteiler- und Verbrauchersystem ermitteln läßt. Entsprechend der Anzahl dieser Einzelelemente, ihrer Anbindung und Größe der Impedanzen ergeben sich u. a. Eigenresonanzwerte im betrachteten Netzteil, die — wie bereits ausgeführt — bei Anregung Strom- oder Spannungsüberhöhungen in den angeschlossenen Bauelementen und Geräten verursachen können. Diese Anregungen treten insbesondere durch Stromrichtereinheiten auf, wie sie in Windkraft- und Photovoltaikanlagen oder Batteriesystemen eingesetzt werden. Derartige Stromumformer erzeugen nichtsinusförmige Strom- und Spannungsverläufe, die neben der Grundschwingungsfrequenz auch höherfrequente Anteile (Oberschwingungen) beinhalten. Es ist auch nicht zu verkennen, daß Oberschwingungen in Erzeuger- und Verbrauchersystemen zusätzliche Verluste und auch Alterungseffekte (z. B. bei Kondensatoren) zur Folge haben.

Nach der DE-OS 23 17 068 werden in einem Verbundnetz bzw. in Teil- oder Inselnetzen störende Oberschwingungen vorwiegend durch Filtereinrichtungen auf ein für Verbraucher- und Erzeugersysteme erträgliches Maß abgebaut.

So ist insbesondere die Anordnung von Filtern zum Abbau der störenden Oberschwingungen zwar die Maßnahme, die nach dem Stand der Technik zu den besten Ergebnissen führt, der Einsatz von Filtern verursacht jedoch zusätzliche Kosten und verliert beim Auftreten von höherfrequenten Resonanzen an Wirksamkeit.

Aus der EP 473 257 A2 ist bekannt, daß zur elektrischen Energieumsetzung z. B. durch Parallelschaltung von mehreren Stromrichterbrücken Netzschwingungen reduziert und Gleichstromversorgungen insgesamt günstiger gestaltet werden können. Die EP 353 715 A2 hat die Unterdrückung von Schwingungen durch Pulsation der Gleichspannung bei Frequenzwandlern zum Inhalt.

Eine Stromversorgungseinrichtung der eingangs genannten Art ist aus der DE 30 23 195 A1 bekannt. Das Ziel dieser Stromversorgungseinrichtung für ein Wechsel- oder Drehstromnetz besteht darin, das Wechsel- oder Drehstromnetz nur gering mit Blindleistung zu belasten. Dies wird mit Hilfe von DC/DC-Wandlern durch große Steuerwinkel erreicht.

Der Erfindung liegt die Aufgabe zugrunde, bei einer Stromversorgungseinrichtung der eingangs genannten Art das Auftreten von unerwünschten Oberschwingungen derart zu vermindern, daß sie keine Gefahr für Verbraucher- und Erzeugersysteme darstellen.

Die Aufgabe wird erfindungsgemäß durch die Merkmale des Anspruchs 1 gelöst. Hierdurch wird erreicht, daß im Gegensatz zu den bekannten Möglichkeiten in vorhandenen oder zu installierenden Systemen eine gezielte Reduzierung von Oberschwingungen und Klirrfaktorwerten erfolgt.

Weitere vorteilhafte Ausführungsformen ergeben sich aus den Unteransprüchen.

Eine besondere Ausführungsform einer Stromversorgungseinrichtung mit mindestens zwei Stromquellen ist z. B. eine Anordnung von Windkraftanlagen mit Wechselrichtern, die derart ausgerüstet sind, daß sie sich mit unterschiedlichen Steuerwinkeln betreiben lassen. Dies kann z. B. dadurch erreicht werden, daß die stromrichterseitige Trafowicklung der einen Stromquelle eine andere Spannungsebene aufweist als die Trafoseite der anderen Stromquelle. Dadurch, daß die Trafos bzw. Trafowicklungen von beispielsweise zwei Windkraftanlagen jeweils eine unterschiedliche Spannungsebene haben, wird erreicht, daß der Stromrichter beispielsweise als Wechselrichter der jeweiligen Windkraftanlage mit einem anderen Steuerwinkel betrieben wird. Die Spannungsebenen der beiden Trafos sind daher so zu wählen, daß eine Auslöschung oder zumindest partielle Überdeckung der durch den jeweiligen Wechselrichter erzeugten Phasen erzielt wird. Zur Auslöschung oder Überdeckung von Phasen bestimmter Oberschwingungen ist die halbe Periodendauer der kritischen Oberschwingungszahl als Phasenverschiebungswinkel geeignet. Bei der Auswahl der Oberschwingungszahl, die ausgelöscht werden soll, ist die kritische Netzfrequenz zu wählen, die besondere Beeinträchtigungen hervorruft, z. B. die Frequenz, die nahe der Netzeigenresonanz- oder Rundsteuerfrequenz liegt.

Nach einer anderen Ausführungsform wird zur Auslöschung oder zumindest partiellen Überdeckung der

Phasen von Oberschwingungen bei elektrisch erregten Generatoren die Zwischenkreisspannung entsprechend geändert.

Das heißt, durch die Erregung des Generators wird die Zwischenkreisspannung so geändert, daß sich entsprechende Steuerwinkel ergeben und sich die Phasen der Oberschwingungen des einen Generators mit denen eines weiteren Generators auslöschen bzw. überdecken.

Sowohl bei elektrisch erregten als auch bei permanenterregten Generatoren besteht darüber hinaus die Möglichkeit, daß der Gleichrichter durch die Wahl des Steuerwinkels derart betrieben wird, daß durch eine Einstellung der Zwischenkreisspannung eine Auslöschung oder Überdeckung von Phasen von Oberschwingungen am Wechselrichterausgang erfolgt. Das heißt, soll eine bestimmte Oberschwingung abgebaut werden, muß die Zwischenkreisspannung entsprechend eingestellt bzw. geregelt werden.

Eine weitere Möglichkeit ist dadurch gegeben, die Statorwicklung jeweils zweier Maschinen derart zu wählen, daß durch die unterschiedliche Zwischenkreisspannung einer jeden Maschine eine derartige Steuerwinkeldifferenz erzeugt wird, daß sich die entsprechenden Phasen von Oberschwingungen überdecken oder auslöschen. Das heißt, die Statorwicklung bei zwei Maschinen wird derart gewählt, daß sich die jeweils ergebenden Zwischenkreisspannungen in geeigneter Weise einstellen und hierdurch eine Steuerwinkeldifferenz entsteht, wobei die Differenz so zu wählen ist, daß sich hier die Phasen der Oberschwingungen auslöschen oder zumindest partiell überdecken bzw. in der Summe vermindern, um insbesondere hierdurch den Klirrfaktor zu reduzieren.

Durch die Wahl der Auslegungs-, Steuer- oder Regelungsgrößen ist es möglich, bestimmte Oberschwingungen, Gruppen von Oberschwingungen, sowie den gesamten Oberschwingungsgehalt zu vermindern. Dabei lassen sich durch die Erhöhung der Anzahl von Systemen die Freiheitsgrade erhöhen. Das heißt, durch den Einsatz von z. B. 3 Einheiten ist es möglich, eine Abstimmung auf 2 Oberschwingungen zu erreichen.

In den **Fig.** 1 bis **Fig.** 4 sind Beispiele für Systeme mit Gleich- und Wechselrichter dargestellt.

Zwei oder mehr elektrische Versorgungssysteme können nach **Fig.** 1 von einer gemeinsamen Spannungsebene ausgehend direkt oder über einen Transformator in das Netz einspeisen, bzw. nach **Fig.** 2, 3 und 4 über parallele Zweige getrennt oder magnetisch gekoppelt mit dem Netz verbunden werden. Dabei kann die Verbindung nieder-, mittel- oder hochspannungsseitig geschaffen werden.

Die Konfiguration nach **Fig.** 2 soll im folgenden beispielhaft betrachtet werden. Dabei wird die 25. Oberschwingung ausgewählt, die stark vermindert werden soll, weil im Bereich der 25. Oberschwingung die Netzeigenresonanzfrequenz besteht. Somit ergibt sich ein Differenzwinkel von $360°/2 \times 25 = 7{,}2°$ für die Ansteuerung. Wechselrichter, die auch bei ca. 10% Spannungsschwankung vor sogenanntem "Kippen" geschützt werden, lassen sich bei einem Ansteuerwinkel von etwa 140° sicher betreiben. Somit wird der Wechselrichter der ersten Stromquelle mit 140° und die zweite Stromquelle mit 132,8° betrieben. Um diesen Zustand z. B. im Nennbetrieb zu erhalten, sind die Übersetzungsverhältnisse der Transformatoren mit ca. 12% Unterschied zu wählen. Die Gesamtblindleistung erhöht sich dadurch um ca. 12%. Dabei wird die 25. Oberschwingung um 95%, die 23. um etwa 87% bis hin zur 11. um ungefähr 20% vermindert. Ohne wesentliche Zusatzkosten wird dadurch der Filteraufwand erheblich verringert.

Patentansprüche

1. Stromversorgungseinrichtung mit mindestens zwei Stromquellen, wobei jede Stromquelle über einen zugeordneten Stromrichter in ein Wechselstromnetz einspeist, **dadurch gekennzeichnet,** daß zur Herabsetzung der Amplitude einer bestimmten vorhandenen Oberschwingung die Spannung von mindestens einem der Stromrichter mit Hilfe eines Steuerwinkels phasenverschoben zu mindestens einem anderen Stromrichter in das Netz einspeisbar ist.
2. Stromversorgungseinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß jedem Stromrichter ein Transformator nachgeschaltet ist, dessen stromrichterseitige Wicklungen unterschiedliche Spannungsebenen aufweisen.
3. Stromversorgungseinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß jeder Stromrichter aus einem Gleichrichter und einem diesem nachgeschalteten Wechselrichter besteht, wobei der Gleichrichter zur Veränderung der Gleichstrom-Zwischenkreisspannung mit Hilfe seines Steuerwinkels steuer- oder regelbar ist.
4. Stromversorgungseinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Ausgangsspannung der mindestens zwei Stromquellen änderbar bzw. regelbar ist.

Hierzu 1 Seite(n) Zeichnungen

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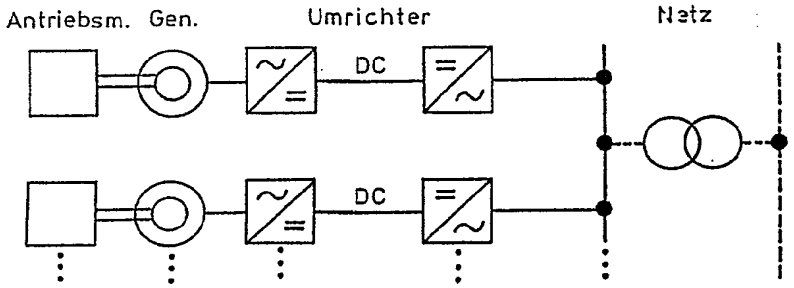


Fig. 1

Systeme mit gemeinsamer Netzkopplung

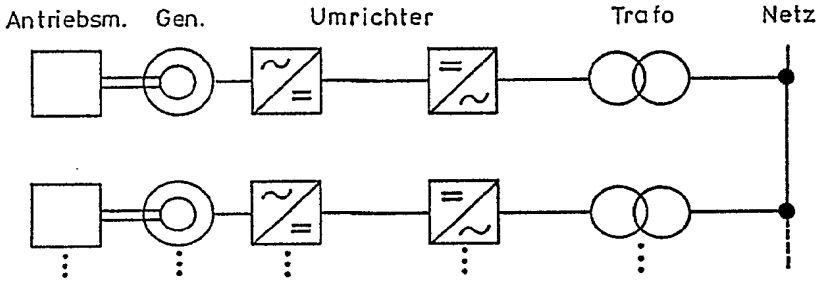


Fig. 2

Systeme mit getrennter Netzkopplung

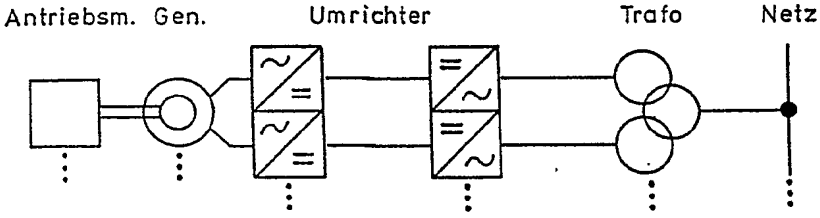


Fig. 3

Systeme mit galvanisch getrennten Zweigen (auch räumlich bzw. elektrisch versetzt)

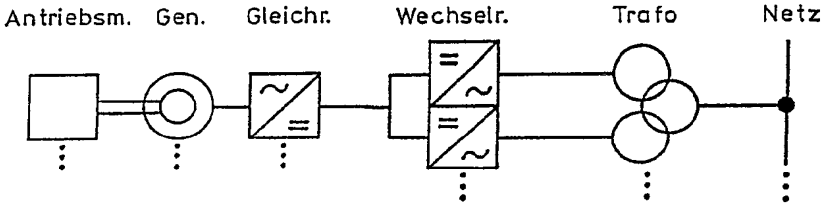


Fig. 4

Systeme mit getrennten Wechselrichterzweigen

602 162/99

Arrangement for decentralized supply of regenerative energy performs voltage regulation at combination point for controlled improvement of quality of electrical supply

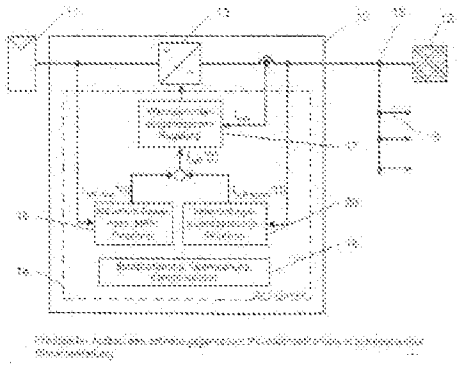
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DE19819869 (A1)
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Abstract of **DE 19961705 (A1)**

The arrangement regulates the voltage at a combination point for controlled electrical supply quality improvement. The arrangement for supplying power and the voltage regulator are in one unit. The regulator has arrangements for specifying a desired voltage spectrum at the combination point, diagnosing the state of the supply network and determining demand values of harmonics and/or a fundamental frequency reactive power to be compensated. The arrangement performs voltage regulation at a combination point for controlled improvement of the quality of the electrical supply. The arrangement for supplying power and the voltage regulator are contained in one unit.; The regulator (17,20) has arrangements for specifying a desired voltage spectrum at the combination point, for diagnosing the state of the supply network and for determining demand values of harmonics to be compensated and/or a fundamental frequency reactive power to be compensated. Independent claims are also included for the following: a current converter.



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(51) Int Cl.[7]: **H02J 3/38**
H02J 3/01, H02M 7/48, H02M 1/12, G05F 1/10, G05F 1/67

Innerhalb von drei Monaten nach Veröffentlichung der Patenterteilung kann nach § 59 Patentgesetz gegen das Patent Einspruch erhoben werden. Der Einspruch ist schriftlich zu erklären und zu begründen. Innerhalb der Einspruchsfrist ist eine Einspruchsgebühr in Höhe von 200 Euro zu entrichten(§ 6 Patentkostengesetz in Verbindung mit der Anlage zu § 2 Abs. 2 Patentkostengesetz).

(73) Patentinhaber:
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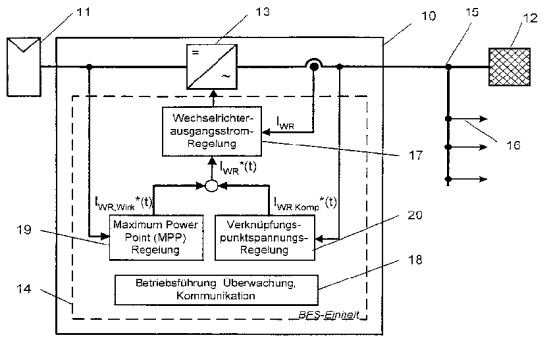
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(56) Für die Beurteilung der Patentfähigkeit in Betracht gezogene Druckschriften:
DE 198 19 869 A1
DE 197 56 777 A1
EN 6100;

(54) Bezeichnung: **Vorrichtung zur dezentralen Einspeisung regenerativer Energie**

(57) Hauptanspruch: Vorrichtung zur dezentralen Energieversorgung eines elektrischen Energienetzes (12) mit insbesondere regenerativer Energie, aufweisend Mittel (13) zur Einspeisung von elektrischer Energie in das Energienetz (12) mit einer an einem Verknüpfungspunkt mit dem Energienetz (12) angeordneten Spannungsregelung (17, 20), dadurch gekennzeichnet, dass die am Verknüpfungspunkt angeordnete Spannungsregelung (17, 20) Mittel (20) zur Erfassung einer am Verknüpfungspunkt anliegenden Energienetzspannung, Mittel (33) zur Vorgabe eines am Verknüpfungspunkt gewünschten Spannungsspektrums, Mittel (31) zur Diagnose der erfassten Energienetzspannung in Bezug auf das gewünschte Spannungsspektrum, Mittel (32) zur Bestimmung von Sollwerten von zu kompensierenden Oberschwingungen und/oder einer zu kompensierenden Grundschwingungsblindleistung aus dem gewünschten Spannungsspektrum sowie Mittel zur Regelung der am Verknüpfungspunkt anliegenden Spannung mittels der Sollwerte der zu kompensierenden Oberschwingungen und/oder der zu kompensierenden Grundschwingungsblindleistung aufweist.



Beschreibung

[0001] Die Erfindung betrifft eine Vorrichtung zur dezentralen Energieversorgung eines elektrischen Energienetzes gemäß dem Oberbegriff des Anspruchs 1. Ferner bezieht sich die Erfindung auf einen entsprechenden Stromrichter gemäß dem Oberbegriff des Anspruches 12.

Stand der Technik

[0002] Die Merkmale der Oberbegriffe sind aus DE 197 56 777 A1 bekannt.

[0003] In der Druckschrift DE 197 57 777 A1 ist ein Verfahren zur Regelung der Spannung am Verknüpfungspunkt beschrieben. Hierbei wird die effektive Spannung, d. h. der geometrische Mittelwert aller Oberschwingungsspannungsteile, in einem vorgegebenen Zeitbereich erfasst. Sinkt die Spannung, wird entsprechend Wirk- oder Blindleistung in das Netz eingespeist. Insbesondere werden dort ausschließlich die netzfrequenten Anteile auf einen Sollwert geregelt, und zwar die jeweilige Amplitude eines von mehreren Frequenzanteilen.

[0004] Auf dem Gebiet der Photovoltaik (PV) sind PV-Wechselrichter bekannt, die Stromrichter darstellen, deren Aufgabe die Umwandlung von Gleichspannungsleistung in Wechselspannungsleistung darstellt, mit dem Ziel, photovoltaisch erzeugte Leistung in ein elektrisches Inselnetz oder in ein großräumiges elektrisches Energieversorgungsnetz einzuspeisen. Die Qualität der elektrischen Energieversorgung ist neben der Verfügbarkeit des Netzes im wesentlichen bestimmt durch Netzspannungseffektivwert, Netzfrequenz und Kurvenform der Netzspannung. Die Liberalisierung des europäischen Strommarktes birgt die Gefahr einer Verschlechterung der Stromversorgungsqualität. Durch die zunehmende Zahl der Anschlüsse elektronischer Geräte mit nicht-linearer Verbraucherkennlinie wird die Notwendigkeit für aktive Maßnahmen zur Verbesserung der Stromqualität noch weiter erhöht.

[0005] Eine Verbesserung der Stromversorgungsqualität (Spannungsqualität) kann prinzipiell geschehen durch

a) gezieltes Einspeisen bzw. Verbrauchen von Grundschwingungsblindleistung zur Anhebung bzw. Absenkung des Netzspannungseffektivwertes mittels (geschalteter) Kondensatoren oder geeigneter Stromrichter;

b) gezieltes Einspeisen bzw. Herausfiltern von Oberschwingungsströmen zur 'Entzerrung' der Netzspannungskurven (Verringerung des Klirrfaktors) mittels passiver Filter (Bandpässen bzw. Bandsperren) oder geeigneter Stromrichter (aktive Filter).

[0006] Um der Verschlechterung der Netzqualität entgegenzuwirken, werden bei PV-Anlagen sogenannte selbstgeführte Wechselrichter eingesetzt, die meist nur reine Wirkleistung ins Netz einspeisen. Nachts werden diese Wechselrichter in der Regel vom Netz getrennt, da dann kein solares Energieangebot vorliegt und Stand by-Verluste vermieden werden sollen. Abhängig von der Schaltfrequenz der Wechselrichter ist der Oberschwingungsgehalt des Klemmenstroms relativ gering, so dass man häufig auch von "ideal sinusförmiger" Einspeisung redet. Die heutigen PV-Wechselrichter können allerdings nicht zur aktiven Verbesserung der Netzspannungsqualität eingesetzt werden.

[0007] Maßnahmen zur Spannungsqualitätsverbesserung kommen in den meisten Fällen an zentralen Netzpunkten (Sammelschienen oder Unterverteilungen) zum Einsatz. Um eine optimale Wirkung zu erzielen, muss die Kompensation von Oberschwingungsströmen und Blindleistung jedoch dezentral stattfinden, da auch deren Generierung in den Verbrauchern dezentral geschieht. Derzeit hierfür eingesetzte Filter werden allerdings ausschließlich 'gesteuert' betrieben, d.h. die Sollwerte für die zu kompensierende Blindleistung und/oder Oberschwingungsströme werden stationär von außen vorgegeben. Eine 'Regelung' der Spannungsqualität findet nicht statt. Desweiteren erlauben diese aktiven Filter im Allgemeinen nicht die Einspeisung von Wirkleistung in das Netz über einen längeren Zeitraum.

Aufgabenstellung

[0008] Der vorliegeden Erfindung liegt somit die Aufgabe zugrunde, eine Vorrichtung bzw. einen entsprechenden Stromrichter anzugeben, welche die Stromqualität der in ein Netz eingespeisten elektrischen Energie verbessern.

[0009] Diese Aufgabe wird durch die Merkmale der Ansprüche 1 bzw. 12 gelöst. Vorteilhafte Ausgestaltungen sind in den Unteransprüchen angeführt.

[0010] Der Erfindung liegt das Konzept zugrunde, die Kompensation von Oberschwingungsströmen und Blindleistung geregelt und dezentral stattfinden zu lassen. Da auch deren Generierung in den Verbrauchern dezentral geschieht, bietet ein ebenfalls dezentrales Entgegenwirken den höchsten Grad an erzielbarer Wirkung, da es direkt an der Quelle ansetzt. Durch diese dezentrale und geregelte Art der Blindleistungs- und Oberschwingungskompensation werden insbesondere Verluste und Störungen vermieden, die durch eventuelle Über- bzw. Unterkompensation und/oder große räumliche Distanz zwischen störaussendender Quelle und Geräte zur Stromversorgungs-Qualitätsverbesserung in unnötiger Weise entstehen.

Exhibit 1016 (Pt. 2 of 2)
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[0011] Die Besonderheit der Erfindung liegt nun darin, die Einspeisung regenerativer Energie in ein Netz und eine kontrollierte Einflussnahme auf die Netzqualität in einer einzigen Vorrichtung gleichzeitig durchzuführen. Zu diesem Zweck wird eine Betriebsführungseinheit des Stromrichters erfindungsgemäß um einen Funktionsblock "Regelung der Spannung am Verknüpfungspunkt (VP)" erweitert, der den Zustand des angeschlossenen Netzes diagnostiziert und entsprechende Sollwerte für die zu kompensierenden Oberschwingungsströme und Blindleistung ermittelt. Dadurch wird eine geregelte Einflussnahme auf das Spannungsspektrum der Versorgungsspannung (Spannung am Verknüpfungspunkt) ermöglicht. Zudem ermöglicht der vorgeschlagene PV-Wechselrichter eine Regelung der Grundschwingungsamplitude der Verknüpfungspunktspannung an entfernt liegenden Verknüpfungs-Einspeisepunkten durch eine gezielte Einspeisung von Wirkleistung und/oder kapazitiver bzw. induktiver Blindleistung.

[0012] Natürlich kann die Einspeisung von Oberschwingungsströmen und kapazitiver bzw. induktiver Blindleistung auch weiterhin gesteuert erfolgen.

[0013] Der Einsatz eines PV-Wechselrichters mit integrierter, geregelter Filterfunktion ist zudem wirtschaftlich günstiger als der Einsatz von zwei getrennten Einheiten zur Einspeisung von PV-Energie und der Kompensation der Störgrößen, und zwar ein PV-Wechselrichter und daneben ein aktives Filter. Der vorgeschlagene Wechselrichter ist daher billiger und kleiner herstellbar als bekannte Geräte.

[0014] Bei der technischen Realisierung eines erfindungsgemäßen Stromrichters, insbesondere im Zusammenhang mit der erforderlichen Signal- bzw. Datenverarbeitung bei der Erfassung und Auswertung der genannten Netzgrößen, können vorteilhaft kostengünstige Digitale Signalprozessoren (DSP) eingesetzt werden.

Ausführungsbeispiel

[0015] Weitere Eigenschaften, Merkmale und Vorteile der Erfindung ergeben sich aus der nachfolgenden detaillierten Beschreibung eines Ausführungsbeispieles.

[0016] Im Einzelnen zeigen:

[0017] Fig. 1 Prinzipieller Aufbau eines erfindungsgemäßen PV-Wechselrichters in schematischer Blockdarstellung;

[0018] Fig. 2 die Struktur des Wechselrichterausgangsstrom-Regelkreises;

[0019] Fig. 3 die Funktionsgruppen der Verknüpfungspunktspannungs (U_{VP})-Regelung;

[0020] Fig. 4 die Struktur des U_{VP}-Regelkreises;

[0021] Fig. 1 zeigt den Prinzipaufbau eines erfindungsgemäßen Photovoltaik (PV)-Wechselrichters **10**, der am Verknüpfungspunkt (VP) **15** gemeinsam mit anderen Verbrauchern **16** an das Energieversorgungsnetz **12** angeschlossen ist. Der PV-Wechselrichter **10** verbindet einen Solargenerator **11** mit einem elektrischen Energieversorgungsnetz **12**, wobei eine vom Solargenerator **11** gelieferte Gleichspannung über ein Wechselrichterleistungsteil **13** in eine Wechselspannung umgewandelt wird.

[0022] Der PV-Wechselrichter **10** ist erfindungsgemäß als aktives Filter zur Regelung der Spannung bzw. Verbesserung der Spannungsqualität am Verknüpfungspunkt ausgebildet. Der PV-Wechselrichter besteht im Einzelnen aus einem leistungselektronischen Stellglied mit hoher Dynamik **13** und einer Betriebsführungs- und Systemsteuerungseinheit (BFS) **14**. Die BFS umfasst eine Funktionseinheit **18**, die die Überwachung sowie den Schutz des Wechselrichterleistungsteils übernimmt, so dass ein sicherer Betrieb der gesamten Anlage **10**–**12** gewährleistet ist. Desweiteren übernimmt diese Funktionseinheit die Kommunikation mit dem Benutzer.

[0023] Es existieren mehrere, kaskadierte Regelkreise, die ebenso Teil der BFS-Einheit sind. Der innerste Regelkreis ist die Wechselrichterausgangsstrom (I_{Wr})-Regelung. Die überlagerten Regelkreise sind die Maximum Power Point (MPP)-Regelung **19** und die Verknüpfungspunktspannungs (U_{VP})-Regelung **20**. Dabei ist $I_{WR,Wirk}^{*}$ die Stellgröße des MPP-Reglers und $I_{WR,Komp}^{*}$ die Stellgröße des U_{VP}-Reglers.

[0024] Wie in Fig. 1 zu erkennen ist, setzt sich der Sollwert des I_{WR}-Regelkreises aus der Summe des Wirkstromsollwertes $I_{WR,Wirk}^{*}$, der vom MPP-Regler vorgegeben wird, und dem Kompensationsstromsollwert $I_{WR,Komp}^{*}$ vorgegeben vom U_{VP}-Regler, zusammen.

[0025] Die Struktur der I_{WR}-Regelung ist in Fig. 2 dargestellt. Als Überlastungsschutz (z.B. Schutz der Leistungshalbleiter des PV-Wechselrichters vor zu hohen Strömen) enthält der I_{WR}-Regelkreis eine Sollwertbegrenzung. Bei Überschreiten des maximal zulässigen Wertes wird eine Rückmeldung an den U_{VP}- und/oder MPP-Regler gegeben, damit die Sollwerte ($I_{WR,Wirk}^{*}$ bzw. $I_{WR,Komp}^{*}$) entsprechend verzerrungsfrei reduziert werden können.

[0026] Der PV-Wechselrichter dient als leistungselektronisches Stellglied. Die Verknüpfungspunktspannung U_{VP} kann als Störgröße für den I_{WR}-Regelkreis aufgefasst werden.

[0027] Die Anforderungen an die I_{WR}-Regelung sind

hohe Dynamik sowohl im Führungsverhalten als auch im Störverhalten. Die Grenzfrequenz der Regelung muss in jedem Fall größer sein als die höchste Frequenz des zu kompensierenden Oberschwingungsspektrums.

[0028] Die Implementierung dieser Regelung kann sowohl digital in einem Mikrorechner als auch analog geschehen.

[0029] Der 'Maximum Power Point Regler' sorgt durch die Vorgabe eines geeigneten Wirkanteils des Wechselrichterausgangsstrom-Sollwertes ($I_{WR,Wirk}^*$) für eine optimale Ausnutzung der vom Solargenerator **11** gelieferten Leistung.

[0030] Die vorliegende Erfindung benötigt keine besondere MPP-Regelstrategie. Es kann ein beliebiges aus der Vielzahl der in der Literatur beschriebenen Verfahren gewählt werden. Normalerweise wird die MPP-Regelung in einem Mikrorechner implementiert.

[0031] Wie in Fig. 3 zu sehen, umfasst die U_{VP} Regelung **20** folgende Funktionsblöcke: "Diagnose des Netzzustandes" **31**, "Sollwertvorgabe eines gewünschten Spektrums der Verknüpfungspunktspannung" **32** und "Bestimmung des Kompensationsstromsollwertes" **33**.

[0032] Alle Blöcke werden zyklisch abgearbeitet; somit erreicht man eine dynamische Anpassung des Kompensationsstromsollwertes an den aktuellen Netzzustand und man vermeidet Über- oder Unterkompensation. Die Realisierung der U_{VP}-Regelung kann beispielsweise in einem Mikrorechner bzw. digitalen Signalprozessor geschehen.

[0033] Der Funktionsblock "Diagnose des Netzzustandes" stellt das Messglied des U_{VP} Regelkreises dar. Dieser Funktionsblock ist notwendig, um ein Bild von den Netzverhältnissen am Verknüpfungspunkt zu bekommen. Mögliche Realisierungen sind Messung und spektrale Analyse der Verknüpfungspunktspannung $\underline{U}_{VP}$ und/oder Netzimpedanz $\underline{Z}_{VP}$(Z_{VP}-Erfassung ist für die Funktionsweise nicht notwendig).

[0034] Für den Fall, dass die Verknüpfungspunktspannungs-Regelung n Frequenzanteile f_1 bis f_n (z.B. n = 3, f_1 = 50 Hz, f_2 = 150 Hz, f_3 = 250 Hz) berücksichtigt, erhält man als Ausgabe der "Diagnose des Netzzustandes" m = 2 n Signale. Dies kann beispielsweise Betrag und Phase oder auch Real- und Imaginärteil des entsprechenden Frequenzanteils der Spannung bzw. Impedanz sein.

[0035] Der Funktionsblock "Sollwertvorgabe....." **33** liefert die gewünschten spektralen Anteile (Frequenzanteil) der Verknüpfungspunktspannung (einschließlich der gewünschten Amplitude der Grundschwingung). Idealerweise wird man ein Spektrum ohne Oberschwingungsgehalt vorgeben. Da es sich beim Sollwert der Verknüpfungspunktspannung wie auch bei deren Istwert um eine komplexe Größe handelt, sind auch hier zwei Signale für jeden Frequenzanteil, also insgesamt m = 2 × n Signale zur Beschreibung des gewünschten Spektrums der Verknüpfungspunktspannung $\underline{U}_{VP}^*$ notwendig. Dies ist jedoch in vielen Fällen unwirtschaftlich, denn es kann zu einem sehr großen Kompensationsstromsollwert führen. Ein weiterer möglicher Betriebsmodus besteht darin, dass Frequenzanteile der Oberschwingungsspannung unkompensiert bleiben. Dies ist denkbar für den Fall, dass die gemessenen Oberschwingungsspannungen innerhalb eines gewissen, vom Anlagenbetreiber vorgebbaren Toleranzbereiches liegen.

[0036] Für den Fall, dass der Wechselrichterausgangsstrom-Regler eine Sollwertbegrenzung anzeigt, muss der Kompensationsstromsollwert verringert werden. Dies kann durch eine Änderung des gewünschten Spektrums der Verknüpfungspunktspannung geschehen.

[0037] Im Funktionsblock "Bestimmung des Kompensationsstromsollwertes" **32** wird der Kompensationsanteil des Wechselrichterausgangsstromsollwertes ($I_{WR,Komp}^*$) basierend auf der Kenntnis des Netzzustandes, so berechnet, dass die vorgegebenen Sollwerte der Oberschwingungsspannungen und der Grundschwingungsspannung eingeregelt werden können. Der Kompensationsstromsollwert wird dann an den unterlagerten Wechselrichterausgangsstrom-Regelkreis übergeben.

[0038] Die Funktionsweise der U_{VP} Regelung wird anhand von Fig. 4 erläutert. Für jeden zu kompensierenden Frequenzanteil f_1 ... f_n ist ein gesonderter Regler vorzusehen. Jede dieser n Reglerbaugruppen **41**–**43** kann, wie beispielsweise bei der feldorientierten Regelung von Drehfeldmaschinen weit verbreitet, in einem mit der entsprechenden Frequenz (f_1 ... f_n) rotierenden Koordinatensystem realisiert werden. Für den Fall, dass die Netzimpedanz am Verknüpfungspunkt zur Diagnose des Netzzustandes gemessen wird, kann ein dem Quotienten aus gemessener Verknüpfungspunktspannung und Impedanz am Verknüpfungspunkt proportionaler Wert (z.B. $\underline{I}_{WR,Komp}^*(f_1)$"= $\underline{U}_{VP,ist}(f_1)\cdot\underline{K}(f_1)/\underline{Z}_{VP}(f_1)$) auf den Reglerausgang (z.B. $\underline{I}_{WR,Komp}^*(f_1)$') in Form einer Vorsteuerung **45** aufgeschaltet werden. Eine eventuelle notwendige Begrenzung der Höhe des Stromsollwertanteils $\underline{I}_{WR,Komp}^*(t)$ kann durch Anpassung des Proportionalitätsfaktors (z.B. $\underline{K}(f_1)$) realisiert werden.

[0039] Zur Rücktransformation der Sollwerte ($\underline{I}_{WR,Komp}^*(f_n)$) in den Zeitbereich ($\underline{I}_{WR,Komp}^*(t)$ kann beispielsweise die Fouriertransformation verwendet werden.

[0040] Das Einsatzspektrum des vorgeschlagenen Stromrichters umfasst allgemein Netzanschlüsse von vorbeschriebenen PV-Anlagen, insbesondere Anschlüsse von PV-Anlagen an Verknüpfungspunkten mit hoher Netzimpedanz, d.h. 'schwachen Netzen'. Es versteht sich, dass der Stromrichter auch – über die beschriebene Anwendung im Bereich der Photovoltaik hinaus – bei Industrieanlagen, in denen sowohl Blind- und/oder Wirkleistungsschwankungen als auch Verzerrungen der Netzspannung in unterschiedlichem Maße auftreten, vorteilhaft eingesetzt werden kann. Letztere Störgrößen können beispielsweise durch einen diskontinuierlichen Produktionsprozess oder stark schwankende Tageslastkurven hervorgerufen sein.

Patentansprüche

1. Vorrichtung zur dezentralen Energieversorgung eines elektrischen Energienetzes (**12**) mit insbesondere regenerativer Energie, aufweisend Mittel (**13**) zur Einspeisung von elektrischer Energie in das Energienetz (**12**) mit einer an einem Verknüpfungspunkt mit dem Energienetz (**12**) angeordneten Spannungsregelung (**17**, **20**), **dadurch gekennzeichnet**, dass die am Verknüpfungspunkt angeordnete Spannungsregelung (**17**, **20**) Mittel (**20**) zur Erfassung einer am Verknüpfungspunkt anliegenden Energienetzspannung, Mittel (**33**) zur Vorgabe eines am Verknüpfungspunkt gewünschten Spannungsspektrums, Mittel (**31**) zur Diagnose der erfassten Energienetzspannung in Bezug auf das gewünschte Spannungsspektrum, Mittel (**32**) zur Bestimmung von Sollwerten von zu kompensierenden Oberschwingungen und/oder einer zu kompensierenden Grundschwingungsblindleistung aus dem gewünschten Spannungsspektrum sowie Mittel zur Regelung der am Verknüpfungspunkt anliegenden Spannung mittels der Sollwerte der zu kompensierenden Oberschwingungen und/oder der zu kompensierenden Grundschwingungsblindleistung aufweist.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, dass die Mittel (**13**) zur Einspeisung von elektrischer Energie und die Spannungsregelung (**17**, **20**) in einer Baueinheit angeordnet sind.

3. Vorrichtung nach Anspruch 1, gekennzeichnet durch Mittel (**31**) zur Bestimmung eines Netzspannungs-Istwertes sowie Mittel (**32**) zur insbesondere dynamischen Bestimmung eines Kompensationsstrom-Sollwertes aus dem ermittelten Netzspannungs-Istwert.

4. Vorrichtung nach Anspruch 3, gekennzeichnet durch Mittel zur insbesondere dynamischen Bestimmung eines Soll-Ausgangsstromes unter Berücksichtigung des Kompensationsstrom-Sollwertes und eines Wirkstromes.

5. Vorrichtung nach einem oder mehreren der vorangehenden Ansprüche, gekennzeichnet durch ein geregeltes, aktives Leistungsfilter.

6. Vorrichtung nach Anspruch 5, dadurch gekennzeichnet, dass das geregelte Filter Mittel zur Regelung der Blindleistungsaufnahme aus bzw. Blindleistungslieferung an das Energienetz und/oder Mittel zur Regelung des Spektrums der Spannung am Verknüpfungspunkt mit dem Netz aufweist.

7. Vorrichtung nach einem der voranstehenden Ansprüche, dadurch gekennzeichnet, dass bei der Ermittlung von Sollwerten eine Begrenzung der Höhe des Sollwertes stattfindet, um den Wechselrichter vor Überlast zu schützen.

8. Vorrichtung nach Anspruch 7, dadurch gekennzeichnet, dass durch das Mittel (**33**) zur Sollwertvorgabe der Verknüpfungsspannung ($\underline{U}_{VP}^{*}$) die Begrenzung der Höhe des Wechselrichterausgangsstrom-Sollwertes ($\underline{I}_{WR}$) auf der Basis des Frequenzbereiches erfolgt.

9. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, dass für jeden Frequenzanteil (f_i) des Spektrums der Verknüpfungspunktspannung eine Regelbaugruppe (**41**–**43**) vorgesehen ist, wobei durch diesen Regler ein Wechselrichterstrom-Sollwert $\underline{I}_{WR,Komp}^{*}(f_i)$ vorgegeben wird, wobei aus der Gesamtheit der Wechselrichterstrom-Sollwerte $\underline{I}_{WR,Komp}^{*}(f_1)$ ....$\underline{I}_{WR,Komp}^{*}(f_n)$ durch Rücktransformation vom Frequenzbereich zum Zeitbereich der Sollwert des Kompensationsstroms im Zeitbereich $\underline{I}_{WR,Komp}^{*}(t)$ erzeugt wird.

10. Vorrichtung nach Anspruch 1 oder 9, dadurch gekennzeichnet, dass in Abhängigkeit von der Netzimpedanz am Verknüpfungspunkt und/oder Spannung am Verknüpfungspunkt für jeden Frequenzanteil (f_i) ein Stromsollwert $\underline{I}_{WR,Komp}^{*}(f_i)$", berechnet aus Impedanz und einem der Spannung proportionalen Wert, auf den $\underline{I}_{WR,Komp}^{*}(f_i)$' aufgeschaltet wird.

11. Vorrichtung nach Anspruch 10, dadurch gekennzeichnet, dass durch Auswahl des Proportionalitätsfaktors der Spannung die Höhe des Stromsollwertes $\underline{I}_{WR,Komp}^{*}(f_i)$" begrenzt ist

12. Stromrichter, insbesondere Photovoltaik-Wechselrichter, mit einer ersten Funktionseinheit (**14**) zur Einspeisung von insbesondere regenerativer Energie in ein Energienetz (**12**) an einem Verknüpfungspunkt des Stromrichters mit dem Energienetz (**12**), gekennzeichnet durch eine wenigstens zweite Funktionseinheit (**20**) aufweisend Mittel zur Erfassung einer am Verknüpfungspunkt vorliegenden Energienetzspannung, Mittel (**31**) zur Diagnose der erfassten Energienetzspannung in Bezug auf ein gewünschtes Spannungsspektrum, Mittel (**32**) zur Er-

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mittlung von Sollwerten von zu kompensierenden Oberschwingungen und/oder einer zu kompensierenden Grundschwingungsblindleistung aus dem gewünschten Spannungsspektrum sowie Mittel zur Regelung der Blindleistungsaufnahme aus bzw. der Blindleistungsabgabe an das Energienetz (**12**) mittels der Sollwerte der zu kompensierenden Oberschwingungen und/oder der zu kompensierenden Grundschwingungsblindleistung.

13. Stromrichter nach Anspruch 12, gekennzeichnet durch Mittel (**31**) zur Erfassung eines Netzspannungs-Istwertes sowie Mittel (**32**) zur dynamischen Bestimmung eines Kompensationsstrom-Sollwertes aus dem ermittelten Netzspannungs-Istwert.

14. Stromrichter nach einem oder mehreren der Ansprüche 12 und 13, gekennzeichnet durch einen oder mehrere Mikroprozessoren und/oder digitale Signalprozessoren (DSP) zur Ausführung der Diagnose und/oder Ermittlung der Kompensationsstrom-Sollwerte und/oder Vorgabe einer gewünschten spektralen Zusammensetzung der Spannung am Verknüpfungspunkt und/oder Realisierung der Reglerbaugruppen und/oder Rücktransformation in den Zeitbereich.

15. Stromrichter nach einem der voranstehenden Ansprüche 12 bis 14, dadurch gekennzeichnet, dass bei der Ermittlung von Sollwerten eine Begrenzung der Höhe des Sollwertes stattfindet, um den Wechselrichter vor Überlast zu schützen.

16. Stromrichter nach Anspruch 15, dadurch gekennzeichnet, dass durch das Mittel (**33**) zur Sollwertvorgabe der Verknüpfungsspannung ($\underline{U}_{VP}^{*}$) die Begrenzung der Höhe des Wechselrichterausgangsstrom-Sollwertes ($\underline{I}_{WR}$) auf der Basis des Frequenzbereiches erfolgt.

17. Stromrichter nach Anspruch 12, dadurch gekennzeichnet, dass für jeden Frequenzanteil (f_i) des Spektrums der Verknüpfungspunktspannung eine Regelbaugruppe (**41**–**43**) vorgesehen ist, wobei durch diesen Regler ein Wechselrichterstrom-Sollwert $\underline{I}_{WR,Komp}^{*}(f_i)$ vorgegeben wird, wobei aus der Gesamtheit der Wechselrichterstrom-Sollwerte $\underline{I}_{WR,Komp}^{*}(f_1)''$ $\underline{I}_{WR,Komp}^{*}(f_n)$ durch Rücktransformation vom Frequenzbereich zum Zeitbereich der Sollwert des Kompensationsstroms im Zeitbereich $\underline{I}_{WR,Komp}^{*}(t)$ erzeugt wird.

18. Stromrichter nach einem der Ansprüche 12 bis 17, dadurch gekennzeichnet, dass in Abhängigkeit von der Netzimpedanz am Verknüpfungspunkt und/oder Spannung am Verknüpfungspunkt für jeden Frequenzanteil (f_i) ein Stromsollwert $\underline{I}_{WR,Komp}^{*}(f_i)''$, berechnet aus Impedanz und einem der Spannung proportionalen Wert, auf den $\underline{I}_{WR,Komp}^{*}(f_i)'$ aufgeschaltet wird.

19. Stromrichter nach Anspruch 18, dadurch gekennzeichnet, dass durch Auswahl des Proportionalitätsfaktors der Spannung die Höhe des Stromsollwertes $\underline{I}_{WR,Komp}^{*}(f_i)''$ begrenzbar ist.

Es folgen 4 Blatt Zeichnungen

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Anhängende Zeichnungen

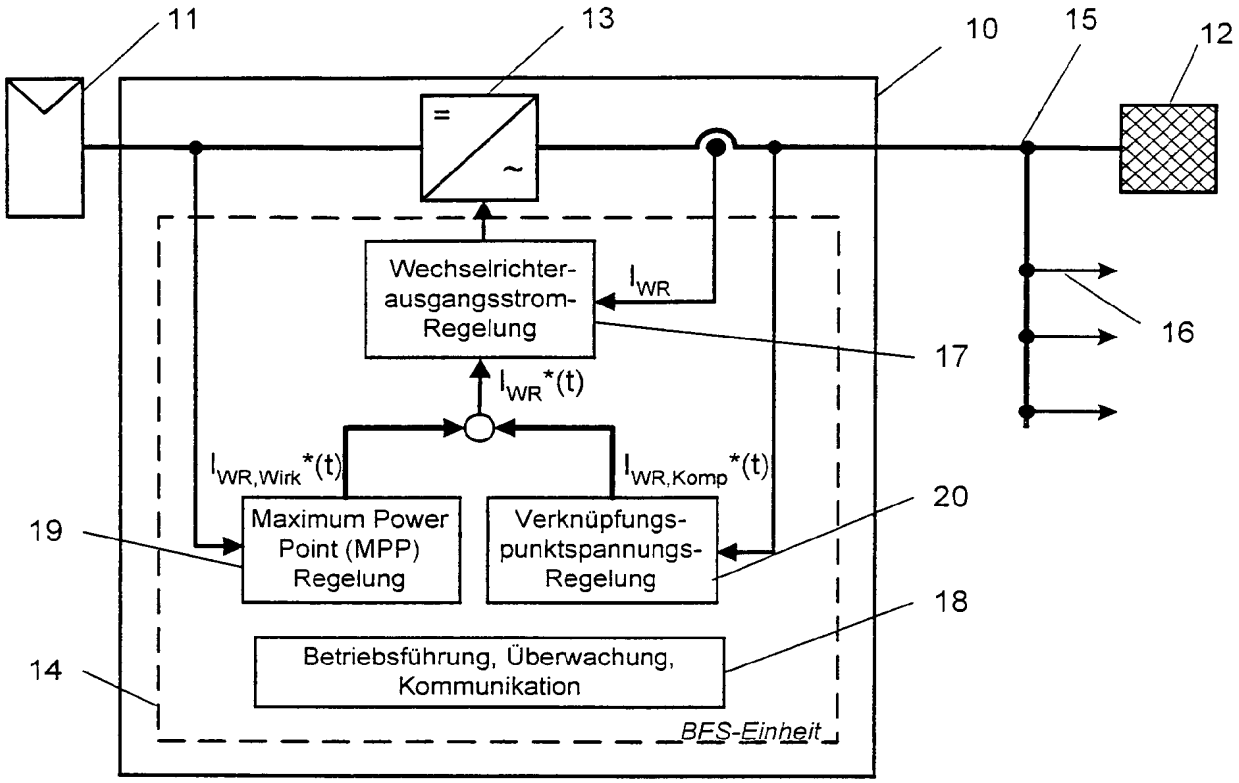


Fig. 1: Prinzipieller Aufbau des erfindungsgemäßen PV-Wechselrichters in schematischer Blockdarstellung

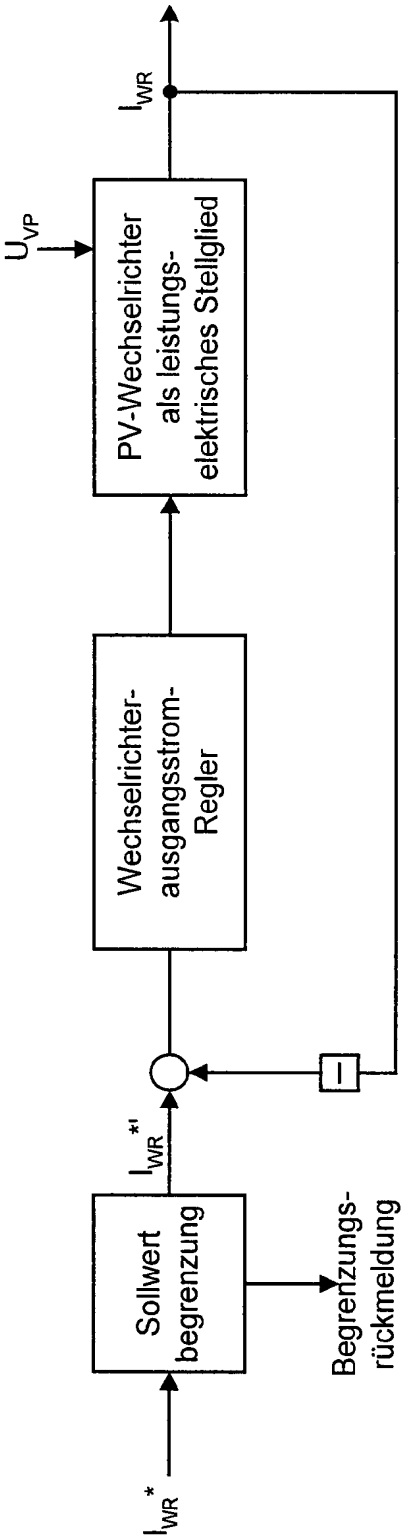


Fig. 2: Struktur des Wechselrichterausgangsstrom-Regelkreises

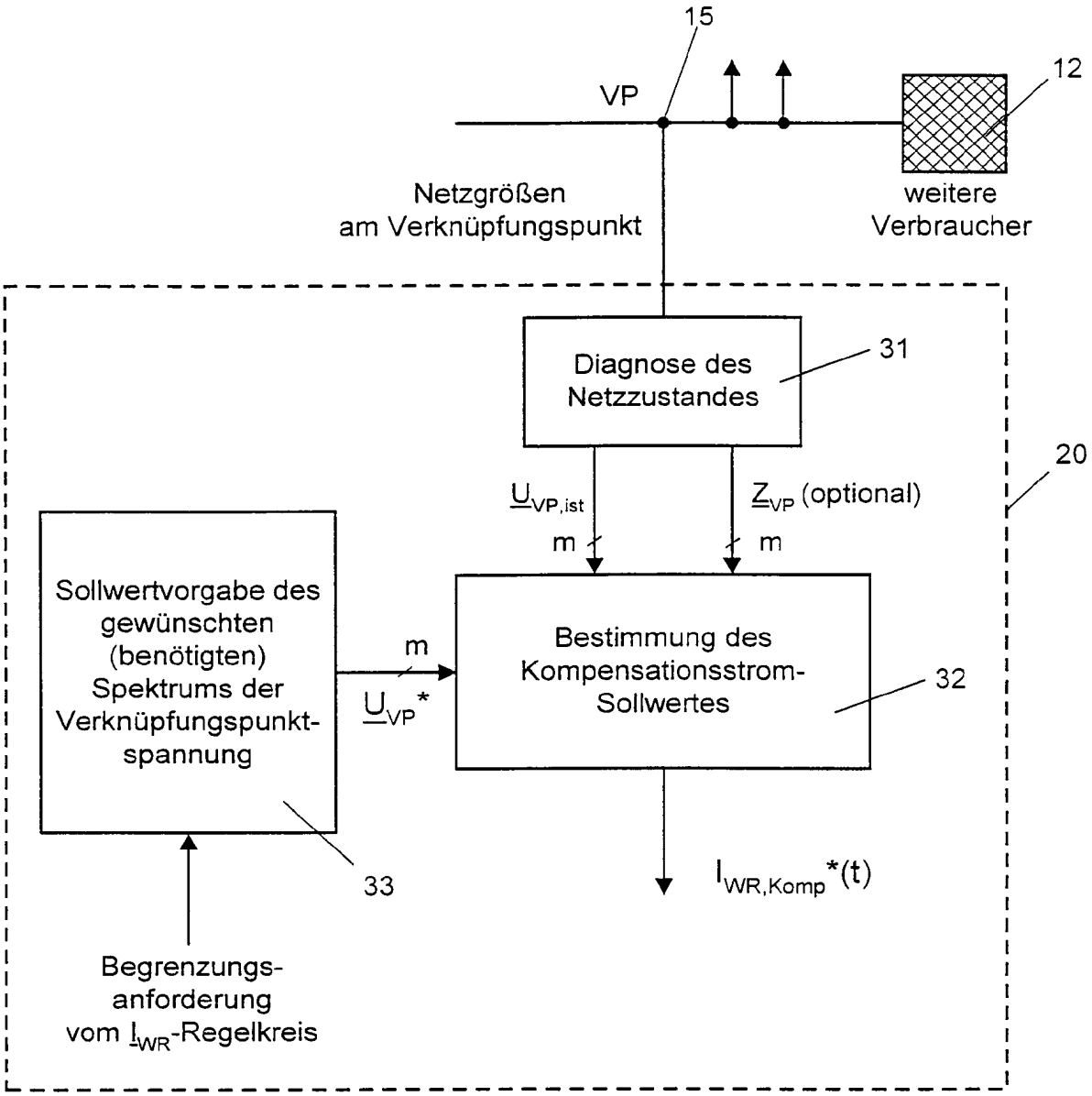


Fig. 3: Funktionsgruppen der Verknüpfungspunktspannungs-Regelung

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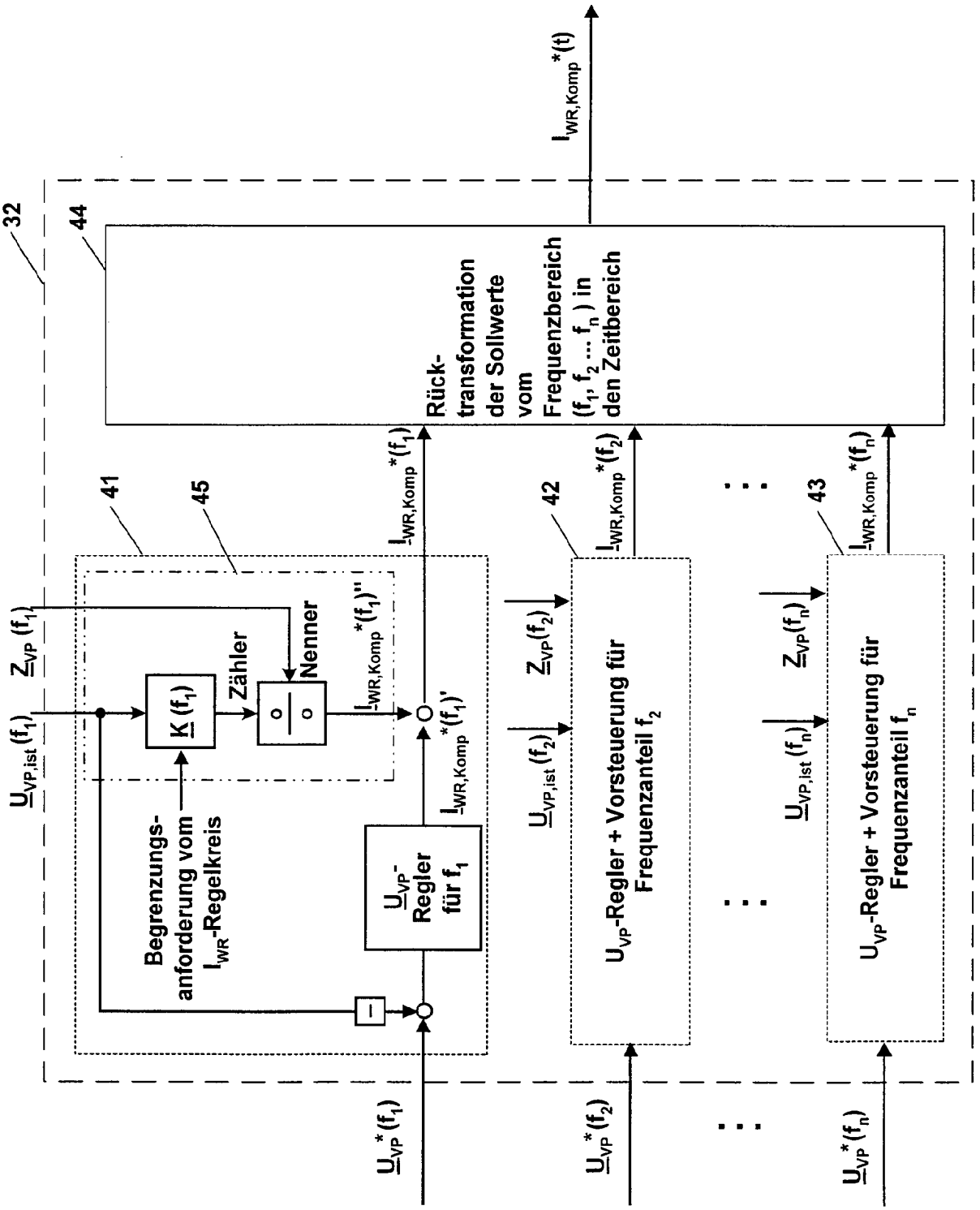


Fig 4 · Struktur des Verknüpfungspunktspannungs-Regelkreises

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Source conditioning circuit at a maximum power point

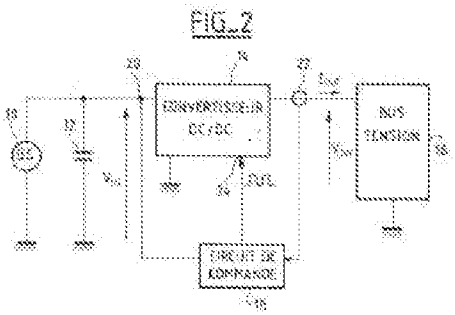
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Publication date: 2004-02-11
Inventor(s): DELEPAUT CHRISTOPHE [BE] +
Applicant(s): CIT ALCATEL [FR] +
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Abstract of **EP 1388774 (A1)**

The solar generator (10) is connected to a DC- DC converter (14). A control acts on the DC-DC converter in order to manage the output voltage provided, thus enabling maximum power to be drawn from the solar generator. The power source (10), such as a solar generator, offers a power graph which is a function of the voltage on its terminals, with a maximum value. The source is connected to provide power to a DC- DC converter (14). In order to manage the source, an input power reference is applied to the converter. An increasing input power reference is applied to the converter, such that the derivative of the converter input voltage with respect to time is greater that a first negative threshold value, and a decreasing input power reference is applied such that the derivative of the converter input voltage with respect to time is less than a second positive threshold value. The rate of variation of the average power when the reference in increasing is chosen to be less than the opposite of the rate of variation of the average power when the reference is decreasing.



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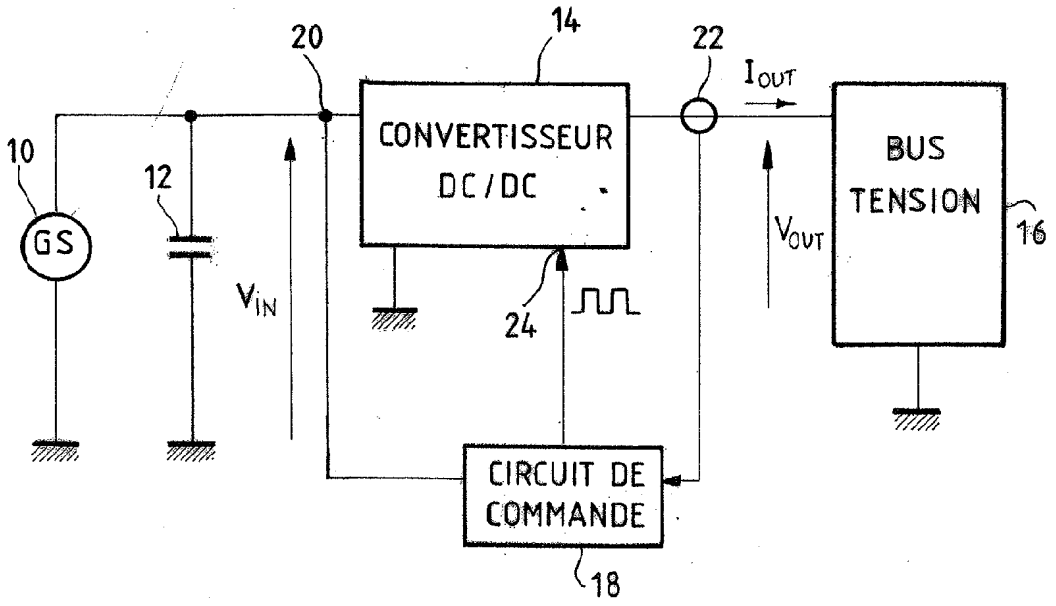
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(54) Circuit de conditionnement d'une source au point de puissance maximum

(57) Une source de puissance (10), comme un générateur solaire, présente un graphe de la puissance fournie en fonction de la tension à ses bornes avec un maximum. La source alimente un convertisseur continu / continu. Pour conditionner la source, on applique au convertisseur une consigne de puissance d'entrée croissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est supérieure à une première valeur seuil négative et décroissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est inférieure à une deuxième valeur seuil positive. Le taux de variation de la puissance moyen lorsque la consigne est croissante est choisi inférieur à l'opposé du taux de variation de la puissance moyen lorsque la consigne est décroissante.

Ce conditionnement permet de faire débiter la source au point de puissance maximum et peut être implémenté simplement.

FIG_2



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Description

[0001] La présente invention concerne les sources de puissance et plus précisément l'exploitation de sources de puissance pour lesquelles la courbe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum.

[0002] Pour une telle source, la puissance fournie est maximale lorsque la tension présente une valeur donnée. Il est intéressant pour exploiter au mieux la source de puissance - en tirer une puissance maximale - que la tension aux bornes de la source soit autant que possible égale à cette valeur donnée.

[0003] Les générateurs solaires utilisés pour les satellites constituent un exemple d'une telle source de puissance. La figure 1 montre un graphe du courant et de la puissance en fonction de la tension aux bornes du générateur, dans l'exemple d'un générateur formé d'un montage série de 102 cellules Si BSR (Back Surface Reflector) ; de telles cellules sont disponibles dans l'industrie spatiale. On a porté le long de l'axe des ordonnées le courant fourni par le générateur solaire, en ampères, ainsi que la puissance délivrée par le générateur, en watts; on a porté le long de l'axe des abscisses la tension aux bornes du générateur, en volts. Les courbes 1 et 2 sur la figure 1 correspondent à un fonctionnement à une température de + 100°C; les courbes 3 et 4 correspondent à un fonctionnement à une température de -100°C. La courbe 2 sur la figure 1 est un graphe du courant en fonction de la tension; elle montre que le courant fourni par les cellules diminue lorsque la tension dépasse une valeur de l'ordre de 35 V, ce qui s'explique par un phénomène de saturation des cellules; la courbe 4 est similaire, à ceci près que la tension de saturation est de l'ordre de 75 V. La courbe 1 sur la figure 1 est un graphe de la puissance fournie par le générateur solaire; elle montre que la puissance fournie présente un maximum, qui dans l'exemple présente une valeur de l'ordre de 100 W et est atteint pour une valeur V0 de la tension qui est de l'ordre de 38 V. La courbe 3 est similaire à la courbe 2, avec des valeurs de puissance maximale et de tension V0 respectivement de l'ordre de 200 W et 70V. Ces courbes ne constituent qu'un exemple particulier de générateur dans lequel le graphe de la puissance fournie en fonction de la tension de sortie présente un maximum.

[0004] Pour exploiter un tel générateur solaire ou plus généralement une telle source de puissance, il est intéressant que la tension aux bornes de la source soit aussi proche que possible de la valeur V0 de la tension pour laquelle la source délivre une puissance maximale. Ce problème se pose avec une acuité particulière dans le cas des générateurs solaires utilisés dans les satellites. En effet, pour ces générateurs solaires, la tension V0 pour laquelle la puissance fournie par le générateur est maximale varie en fonction de la température à laquelle le générateur est soumis, comme représenté à la figure 1; cette tension V0 varie aussi en fonction

- de l'intensité du rayonnement solaire auquel le générateur est exposé;
- du vieillissement du générateur.

[0005] Pour un satellite, la température peut typiquement varier dans une plage de - 100°C à +100°C, dans l'exemple d'une orbite terrestre basse. Pour une orbite Mercure, la variation de température serait encore plus important et la température pourrait varier dans une plage de - 150 °C à + 250 °C. L'intensité du rayonnement solaire peut varier en fonction de l'éloignement du soleil; pour une mission depuis la Terre vers Mars, l'intensité du rayonnement solaire peut varier dans un rapport de 3 à 1. Le vieillissement du générateur provoque la mise en court-circuit de certaines cellules. Dans l'ensemble, la tension V0 peut typiquement varier dans un rapport de 1 à 2, et pourrait par exemple varier de 40 à 80 V.

[0006] Il a donc été proposé d'exploiter les générateurs solaires, pour en extraire une puissance maximale, en recherchant que la tension aux bornes du générateur soit proche de la tension V0. Ces techniques sont connues sous le nom de "Maximum Power Point Tracking" (suivi du point de puissance maximal en langue française).

[0007] W. Denzinger, *Electrical Power Subsystem of Globalstar*, Proceedings of the European Space Power Conference, Poitiers, France, 4-8 Septembre 1995, décrit le sous-système de puissance des satellites Globalstar. La recherche du point de puissance maximale s'effectue en considérant que le point de puissance maximale est atteint lorsque l'impédance dynamique du générateur est égale à l'impédance statique, autrement dit lorsque

$$V/I = dV/dI$$

c'est-à-dire lorsque

$$dI/I = dV/V$$

En toute rigueur, VI=max implique VdI+IdV=0 et donc V/I=-dV/dI. Denzinger oublie le signe -.

Ce document décrit un circuit utilisant un capteur de courant, un capteur de tension, deux circuits échantillonneurs, deux comparateurs, une bascule et un intégrateur.

[0008] Kevin Kyeong-Il Choi et Alphonse Barnaba, *Application of the maximum power point tracking (MPPT) to the on-board adaptative power supply subsystem,* Note technique du CNES n°138, juillet 1998, décrit un sous-système d'alimentation électrique pour les satellites de faible puissance. Pour le suivi du point de puissance maximum, ce sous-système utilise un microcontrôleur associant une multiplication numérique du courant par l'intensité et un algorithme de poursuite de la puissance à partir des valeurs calculées.

[0009] Ces solutions sont complexes à mettre en oeuvre. Ceci conduit à centraliser le contrôle de suivi du point de puissance maximum des différents générateurs solaires ; cette centralisation affecte la fiabilité du sous-système d'alimentation électrique et est incompatible de points de puissance maximum différents en tension d'une section de générateur solaire à l'autre. En outre, ces solutions exploitent les composantes directes de courants et/ou tensions, lesquelles quantités n'étant pas caractéristiques du suivi de point de puissance maximum.

[0010] Ce problème expliqué en référence aux générateurs solaires dans les conditions des satellites se pose plus généralement pour toute source de puissance pour le graphe de la puissance fournie en fonction de la tension présente un maximum.

[0011] Il existe donc un besoin d'une solution permettant l'exploitation d'une source de puissance pour laquelle la courbe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum. Une telle solution devrait, avec des moyens aussi simples et robustes que possible, assurer que la tension aux bornes de la source de puissance est dans la mesure du possible aussi proche que possible de la tension pour laquelle la puissance débitée est maximale.

[0012] Dans un mode de réalisation, l'invention propose en conséquence un circuit de conditionnement d'une source de puissance pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum, le circuit comprenant :

- un convertisseur continu / continu avec une entrée pour l'alimentation par la source de puissance et une sortie pour alimenter une charge;
- un circuit de commande du convertisseur par une consigne de puissance appliqué au convertisseur

- croissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est supérieure à une première valeur seuil négative et
- décroissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est inférieure à une deuxième valeur seuil positive,

le taux de variation de la puissance moyen lorsque la consigne est croissante étant inférieur à l'opposé du taux de variation de la puissance moyen lorsque la consigne est décroissante.

[0013] Avantageusement, la première et/ou la deuxième valeur seuil sont / est constante. On peut alors prévoir que les première et deuxième valeur seuil sont opposées.

[0014] Dans un mode de réalisation, la consigne de puissance croissante appliquée au convertisseur est une consigne de dérivée constante et positive de la puissance par rapport au temps.

[0015] Dans encore un mode de réalisation, la consigne de puissance décroissante appliquée au convertisseur est une consigne de dérivée constante et négative de la puissance par rapport au temps.

[0016] On peut aussi prévoir que la dérivée constante et positive est inférieure à l'opposé de la dérivée constante et négative.

[0017] L'invention propose aussi un générateur conditionné, comprenant un tel circuit et une source de puissance pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum; la puissance fournie par la source est appliquée en entrée du convertisseur continu / continu.

[0018] Dans un mode de réalisation, le générateur comprend une capacité en parallèle à la source de puissance. La source peut aussi présenter une capacité intrinsèque. De préférence, la source de puissance est un générateur solaire.

[0019] L'invention propose enfin un procédé de conditionnement d'une source de puissance pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum, la puissance fournie par la source étant appliquée à un convertisseur continu /continu; le procédé comprend l'application au convertisseur d'une consigne de puissance d'entrée

- croissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est supérieure à une première valeur seuil négative et
- décroissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est inférieure à une deuxième valeur seuil positive,

le taux de variation de la puissance moyen lorsque la consigne est croissante étant inférieur à l'opposé du taux de variation de la puissance moyen lorsque la consigne est décroissante.

[0020] On peut prévoir que la première valeur seuil est constante, et / ou encore que la deuxième valeur seuil est constante. Il est alors possible que les première et deuxième valeur seuil soient opposées.

[0021] Avantageusement, la consigne de puissance croissante appliquée au convertisseur est une consigne de dérivée constante et positive de la puissance par rapport au temps. Il est aussi possible que la consigne de puissance décroissante appliquée au convertisseur soit une consigne de dérivée constante et négative de la puissance par rapport au temps. Si tel est le cas, la dérivée constante et positive peut être inférieure à l'opposé de la dérivée constante et négative.

[0022] D'autres caractéristiques et avantages de l'invention apparaîtront à la lecture de la description qui suit de modes de réalisation, donnés à titre d'exemple et en référence aux dessins, qui montrent :

- figure 1, un graphe du courant et de la puissance en fonction de la tension aux bornes d'une source

de puissance à laquelle l'invention s'applique;
- figure 2, une représentation schématique d'un générateur conditionné selon un mode de réalisation de l'invention;
- figure 3, un graphe de la puissance délivrée par la source de puissance en fonction de la tension à ses bornes, dans le générateur conditionné de la figure 2;
- figure 4, une vue plus détaillée du circuit de commande du générateur conditionné de la figure 2.

[0023] On donne dans la suite de la description un exemple d'application de l'invention au suivi du point de puissance maximum dans un générateur solaire. Comme expliqué ci-dessus, un tel générateur n'est qu'un exemple d'une source de puissance pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum.

[0024] La figure 2 est une représentation schématique d'un générateur conditionné selon un mode de réalisation de l'invention, dans une application d'alimentation en tension d'un bus de satellite. Le générateur conditionné présente d'une part un générateur solaire 10, et d'autre part un circuit de conditionnement. Ce circuit de conditionnement permet au générateur conditionné de délivrer une puissance sous une tension fixe, autrement dit de se comporter comme une source de tension, tant que la puissance délivrée est inférieure à la puissance maximale que peut fournir le générateur solaire, alors que le générateur solaire n'est capable de fournir une puissance variable, à concurrence du maximum de puissance disponible, qu'à des tensions variables.

[0025] La figure montre le générateur solaire 10 - la source de puissance - qui est monté en parallèle à une capacité 12. La tension Vin aux bornes du générateur solaire et de la capacité est appliquée en entrée d'un convertisseur continu / continu (ou convertisseur DC/DC) 14. Cette représentation de la source, de la capacité et du convertisseur est schématique; de fait, un générateur solaire présente intrinsèquement une capacité; le convertisseur peut aussi en entrée présenter une capacité. La capacité 12 n'est pas nécessairement un composant distinct du générateur et du convertisseur, mais peut être constituée par la capacité du générateur et/ou du convertisseur. La capacité 12 peut aussi correspondre à la combinaison de la capacité intrinsèque du générateur solaire, d'une capacité additionnelle et d'une capacité prévue dans le convertisseur.

[0026] La tension Vout en sortie du convertisseur 14 correspond au bus de tension du satellite 16; celui-ci comprend habituellement une batterie alimentant les charges, mais ceci est sans incidence sur le fonctionnement du circuit.

[0027] Le convertisseur 14 est commandé par un circuit de commande 18. Ce circuit de commande 18 reçoit en entrée la tension d'entrée Vin appliquée au convertisseur ainsi que le courant Iout en sortie du convertisseur; la figure montre schématiquement le capteur de tension 20 et le capteur de courant 22. Le circuit de commande fournit un signal de commande appliqué à l'entrée de commande du convertisseur 14, comme représenté en 24 sur la figure.

[0028] Comme expliqué plus haut, la puissance fournie par le générateur solaire 10 est fonction de la tension Vin aux bornes du générateur; la tension pour laquelle la puissance fournie est maximale peut varier dans une plage [V0min, V0max], dans l'exemple une plage de 40 à 80 V. Une solution courante est que le bus de tension du satellite fonctionne à une tension nominale de 28 V, qui varie entre 23 et 37 V en fonction de la charge et de l'alimentation du bus de tension. En pratique, la tension nominale du bus est inférieure la borne inférieure V0min de la plage dans laquelle varie la tension pour laquelle la puissance fournie est maximale. Dans une telle configuration, le convertisseur 14 peut être un convertisseur PWM (à modulation de la largeur d'impulsion) du type Buck. Ce convertisseur est particulièrement adapté à fonctionner avec une tension de sortie inférieure à la tension d'entrée. Le signal d'entrée est dans un tel cas un signal représentatif du rapport cyclique de modulation de la largeur d'impulsion.

[0029] Le circuit de commande 18 contrôle le convertisseur 14, à partir des mesures de tension d'entrée Vin et de courant de sortie Iout du convertisseur, par application de consigne de courant de sortie croissante ou décroissante. Ces consignes de courant sont assimilables à des consignes de puissance au facteur de proportionnalité près que constitue la valeur en tension du bus. Plus spécifiquement, le circuit de commande applique au convertisseur une consigne de puissance croissante tant que la dérivée par rapport au temps de la tension extraite du générateur solaire 10 et de la capacité 12 en entrée du convertisseur est supérieure à une première valeur seuil négative. Le circuit de commande applique au convertisseur une consigne de puissance décroissante tant que la dérivée par rapport au temps de la tension extraite du générateur solaire 10 et de la capacité 12 en entrée du convertisseur est inférieure à une deuxième valeur seuil positive. Ainsi, le convertisseur est piloté de sorte à assurer que

$$\frac{dP_{IN}}{dt} > 0$$

tant que

$$\frac{dV_{IN}}{dt} > V'_r$$

V'_r constituant la première valeur seuil négative. P_{in} est la puissance extraite de la source et de la capacité, autrement dit la puissance appliquée en entrée du convertisseur. Le convertisseur est piloté de sorte à assurer

que

$$\frac{dP_{IN}}{dt} < 0$$

tant que

$$\frac{dV_{IN}}{dt} < V'_f$$

V'_f constituant la deuxième valeur seuil positive.

[0030] Dans les solutions de W. Denzinger et Kevin Kyeong-Il Choi mentionnées ci-dessus, il est proposé d'exploiter les composantes directes de courants et/ou tensions. Or ces quantités ne sont pas caractéristiques du suivi de point de puissance maximum. A l'inverse, la solution proposée par l'invention n'exploite par contre que les dérivées temporelles de ces quantités; ces dérivées sont bien caractéristiques du suivi du point de puissance maximum, quelles que soient les valeurs des composantes directes.

[0031] La figure 3 montre un graphe de la puissance délivrée par le générateur solaire en fonction de la tension aux bornes de ce générateur. On a porté en ordonnée la puissance fournie par le générateur solaire 10, et en abscisse la tension aux bornes de ce générateur. La figure montre en traits fins la courbe de la puissance délivrée par le générateur solaire 10 en fonction de la tension à ses bornes; cette courbe présente un maximum noté MPP sur la figure; en ce point, pour une tension V_{MPP}, le générateur solaire délivre une puissance P_{MPP} maximum. Cette courbe en traits fins pourrait être qualifiée de courbe de puissance statique - dans la mesure où elle est représentative d'une caractéristique puissance /tension du générateur solaire isolé. La figure 3 montre en traits gras le cycle de puissance suivi lorsqu'est appliquée au convertisseur la commande définie plus haut. La courbe en traits gras montre la puissance extraite de l'ensemble générateur solaire 10 et capacité 12.

[0032] Dans l'exemple considéré, on a

- une consigne de puissance croissante ayant une dérivée k_r constante,
- une consigne de puissance décroissante ayant une dérivée k_f constante,
- des valeurs de seuil V'_r et V'_f opposées.

[0033] Les deux premières conditions sont choisies pour la simplicité de l'explication; la troisième condition assure un fonctionnement autour du point de puissance maximum statique, comme expliqué plus bas. On a noté R et F sur la figure les points du cycle correspondant aux puissances dynamiques maximale et minimale.

[0034] On suppose au départ que le générateur solaire fonctionne avec une puissance légèrement inférieure à la puissance maximale P_{MPP} et que la tension est supérieure à la tension V_{MPP}. On suppose aussi que la consigne appliquée au convertisseur est une consigne de puissance croissante. Le convertisseur continu / continu assure donc que la puissance totale, extraite du générateur solaire 10 et du condensateur 12, croît. Le point de fonctionnement du générateur solaire 10 se déplace sur la courbe en traits fins, vers le maximum MPP ; la capacité 12 est déchargée pour compléter la puissance fournie par le générateur solaire 10. La tension décroît lentement.

[0035] Lorsque la puissance maximum du générateur solaire 10 est atteinte, le générateur solaire ne 10 peut pas fournir de puissance supplémentaire : la capacité 12 est alors déchargée plus rapidement pour fournir la puissance requise par le convertisseur, sous la consigne de puissance croissante. Ceci accroît la vitesse de chute de la tension V_{IN}; du fait de la chute de tension, la puissance fournie par le générateur solaire 10 chute aussi, ce qui accentue encore la décharge de la capacité 12. La dérivée de la tension V_{IN} par rapport au temps chute de plus en plus vite.

[0036] Lorsque cette dérivée de la tension V_{IN} atteint la valeur seuil négative V'_f, le circuit 18 applique au convertisseur 14 une consigne de puissance décroissante. Le basculement correspond au point R de la courbe en traits gras.

[0037] Le convertisseur reçoit alors une consigne de puissance d'entrée décroissante. Dans un premier temps, la tension décroît, avec une variation plus lente, la capacité 12 continuant à se décharger. Lorsque la puissance extraite de la source et de la capacité continue à diminuer, il arrive un moment où la capacité cesse de se décharger, ce qui correspond sur la courbe en traits gras à l'intersection de la partie gauche de la courbe avec la courbe en traits fins et au minimum de la tension. La puissance extraite du générateur solaire 10 est alors suffisante pour fournir la puissance requise par le convertisseur 14. Comme la consigne appliquée au convertisseur est encore une consigne de puissance décroissante, la capacité se recharge; la tension remonte; compte tenu de la consigne de puissance décroissante appliquée au convertisseur, la puissance extraite par le convertisseur continue de décroître. Comme la tension remonte, la puissance fournie par le générateur solaire tend à croître, ce qui augmente encore la dérivée de la tension par rapport au temps.

[0038] Lorsque la dérivée de la tension par rapport au temps dépasse la deuxième valeur seuil positive, le circuit de commande applique au convertisseur une consigne de puissance croissante. On revient à l'état initial considéré plus haut.

[0039] La stabilité de la commande est assurée, dans le cas où l'on applique une consigne de dérivée de puissance constante, par la condition

$$k_r < - k_f$$

Intuitivement, ceci revient à dire que le passage sur la courbe en gras de la figure 3 du point R au point F est plus "rapide" que le passage du point F au point R. Autrement dit, il est expliqué plus haut que le seuil de dV/dt négatif est atteint avec une chute de plus en plus rapide de la tension; la condition $k_r < - k_f$ signifie que l'on applique une consigne de puissance "assez" croissante pour rapidement revenir vers une situation stable. Un rapport de 1 entre les valeurs absolues correspond à la limite de stabilité. Le choix d'une valeur dépend essentiellement du convertisseur : rapprocher la valeur du rapport de 1 impose de disposer d'un convertisseur de performances plus précises, et augmente le coût. Dans les applications à des satellites, les variations de la courbe de puissance en fonction de la tension pour le générateur solaire (le passage des courbes 1 et 2 aux courbes 3 et 4) sur la figure 1, comme les vitesses de variations des caractéristiques de la batterie appliquée comme charge du circuit conditionné sont lentes et ne sont donc pas généralement dimensionnantes. On peut typiquement sélectionner un rapport $- k_f/k_r$ voisin de 2, avec par exemple

$k_r = 50$ W/ms et
$k_f = -100$ W/ms.

[0040] On notera que le fonctionnement décrit ci-dessus est indépendant que la valeur de la consigne de puissance croissante ou décroissante appliquée au convertisseur. Il est plus simple, comme le montre la figure 4, d'utiliser des valeurs de consigne de puissance constantes, mais ceci n'a pas d'incidence sur le principe de pilotage du convertisseur. Si les consignes de puissance proposées ne sont pas constantes - autrement dit si les valeurs de dP_{IN}/dt appliquées au convertisseur ne sont pas constant, la condition de stabilité peut alors s'exprimer en indiquant que le taux de variation de la puissance moyen lorsque la consigne est croissante est inférieur à l'opposé du taux de variation de la puissance moyen lorsque la consigne est croissante. Ceci revient à généraliser sur les intervalles temporels de consigne de puissance croissante et décroissante la condition instantanée $k_r < - k_f$.

[0041] L'application des consignes proposées au convertisseur continu /continu permet ainsi de faire varier la tension autour de la valeur de tension pour laquelle la puissance extraite du générateur solaire 10 est maximum. Le choix des valeurs de consigne appliquées au convertisseur, comme des valeurs seuils, permet d'adapter le fonctionnement du circuit de conditionnement.

[0042] Plus spécifiquement, il est plus simple, du point de vue de l'implémentation du circuit de commande d'avoir des valeurs de seuil V'_r et V'_f constantes. Ceci ne fait que faciliter la conception du circuit de commande. On pourrait toutefois faire varier ces valeurs seuil en fonction du temps - par exemple pour tenir compte des variations du point MPP.

[0043] Le rapport des valeurs absolues des valeurs de seuil V'_r et V'_f permet de déterminer le point du graphe de la puissance en fonction de la tension autour duquel on se déplace. Dans l'exemple considéré plus haut, des valeurs de seuil constantes et opposées V'_r et V'_f correspondent à un déplacement autour du point MPP de puissance maximum. Un rapport de valeurs absolues égal à 1 est donc avantageux. Toutefois, on peut aussi choisir d'autres valeurs, ce qui conduit simplement à écarter le point de fonctionnement du point de puissance maximum. Ceci peut être avantageux en fonction de contraintes autres sur le circuit de conditionnement ou sur le générateur.

[0044] La figure 4 montre un exemple du principe de réalisation du circuit de commande, dans le cas d'un convertisseur Buck. Le circuit 18 présente un dériveur 26 qui reçoit la tension d'entrée du convertisseur et en fournit la dérivée. La dérivée de la tension est appliquée à un comparateur 28. La sortie du comparateur fournit un signal logique dont l'état dépend de la comparaison entre la valeur de la dérivée de la tension et les valeurs seuils V'r et V'f du comparateur. Le circuit présente un autre dériveur 30 qui reçoit le signal de courant de sortie du convertisseur et en fournit la dérivée. Un additionneur 32 fournit un signal représentatif de la différence entre le signal du comparateur 28 et le signal de dérivée fourni par le deuxième dériveur 30. Le signal fourni par l'additionneur est appliqué à un contrôleur 34 dont le rôle est d'annuler la consigne. Le signal de sortie du contrôleur forme le signal de sortie du circuit de commande 18.

[0045] Le fonctionnement du circuit de la figure 4 est le suivant. Le comparateur fournit en sortie un signal fonction de la position de la dérivée de la tension d'entrée du convertisseur par rapport aux valeurs seuil V'_r et V'_f. Ce signal est comparé à la dérivée du courant de sortie du convertisseur, après une mise à l'échelle non-représentée sur la figure. Cette dérivée du courant de sortie constitue une bonne approximation de la dérivée de la puissance appliquée en entrée du convertisseur, du fait que :

- la puissance consommée par le convertisseur continu / continu est faible;
- la tension de sortie du convertisseur est sensiblement constante, dans la mesure où le convertisseur est utilisé comme source de tension.

Le contrôleur assure donc que

$dI_{out}/dt < 0$ ou > 0 (dans un rapport $< - 1$)

en fonction du résultat de la comparaison de dV_{IN}/dt avec les valeurs seuils. Avec V_{OUT} sensiblement constante, on a bien la consigne requise.

[0046] Le montage de la figure 4 n'est qu'un exemple d'un circuit de commande utilisable pour le convertisseur continu /continu. On peut aussi utiliser d'autres types de circuits de commande pour comparer les dérivées des tensions et appliquer les consignes requises.

On peut aussi prévoir d'autres capteurs que les capteurs 20, 22 de la figure 2. Le montage des figures 2 et 4 présente néanmoins l'avantage de la simplicité; ainsi, il n'est pas nécessaire de disposer d'un microcontrôleur; le nombre de composants est aussi plus restreint que dans la solution proposée dans l'article de W. Denzinger plus haut.

[0047] Bien entendu, l'invention n'est pas limitée aux exemples décrits plus haut. Ainsi, on a mentionné un convertisseur Buck, adapté au cas d'une tension de sortie inférieure à la tension d'entrée. On pourrait aussi utiliser d'autres types de convertisseurs; par exemple, si la tension d'entrée est inférieure à la tension de sortie, on pourrait utiliser un convertisseur PWM du type Boost. D'autres topologies de convertisseurs permettent aussi un fonctionnement lorsque le rapport entre la tension d'entrée et la tension de sortie varie autour de 1. Le type de convertisseur utilisé ne change pas le principe de la commande décrit en référence à la figure 3.

Revendications

1. Un circuit de conditionnement d'une source de puissance (10) pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum, le circuit comprenant :

   - un convertisseur continu / continu (14) avec une entrée pour l'alimentation par la source de puissance et une sortie pour alimenter une charge;
   - un circuit de commande du convertisseur par une consigne de puissance appliqué au convertisseur

   croissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est supérieure à une première valeur seuil négative et

   décroissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est inférieure à une deuxième valeur seuil positive,

   le taux de variation de la puissance moyen lorsque la consigne est croissante étant inférieur à l'opposé du taux de variation de la puissance moyen lorsque la consigne est décroissante.

2. Le circuit de la revendication 1, **caractérisé en ce que** la première valeur seuil est constante.

3. Le circuit de la revendication 1 ou 2, **caractérisé en ce que** la deuxième valeur seuil est constante.

4. Le circuit des revendications 3 et 4, **caractérisé en ce que** les première et deuxième valeur seuil sont opposées.

5. Le circuit de l'une des revendications 1 à 4, **caractérisé en ce que** la consigne de puissance croissante appliquée au convertisseur est une consigne de dérivée constante et positive de la puissance par rapport au temps.

6. Le circuit de l'une des revendications 1 à 5, **caractérisé en ce que** la consigne de puissance décroissante appliquée au convertisseur est une consigne de dérivée constante et négative de la puissance par rapport au temps.

7. Le circuit des revendications 5 et 6, **caractérisé en ce que** la dérivée constante et positive est inférieure à l'opposé de la dérivée constante et négative.

8. Un générateur conditionné, comprenant :

   - un circuit selon l'une des revendications 1 à 7;
   - une source de puissance (10) pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum, la puissance fournie par la source étant appliquée en entrée du convertisseur continu / continu (14).

9. Le générateur de la revendication 8, **caractérisé par** une capacité (12) en parallèle à la source de puissance.

10. Le générateur de la revendication 8, **caractérisé en ce que** la source présente une capacité intrinsèque.

11. Le générateur de la revendication 8, 9 ou 10, **caractérisé en ce que** la source de puissance est un générateur solaire.

12. Un procédé de conditionnement d'une source de puissance (10) pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum, la puissance fournie par la source (10) étant appliquée à un convertisseur continu /continu (12), le procédé comprenant l'application au convertisseur d'une consigne de puissance d'entrée

    - croissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est supérieure à une première valeur seuil négative et
    - décroissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est inférieure à une deuxième valeur seuil positive,

    le taux de variation de la puissance moyen lorsque la consigne est croissante étant inférieur à l'opposé du taux de variation de la puissance

moyen lorsque la consigne est décroissante.

13. Le procédé de la revendication 12, **caractérisé en ce que** la première valeur seuil est constante.

14. Le procédé de la revendication 12 ou 13, **caractérisé en ce que** la deuxième valeur seuil est constante.

15. Le procédé des revendications 13 et 14, **caractérisé en ce que** les première et deuxième valeur seuil sont opposées.

16. Le procédé de l'une des revendications 12 à 15, **caractérisé en ce que** la consigne de puissance croissante appliquée au convertisseur est une consigne de dérivée constante et positive de la puissance par rapport au temps.

17. Le procédé de l'une des revendications 12 à 16, **caractérisé en ce que** la consigne de puissance décroissante appliquée au convertisseur est une consigne de dérivée constante et négative de la puissance par rapport au temps.

18. Le procédé des revendications 16 et 17, **caractérisé en ce que** la dérivée constante et positive est inférieure à l'opposé de la dérivée constante et négative.

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FIG_1

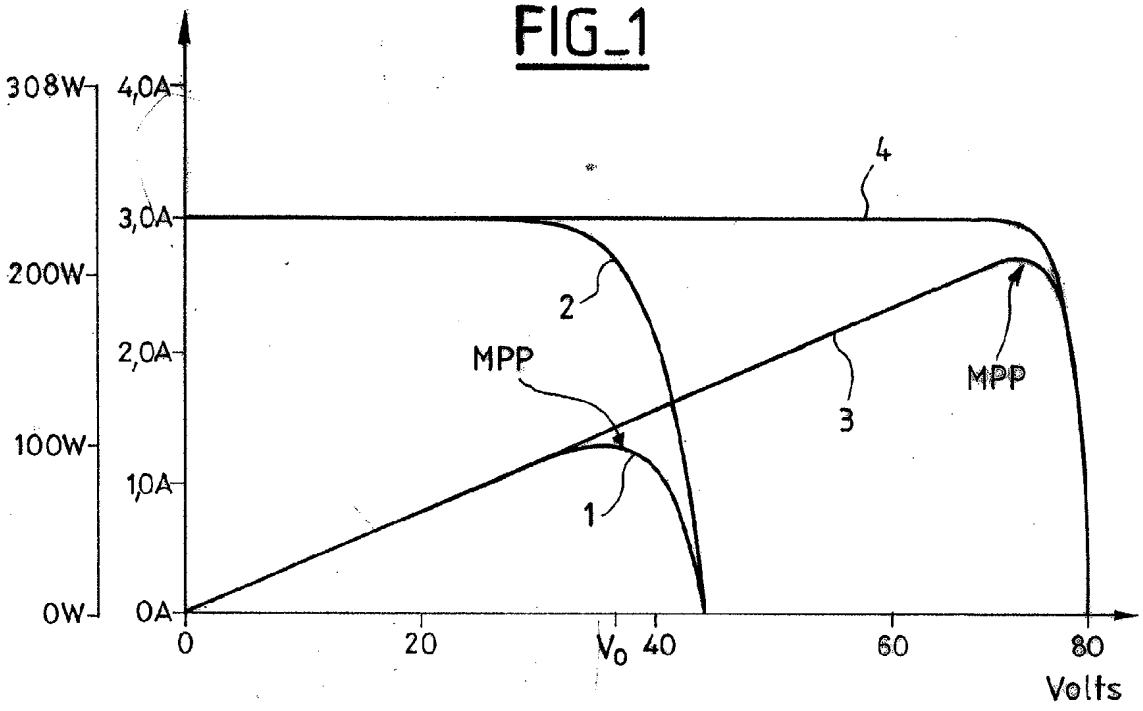

308W
200W
100W
0W
4,0A
3,0A
2,0A
1,0A
0A
0
20
V_o 40
60
80
Volts
4
2
MPP
3
MPP
1

FIG_2

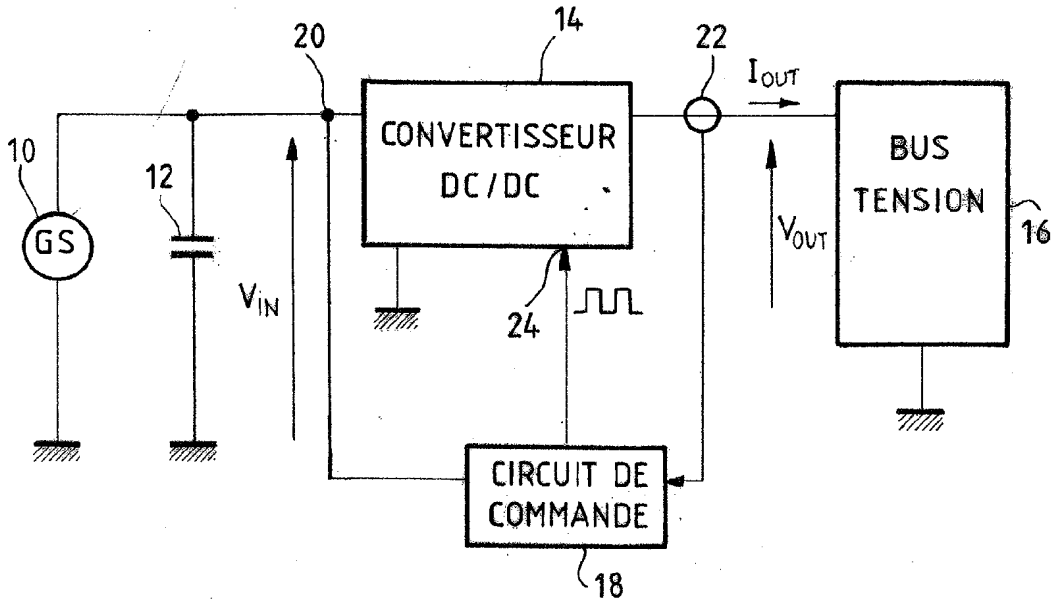

20
14
22
I_{OUT}
CONVERTISSEUR
DC/DC
BUS
TENSION
16
10
GS
12
V_{IN}
V_{OUT}
24
CIRCUIT DE
COMMANDE
18

FIG_3

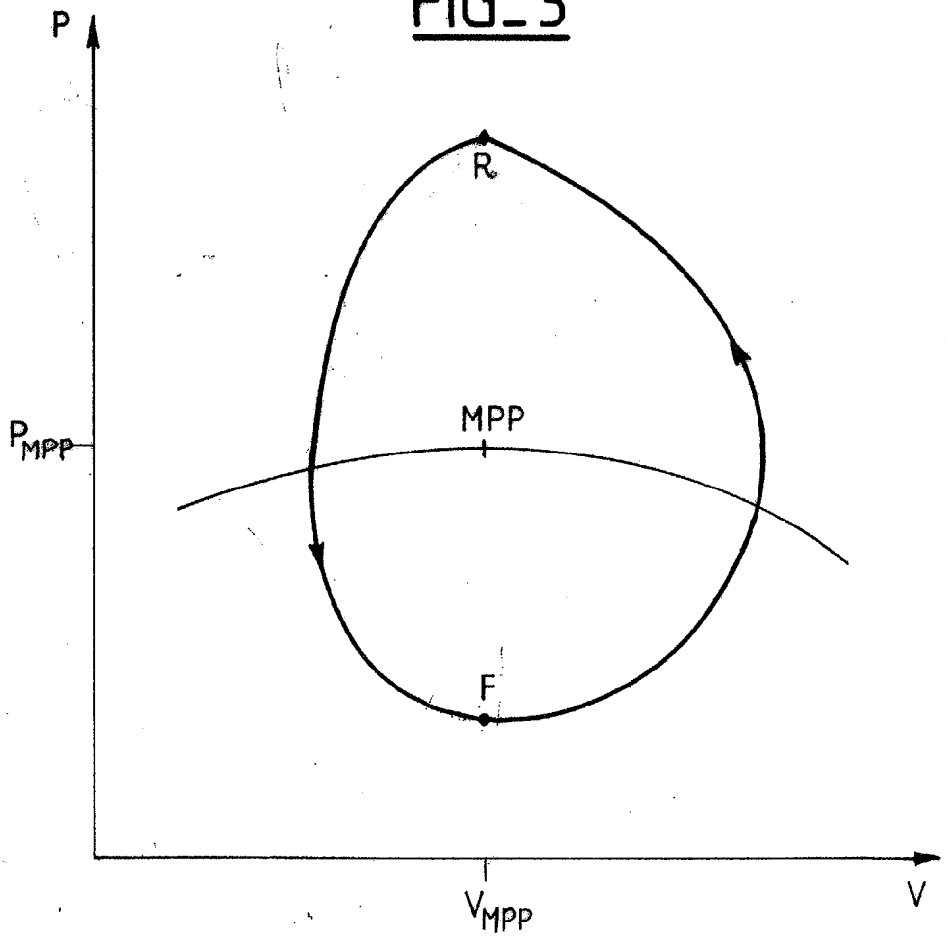
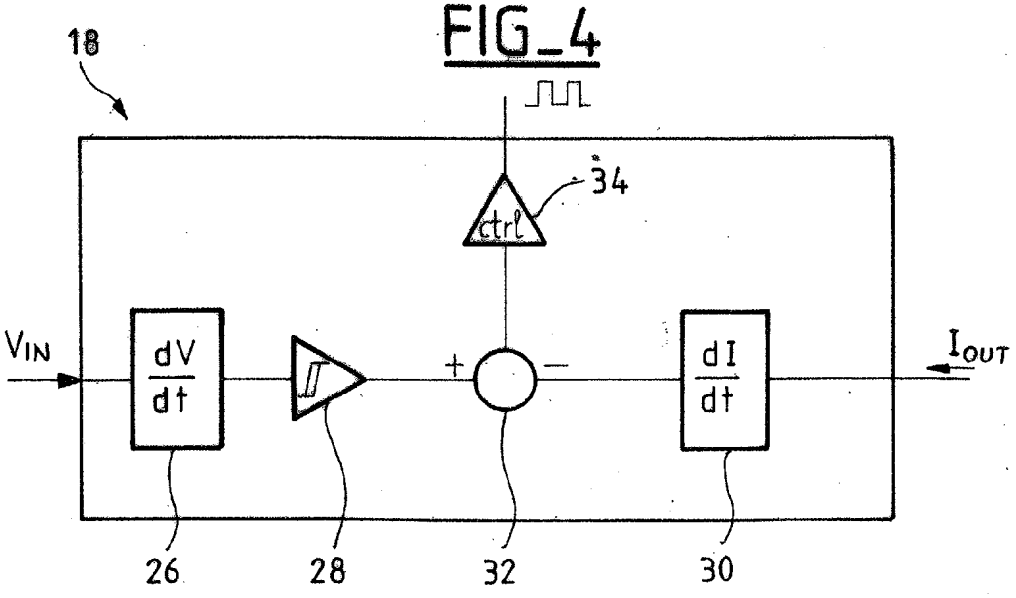


FIG_4



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RAPPORT DE RECHERCHE EUROPEENNE

Numéro de la demande
EP 03 29 1745

DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes	Revendication concernée	CLASSEMENT DE LA DEMANDE (Int.Cl.7)
X	FR 2 819 653 A (CNRS) 19 juillet 2002 (2002-07-19)	1,8,12	G05F1/67
A	* le document en entier *	2-7, 9-11, 13-18	

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	-/--		

Le présent rapport a été établi pour toutes les revendications

Lieu de la recherche	Date d'achèvement de la recherche	Examinateur
LA HAYE	15 octobre 2003	Schobert, D

CATEGORIE DES DOCUMENTS CITES

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EPO FORM 1503 03.82 (P04C02)

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RAPPORT DE RECHERCHE EUROPEENNE

Numéro de la demande
EP 03 29 1745

DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes	Revendication concernée	CLASSEMENT DE LA DEMANDE (Int.Cl.7)
X	GOW J A ET AL: "A MODULAR DC-DC CONVERTER AND MAXIMUM POWER TRACKING CONTROLLER FORMEDIUM TO LARGE SCALE PHOTOVOLTAIC GENERATING PLANT" 8TH EUROPEAN CONFERENCE ON POWER ELECTRONICS AND APPLICATIONS. LAUSANNE, CH, SEPT. 7 - 9, 1999, EPE. EUROPEAN CONFERENCE ON POWER ELECTRONICS AND APPLICATIONS, BRUSSLS: EPE ASSOCIATION, BE, vol. CONF. 8, 7 septembre 1999 (1999-09-07), pages 1-8, XP000883026 ISBN: 90-75815-04-2	1,8,12	
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	-/--		

Le présent rapport a été établi pour toutes les revendications

Lieu de la recherche	Date d'achèvement de la recherche	Examinateur
LA HAYE	15 octobre 2003	Schobert, D

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Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes	Revendication concernée	CLASSEMENT DE LA DEMANDE (Int.Cl.7)
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Lieu de la recherche	Date d'achèvement de la recherche	Examinateur
LA HAYE	15 octobre 2003	Schobert, D

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ANNEXE AU RAPPORT DE RECHERCHE EUROPEENNE RELATIF A LA DEMANDE DE BREVET EUROPEEN NO. EP 03 29 1745

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Pour tout renseignement concernant cette annexe : voir Journal Officiel de l'Office européen des brevets, No.12/82

(19) OFICINA ESPAÑOLA DE PATENTES Y MARCAS

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H01L 31/042 (2006.01)
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(74) Agente: **Carpintero López, Francisco**

(54) Título: **Módulo fotovoltaico inteligente.**

(57) Resumen:
Módulo fotovoltaico inteligente.
El módulo fotovoltaico está compuesto por un panel fotovoltaico (1) y un circuito electrónico (2), integrado en el propio módulo, que incluye un convertidor DC-DC (3) controlado por un algoritmo de seguimiento del punto de máxima potencia. Este módulo se conecta a otros módulos, a través del convertidor DC-DC (3) y éstos a su vez a un inversor (7) que suministra la corriente alterna a la instalación a alimentar, reduciendo las pérdidas debidas a desadaptaciones entre los distintos módulos de la instalación.

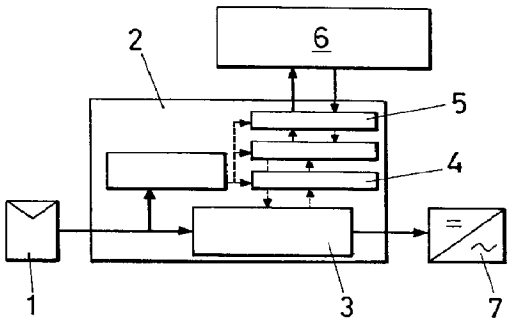


FIG.1

ES 2 249 147 A1

DESCRIPCIÓN

Módulo fotovoltaico inteligente.

Objeto de la invención

La presente invención se refiere a un módulo fotovoltaico que integra medios electrónicos que permiten realizar el seguimiento del punto de máxima potencia individual de cada panel fotovoltaico y conectarse a otros paneles, según una arquitectura distribuida que permite reducir las pérdidas de potencia de la instalación fotovoltaica.

Antecedentes de la invención

Un sistema fotovoltaico para la transformación de energía solar en energía eléctrica se basa en la utilización de múltiples paneles fotovoltaicos que se conectan eléctricamente entre sí, obteniéndose, en condiciones óptimas, una potencia eléctrica total que correspondería a la suma de las potencias máximas de cada panel.

Tradicionalmente, los paneles fotovoltaicos se disponen según una arquitectura centralizada, conectándose todo el conjunto a un inversor que suministra corriente alterna a la red o instalación que se debe alimentar. El inversor realiza un seguimiento del punto de máxima potencia de todo el conjunto.

No obstante, en cualquier sistema fotovoltaico se producen pérdidas eléctricas, cercanas al 25% de la potencia, que se deben principalmente a las desadaptaciones entre los diferentes paneles fotovoltaicos que constituyen el sistema y que están derivadas de la propia arquitectura del sistema que hacen que cuando uno de los paneles no puede suministrar toda su potencia máxima, el resto de paneles se ven afectados y tampoco pueden dar su potencia máxima.

Estas desadaptaciones se originan bien por sombras parciales, bien por las diferentes orientaciones e inclinaciones de los paneles o bien por diferencias en el proceso de fabricación o por envejecimiento de los mismos.

Una alternativa para tratar de solucionar estos problemas se describe en las Patentes alemanas nºs. 19919766 y 4305326 en las cuales se propone, en lugar de la arquitectura centralizada mencionada anteriormente, una arquitectura parcialmente distribuida en la cual los paneles fotovoltaicos se reparten en grupos que se conectan en serie a respectivos convertidores DC-DC, siendo estos convertidores los que se conectan finalmente al inversor. En este caso, cada uno de los convertidores DC-DC realiza su propio seguimiento del punto de máxima potencia de los paneles de su grupo mejorando en parte la eficiencia del sistema.

En cualquier caso, este sistema no evita que se produzcan importantes pérdidas de potencia que dependen, del número de paneles conectados en cada grupo y del número de grupos establecidos.

Además, estas arquitecturas resultan poco apropiadas para realizar modificaciones o ampliaciones futuras de la instalación.

Descripción de la invención

Es objeto de la invención el módulo fotovoltaico que permite resolver la problemática expuesta anteriormente reduciendo todas las pérdidas debidas a las desadaptaciones existentes entre los distintos paneles fotovoltaicos.

Para ello, se propone un módulo fotovoltaico que esta compuesto por un panel fotovoltaico que integra una serie de equipos electrónicos y, en especial, un convertidor DC-DC con su correspondiente algoritmo de seguimiento del punto de máxima potencia del módulo. El circuito electrónico incorpora también elementos que permiten la monitorización del estado del módulo y su comunicación con un sistema de control remoto.

La incorporación de un convertidor DC-DC en cada módulo fotovoltaico permite eliminar las pérdidas debidas a las desadaptaciones entre los distintos módulos del sistema y extraer la máxima potencia disponible en cada uno de ellos, con independencia de la potencia que estén suministrando el resto de módulos.

Con estos módulos, que podríamos denominar inteligentes, se puede configurar un sistema completamente distribuido, en el cual los módulos fotovoltaicos se conectan al inversor, a través de sus correspondientes convertidores DC-DC, lo que permite reducir todas las pérdidas debidas a las desadaptaciones entre los módulos.

Además, resulta muy sencillo dimensionar la instalación y realizar ampliaciones y modificaciones futuras, simplemente añadiendo o eliminando módulos inteligentes.

Adicionalmente, el circuito electrónico del módulo fotovoltaico integra sensores que permiten conocer el estado del módulo, así como un módulo de comunicaciones que envía estos datos a una unidad de control y supervisión.

Con la información recogida de cada uno de los módulos de la planta o instalación fotovoltaica, se facilitan las tareas de monitorización, mantenimiento y detección de fallos.

Descripción de los dibujos

Para complementar la descripción que se está realizando y con objeto de ayudar a una mejor comprensión de las características de la invención, se acompaña como parte integrante de dicha descripción, un juego de dibujos en donde con carácter ilustrativo y no limitativo, se ha representado lo siguiente:

Figura 1.- Muestra un esquema general del módulo fotovoltaico inteligente objeto de la invención.

Figura 2.- Muestra un esquema de arquitectura de una instalación fotovoltaica constituida a partir de módulos inteligentes según objeto de la invención.

Figura 3.- Muestra un esquema de instalación utilizando paneles fotovoltaicos convencionales.

Figura 4.- Muestra la curva de potencia de salida de paneles soleados y en sombra.

Figura 5.- Muestra la curva de potencia de salida para una instalación con 20 paneles convencionales.

Realización preferente de la invención

El módulo fotovoltaico objeto de la invención está constituido por un panel fotovoltaico (1) que integra un circuito electrónico (2) que comprende, entre otros elementos, un convertidor DC-DC (3).

Con el módulo objeto de la invención, tal y como se observa en la figura 2, se pueden configurar sistemas completamente distribuidos compuestos por paneles fotovoltaicos (1), con sus correspondientes convertidores DC-DC (3), conectándose estos últimos, a un inversor (4) que alimenta la instalación correspondiente.

Los convertidores DC-DC (3) integrados en cada panel (1), incorporan un algoritmo de seguimiento del punto de máxima potencia, lo que permite reducir todas las pérdidas de la instalación debidas a desadaptaciones entre los distintos paneles (1).

El circuito electrónico (2) incorpora también unos

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sensores (4) capaces de determinar el estado del módulo y transmitir estos datos, a través de un módulo de comunicaciones (5), a una unidad de control y supervisión (6) de la instalación completa.

En la unidad de control y supervisión (6) se realizan tareas de monitorización, mantenimiento y detección de fallos de toda la instalación fotovoltaica. Las comunicaciones entre módulos y la unidad (6) se realizan a través del propio cableado de continuo empleando la modulación FSK, por lo que no se requiere un cableado adicional.

El protocolo de comunicación es MODBUS-RTU, con arquitectura maestro-esclavo, siendo el maestro la unidad de control y supervisión (6) y los esclavos cada uno de los módulos que envían a la unidad (6) los valores de tensión y corriente, tanto a la entrada como a la salida de su convertidor DC-DC, así como la temperatura de funcionamiento del equipo.

A continuación, se va a describir un ejemplo de funcionamiento, comparando la potencia obtenida con un sistema centralizado, con módulos convencionales, frente a un sistema distribuido con módulos inteligentes de acuerdo al objeto de la invención. Las figuras 4 y 5 muestran unas gráficas de potencia de salida incluidas para ilustrar este ejemplo de funcionamiento.

Supongamos una instalación fotovoltaica con 20 módulos situados por ejemplo en la azotea de un edificio. En este tipo de aplicación resulta imposible evitar sombras parciales, como por ejemplo, las generadas por la chimenea del edificio.

Supongamos también que de los 20 módulos de la instalación, 5 se encuentran parcialmente en sombra debido a la proximidad de una chimenea.

En la figura 4, se han representado las curvas de potencia de salida para módulos soleados y módulos en sombra. En concreto, muestra la potencia de salida máxima de un módulo soleado tipo BP580F (900 W/m^2) y de un módulo sombreado (500 W/m^2). Se puede apreciar como, mientras el primero presenta un máximo de potencia de 82 W, el segundo alcanza un máximo de 44 W. Además, se puede observar como las corrientes para las que se obtiene la máxima potencia son diferentes en cada uno de los casos.

En el caso de una instalación compuesta por módulos fotovoltaicos convencionales, conectados en serie a un único convertidor con seguimiento del punto de máxima potencia, al estar conectados en serie todos los módulos, deben conducir la misma corriente, por lo que la potencia de salida del conjunto corresponde a la curva representada en la figura 4.

En esta curva se puede observar cómo esta conexión en serie provoca la aparición de un máximo de potencia relativo y un máximo de potencia absoluto. Por tanto, en el mejor de los casos, se podría alcanzar el máximo de potencia absoluto, que corresponde a una potencia suministrada de 1213 W.

En el caso de una arquitectura compuesta por 20 módulos fotovoltaicos inteligentes, según el objeto de la invención, resulta posible obtener de cada módulo su potencia máxima disponible, es decir, 44 W para los cinco módulos sombreados y 82 W para los quince módulos soleados. De esta forma, la potencia máxima de la instalación sería de 1450 W que representa casi un 20% mas que con la configuración tradicional.

Exhibit 1016 (Pt. 2 of 2)
Page 123 of 324

REIVINDICACIONES

1. Módulo fotovoltaico, **caracterizado** porque está compuesto por un panel fotovoltaico (1) y un circuito electrónico (2), integrado en el propio panel (1), que incluye un convertidor DC-DC (3) controlado por un algoritmo de seguimiento del punto de máxima potencia.

2. Módulo fotovoltaico según reivindicación 1, **caracterizado** porque el circuito electrónico (2) incorpora sensores (4) que permiten conocer el estado del módulo fotovoltaico y, en concreto, los valores de tensión y corriente, a la entrada y salida del convertidor (3), y la temperatura de funcionamiento del equipo; así como un módulo de comunicaciones (5) que envía los datos recogidos por los sensores (4) a una unidad de control y supervisión (6), para la monitorización, mantenimiento y detección de fallos de la instalación completa.

3. Módulo fotovoltaico según reivindicación 1, **caracterizado** porque se conecta a otros módulos, a través del convertidor DC-DC (3) y éstos a su vez a un inversor (7) que suministra la corriente alterna a la instalación a alimentar, consiguiendo una arquitectura de conexión distribuida entre los distintos módulos.

Exhibit 1016 (Pt. 2 of 2)
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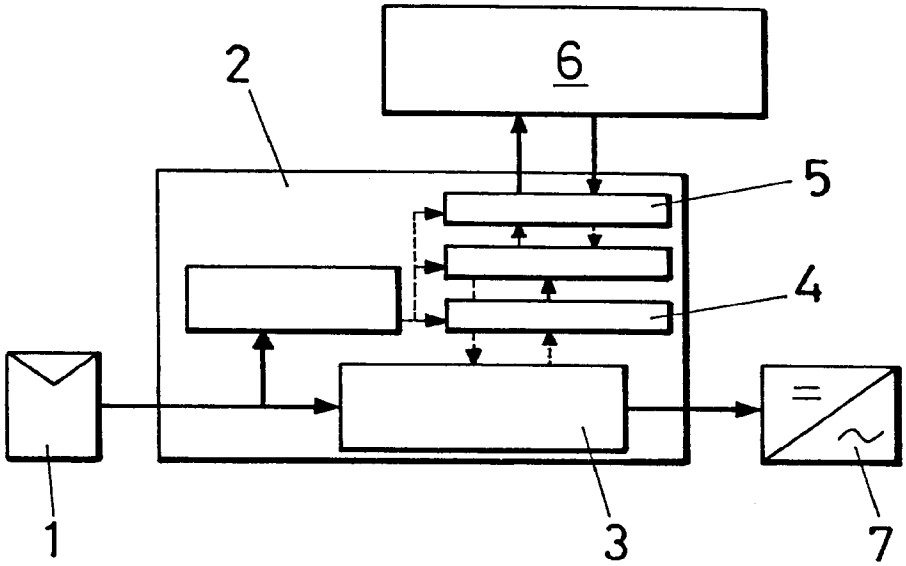


FIG.1

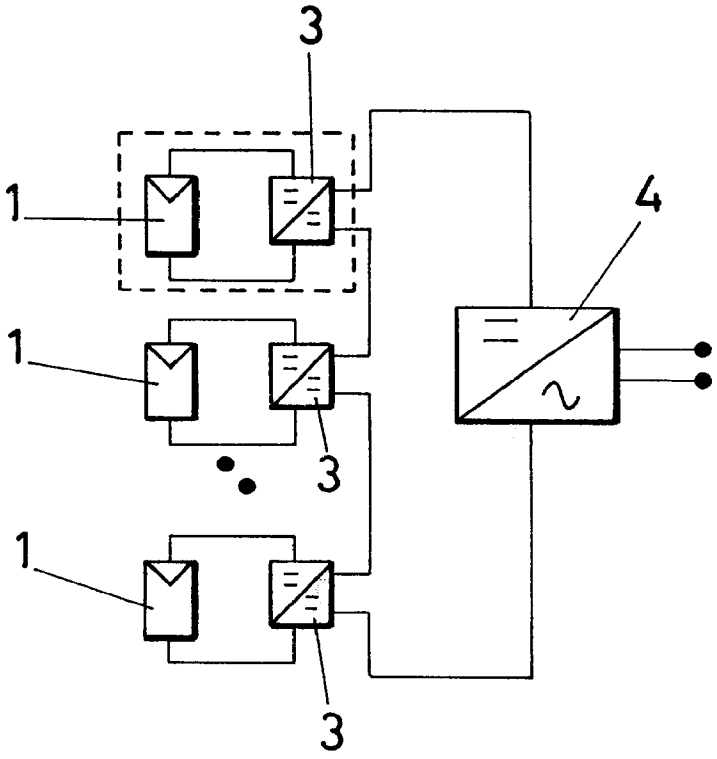


FIG.2

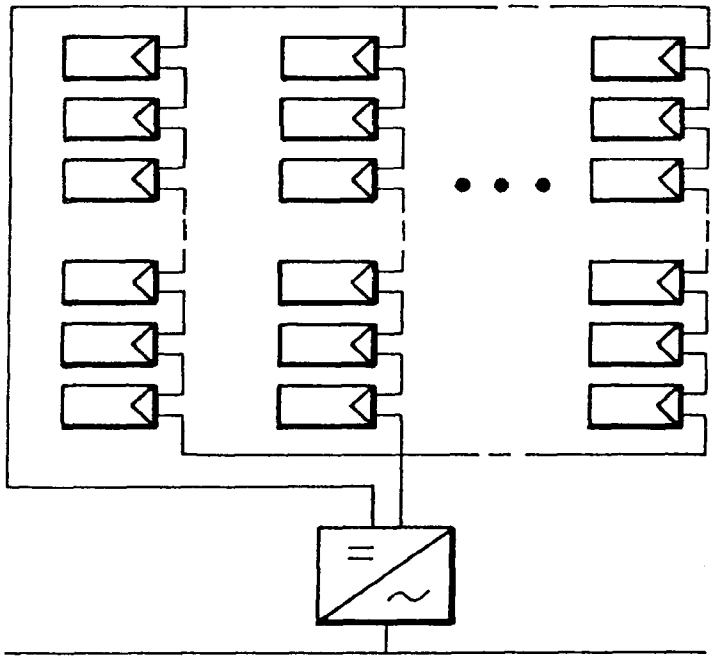


FIG. 3

Exhibit 1016 (Pt. 2 of 2)
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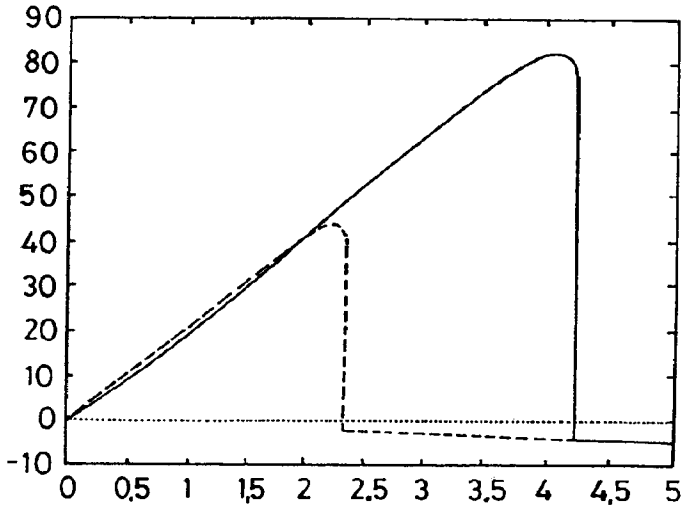

90
80
70
60
50
40
30
20
10
0
-10
0 0,5 1 1,5 2 2,5 3 3,5 4 4,5 5

FIG.4

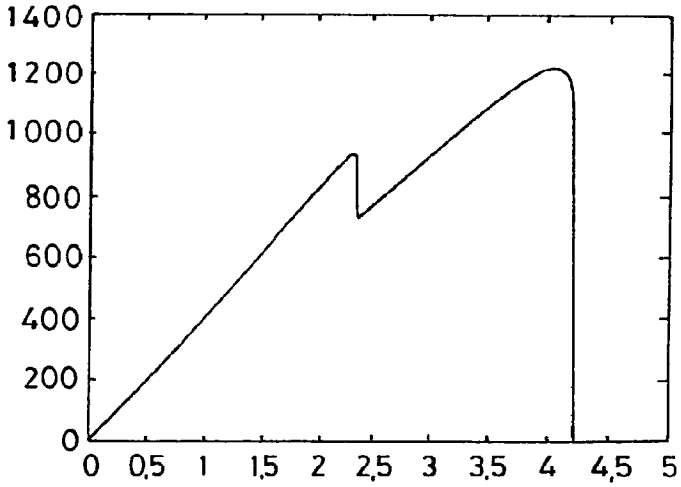

1400
1200
1000
800
600
400
200
0
0 0,5 1 1,5 2 2,5 3 3,5 4 4,5 5

FIG.5

OFICINA ESPAÑOLA DE PATENTES Y MARCAS

ESPAÑA

(11) ES 2 249 147

(21) Nº de solicitud: 200401597

(22) Fecha de presentación de la solicitud: **01.07.2004**

(32) Fecha de prioridad:

INFORME SOBRE EL ESTADO DE LA TÉCNICA

(51) **Int. Cl.:** Ver hoja adicional

DOCUMENTOS RELEVANTES

Categoría	Documentos citados	Reivindicaciones afectadas
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A		2
X	JP 11318042 A (SHARP KK) 16.11.1999, resumen; figura. Extraída de la Base de Datos PAJ en EPODOC.	1,3
A		2
X	JP 2004055603 A (CANON KK) 19.02.2004, resumen; figura. Extraída de la Base de Datos PAJ en EPODOC.	1
A	JP 2001224142 A (NISSIN ELECTRIC CO LTD) 17.08.2001, resumen; figura. Extraída de la Base de Datos PAJ en EPODOC.	1-3
A	JP 8191573 A (SANYO ELECTRIC CO) 23.07.1996, resumen; figura. Extraída de la Base de Datos PAJ en EPODOC.	1,2

Categoría de los documentos citados

X: de particular relevancia
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El presente informe ha sido realizado

☒ para todas las reivindicaciones ☐ para las reivindicaciones nº:

Fecha de realización del informe	Examinador	Página
27.02.2006	P. Pérez Fernández	1/2

CLASIFICACIÓN DEL OBJETO DE LA SOLICITUD

G05F 1/67 (2006.01)
H01L 31/042 (2006.01)
H02J 3/38 (2006.01)

ES2249147: Intelligent Photovoltaic Module

ABSTRACT

The photovoltaic module comprises a photovoltaic panel (1) and an electronic circuit (2), integrated the module itself, which includes a converter OC-OC (3) controlled by a tracking algorithm point maximum power. This module is connected to other modules, through the converter OC-OC (3) And these in turn to an inverter (7) which supplies alternating current at the feed installation, reducing losses to maladaptations between modules of the installation.

SPECIFICATION

Object of the invention

The present invention talks about a photovoltaic module that integral electronic means that allow to make the tracking of the point of Maxima individual power of each photovoltaic patch and to connect themselves to other patches, according to a distributed architecture that allows to reduce the power losses of the photovoltaic installation.

Background of the invention

A photovoltaic system for the transformation of solar energy in electrical energy is based on the use of multiple photovoltaic patches that are connected electrically to each other, obtaining itself, in optimum conditions, an electric power total that would correspond to the sum of the maximum powers of each patch.

Traditionally, the photovoltaic patches are arranged according to a centralized architecture, connecting all the assembly to an inverter that provides to alternate stream to the network octyns installation that is due to feed. The inverter makes a tracking of the point of Maxima power of all the assembly.

However, in any photovoltaic system electrical, close losses take place 25% of the power, that must mainly to the mismatches between the different photovoltaic patches that constitute the system and that are derived of the own architecture of the system which they do that when one of the patches cannot provide all its Maxima power, the remainder of patches are affected and either they cannot give its Maxima power.

These mismatches are originated either by partial shadows, or by the different orientations and inclinations of the patches or by differences in the manufacturing process octyns by aging of such.

An alternative to try to solve these problems is described in Apparent German us. 19919766 and 4305326 in which one sets out, instead of the mentioned centralized architecture previously, a partially distributed architecture in which the photovoltaic patches are distributed in groups that are connected in series to respective converters DC-DC, being these converters those that are connected finally to the inverter. In this case, each one of converters DC-DC makes its own tracking of the point of Maxima power of the patches of its group improving partly the efficiency of the system.

In any case, this system does not avoid that important power losses that depend, of the number of connected patches in each group and of the established group number take place.

In addition, these architectures are little appropriate to make modifications octyns future magnifications of the installation.

Description of the invention

The photovoltaic module is object of the invention that allows to solve problematic the exposed one previously reducing all the due losses to the existing mismatches between the other photovoltaic patches.

For it, a photovoltaic module sets out that this compound by integral a photovoltaic patch that series of electronic equipments and, in special, a converter DC-DC with its corresponding algorithm of tracking of the point of Maxima power of the module. The electronic circuit also incorporates elements that allow to the monitoring of the state of the module and its communication with a remote control system.

The incorporation of a converter DC-DC in each photovoltaic module allows to eliminate the due losses the mismatches between the other modules of the system and to extract the Maxima available power in each one of them, independently of the power who are providing the remainder of modules.

With these modules, that we could denominate intelligent, a completely distributed system can be formed, in which the photovoltaic modules are connected to the inverter, through their corresponding converters DC-DC, which allows to reduce all the due losses to the mismatches between the modules.

In addition, it turns out very simple to determine the proportions the installation and to make future magnifications and modifications, simply adding to octyns eliminating intelligent modules.

Additionally, the electronic circuit of the integral photovoltaic module sensors that allow to know the state the module, as well as a module of communications that send these data to a control unit and supervision.

With the collected information of each one of the modules of the plant octyns photovoltaic installation, the tasks of monitoring, maintenance and detection of failures are facilitated.

Description of the drawings

In order to complement the description that is being made and with object to help one better understanding of the features of the invention, it is accompanied like integral part of mentioned description, a game of drawings in where with illustrative and nonlimitative character, the next thing is had shown:

Figure 1. - Sample a block diagram of the intelligent photovoltaic module object of the invention.

Figure 2. - Sample a scheme of architecture of a formed photovoltaic installation from intelligent modules according to object of the invention.

Figure 3. - Sample an installation scheme using conventional photovoltaic patches.

Figure 4. - Sample the curve of output power of sunny patches and in shadow.

Figure 5. - Sample the curve of output power for an installation with 20 conventional patches.

Preferred embodiment of the invention

The photovoltaic module object of the invention is in favor formed of a photovoltaic patch (1) that integral an electronic circuit (2) that includes/understands, among other elements, a converter DC-DC (3).

With the module object of the invention, so and as it is observed in Figure 2, are possible to be formed systems completely distributed compounds by photovoltaic patches (1), with its corresponding converters DC-DC (3), connecting these last ones, to an inverter (4) that feeds the corresponding installation.

Integrated converters DC-DC (3) in each patch (1), incorporate an algorithm of tracking of the point of Maxima power, which allows to reduce all the due losses of the installation to mismatches between the other patches (1).

The electronic circuit (2) also incorporates capable sensors (4) to determine the state of the module and to transmit these data, through a module of communications (5), to a control unit and supervision (6) of the complete installation.

In the control unit and supervision (6) monitoring tasks are made, maintenance and detection of failures of all the photovoltaic installation. The communications between modules and the unit (6) are made through own wiring of continuous using modulation FSK, reason why an additional wiring is not required.

The communication protocol is MODBUS-RTU, with architecture master-slave, being the master the control unit and supervision (6) and the slaves each one of the modules that send to the unit (6) the voltage values and stream, as much to the input as when coming out of their converter DC-DC, as well as the operating temperature of the equipment.

Next, one is going away to describe to an operation example, comparing the obtained power with a centralized system, with conventional modules, vs to a distributed system with intelligent modules according to the object of the invention. Figures 4 and 5 show included graphs of output power to illustrate this example of operation.

Let us suppose a photovoltaic installation with 20 located modules for example in the roof of a building. In this type of application it turns out impossible to avoid partial shadows, like for example, the generated ones by the chimney of the building.

Also let us suppose that of the 20 modules of the installation, 5 are partially in shadow due to the vicinity of a chimney.

In Figure 4, the curves of output power for sunny modules and modules in shadow are had shown. In particular, sample the Maxima output power of a sunny module type BP580F (900 W/m2) and of a shaded module (500 W/m2). It is possible to be appreciated like, while first W presents/displays a maximum of power of 82, the second reaches a maximum of 44 W. In addition, it is possible to be observed like the streams for which one obtains the different Maxima power are in each one of the cases.

In the case of an installation composed by conventional, connected photovoltaic modules in series to a single converter with tracking of the point of Maxima power, when being connected in series all the modules, must lead the same stream, reason why the output power of the assembly corresponds to the shown curve in Figure 4.

In this curve it is possible to be observed how this series connection causes the occurrence of a maximum of relative power and an absolute maximum of power. Therefore, in the best one of the cases, the absolute maximum of power could be reached, that corresponds to a supplied power of 1213 W.

In the case of an architecture composed by 20 intelligent photovoltaic modules, according to the object of the invention, it turns out possible to obtain from each module its available Maxima power, that is to say, 44 W for five shaded modules and 82 W for the fifteen sunny modules. Of this form, the Maxima power of the serious installation of 1450 W that almost represents a 20% but that with the conventional configuration.

CLAIMS

1. A photovoltaic module, comprising a photovoltaic panel (1) and an electronic circuit (2), built into the panel (1), which includes a DC-DC converter (3) controlled by an algorithm point tracking full potential.

2. Photovoltaic module according to claim 1, wherein the electronic circuit (2) includes sensors (4) for the state of photovoltaic modules, in particular, the values of voltage and current, the input and output of the converter (3) and the operating temperature of the equipment, and a communications module (5) that sends the data collected by the sensors (4) to a control and monitoring unit (6), for monitoring, maintenance and fault detection of complete installation.

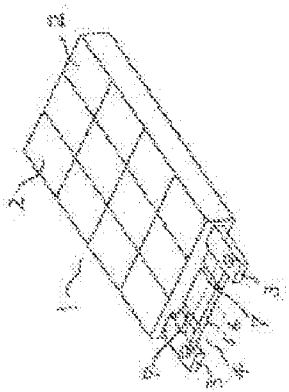
3. Photovoltaic module according to claim 1, wherein connecting to other modules via the converter DC-DC (3) and these in turn to an inverter (7) which supplies alternating current to feed the plant, getting an architecture distributed connection between modules.

SOLAR BATTERY PANEL AND ITS CONNECTION

Publication number: JP4219982 (A)
Publication date: 1992-08-11
Inventor(s): ISHIKAWA AKIRA; HASUNUMA MASAHIKO; INOUE HIROSHI
Applicant(s): SANYO ELECTRIC CO
Classification:
- international: ***H01L31/042;*** **H01L31/042**; (IPC1-7): H01L31/042
- European:
Application number: JP19900404322 19901220
Priority number(s): JP19900404322 19901220

Abstract of **JP 4219982 (A)**

PURPOSE:To prevent an electric shock accident by a method wherein the title panel is constituted in such a way that a short-circuit means is opened of a connecting switch is closed so that a photoelectromotive force can be taken out from output terminals of the panel. CONSTITUTION:A short-circuit means 4 is installed across both + and - output terminals 3 from which electric power generated at a solar battery panel 1 is taken out. A normally-open connecting switch is installed in series with both + and - output terminals 3 from which the electric power generated at the solar battery panel 1 is taken out. The solar battery panel 3 is installed outdoors; the panel is connected electrically; after that, the short-circuit means 4 and the connecting switch are opened and closed by applying an external force.; Thereby, it is possible to completely eliminate an electric shock accident when the solar battery panel installed outdoors is connected electrically.



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(54)【発明の名称】　太陽電池パネル並びにその接続方法

(57)【要約】

【目的】　太陽電池パネルの設置後に行う配線作業の安全性を確保する。

【構成】　太陽電池パネルにて発電された電力を取り出す＋、－両出力端子間に跨って短絡手段を設け、また太陽電池パネルにて発電された電力を取り出す＋、－両出力端子に対して直列に常開の接続スイッチを設け、太陽電池パネルを屋外に設置してそのパネルに対する電気的な接続を終えた後に上記短絡手段や接続スイッチに外力を加えて開成、或るいは閉成するものである。

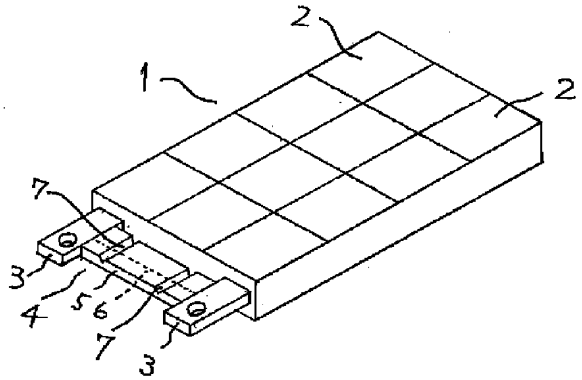


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【特許請求の範囲】

【請求項１】　屋外に設置してハイパワーの光起電力を発生させる太陽電池パネルにおいて、該パネルにて発電された電力を取り出す＋、－両出力端子間に跨って短絡手段が設けられており、この短絡手段はパネル外から外力を加えることによって開成される構成であることを特徴とした太陽電池パネル。

【請求項２】　上記短絡手段はパネル外に延存せしめられた短絡線から構成され、その延存個所に外力を加えて短絡線を切断することを特徴とした請求項１記載の太陽電池パネル。

【請求項３】　上記短絡線は上記パネルから延設された樹脂片に一体的に埋設されてなり、該樹脂片は外力を加えることによって埋設された短絡線共々切断される構成であることを特徴とした請求項２記載の太陽電池パネル。

【請求項４】　上記樹脂片にはその切断を容易とするための切り溝が設けられていることを特徴とした請求項３記載の太陽電池パネル。

【請求項５】　屋外に設置してハイパワーの光起電力を発生させる太陽電池パネルにおいて、該パネルにて発電された電力を取り出す＋、－両出力端子に対して直列に常開の接続スイッチが設けられており、この接続スイッチはパネル外から外力を加えることによって閉成される構成であることを特徴とした太陽電池パネル。

【請求項６】　上記接続スイッチは離間対向した導電材料製の凹凸舌片から構成され、外力にて該両舌片を嵌合させることによって該スイッチを閉成することを特徴とした請求項５記載の太陽電池パネル。

【請求項７】　ハイパワーの光起電力を発生させる太陽電池パネルを屋外に設置すると共に、該光起電力を負荷側に導いて消費するシステムにおいて、請求項１、請求項２、請求項３、または請求項４記載の太陽電池パネルの出力端子を負荷側に配線し終えた後に上記短絡手段に外力を加えて開成することを特徴とした太陽電池パネルの接続方法。

【請求項８】　ハイパワーの光起電力を発生させる太陽電池パネルを屋外に設置すると共に、該光起電力を負荷側に導いて消費するシステムにおいて、請求項５、または請求項６記載、の太陽電池パネルの出力端子を負荷側に配線し終えた後に上記接続スイッチに外力を加えて閉成することを特徴とした太陽電池パネルの接続方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は屋外に設置してハイパワーの光起電力を発生させる太陽電池パネル、並びにその接続方法に関する。

【０００２】

【従来の技術】近年、地球環境問題から、屋外に設置してハイパワーの光起電力を発生させる太陽電池に大きな

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期待が寄せられている。その身近な応用として、一般家庭の屋根に太陽電池を設置し、その発電電力で日中の消費電力の殆どを賄う構想が提案され、一部試験的にではあるが実用化されようとしている。

【０００３】そして一般家庭向けのシステムにおいては太陽電池の発電電力として1～2ｋW程度のものが必要とされている。

【０００４】

【発明が解決しようとする課題】ところが太陽電池は太陽光の照射を受けると発電動作を行うので、太陽電池を設置するために太陽電池パネルを屋根まで運び上げるとその太陽電池は発電動作を自動的に開始してしまう。従って上記したように１～２ｋW程度の光起電力を持つハイパワーの太陽電池パネル設置後に行う配線作業が通電状態で行わなければならず、極めて危険なものであった。特に太陽電池から発電される電力が直流であるので、交流に比べて危険度が高い。

【０００５】その解決手段としては、

１．太陽光が照らない夜間に配線作業を行う、

２．感電事故に細心の注意を払って配線を行う、方法が考えられる。

【０００６】ところが、１．の方法は夜間作業であるので能率が上がらないうえに、屋根から転落するなどの別の事故の危険性が高まり、また２．の方法は熟練した作業員であれば可能ではないが、斯る分野の知識レベルの低い作業員には不可能で一般性のある方法とは云えない。

【０００７】

【課題を解決するための手段】本発明はこのような課題に鑑みて為されたものであって、太陽電池パネルにて発電された電力を取り出す＋、－両出力端子間に跨って短絡手段を設け、また太陽電池パネルにて発電された電力を取り出す＋、－両出力端子に対して直列に接続スイッチを設け、太陽電池パネルを屋外に設置してそのパネルに対する電気的な接続を終えた後に上記短絡手段や接続スイッチに外力を加えて開成、或るいは閉成するものである。

【０００８】

【作用】短絡手段を開成、或るいは接続スイッチを閉成することによって始めてパネルの出力端子から光起電力が取り出されるので、パネルの接続作業時の感電事故を防止することができる。

【０００９】

【実施例】図１は本発明太陽電池パネル１の斜視図であって、単結晶、多結晶、或るいはアモルファスから構成された多数の太陽電池セル２、２、・・・を有している。３、３はこの太陽電池パネル１で発電された電力を取り出す＋、－の出力端子で、各セル２、２、・・・と直列、並列、或るいは直並列に連なっている。４はこの両出力端子３、３に跨って設けられた短絡手段であっ

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て、両出力端子３、３を橋絡する如く設けられた樹脂片５と、この樹脂片５内に埋設され両出力端子３、３を電気的に短絡する短絡線６とから構成されている。更にこの樹脂片５には、その樹脂片５に金鎚などによる外力を加えた時に容易に切断し得る切り溝７、７が設けられている。

【００１０】具体的な数値を挙げてより詳しく説明する。太陽電池パネルとしては、例えば結晶系材料を用いた縦１２０㎝、横４０㎝の大きさの場合、１６Ｖ、３Ａで４８Ｗ程度の定格出力を有するとされている。このようなパネルの場合、出力端子３、３間を電気的に橋絡する短絡線６としては３Ａの電流に耐え得る直径約０．８㎜の錫メッキを施した銅線が用いられ、また樹脂片５としてはこの短絡線６を鋳込み得る、例えば厚２㎜、幅１０㎜程度に選ばれる。

【００１１】図２は本発明パネル１の他の実施例を示しており、＋、－の出力端子３、３としてはリード線方式が採られており、短絡手段４はパネル１の一側面に延存せしめられた樹脂片５と短絡線６とから構成されている。勿論この場合も樹脂片５には切断容易なように切り溝７、７を設けておくのが望ましい。

【００１２】図３はこれら図１、図２に示された太陽電池パネル１の内部結線図を示しており、太陽電池セル２、２・・・からなる発電部分８の両端は出力端子３、３に連なっており、その両端子３、３間に跨って短絡手段４の短絡線６が接続されている。

【００１３】図４は本発明パネルの更に他の実施例を示している。図１、２の実施例の場合は太陽電池パネル１にて発電される電力を短絡線６にて短絡してパネル１外に出力されないようにしているが、この実施例の場合は図５に示すように、発電部分８と太陽電池パネル１の両出力端子３、３に対して直列に挿入された接続スイッチ９を設けている。そしてこの接続スイッチ９はパネル１の側面などに延設されていて、通常は解放状態にあって、パネル１に太陽光が照射されてもその出力端子３、３には電力は出力されず、このスイッチ９をＯＮすることによって始めて電力が出力される構成となっている。この接続スイッチ９の具体的な一例を挙げると、図６に示されたように、燐青銅にニッケルメッキなどを施した導電材料製の対向した凹凸舌片１０、１１から成り、この舌片１０、１１は外力を加えることによって嵌合し、電気的に導通状態となる。

【００１４】次に図１、図２、図４に示された太陽電池パネル１の多数を屋上などの太陽光を良く受ける場所に設置した後、それらのパネル１、１・・・を電気的に接続する方法について説明する。

【００１５】図７は図１、図２に示した太陽電池パネルの場合の接続方法を示したもので、太陽電池パネル１、１・・・を屋上などの所定の個所に設置すると同時に各パネル１、１・・・の出力端子３、３を直列、或るいは並列に適宜電気的に接続すると同時に、例えば家屋内に置かれたエアコン、その他の負荷１２に対する配線を施す。所定の電気的接続作業が終了すると、短絡手段４の短絡線６を鋳込んだ樹脂片５をその切り溝７、７近辺に金鎚などで瞬間的な大きな外力を加えて破断すると同時に、短絡線６を電気的に切断することによって、負荷１２に給電を開始する。

【００１６】図８は図４に示したパネルの接続方法を示しており、各パネル１、１・・・間の接続、並びに負荷１２への接続を完了した後、接続スイッチ９の凹凸舌片１０、１１に金鎚などで瞬間的な大きな外力を加えて両舌片１０、１１を嵌合させて電気的に接続状態とし、負荷１２へ太陽電池パネル１、１・・・で発電した電力を供給する。

【００１７】この太陽電池パネル１、１・・・間、並びに負荷１２への電気的接続は、太陽光が照射されている昼間であっても各パネル１、１・・・の出力端子３、３には電気的出力はないので、その接続作業時に感電の恐れは全くなく、電気面での熟練度のない作業者でも行わしめることができる。

【００１８】一般に、通電状態にある導線を切断する場合、或るいは電位差のある導線を接続する場合、その個所でアークが発生し、特に直流電流の場合、その現象は顕著であることが良く知られている。従ってこのような切断や接続には危険が伴うものとされている。

【００１９】ところが本発明においては、切断や、接続は金鎚などによる瞬間的な大きな外力によって行われるので、アーク発生に伴う危険性は排除される。

【００２０】

【発明の効果】本発明は以上の説明から明らかなように、太陽電池パネルにて発電された電力を取り出す＋、－両出力端子間に跨って短絡手段を設け、また太陽電池パネルにて発電された電力を取り出す＋、－両出力端子に対して直列に常開の接続スイッチを設け、太陽電池パネルを屋外に設置してそのパネルに対する電気的な接続を終えた後に上記短絡手段や接続スイッチに外力を加えて開、閉成する構成であるので、屋外に設置した太陽電池パネルを電気的に接続する際の感電事故を皆無とすることができると同時に、その感電事故防止のための構成は簡単であり、コスト的な負担は少なく、またパネル接続後の負荷への電力供給、即ちシステムの立ち上げ方法も極めて簡単で、全くの熟練性も要求されない。

【図面の簡単な説明】

【図１】本発明太陽電池パネルの斜視図である。

【図２】本発明太陽電池パネルの他の実施例の斜視図である。

【図３】図１、図２に示された太陽電池パネルの内部結線図である。

【図４】本発明太陽電池パネルの更に他の実施例の斜視図である。

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【図５】図４に示された太陽電池パネルの内部結線図である。

【図６】図４に示された太陽電池パネルの要部の拡大断面図である。

【図７】図１、図２に示された太陽電池パネルの接続状態を示す回路図である。

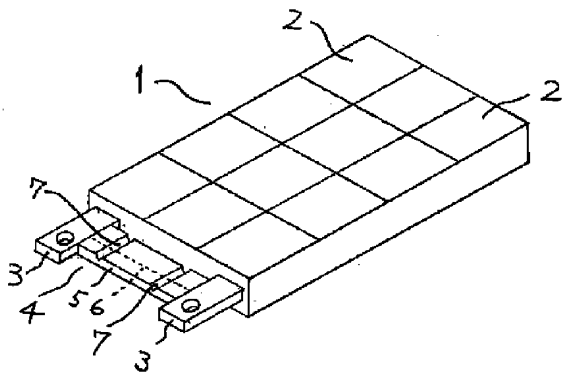
【図８】図４に示された太陽電池パネルの接続状態を示す回路図である。

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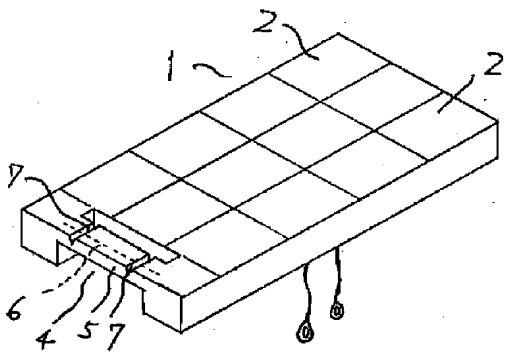
【符号の説明】

１	太陽電池パネル
３	出力端子
４	短絡手段
８	発電部分
９	接続スイッチ
１２	負荷

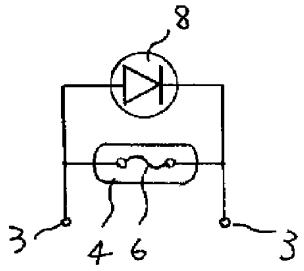
【図１】



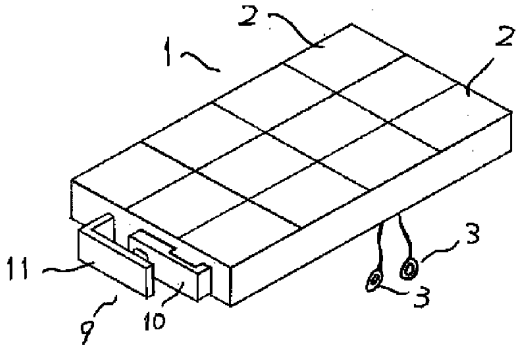
【図２】



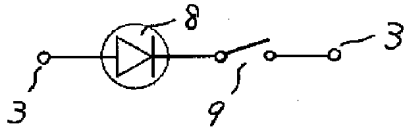
【図３】



【図４】



【図５】



【図６】

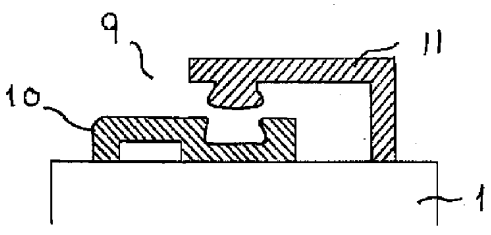
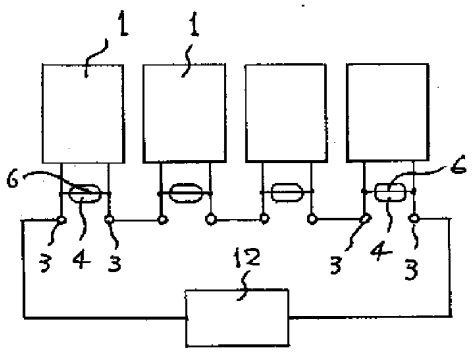


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【図７】



【図８】

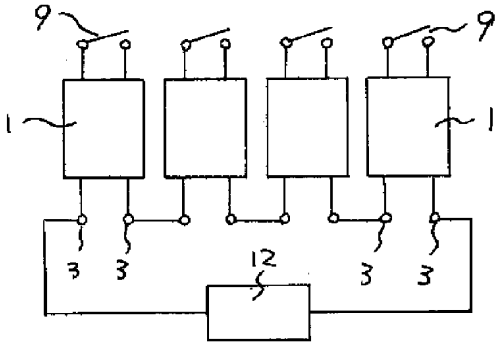


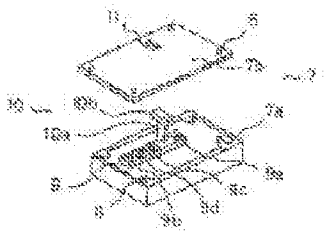
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SOLAR CELL POWER GENERATOR

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Publication date: 1996-04-12
Inventor(s): IGUCHI MASATOSHI; AKASHI NAOYOSHI
Applicant(s): NISSIN ELECTRIC CO LTD
Classification:
- international: ***H01L31/04; H01L31/042;*** **H01L31/04; H01L31/042;** (IPC1-7): H01L31/042; H01L31/04
- European:
Application number: JP19940254822 19940922
Priority number(s): JP19940254822 19940922

Abstract of **JP 8097460 (A)**

PURPOSE: To prevent the electric shock from the installation works such as mounting of solar cell panels on a pedestal or connection thereof, thereby ensuring the safety. CONSTITUTION: The title generator comprises connecting boxes 9 attached to individual solar cell panels and having connecting terminal bases 9, and switches 10, at least, the boxes 9 of, at least, a part of the cell panels and connected in series to the panels.



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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This invention relates to the solar cell power plant formed by carrying out the series connection of two or more solar panels.
[0002]
[Description of the Prior Art]the output per the former and solar panel -- about -- 15V and several 10 -- it is about W, and when considering it as the power supply for electric power, as shown in drawing 4, the series connection of the solar panel 1 of several ten sheets is carried out, a solar cell power plant is formed, and load electric supply of the output of this power plant is carried out via the breaker 2 of output port.
[0003]At this time, it is attached and fixed to the inclined stand 3 by matrix form, and each solar panel 1 is installed in the roof etc., as shown in drawing 5. As shown in drawing 6 (a) and (b), each solar panel 1 attaches the surface solar cell 1a to the frame 2a, and is formed, and the joint box 4 for connection with adjoining solar panel 1 grade is formed in the back side (rear-face side).
[0004]And this joint box 4 is formed of the case body 4a and the lid 4b which blockades this main part 4a airtightly, as shown in drawing 7, and the terminal block 5 is formed in the main part 4a. Two or more mounting holes 6 for a screw clamp which attach the lid 4b to the main part 4a are formed in the main part 4a and the lid 4b. And after each solar panel 1 is attached to the stand 3, connection work, such as terminal strapping of the joint box 4, is performed.
[0005]
[Problem(s) to be Solved by the Invention]In the case of said conventional solar cell power plant, construction of the attachment to the stand 3 of each solar panel 1, connection, etc. is certainly performed by an owner voltage condition, and it is dangerous.
[0006]Namely, since the voltage which these work is usually done at the daytime when rain is not falling, and each solar panel 1 is in a power generation state at this time, and carried out the series connection of these panels 1 is also hundreds of volts depending on a place, There is a risk of receiving an electric shock of a constant current source, if it works by an owner voltage condition, although the current value is small.

[0007]And especially in the operation in height, there is a danger that authorized personnel will fall in response to a shock by electric shock, and there is a possibility that it may be connected with a fatal accident. This invention aims to let construction of the attachment to the stand of each solar panel, connection, etc. to prevent an electric shock and enable it to perform it safely.

[0008]

[Means for Solving the Problem]In order to attain the aforementioned purpose, in the case of a solar cell power plant of this invention, it is provided for every solar panel, is provided in a joint box which has a terminal block for connection, and a joint box of at least some solar panels, and has a switch by which the series connection was carried out to a solar panel.

[0009]

[Function]Since in the case of the solar cell power plant of this invention constituted as mentioned above a switch is formed in the joint box of at least some solar panels and the series connection of these switches is carried out to a solar panel, The electric shock under construction accompanying power generation of each solar panel is prevented by opening each switch wide and working the attachment to the stand of a solar panel, connection, etc.

[0010]

[Example]One example is described with reference to drawing 1 thru/or drawing 3. In those drawings, what is the same as for drawing 4 thru/or drawing 7, and identical codes, or corresponds is shown, 7 is the joint box provided in the back side of each solar panel 1 instead of the conventional joint box 4, it consists of the case body 7a and the lid 7b, and two or more of the same mounting holes 8 as the attaching hole 6 of drawing 7 are formed in the case body 7a and the lid 7b.

[0011]9 is the disconnection terminal block provided in the case body 7a, and has the two terminals 9a and 9b for external connection provided in both ends and the ** 2 terminal 9a, and the two terminals 9c and 9d for self-panels provided among 9b. 10 is the terminal 9a and the switch by which was formed among 9c and the series connection was carried out to the solar panel 1, it has the terminal 9a and the short body 10a which short-circuits between 9c and in which a plug is free, and the control column 10b is formed in the end of this short body 10a. 11 is the plug opening formed in the lid 7b, and the short body 10a is inserted between the terminal 9a and 9c from the exterior via this opening 11.

[0012]And the short body 10a is not inserted until a series of construction of the attachment to the stand 3 of each solar panel 1, connection, etc. is completed, but the switch 10 is held during this work at an opened condition.

[0013]The output both ends of a solar panel (self-panel) in which this joint box 7 was formed are connected to the terminals 9c and 9d of the joint box 7, and the path cord for series connections pulled out from the terminals 9a and 9b of the neighboring solar panels 1, etc. is connected to the terminals 9a and 9b.

[0014]Since between the terminal 9a and 9c has opened wide with the switch 10 at this time, even if between the terminal 9b and 9d has connected too hastily, the solar panel 1 can deal with it in the state of no voltage, there is no possibility of receiving an electric shock during

construction, and safety improves remarkably.

[0015]And if the short body 10a of each joint box 7 is inserted after the end of work, between the terminal 9a and 9c connects too hastily and each switch 10 closes, the series circuit of each solar panel 1 will carry out a closed circuit, and load electric supply will start by closing of the breaker 2.

[0016]Since it can carry out at this time, without closing operation of the switch 10 demounting the lid 7b from the joint box 7, there is also an advantage on which improvement in workability, etc. are achieved. Also when connecting and carrying out unitization of the solar panel 1 of two or more sheets at a factory etc., safety is secured by working opening each switch 10 wide.

[0017]And it may be made to form the switch 10 only in the solar panel 1 for every number of sheets which is a grade which it is not necessary to establish for every solar panel for example, and the shock by electric shock does not produce. Of course, various shape and the switch of structure may be used as the switch 10.

[0018]

[Effect of the Invention]Since this invention is constituted as explained above, it does so the effect indicated below. Since the switch 10 is formed in the joint box 7 of at least some solar panels 1 and the series connection of these switches 10 is carried out to the solar panel 1, By opening the switch 10 wide and working the attachment to the stand of a solar panel, connection, etc., the electric shock under construction accompanying power generation of each solar panel 1 is prevented, and safety improves.

[Translation done.]

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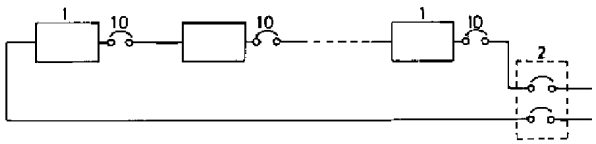
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(54)【発明の名称】　太陽電池発電装置

(57)【要約】

【目的】　各太陽電池パネルの架台への取付け，接続等の施工作業が感電を防止して安全に行えるようにする。

【構成】　太陽電池パネル１毎に設けられ，接続用の端子台９を有する接続箱７と、少なくとも一部の太陽電池パネル１の接続箱７に設けられ，太陽電池パネル１に直列接続された開閉器１０とを備える。



１　太陽電池パネル　　９　断路端子台
７　接続箱　　１０　開閉器

1

【特許請求の範囲】

【請求項１】　複数の太陽電池パネルを直列接続して形成された太陽電池発電装置において、

前記太陽電池パネル毎に設けられ，接続用の端子台を有する接続箱と、

少なくとも一部の前記太陽電池パネルの前記接続箱に設けられ，前記太陽電池パネルに直列接続された開閉器とを備えたことを特徴とする太陽電池発電装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、複数の太陽電池パネルを直列接続して形成された太陽電池発電装置に関する。

【０００２】

【従来の技術】従来、太陽電池パネル１枚当りの出力は約１５Ｖ，数１０Ｗ程度であり、電力用の電源とする場合は、図４に示すように、数１０枚の太陽電池パネル１を直列接続して太陽電池発電装置を形成し、この発電装置の出力を取出口の遮断器２を介して負荷給電する。

【０００３】このとき、各太陽電池パネル１は図５に示すように、傾斜した架台３にマトリクス状に取付けられて固定され、屋上等に設置される。また、図６（ａ），（ｂ）に示すように、各太陽電池パネル１は表面の太陽電池１ａをフレーム２ａに取付けて形成され、その背面側（裏面側）には隣接の太陽電池パネル１等との接続用の接続箱４が設けられている。

【０００４】そして、この接続箱４は図７に示すように、ケース本体４ａとこの本体４ａを気密に閉塞する蓋体４ｂとにより形成され、本体４ａには端子台５が設けられている。なお、本体４ａ，蓋体４ｂには、蓋体４ｂを本体４ａに取付けるねじ止め用の複数の取付孔６が形成されている。そして、各太陽電池パネル１は架台３に取付けられた後、接続箱４の端子接続等の接続作業が施される。

【０００５】

【発明が解決しようとする課題】前記従来の太陽電池発電装置の場合、各太陽電池パネル１の架台３への取付け，接続等の施工作業が必ず有電圧状態で行われ、危険である。

【０００６】すなわち、これらの作業は、通常、雨の降っていない昼間に行われ、このとき、各太陽電池パネル１が発電状態にあり、これらのパネル１を直列接続した電圧が場所によっては数百ボルトにもなるため、定電流源でその電流値が小さいとはいえ、有電圧状態で作業を行うと、感電する危険がある。

【０００７】そして、とくに高所作業においては、感電により作業員がショックを受けて落下等する危険性もあり、死亡事故につながる恐れがある。本発明は、各太陽電池パネルの架台への取付け，接続等の施工作業が感電を防止して安全に行えるようにすることを目的とする。

【０００８】

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【課題を解決するための手段】前記の目的を達成するために、本発明の太陽電池発電装置の場合、太陽電池パネル毎に設けられ，接続用の端子台を有する接続箱と、少なくとも一部の太陽電池パネルの接続箱に設けられ，太陽電池パネルに直列接続された開閉器とを備える。

【０００９】

【作用】前記のように構成された本発明の太陽電池発電装置の場合、少なくとも一部の太陽電池パネルの接続箱に開閉器が設けられ、これらの開閉器が太陽電池パネルに直列接続されるため、各開閉器を開放して太陽電池パネルの架台への取付け，接続等の作業を実施することにより、各太陽電池パネルの発電に伴う施工作業中の感電が防止される。

【００１０】

【実施例】１実施例について、図１ないし図３を参照して説明する。それらの図面において、図４ないし図７と同一符号は同一もしくは相当するものを示し、７は従来の接続箱４の代わりに各太陽電池パネル１の背面側に設けられた接続箱であり、ケース本体７ａと蓋体７ｂとからなり、ケース本体７ａ，蓋体７ｂには図７の取付穴６と同様の複数の取付孔８が形成されている。

【００１１】９はケース本体７ａに設けられた断路端子台であり、両端に設けられた外部接続用の２端子９ａ，９ｂ及びこ２端子９ａ，９ｂ間に設けられた自パネル用の２端子９ｃ，９ｄを有する。１０は端子９ａ，９ｃ間に設けられて太陽電池パネル１に直列接続された開閉器であり、端子９ａ，９ｃ間を短絡する差込自在の短絡体１０ａを有し、この短絡体１０ａの端部には操作杆１０ｂが形成されている。１１は蓋体７ｂに形成された差込開口であり、短絡体１０ａがこの開口１１を介して外部から端子９ａ，９ｃ間に差込まれる。

【００１２】そして、短絡体１０ａは各太陽電池パネル１の架台３への取付け，接続等の一連の施工作業が終了するまで差込まれず、この作業中は開閉器１０が開放状態に保持される。

【００１３】また、接続箱７の端子９ｃ，９ｄにはこの接続箱７が設けられた太陽電池パネル（自パネル）の出力両端が接続され、端子９ａ，９ｂには両隣の太陽電池パネル１の端子９ａ，９ｂ等から引出された直列接続用の接続線が接続される。

【００１４】このとき、端子９ａ，９ｃ間が開閉器１０により開放しているため、端子９ｂ，９ｄ間が短絡していても、太陽電池パネル１が無電圧状態で取扱え、施工作業中に感電する恐れがなく、安全性が著しく向上する。

【００１５】そして、作業終了後に各接続箱７の短絡体１０ａが差込まれて端子９ａ，９ｃ間が短絡し、各開閉器１０が閉成すると、各太陽電池パネル１の直列回路が閉路し、遮断器２の閉成により負荷給電が始まる。

【００１６】このとき、開閉器１０の閉成操作が接続箱

Exhibit 1016 (Pt. 2 of 2)
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７から蓋７ｂを取外すことなく行えるため、作業性の向上等が図られる利点もある。なお、工場等で複数枚の太陽電池パネル１を接続してユニット化する際にも、各開閉器１０を開放して作業することにより、安全性が確保される。

【００１７】そして、開閉器１０は太陽電池パネル１毎に設けなくてもよく、例えば感電によるショックが生じない程度の枚数毎の太陽電池パネル１にのみ設けるようにしてもよい。また、開閉器１０として種々の形状，構造の開閉器を用いてよいのは勿論である。

【００１８】

【発明の効果】本発明は、以上説明したように構成されているため、以下に記載する効果を奏する。少なくとも一部の太陽電池パネル１の接続箱７に開閉器１０が設けられ、これらの開閉器１０が太陽電池パネル１に直列接続されるため、開閉器１０を開放して太陽電池パネルの架台への取付け，接続等の作業を実施することにより、各太陽電池パネル１の発電に伴う施工作業中の感電が防

止され、安全性が向上する。

【図面の簡単な説明】

【図１】本発明の１実施例の結線図である。

【図２】（ａ），（ｂ）は図１の太陽電池パネルの正面側，背面側それぞれからみた斜視図である。

【図３】図２の接続箱の蓋を開いた状態の斜視図である。

【図４】従来装置の結線図である。

【図５】従来装置の斜視図である。

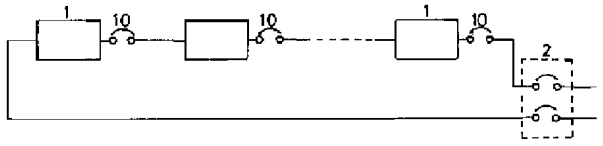
【図６】（ａ），（ｂ）は図４の太陽電池パネルの正面側，背面側それぞれからみた斜視図である。

【図７】図６の接続箱の蓋を開いた状態の斜視図である。

【符号の説明】

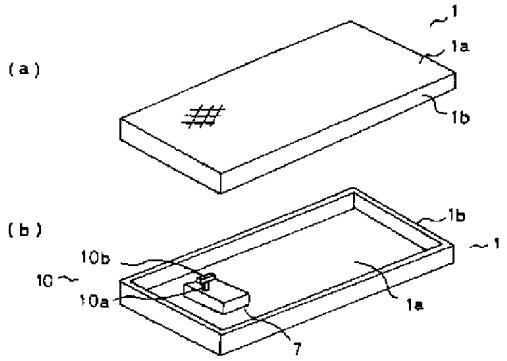
１　太陽電池パネル
７　接続箱
９　断路端子台
１０　開閉器

【図１】

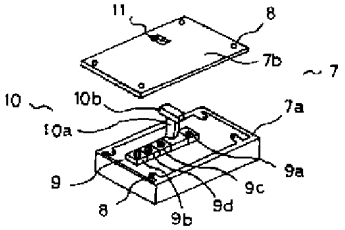


１　太陽電池パネル　　９　断路端子台
７　接続箱　　１０　開閉器

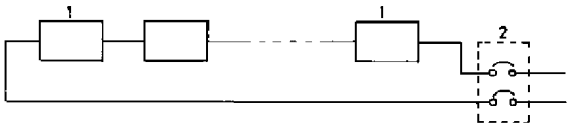
【図２】



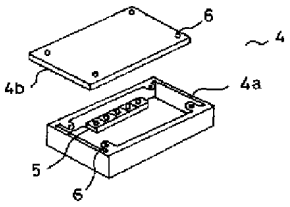
【図３】



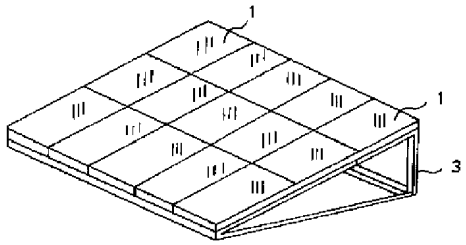
【図４】



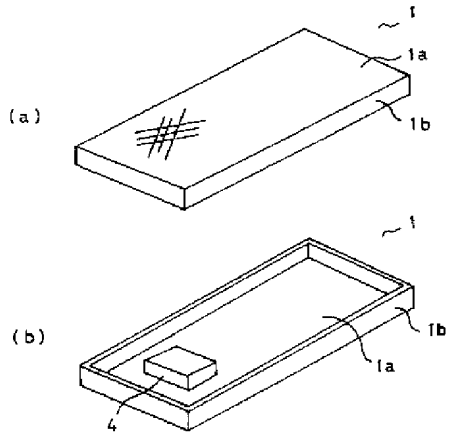
【図７】



【図５】



【図６】

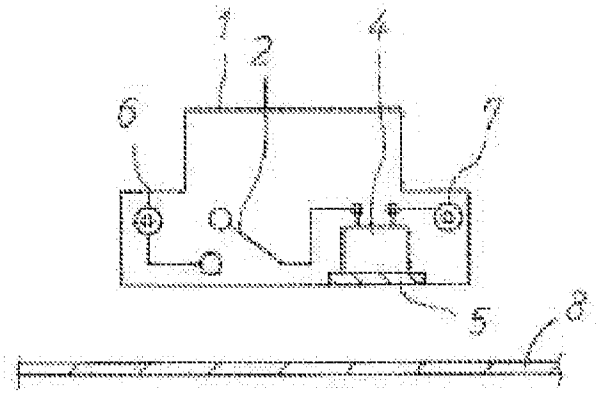


SOLAR DISCONNECTING SWITCH

Publication number: JP8116628 (A)
Publication date: 1996-05-07
Inventor(s): ANDO KENJI
Applicant(s): NITTO KOGYO KK
Classification:
- international: ***H01L31/04; H02J7/35;*** **H01L31/04; H02J7/35;** (IPC1-7): H02J7/35; H01L31/04
- European:
Application number: JP19940248996 19941014
Priority number(s): JP19940248996 19941014

Abstract of **JP 8116628 (A)**

PURPOSE: To improve the workability of wire connecting work to a solar disconnecting switch and to prevent the reliability deterioration of the switch caused by the overheating of a diode by incorporating at least a contact for disconnection and reverse-current preventing element in the switch and, at the same time, fitting the heat radiating plate of the reverse-current preventing element on the lower surface of a case which is in close contact with a mounting base. CONSTITUTION: A solar disconnecting switch is constituted by providing at least a contact 2 for disconnection, reverse-current preventing element 4 composed of a diode, heat radiating plate 5 fitted to the element 4, solar battery unit array-side terminal 6, and inverter-side terminal 7 in a case 1 and fitting the heat radiating plate 5 of the element 4 to the lower surface of the case 1 which is closely adhered to a mounting base 8. Therefore, electric wires can be easily connected to this disconnecting switch and the reliability deterioration of the switch caused by the overheating of the diode can be prevented, because the heat generated from the element 4 can be smoothly radiated to the base 8.



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(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開平8－116628

(43)公開日　平成８年(1996)５月７日

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０２Ｊ　7/35		Ｈ		
Ｈ０１Ｌ　31/04				
			Ｈ０１Ｌ　31/ 04	Ｋ

審査請求　未請求　請求項の数３　ＯＬ　（全　４　頁）

(21)出願番号　特願平6－248996

(22)出願日　平成６年(1994)10月14日

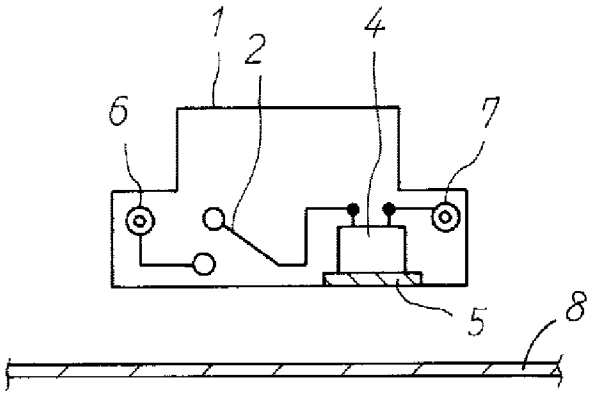
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(72)発明者　安藤　健志
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(74)代理人　弁理士　名嶋　明郎　（外２名）

(54)【発明の名称】　ソーラ断路器

(57)【要約】
【目的】　結線作業の施行性に優れ、しかもダイオードの過熱を防止できるソーラ断路器を提供する。
【構成】　ケース１の内部に、少なくとも断路用の接点２とダイオード等の逆流防止素子４とを組み込む。この逆流防止素子４の放熱板５を取付けベース８と密着するケース１の底面に設け、取付けベース８への放熱を円滑に行わせる。



【特許請求の範囲】
【請求項１】　ケースの内部に、少なくとも断路用の接点と逆流防止素子とを組み込むとともに、この逆流防止素子の放熱板を取付けベースと密着するケースの底面に設けたことを特徴とするソーラ断路器。
【請求項２】　放熱板を弾性体により取付けベースと密着させた請求項１に記載のソーラ断路器。
【請求項３】　ケースの底面全体を放熱板とした請求項１に記載のソーラ断路器。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は、太陽光発電システムにおいて用いられるソーラ断路器に関するものである。
【０００２】
【従来の技術】太陽光発電システムにおいては、一般に５～８組の太陽電池ユニットアレイが用いられており、これらの太陽電池ユニットアレイからの直流電流を接続箱（分電盤）に集めてインバータへ供給する構成が取られている。この接続箱の内部には、図８に示すように断路器21、サージ吸収器22、接続端子台23、逆流防止素子24、開閉器25などが組み込まれている。なお26は太陽電池ユニットアレイ、27はインバータである。ところが図８に示したような従来の接続箱の内部には多くの機器を組み込む必要があるため、回路の組み立てが複雑であり、また結線の施行性が悪いという欠点がある。
【０００３】そこで本発明者は、図１、図２に示すように単一のケース１の内部に、断路用の接点２と、サージ吸収器３と、逆流防止素子４とを組み込んだソーラ断路器を開発中である。このソーラ断路器を使用すれば、図３に示すように太陽電池ユニットアレイの数に対応するソーラ断路器を接続箱の内部に整然と配列することができ、しかも結線作業も大幅に簡素化できるのでトータルコストの低減に大きく寄与するものと考えられる。
【０００４】ところが、ソーラ断路器の逆流防止素子４として使用されるダイオードは作動中に発熱するため、図２に示すようにケース１の内部に収納すると過熱によって寿命が短くなり、機器の信頼性を低下させるおそれがあることが判明した。
【０００５】
【発明が解決しようとする課題】本発明は上記した従来の問題点を解決し、結線作業の施行性に優れ、しかもダイオードの過熱による信頼性の低下を防止したソーラ断路器を提供するためになされたものである。
【０００６】
【課題を解決するための手段】上記の課題を解決するためになされた本発明のソーラ断路器は、ケースの内部に、少なくとも断路用の接点と逆流防止素子とを組み込むとともに、この逆流防止素子の放熱板を取付けベースと密着するケースの底面に設けたことを特徴とするものである。
【０００７】
【作用】本発明のソーラ断路器は、ケースの内部に少なくとも断路用の接点と逆流防止素子とを組み込んだものであるから、接続箱の内部の配列を簡素化することができ、結線の施行性を向上させることができる。しかも、逆流防止素子の放熱板をケースの底面に設けて取付けベースと密着させたため、逆流防止素子として使用されるダイオードの過熱を防止し、機器の信頼性を高めることができる。
【０００８】
【実施例】以下に本発明を図示の実施例によって更に詳細に説明する。図４は本発明の第１の実施例のソーラ断路器を示すもので、１はケース、２は断路用の接点、４はダイオードからなる逆流防止素子、５はこの逆流防止素子４に取り付けられた放熱板、６は太陽電池ユニットアレイ側の端子、７はインバータ側の端子である。このようなソーラ断路器は取付けベース８に固定されるのであるが、本発明では逆流防止素子４の放熱板５を、取付けベース８と密着するケース１の底面に設けてある。
【０００９】このように構成しておけば、逆流防止素子４で発生した熱は放熱板５を介して取付けベース８に円滑に移動するので、逆流防止素子４は常に冷却されることとなり、素子の過熱による信頼性の低下を防止することが可能となる。
【００１０】図５は放熱板５と取付けベース８との密着性をより高めるために、放熱板５をケース１の底面からわずかに突出させた第２の実施例を示すものである。しかしながら、図５の構造ではケース１を取付けベース８に取り付ける際に取付用ねじ９を強く締め過ぎると、突出部に過大な荷重が発生して破損その他の強度的な問題を生ずる可能性がある。
【００１１】そこで図６に示す第３の実施例では、逆流防止素子４を載せた放熱板５をばね等の弾性体10によりケース１の底面から突出するように取付けてある。このようにしておけば、ケース１を取付けベース８に固定したとき放熱板５は適度な力で取付けベース８に押圧され、熱移動が確実に行われるとともに強度的な問題を回避することができる。
【００１２】また図７に示す第３の実施例では、ケース１の底面全体を放熱板11とし、逆流防止素子４の放熱板５を放熱板11と密着させてある。このようにしておけば、ケース１を取付けベース８に固定したとき放熱板11は必ず取付けベース８に密着することとなり、熱移動が確実に行われるとともに強度的な問題が生ずるおそれがない。
【００１３】
【発明の効果】以上に説明したように、本発明のソーラ断路器はケースの内部に少なくとも断路用の接点と逆流防止素子とを組み込んだものであるから、これを接続箱の内部に組み込めば、結線の施行性を向上させることが

できる利点がある。しかも逆流防止素子の放熱板を取付けベースと密着するケースの底面に設けたので、素子から発生する熱を円滑に取付けベースに放熱することができ、素子の過熱による信頼性の低下を防止することができる。よって本発明は太陽光発電システムにおいて用いられるソーラ断路器として、価値の高いものである。

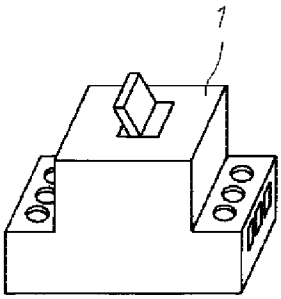
【図面の簡単な説明】

【図１】ソーラ断路器の斜視図である。
【図２】ソーラ断路器の回路図である。
【図３】ソーラ断路器の結線図である。
【図４】第１の実施例を示す断面図である。
【図５】第２の実施例を示す断面図である。
【図６】第３の実施例を示す断面図である。
【図７】第４の実施例を示す断面図である。
【図８】従来例を示す回路図である。

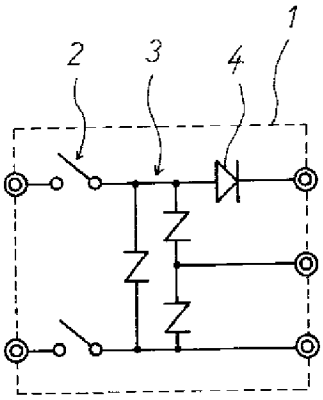
【符号の説明】

1　ケース
2　断路用の接点
3　サージ吸収器
4　ダイオードからなる逆流防止素子
5　逆流防止素子の放熱板
6　太陽電池ユニットアレイ側の端子
7　インバータ側の端子
8　取付けベース
9　取付用ねじ
10　弾性体
11　放熱板

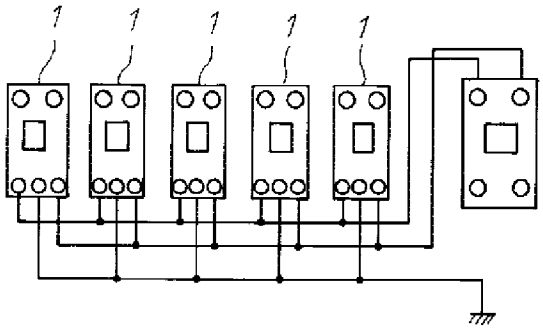
【図１】



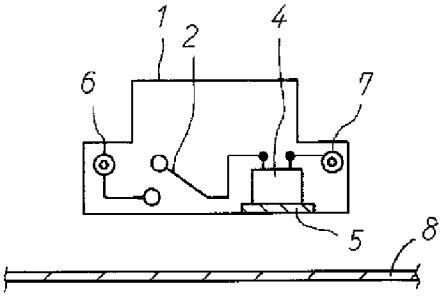
【図２】



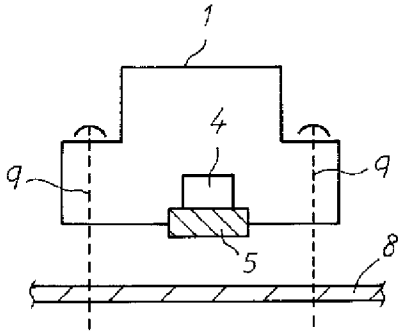
【図３】



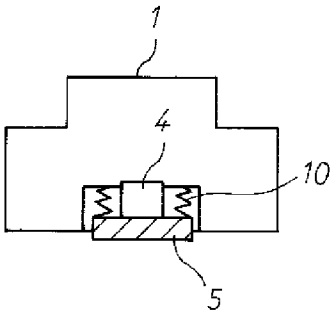
【図４】



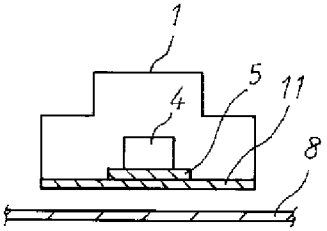
【図５】



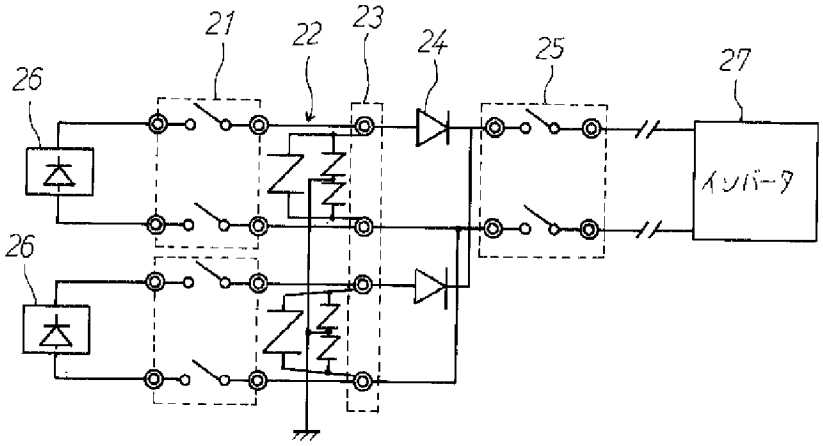
【図６】



【図７】



【図８】



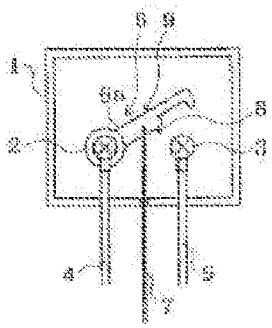
SOLAR BATTERY DEVICE

Publication number: JP8316517 (A)
Publication date: 1996-1-29
Inventor(s): YAGI HIROSATO; FURUKAWA KIMIHIKO; SAKATA HITOSHI; YANAGIURA SATOO
Applicant(s): SANYO ELECTRIC CO
Classification:
- international: ***H01L31/042; H02N6/00;*** **H01L31/042; H02N6/00;** (IPC1-7): H01L31/042; H02N6/00
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Application number: JP19950118112 19950517
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Abstract of **JP 8316517 (A)**

PURPOSE: To provide the safety device of the title solar battery device capable of avoiding leak or electric shock even if a power cord is disconnected when a module falls down from a rack due to an earthquake etc. CONSTITUTION: The title solar battery device is provided with a switch 6 to make both terminals 2 and 3 of a terminal box 1 annexed to a module intermitent as well as an operating wire 7 whose one end side is connected e.g. to a rack and the other end side is connected to a shortcircuit lever 6a operated by shifting or breaking away from the installation position of the module for shortcircuiting the terminals 2 and 3.



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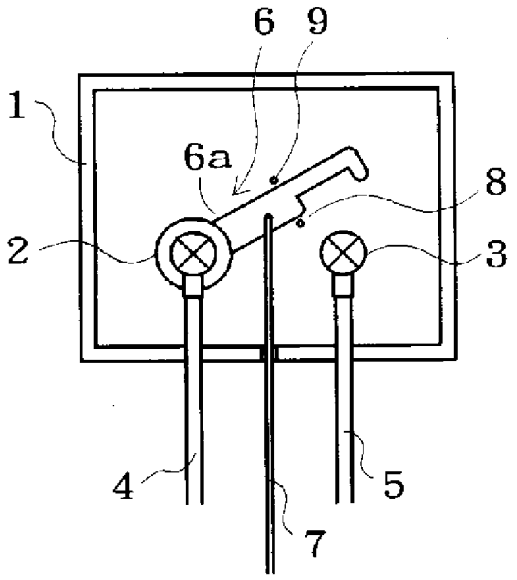
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(54)【発明の名称】　太陽電池装置

(57)【要約】

【目的】　地震等によってモジュールが架台から落下したりして電力コードが断線した場合でも、漏電ないし感電事故を防止することができる太陽電池装置の安全装置を提供することを目的とする。

【構成】　モジュールに付設した端子ボックス１の両端子２・３間を短絡レバー６ａにて断続するスイッチ６と、一端側が例えば架台に他端側が前記短絡レバー６ａに連結され、前記モジュールの設置位置からの移動ないし離脱によって前記短絡レバー６ａを操作して前記端子２・３間を短絡させる操作用ワイヤ７とを備えた。



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【特許請求の範囲】

【請求項１】　太陽電池にて発生される電力を端子ボックスおよび電力コードを介して電力消費部に供給するようにした太陽電池装置において、前記端子ボックスの両端子間を短絡させ得る作動片と、前記太陽電池の設置位置からの移動ないし離脱によって前記作動片を操作して前記両端子間を短絡させる操作用ワイヤとから成る安全装置を備えたことを特徴とする太陽電池装置。

【請求項２】　太陽電池にて発生される電力を端子ボックスおよび電力コードを介して電力消費部に供給するようにした太陽電池装置において、前記端子ボックスの端子と前記電力コードとを着脱可能に接続するコネクタを備えるとともに、前記太陽電池の設置位置からの移動ないし離脱によって前記コネクタが前記電力コードに引かれて外れるように当該電力コードを設けて構成した安全装置を備えたことを特徴とする太陽電池装置。

【請求項３】　太陽電池にて発生される電力を端子ボックスおよび電力コードを介して電力消費部に供給するようにした太陽電池装置において、前記端子ボックスの両端子間を短絡させ得る一対の弾性電極片と、前記一対の弾性電極片間に割込挿入されて当該電極片と前記電力コードとを電気的に接続するプラグとを備えるとともに、前記太陽電池の設置位置からの移動ないし離脱によって前記プラグが前記電力コードに引かれて外れるように当該電力コードを設けて構成した安全装置を備えたことを特徴とする太陽電池装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、太陽電池装置に係り、特に地震によって太陽電池が架台から落下したり、架台が屋根などの設置箇所上で移動したりした時の漏電ないし感電事故を防止できるようにした太陽電池装置に関するものである。

【０００２】

【従来の技術】一般に、太陽電池は製造を容易にしたり、設置箇所への輸送を容易にしたりするために、適当な大きさを有するモジュールとして形成され、図９に示すように、設置箇所に設置された架台１０１上に所要数のモジュール１０２を設置するようにしている。各モジュール１０２にはモジュール１０２どうしを互いに電気的に接続したり、出力を取り出したりするために端子ボックス１０３が設けられており、更に、必要に応じて、複数のモジュール１０２の出力を集積してインバータなどに出力するために家屋壁面等に集電ボックスと呼ばれる端子ボックスが設けられる。

【０００３】図１０に示すように、端子ボックス１０３には外部に電力を取り出すための１対の端子１０４・１０５が設けられ、端子ボックス１０３内に導入された１対の電力コード１０６・１０７の先端がそれぞれビスによってこれら端子１０４・１０５に固定される。

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【０００４】

【発明が解決しようとする課題】ところで、地震が発生した時には、モジュール１０２がこれを支持する架台１０１から脱落したり、架台１０１自体が屋根上から脱落して、端子ボックス１０３あるいは集電ボックスから導出された電力コード１０６・１０７が切断されることがあり、漏電したり、不用意にこれらの電力コード１０６・１０７に触れて感電事故が発生したりするおそれがある。

【０００５】本発明は、上記の事情に鑑み、太陽電池が架台から落下等したときの電力コードの切断による漏電ないし感電事故を防止できるようにした太陽電池装置の提供を目的とする。

【０００６】

【課題を解決するための手段】本発明の第１の太陽電池装置（以下、本第１発明という。）は、太陽電池にて発生される電力を端子ボックスおよび電力コードを介して電力消費部に供給するようにした太陽電池装置において、前記端子ボックスの両端子間を短絡させ得る作動片と、前記太陽電池の設置位置からの移動ないし離脱によって前記作動片を操作して前記両端子間を短絡させる操作用ワイヤとから成る安全装置を備えたことを特徴とする。

【０００７】本発明の第２の太陽電池装置（以下、本第２発明という。）は、太陽電池にて発生される電力を端子ボックスおよび電力コードを介して電力消費部に供給するようにした太陽電池装置において、前記端子ボックスの端子と前記電力コードとを着脱可能に接続するコネクタを備えるとともに、前記太陽電池の設置位置からの移動ないし離脱によって前記コネクタが前記電力コードに引かれて外れるように当該電力コードを設けて構成した安全装置を備えたことを特徴とする。

【０００８】本発明の第３の太陽電池装置（以下、本第３発明という。）は、太陽電池にて発生される電力を端子ボックスおよび電力コードを介して電力消費部に供給するようにした太陽電池装置において、前記端子ボックスの両端子間を短絡させ得る一対の弾性電極片と、前記一対の弾性電極片間に割込挿入されて当該電極片と前記電力コードとを電気的に接続するプラグとを備えるとともに、前記太陽電池の設置位置からの移動ないし離脱によって前記プラグが前記電力コードに引かれて外れるように当該電力コードを設けて構成した安全装置を備えたことを特徴とする。

【０００９】

【作用】本第１発明においては、地震によって太陽電池が架台から落下したり、架台が屋根などの設置箇所上で移動したりすると、操作用ワイヤが端子ボックスの外方に引っ張られて作動片が操作され、端子ボックスの両端子間が短絡する。これにより、端子ボックスから外部に導出された電力コードに電力は供給されなくなるので、

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上記太陽電池が落下するときの張力によって電力コードが切断されたとしても、漏電や感電事故の発生が防止される。

【００１０】本第２発明においては、地震によって太陽電池が架台から落下したり、架台が屋根などの設置箇所上で移動したりすると、電力コードが端子ボックスの外方に引っ張られてコネクタが外れ、第１の発明と同様、端子ボックスから外部に導出された電力コードに電力は供給されなくなる。

【００１１】本第３発明においては、地震によってモジュールが架台から落下したり、架台が屋根などの設置箇所上で移動したりすると、電力コードによってプラグが端子ボックスの外方に引っ張られ、両端子に接続された弾性電極片から離脱し、端子ボックスから外部に導出された電力コードに電力は供給されなくなる。更に、両端子が端子ボックス内で前記弾性電極片を介して互いに接触して短絡するので、二重安全構造が実現される。

【００１２】

【実施例】

（実施例１）以下、本発明の実施例を図面に基づいて具体的に説明する。

【００１３】図１は本第１発明の一実施例の構成図であり、この実施例では、端子ボックス１内に設けた１対の端子２・３にそれぞれ電力コード４・５の先端部がビス止めされている。又、この端子ボックス１内には、両端子２・３のうちの一方の端子（ここでは図上左側の端子）２に回転可能に支持されて、他方の端子３に接離する短絡レバー（作動片）６ａと、他方の端子３とからなるスイッチ６が設けられ、この短絡レバー６ａの先端寄りの部分に一端が図示しない架台に連結された操作用ワイヤー７の他端が連結される。更に、前記端子ボックス１内には、短絡レバー６ａを他方の端子３から離れた所定の位置に係止するためのストッパ８・９が設けられる。

【００１４】この端子ボックス１はモジュールに付設されたものであり、地震が発生してこのモジュールが架台から脱落し、ワイヤー７が端子ボックス１の外方に引っ張られると、図２に示すように、短絡レバー６ａがストッパー８を乗り越えて他方の端子３側に移動して他方の端子３に接触し、両端子２・３が短絡レバー６ａを介して短絡される。これにより、端子ボックス１から導出された電力コード４・５に電力が供給されなくなるので、上記落下によって電力コード４・５が切断されたとしても、漏電や感電事故の発生を防止することができる。なお、短絡レバー６ａの短絡状態は前記ストッパー８により保持されるので、この短絡状態がモジュールの落下の衝撃で解除されることはない。

【００１５】図３に示す本第１発明の他の実施例では、端子ボックス１１内に各端子１２・１３に先端部どうしが互いに重なり合うようにそれぞれ支持された帯板状の

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導体１６ａ・１６ｂと、両導体１６ａ・１６ｂの先端部の間に配置され、両導体１６ａ・１６ｂの弾力により挟持されたシート状の絶縁体（作動片）１６ｃとからなるスイッチ１６が設けられる。又、一端が例えば架台に連結され、他端がこの絶縁体１６ｃに連結された操作用ワイヤー１７が設けられる。

【００１６】この実施例においては、地震が発生してこのモジュールが架台から脱落し、ワイヤー１７が端子ボックス１１の外方に引っ張られると、図４に示すように、絶縁体１６ｃが両導体１６ａ・１６ｂの先端部の重なりの間から引き抜かれ、両導体１６ａ・１６ｂの先端部どうしがこれらの弾性によって互いに接触して、両端子１２・１３が短絡される。これにより、各端子１２・１３に接続された電力コード１４・１５に電力は供給されなくなるので、上記落下によって電力コード４・５が切断されたとしても、漏電や感電事故が発生する恐れはなくなる。

【００１７】（実施例２）図５に示す本第２発明の実施例では、モジュールに付設した端子ボックス２１内に、この端子ボックス２１の端子２２・２３に固定される一方側のコネクタ部２６ａ・２７ａと、これらのコネクタ部２６ａ・２７ａに嵌脱される他方側のコネクタ部２６ｂ・２７ｂとからなるコネクタ２６・２７が設けられ、前記他方側のコネクタ部２６ｂ・２７ｂには電力コード２４・２５が接続される。ここで、各コネクタ２６・２７は、モジュールの重量×１／２×０．８の荷重で外れるように設定されている。また、上記の離脱荷重よりも電力コード２４・２５の引っ張り破断荷重の方が大きく設定される。

【００１８】モジュール同士の電気的接続は、各モジュールの端子ボックス２１に上記の如く接続される前記電力コード２４・２５により行われるので、一つのモジュールのみが架台から脱落するような場合には、当該モジュールに接続される電力コード２４・２５は、架台から離脱しないモジュールにて引っ張られ、コネクタ２６・２７が外れる。一方、モジュールが架台ごと屋根上から脱落する場合には、前記電力コード２４・２５はモジュールに引かれないので、当該電力コード２４・２５を、例えば家屋の所定位置に固定するようにしている。

【００１９】この実施例では、地震が発生してこのモジュールが架台から脱落したり、モジュールが架台ごと屋根から脱落したりすると、電力コード２４・２５が端子ボックス２１の外方に引っ張られ、図６に示すように、コネクタ２６・２７が外れる。これにより、電力コード２４・２５にはモジュールにて発生される電力が供給されなくなり、モジュールの落下によって電力コード２４・２５が切断されたとしても、漏電や感電事故が発生する恐れがなくなる。更に、本実施例の構成であれば、実施例１のような操作用ワイヤを設けずとも電力コード自体が操作用ワイヤ的に働いてコネクタ２６・２７を外す

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ので、設置工事の簡略化が図れる。

【００２０】また、この実施例では、電力コード２４・２５を伝って雨水などが端子ボックス２１内に侵入するのを防止するために、電力コード２４・２５と端子ボックス２１との間にはグロメット２８を介在させてある。そして、端子ボックス内側部分のグロメット２８には、コネクタ部２６ｂ・２７ｂのコード側部分の形状に対応させた凹部２８ａを形成してあり、コネクタ２６・２７が外れると、コネクタ部２６ｂ・２７ｂのコード側部分が前記凹部２８ａにそれぞれ嵌合するようになっている。

【００２１】ここで、本実施例の太陽電池装置の安全装置では、モジュールの落下で端子２２・２３は短絡しないため、前記コネクタ２６・２７が外れた状態で端子ボックス２１内に雨水が侵入すると、端子ボックス２１内のコネクタ部２６ａ・２７ａ間で漏電が発生するおそれがあるが、上記のごとく、コネクタ部２６ｂ・２７ｂのコード側部分が前記凹部２８ａに嵌合するので、雨水の侵入は確実に防止され、上記のごとき漏電の発生は確実に防止される。

【００２２】（実施例３）図７に示す本第３発明の実施例では、例えばモジュールに付設した端子ボックス３１内には、端子３８・３９にそれぞれ接続される１対の弾性電極片３２・３３が設けられている。これら弾性電極片３２・３３は、それぞれの弾力によって互いに他方の電極片に接触できるように設けられている。そして、端子ボックス３１の外部から挿抜されるプラグ３６を両電極片３２・３３の間に差し込むと、両電極片３２・３３が開かれると共に、このプラグ３６に互いに絶縁して支持させた導体３６ａ・３６ｂがそれぞれの電極片３２・３３に接触する。

【００２３】この実施例においても、前記実施例２と同様、一つのモジュールのみが架台から脱落するような場合には、当該モジュールに接続される電力コード３４・３５は、架台から離脱しないモジュールにて引っ張られ、プラグ３６が外れる。一方、モジュールが架台ごと屋根上から脱落する場合には、前記電力コード３４・３５はモジュールに引かれないので、当該電力コード３４・３５を、例えば家屋の所定位置に固定するようにしている。

【００２４】これにより、地震が発生してこのモジュールが架台から脱落したりすると、電力コード３４・３５が端子ボックス３１の外方に引っ張られ、図８に示すように、プラグ３６が両電極片３２・３３の間から抜き取られるので、電力コード３４・３５には電力は供給されなくなり、上記モジュールの落下等によって電力コード３４・３５が切断されたとしても、漏電や感電事故が発生するおそれはなくなる。更に、両端子３２・３３同士がこれらの弾性によって互いに接触して短絡されるので、端子ボックス３１内での漏電の発生も防止される。

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【００２５】なお、この実施例では、電力コード３４・３５を伝って雨水などが端子ボックス３１内に侵入するのを防止するために、電力コード３４・３５と端子ボックス３１との間にはグロメット３７を介在させてある。

【００２６】以上では、モジュールに付設される端子ボックスを例にして説明したが、本発明は、家屋の壁面に付設される集電用の端子ボックス（集電ボックス）にも適用することができる。

【００２７】又、以上の説明では、太陽電池が所定の位置に定置される場合を例にとって説明したが、いわゆる、ソーラーカーなどに搭載して移動される太陽電池についても、本発明を適用することは可能であり、例えば交通事故などによって車体の所定の位置から太陽電池のモジュールあるいはパネル全体がずれる時に端子ボックス内で端子を短絡させたり、端子と線との接続をコネクタを用いて開いたり、あるいは、これらを併用したりすることにより、漏電や感電事故が発生することを防止することができる。

【００２８】

【発明の効果】以上に説明したように、本発明によれば、地震等によって太陽電池が移動ないし離脱したりすると、電力コードに電力は供給されなくなるので、電力コードが切断されたとしても漏電や感電事故の発生を防止できるという効果を奏する。

【図面の簡単な説明】

【図１】平常時の本第１発明の一実施例の構成図である。

【図２】安全作動時の本第１発明の一実施例の構成図である。

【図３】平常時の本第１発明の他の実施例の構成図である。

【図４】安全作動時の本第１発明の他の実施例の構成図である。

【図５】平常時の本第２発明の一実施例の構成図である。

【図６】安全作動時の本第２発明の一実施例の構成図である。

【図７】平常時の本第３発明の一実施例の構成図である。

【図８】安全作動時の本第３発明の一実施例の構成図である。

【図９】一般的な太陽電池システムの説明図である。

【図１０】従来の端子ボックスの構成図である。

【符号の説明】

１　端子ボックス

２、３　端子

４、５　電力コード

６　スイッチ

７　ワイヤー

１１　端子ボックス

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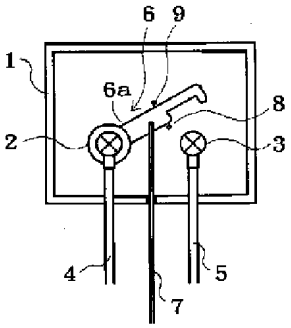
7

１２、１３　端子
１４、１５　電力コード
１６　スイッチ
１７　ワイヤー
２１　端子ボックス
２２、２３　端子
２４、２５　電力コード

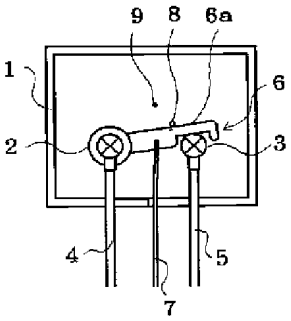
8

２６、２７　コネクタ
２６ａ、２６ｂ、２７ａ、２７ｂ　コネクタ部
３１　端子ボックス
３２、３３　端子
３４、３５　電力コード
３６　プラグ

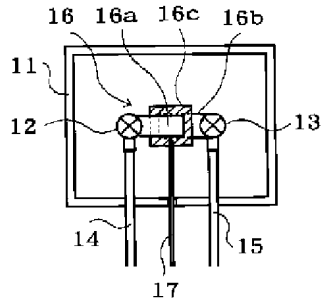
【図１】



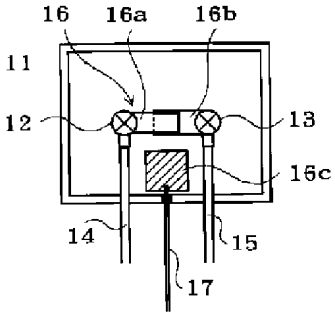
【図２】



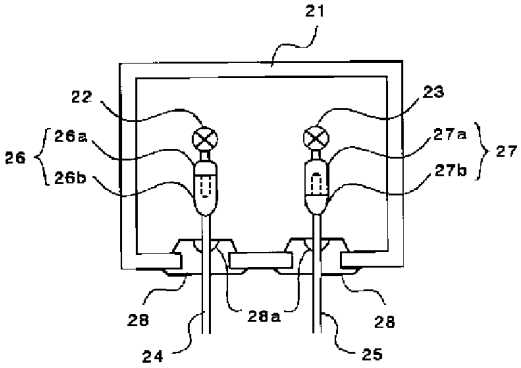
【図３】



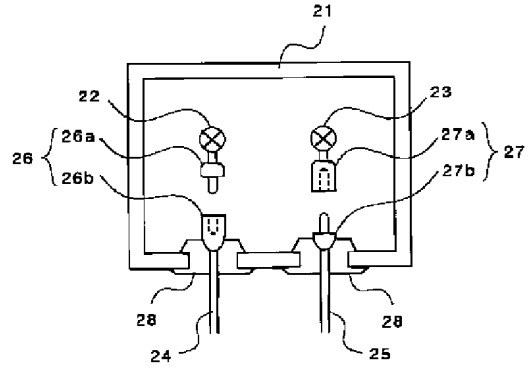
【図４】



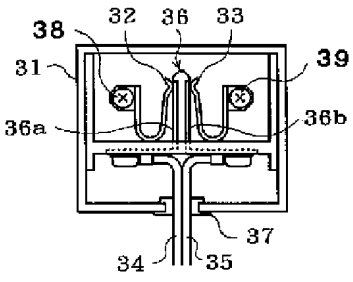
【図５】



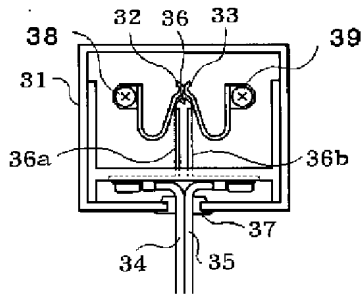
【図６】



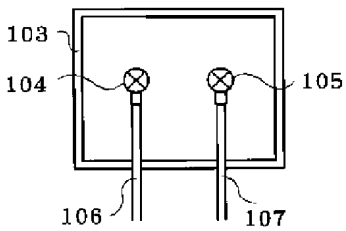
【図７】



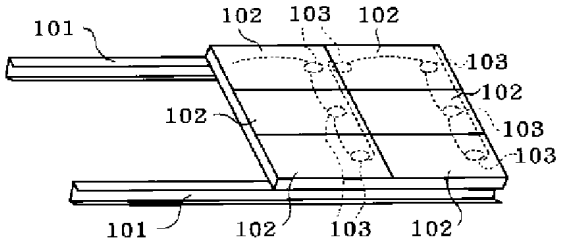
【図８】



【図１０】



【図９】



フロントページの続き

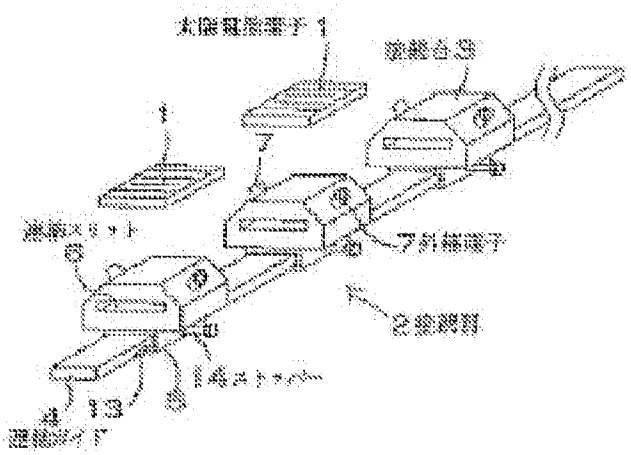
(72)発明者　柳浦　聡生
大阪府守口市京阪本通２丁目５番５号　三
洋電機株式会社内

SOLAR BATTERY DEVICE

Publication number: JP9148611 (A)
Publication date: 1997-06-06
Inventor(s): KATSUBE KOJI
Applicant(s): SANYO ELECTRIC CO
Classification:
- international: ***H01L31/042;*** **H01L31/042;** (IPC1-7): H01L31/042
- European:
Application number: JP19950306000 19951124
Priority number(s): JP19950306000 19951124

Abstract of **JP 9148611 (A)**

PROBLEM TO BE SOLVED: To simplify the switching of the wiring of a solar battery element in series and in parallel, and to prevent poor contact of the wiring. SOLUTION: A connector 2 is composed of a plurality of connection stands 3, a coupling guide 4 and stoppers 14 in this device. The coupling guide 4 couples the connection stands 3 in such a manner that solar battery elements 1 can be moved to the direction where they are pinchingly attached. The stoppers 14 fix the connection stands 3 to the coupling guide 4. The connector 2 of the structure connects the solar battery elements 1 between the connection stands 3 in the state wherein the connection stands 3 can be moved to the coupling guide 4, and under this state, the solar battery elements 1 and the connection stands 3 are electrically connected by fixing the connection stands 3, with which the solar battery elements 1 are connected, to the coupling guide 4 by the stoppers 14. Coupling slits 6, with which the solar battery elements 1 are coupled by inserting their end parts, are provided on the connection stands 3, and also external terminals 7, to be coupled to the solar battery elements 1, are provided.



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(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開平9－148611

(43)公開日　平成９年(1997)６月６日

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ		技術表示箇所
Ｈ０１Ｌ　31/042			Ｈ０１Ｌ　31/04	Ｒ	
				Ｃ	

審査請求　未請求　請求項の数３　ＯＬ　（全　８　頁）

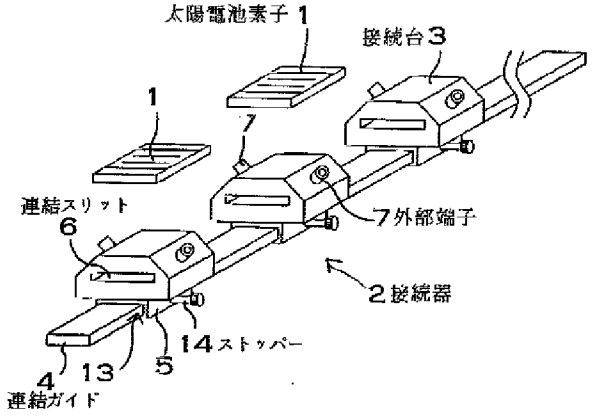
(21)出願番号　特願平7－306000

(22)出願日　平成７年(1995)11月24日

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(74)代理人　弁理士　豊栖　康弘

(54)【発明の名称】　太陽電池装置

(57)【要約】
【課題】　太陽電池素子の配線を簡単に直列、並列に切り換えることができ、また接触不良を防止する。
【解決手段】　太陽電池装置は、複数の接続台３と、連結ガイド４と、ストッパー１４で接続器２を構成する。連結ガイド４は、接続台３を太陽電池素子１を挟着する方向に移動できるように連結する。ストッパー１４は、連結ガイド４に接続台３を固定する。この構造の接続器２は、接続台３を連結ガイド４に移動できる状態として接続台３の間に太陽電池素子１を接続し、この状態で、太陽電池素子１を接続している接続台３をストッパー１４で連結ガイド４に固定して太陽電池素子１と接続台３とを電気接続するように構成している。接続台３には太陽電池素子１の端部を挿入して連結する連結スリット６を設け、また太陽電池素子１に連結される外部端子７を設ける。



【特許請求の範囲】
【請求項１】　複数枚の太陽電池素子(1)と、この太陽電池素子(1)を直列または並列に接続する接続器(2)とを有し、太陽電池素子(1)を接続器(2)に連結する方向を変更して、太陽電池素子(1)の接続を、直列または並列に切り換えるように構成されてなる太陽電池装置において、
接続器(2)が、太陽電池素子(1)を連結する複数の接続台(3)と、この接続台(3)を太陽電池素子(1)を挟着する方向に移動できるように連結している連結ガイド(4)と、この連結ガイド(4)に接続台(3)を固定するストッパー(14)とを備え、接続台(3)を連結ガイド(4)に移動できる状態として接続台(3)の間に太陽電池素子(1)を接続し、太陽電池素子(1)を接続する接続台(3)をストッパー(14)で連結ガイド(4)に固定して太陽電池素子(1)と接続台(3)とを電気接続するように構成されてなることを特徴とする太陽電池装置。
【請求項２】　接続台(3)が、太陽電池素子(1)の端部を挿入して連結する連結スリット(6)を有する請求項１に記載される太陽電池装置。
【請求項３】　接続台(3)が、太陽電池素子(1)に連結される外部端子(7)を有する請求項１に記載される太陽電池装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、主として教材用に使用される太陽電池装置に関する。とくに、本発明は、複数枚の太陽電池素子の接続方向を変更して、直列または並列に切り換えて接続できる太陽電池装置に関する。
【０００２】
【従来の技術】太陽電池は光を電気に変換する。太陽電池の出力は、入射光が強くなると大きくなる。太陽電池は、入射する光の強度で出力電流と出力電圧が変化する。太陽電池の出力電流や出力電圧の関係、さらに、複数の太陽電池の接続状態を変更するために、複数枚の太陽電池素子を直列と並列に切り換えて接続する太陽電池装置が開発されている（実公平６－４８８８２号公報）。
【０００３】この公報に記載される太陽電池装置の断面図を図１に示す。この図の太陽電池素子１は、図において上辺の両側に＋出力端子８Ａを、下辺の両側に－出力端子８Ｂを備える。出力端子８は金属ピンで、太陽電池素子１の外周に設けた凹部９の中央に配設されている。隣接する太陽電池素子１の出力端子８は、筒状の接続ピン１０で連結される。接続ピン１０は、出力端子８を挿入して電気接続するものである。この図の太陽電池装置は、図に示すように、隣接する太陽電池素子１の＋－の出力端子８を接続ピン１０で接続して、並列に接続される。図示しないが、太陽電池素子１を９０度回転して接続すると、隣接する太陽電池素子１は直列に接続される。
【０００４】
【発明が解決しようとする課題】図に示す太陽電池装置は、太陽電池素子１を９０度回転することにより、直列または並列に切り換えて連結できる。この構造の太陽電池装置は、全ての太陽電池素子１を確実に連結するのが難しい。太陽電池素子１の連結位置がずれると、出力端子８等が接触不良を起こしやすくなる。この構造は、多数枚の太陽電池素子１を連結したときに、接触不良が発生しやすい欠点がある。それは、多数枚の太陽電池を連結すると、一部の太陽電池素子１の連結位置がずれて、全ての太陽電池素子１を正確な位置に配設して、出力端子８を確実に連結するのが難しくなるからである。
【０００５】太陽電池素子を定位置に連結するために、図２に示す連結構造も前記の公報に記載される。この太陽電池装置は、固定台１１の表面に突出して連結接点１２を設けている。太陽電池素子１は、連結接点１２に挿入して連結できる出力端子（図示せず）を設けている。この装置は、太陽電池素子１の出力端子を連結接点１２に挿入して、太陽電池素子１を固定台１１の定位置に装着できる。この構造は、多数の太陽電池素子１を位置ずれしないように装着できる。ただ、この構造の装置は、板状の太陽電池素子１をスムーズに脱着できるようにして接触不良を少なくするのが難しい欠点がある。板状の太陽電池素子１は、固定台１１に接近して連結されるので、簡単に引き抜くのが難しい。掴み難い状態で固定台１１に連結されるからである。さらに、板状の太陽電池素子１を無理に引き抜くと曲げ応力が作用して、破損しやすい欠点もある。太陽電池に無理な力が作用しないようにするためには、太陽電池素子１を平行の姿勢で、いいかえると、左右の引き抜き力をバランスよくして引き抜く必要がある。このため、簡単に太陽電池素子１に無理な力が作用しないように脱着するのが難しい。とくに、接触不良を少なくするために、出力端子を連結接点１２に強く押圧して連結すると、軽く脱着できなくなって、この弊害が大きくなる。
【０００６】さらに、図１と図２に示す構造の太陽電池装置は、直列または並列に接続した状態で、太陽電池素子の中間から出力を取り出すのが難しい欠点もある。それは、太陽電池素子を互いに接近して連結し、連結状態で出力端子を表面に表出できないからである。
【０００７】本発明は、このような欠点を解決することを目的に開発されたものである。本発明の重要な目的は、太陽電池素子を簡単かつ容易に、しかも迅速に定位置に脱着できる太陽電池装置を提供することにある。
【０００８】さらに、本発明の他の重要な目的は、直列まはた並列に接続する状態で接触不良を少なくして確実に連結できる太陽電池装置を提供することにある。さらにまた、無理な力がかからないように太陽電池素子を脱着できる太陽電池装置を提供することにある。

【０００９】
【課題を解決するための手段】本発明の太陽電池装置は、複数枚の太陽電池素子１と、この太陽電池素子１を直列または並列に接続する接続器２とを備える。太陽電池素子１を接続器２に連結する方向を変更して、太陽電池素子１の接続が、直列または並列に切り換えられるように構成されている。
【００１０】さらに、本発明の太陽電池装置は、複数の接続台３と、連結ガイド４と、ストッパー１４で接続器２を構成する。接続器２は、複数の太陽電池素子１を連結する。連結ガイド４は、接続台３を太陽電池素子１を挟着する方向に移動できるように連結する。ストッパー１４は、連結ガイド４に接続台３を固定する。この構造の接続器２は、接続台３を連結ガイド４に移動できる状態として接続台３の間に太陽電池素子１を接続し、この状態で、太陽電池素子１を接続している接続台３をストッパー１４で連結ガイド４に固定して太陽電池素子１と接続台３とを電気接続するように構成している。
【００１１】さらに、本発明の請求項２に記載される太陽電池装置は、太陽電池素子１を簡単に、しかも確実に連結するために、太陽電池素子１の端部を挿入して連結する連結スリット６を接続台３に設けている。
【００１２】さらにまた、本発明の請求項３の太陽電池装置は、直列または並列に接続した測定用プローブの接続点から出力を取り出すために、太陽電池素子１に連結される外部端子７を接続台３に設けている。
【００１３】
【作用】本発明の太陽電池装置は、接続台３を介して太陽電池素子１を接続している。すなわち、接続台３の間に太陽電池素子１を挟着して、太陽電池素子１を直列または並列に連結する。接続台３は、連結ガイド４上に挟着方向にのみ移動可能な状態で取り付けられているので、連結部分で各太陽電池素子１は位置ずれすることなく、定位置で確実に電極端子１７は電気的に接続され、接触不良が防止できる。さらに、太陽電池素子１を連結する際、各太陽電池素子１の方向を９０度回転させることで、接続方法を直列、並列に簡単に切り換えることができる。この構造の装置は、各素子の接続を簡単に変えることができるので、教材用の装置として最適である。とくに、素子の方向、すなわち素子同士の連結方法が直列か並列か、目で見て確認できるように構成でき、また切換が簡単にできるので、接続方法の違いによる電圧値、電流値等の電気特性が即座に確認できる。
【００１４】
【発明の実施の形態】以下、本発明の実施の形態を図面に基づいて説明する。ただし、以下に示す実施の形態は、本発明の技術思想を具体化するための太陽電池装置を例示するものであって、本発明は太陽電池装置を下記のものに特定しない。
【００１５】さらに、この明細書は、特許請求の範囲を理解し易いように、実施の形態に示される部材に対応する番号を、「特許請求の範囲の欄」、および「課題を解決するための手段の欄」に示される部材に付記している。ただ、特許請求の範囲に示される部材を、実施の形態の部材に特定するものでは決してない。
【００１６】本発明の太陽電池装置の実施の形態にかかる一例を図３および図４に示す。図３および図４に示す太陽電池装置は、２枚の太陽電池素子１を、３基の接続台３を有する接続器２に連結する様子を示す。これらの図に示す接続器２は、連結ガイド４と接続台３を備える。連結ガイド４上で摺動可能な状態に接続台３は取り付けられている。接続台３の下面には、連結ガイド４上の任意の位置に接続台３を移動できる摺動台５を備える。接続台３を連結ガイド４に沿って摺動させ、接続台３同士の間で太陽電池素子１を挟着する状態で接続台３を連結ガイド４の定位置にストッパー１４でもって固定する。
【００１７】図３に示す連結ガイド４は細長い板状で、プラスチック製、金属製等で構成される。板状の連結ガイド４上に接続台３が複数個、摺動台５を介して摺動自在に装着されている。摺動台５は挿通孔１３を有し、挿通孔１３に連結ガイド４を挿通して接続台３が摺動できるように構成されている。したがって、連結ガイド４の端部から接続台３を追加したり、分離したりすることができる。
【００１８】摺動台５は側面に開口部を有する直方体で、連結ガイド４の大きさ、形状に合わせて挿通孔１３を設ける。挿通孔１３に連結ガイド４を挿通した状態で摺動できるよう、挿通孔１３の開口部の大きさは連結ガイド４より若干大きくなるようにする。図３においては、連結ガイド４の横断面が長方形であるため、摺動台５の挿通孔１３も長方形状に開口している。図示しないが連結ガイドを円柱状とすると、挿通孔は円筒状となる。ただ、円筒状の連結ガイドではストッパーが円周に沿って回転するため、接続台が左右に振れないように、キーやスプラインを設けて回転しないように連結する。連結ガイドおよび挿通孔の断面は、好ましくは長方形もしくは正方形、あるいは多角形とする。
【００１９】摺動台５にはストッパー１４である固定ネジを設けて、連結ガイド４上で動かないように固定できる。摺動台５の一部にネジ孔を設け、ここにストッパー１４を挿通する。摺動台５を貫通するストッパー１４は、締め付けられてネジ部の先端を連結ガイド４に押し付けて、強い摩擦力により動かないように固定できる。この構造のストッパー１４を有する接続台３は、連結ガイド４上を自由に摺動して簡単に位置を変えられ、また任意の位置で簡単に固定できる。図３に示す接続台３は、ストッパー１４を摺動台５の側面の１ヶ所に設けているが、ストッパー１４は側面の複数箇所に設けることも、反対側の側面または両面に設けることもできる。連

結ガイド４上で接続台３を摺動させる場合はストッパー１４を緩め、接続台３を固定する場合はストッパー１４を締め付けて摺動台５を固定する。

【００２０】連結ガイド４上で接続台３を摺動させる構造は、図３に示すものの他、図５に示す構造や図６に示す構造も使用できる。図５に示す連結構造は、連結ガイド４に断面が逆Ｔ字状となるスリット１５を設ける。接続台３の下面に設けられる摺動台（図示せず）も同じく逆Ｔ字状とし、スリット１５と摺動台の形状を同じにして自由に摺動できるようにしている。この図の接続器は、連結ガイド４にストッパー１４である固定ネジを貫通して設けている。ストッパー１４は、連結ガイド４に設けたネジ孔にねじ込んで、摺動台を押圧して停止する。このストッパーは、複数個あって、接続台が太陽電池素子を挟着して停止できる位置に設けられている。さらに図６に示す連結構造は、連結ガイド４自体の断面を逆Ｔ字状とする。接続台３は、連結ガイド４の垂直面に沿って摺動できる２枚の板状の摺動台５を備える。摺動台５の側面にストッパー１４を備え、ストッパー１４でもって摺動台５を連結ガイド４に固定している。

【００２１】摺動台５の上部に固定される接続台３は、連結ガイド４上を摺動自在に移動できるよう取り付けられている。摺動台５は連結ガイド４上を連結ガイド４と平行な方向、いいかえると接続台３が太陽電池素子１を挟着する方向に移動できる。したがって、摺動台５に固定された接続台３も太陽電池素子１を挟着する方向にのみ移動でき、連結ガイド４と直交する方向には移動できない。この構造の接続台３は、予め設計された状態で確実に端子同士を接触させることができる。移動方向に対し左右に振れないので、端子の接続位置がずれることがないからである。

【００２２】接続台３は箱形をしており、また内部の配線を外部から確認できるよう、透明のプラスチック製等にできる。図３に示す接続台３は、摺動方向と平行な上面の端部を、外部端子７を設けるために斜面状としている。また、太陽電池素子１を直列または並列に接続できるよう、太陽電池素子１を接続する連結スリット６を摺動方向と直交する面に設けている。連結スリット６は図７に示すように対向面に対称に設けられている。

【００２３】連結スリット６には、太陽電池素子１を電気的に接続する接続端子１６を設ける。接続端子１６は連結スリット６の全面に設けられているのでなく、連結スリット６の両端の２箇所に設けられ、お互いに絶縁されている。各接続端子１６は、接続台３の長さとほぼ等しい銅板等で、対向する面の連結スリット６内に突出している。したがって対向する連結スリット６で接続端子１６は連続しており、図７に示すよう左右の連結スリット６で接続端子１６は電気的に接続されるが、上部と下部では接続端子１６を別部材として、互いに絶縁している。図８の断面図に示すように、接続端子１６は一枚の銅板とすることもできるが、左右の連結スリット６で別々の部材とし、両者をリード線等で電気的に接続することもできる。接続端子１６の連結スリット６に突出する部分、いいかえると太陽電池素子１と電気的に接触する部分は折曲して凸状とし、太陽電池素子１の電極端子１７に押圧して確実に接触することができる。

【００２４】また、接続端子１６の中間部分に分岐して外部端子７を設けることができる。外部端子７は接続台３の外部に表出させて、測定用プローブの接続点等とすることができ、ここから電圧、電流等の電気信号を検出することができる。図３に示す接続台３は、上面両端縁部を斜面状として、ここにそれぞれ外部端子７を約４５度に突出させ、上方からまたは側方からでも測定プローブを接続しやすくしている。

【００２５】接続台３の両端に設けられた連結スリット６に太陽電池素子１の端部が挿入され、太陽電池素子１の両端は接続台３に挟着されて、各太陽電池素子１同士が直列、または並列に接続される。太陽電池素子１の平面図を図９に、底面図を図１０に示す。太陽電池素子１はアモルファスシリコン等で構成され、光起電力により電極端子１７間に起電力を生じる素子である。図に示す太陽電池素子１は、表面に受光部を設ける１枚のモジュールで構成され、９０度回転させても同じ状態で連結できるよう、正方形の上下左右対称な形状としている。太陽電池素子１の両端部には、起電力を得られるように対向する辺に＋電極端子１７Ａ、－電極端子１７Ｂを設ける。図９に示す太陽電池素子１は、教材として使用しやすいように、＋極、－極を一見して区別できるよう外面に極性を表記している。

【００２６】ただ、本発明の太陽電池素子１は、一辺を全て電極端子１７の導電面とするのでなく、図１０に示すように隅角部のみに電極端子１７を設ける。隅角部に設けられた電極端子１７は、接続台３の連結スリット６に挿入した際、確実に接続端子１６と電気接続できるよう、接続端子１６と対応する位置、幅、大きさに設けられる。この構造の太陽電池素子１は、接続台３の連結スリット６に挿入する面によって接続状態を変更することができる。

【００２７】例えば、図１１に示すように、太陽電池素子１の左辺を＋極、右辺を－極として連結すると、各太陽電池素子１を直列に接続することができる。また、図１２に示すように、太陽電池素子１の上辺を＋極、下辺を－極として連結すると、並列状態に接続することができる。このように、太陽電池素子１の連結する面を変えることにより、簡単に接続状態を変更することができる。それは、太陽電池素子１の電極端子１７と、接続台３の接続端子１６との接触部分を線状でなく点状としているからである。線状の電極では、線同士の接続はできても、９０度回転させると線と点の接続となって、点状の端子を線状の端子でショートさせることになる。点状

の端子であれば９０度回転させても、点と点の接続となり、ショートが起こることはない。したがって、組み合わせを変えられるように＋－を配置することで接続状態を変更することができる。

【００２８】導電面である電極端子１７は、図１０のように太陽電池素子１の底面にだけ設けることもできる。ただ、図示しないが、電極端子は太陽電池素子の上面に設けることも、上面および底面に設けることも、またコ字状として上面から側面を伝って底面に連続するように設けることもできる。これらの場合、対応する位置、形状に接続台の接続端子を設ける。

【００２９】本発明の太陽電池装置は、以下のようにして太陽電池素子１を直列または並列に接続し、分離することができる。

①　太陽電池素子１を接続台３に装着する。ストッパー１４を緩め、連結ガイド４上を自由に摺動できる状態として、接続台３同士の間に太陽電池素子１が挟着できるように間隔をあける。接続台３の全てを使用して太陽電池素子１を連結する必要はなく、必要な個数の太陽電池素子１に応じた個数の接続台３を使用できる。たとえば５個の太陽電池素子１を連結して実験を行う場合、６個の接続台３を使用する。使用しない接続台３は連結ガイド４の端部に集めて適当に固定する。また、多数の太陽電池素子１を連結するために、連結ガイド４上に装着された接続台３の個数が不足する場合は、相当数の接続台３を連結ガイド４の端部から簡単に追加できる。

【００３０】②　次に、接続台３の連結スリット６に太陽電池素子１の端部を挿入する。一方の端部を連結スリット６に挿入し、他方の端部に対し別の接続台３を接近させ、連結スリット６を挿入させる。接続台３は、接続する太陽電池素子１の端面に対し、垂直に接近するので、連結スリット６の接続端子１６は太陽電池素子１の端部と正確な位置で接続される。連結スリット６に挿入される太陽電池素子１の端部は、太陽電池素子１の接続方法が直列か並列かによっていずれの端面かが決まる。いいかえると、配線方法によって、接続台３に設けられた連結スリット６に挿入する太陽電池素子１の辺を決定する。直列に接続する場合は、太陽電池素子１の一辺全面が＋極である辺、すなわち＋電極端子１７Ａを連結スリット６に差し込み、対向する辺、すなわち－電極端子１７Ｂを別の接続台３に連結する。同様に、他の太陽電池素子１も等しい方向に向けて順次接続台３に装着する。

【００３１】または、並列に接続する場合は、直列の状態から９０度回転させて、一端に＋極、他端に－極を有する辺（図９において下辺）を連結スリット６に差し込み、対向する同じく＋極、－極を有する辺（図９において上辺）を別の連結スリット６に差し込む。図１２に示す状態に、太陽電池素子１と挿通孔を連結していく。

【００３２】③　仮止めした状態からストッパー１４を締め付けて、接続台３を連結ガイド４に固定する。この状態で太陽電池素子１は接続台３と強固に固定され、接続台３を介して太陽電池素子１同士は電気接続される。直列または並列に接続された太陽電池装置は、受光部に光を受けて起電力を生じる。この様子を接続台３に設けた外部端子７から信号を得て観察することができる。たとえば、直列に接続した場合、両端に位置する接続台３の外部端子７にオシロスコープの測定用プローブを接続して全体の電圧波形を観測でき、中間の接続台３の外部端子７から各部の電圧が測定できる。

【００３３】④　太陽電池素子１の接続方法を変更する場合や分解する場合は、ストッパー１４を緩めて接続台３をずらし、太陽電池素子の端部を連結スリット６から引き抜くことで簡単に太陽電池素子１を接続台３から分離できる。

【００３４】本発明の太陽電池装置は、教材用として使用すれば最適である。ただ、本発明は、用途を教材用に限定するものでない。本発明の太陽電池装置は、太陽電池素子１の接続方法を変更することで電圧、電流を変更でき、さらに太陽電池素子１の使用枚数の増減によっても起電力を変えることができる。また、中間の接続台３は、外部端子７から出力を取り出すことができるので、太陽電池素子１を直列に接続した状態は、外部端子７を変えて電圧が変わることが実験できる。また、太陽電池素子１を並列に接続した状態では、外部端子７の接続を変えても出力電圧も電流も変わらないことが実験できる。これにより、同じ光量から出力電圧を変更することができる。この特性により、簡単な電源として利用することもできる。また、デモンストレーションや展示等にも使用できる。

【００３５】

【発明の効果】本発明の太陽電池装置は、簡単な構造の装置で太陽電池素子の接続を、容易に直列または並列に変更できる。それは、接続台を連結ガイドに沿って移動して、太陽電池素子を接続台に接続したり分離したりできるからである。さらに、本発明の装置は、太陽電池素子を直列または並列に連結した状態で、連結部分の接触不良を防止できる特長もある。それは、接続台を連結ガイドに沿って移動させることにより、接続台で太陽電池素子を挟着するようにして、電気接続できるからである。連結方向に移動して、連結ガイドに停止される接続台は、太陽電池素子を挟着する状態において、接触不良の原因となる位置ずれを阻止できる。したがって、本発明の太陽電池装置は、簡単かつ正確に太陽電池素子を直列または並列に電気接続でき、接触不良による障害を極減できる特長を実現する。さらに、本発明の装置は、太陽電池素子を挟着する位置に接続台を停止させて、太陽電池素子を接続台に連結できる。このため、接続台を固定する位置を気にすることなく、太陽電池素子を簡単に接続台に接続できる特長がある。

【００３６】さらに本発明の請求項２に記載される太陽電池装置は、接続台に連結スリットを設け、ここに太陽電池素子の端部を挿入して連結する。この構造の太陽電池装置は、太陽電池素子の一端を連結スリットに挿入し、他端は連結ガイドに沿って接続台を接近させて挿入できるので、確実に正確な位置に電極同士を接続できる。したがって、上述した連結ガイド上を摺動し、位置ずれする方向には移動しない接続台と相まって、より簡単かつ確実に太陽電池素子を連結できる特長を実現できる。また太陽電池素子を連結スリットに抜き差しするだけで脱着できるので、脱着が極めて簡単に行え、脱着時の破損や接触不良等の弊害も極減できる。とくに、太陽電池素子を正方形状とすれば、これを９０度回転させても全く同じように接続でき、配線方法の変更が容易に行え、接続も同様に確実にできるメリットもある。

【００３７】さらにまた、本発明の請求項３に記載される太陽電池装置は、接続台に、太陽電池素子と電気的に接続された外部端子を設けている。したがって、接続部の中間から、外部端子によって電圧、電流等の信号を取り出すことができる。この構造の太陽電池装置は、従来必要であった測定用の端子を取り出すための配線替えや端子の装着等の面倒な作業が不要となる。また、直列または並列に配線方法を変える場合は、従来であればこれらの作業をやり直す必要もあった。とくに、中間の接続部で外部に表出する端子を持たない太陽電池装置では、中間部の電気特性を測定することが困難である。本発明の太陽電池装置は、太陽電池素子を直列または並列に接続した状態で、外部端子から出力電圧や電流を測定して、各接続状態における出力電圧や出力電流の状態を観察できる。このため、本発明の装置は、太陽電池素子の接続方法の違いによる電圧、電流等の出力特性の確認が様々な位置で簡単に観察できる。特に教材用として最適な本発明の太陽電池装置は、太陽電池素子の電極端子に＋極、－極の表示をして、しかも、接続台を透明にすることにより、配線の方法が外部から目で見て確認できるので、各接続台の外部端子で電圧、電流等を容易に調べることができることと相まって、配線と出力特性の関係が容易に理解でき、教材用として理想的な特長を実現できる。

【００３８】加えて、本発明の太陽電池装置は、太陽電池素子を装着する接続器を、連結ガイドとここで摺動する接続台という簡単な構成でできるので、コンパクトに設計できる。また接続台と連結ガイドを簡単に連結できるようにすれば、装着、取り外しが容易に行え、使用する太陽電池素子の数に合わせて連結ガイドに装着する接続台の数を容易に増減することができる。また各接続台は全て同一のものが使用できるので、増減する際も並び順等を気にする必要がなく、さらに設計、生産等においても好都合である。

【図面の簡単な説明】

【図１】従来の太陽電池装置を示す断面図

【図２】従来の他の太陽電池装置を示す斜視図

【図３】本発明の太陽電池装置を示す斜視図

【図４】本発明の太陽電池装置に太陽電池素子を装着した状態を示す斜視図

【図５】本発明の他の実施の形態にかかる太陽電池装置を示す斜視図

【図６】本発明の他の実施の形態にかかる太陽電池装置を示す斜視図

【図７】図３の接続台を示す平面図

【図８】図４の接続台の断面図

【図９】図３に示す太陽電池素子の平面図

【図１０】図９の太陽電池素子の底面図

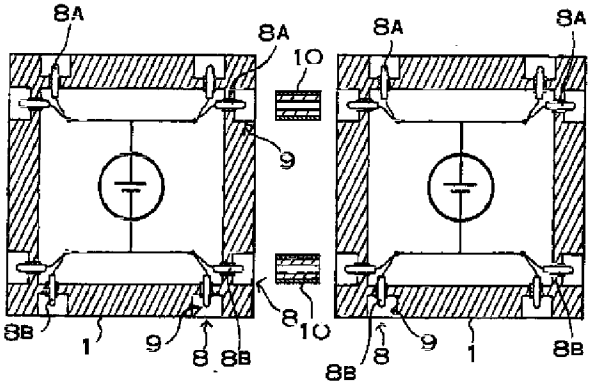
【図１１】太陽電池素子を直列に接続した状態を示す平面図

【図１２】太陽電池素子をを直列に接続した状態を示す平面図

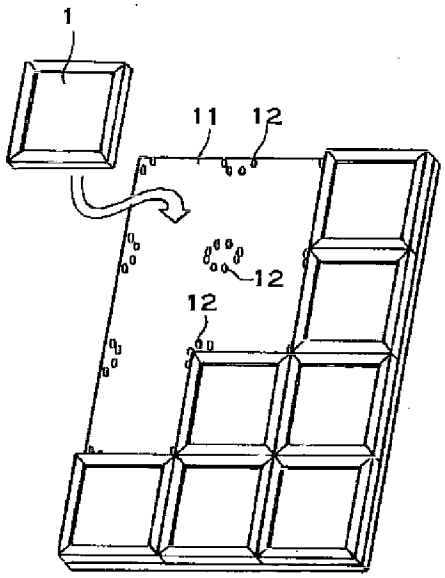
【符号の説明】

１…太陽電池素子
２…接続器
３…接続台
４…連結ガイド
５…摺動台
６…連結スリット
７…外部端子
８…出力端子　　８Ａ…＋出力端子　　８Ｂ…－出力端子
９…凹部
１０…接続ピン
１１…固定台
１２…連結接点
１３…挿通孔
１４…ストッパー
１５…スリット
１６…接続端子
１７…電極端子　　１７Ａ…＋電極端子　　１７Ｂ…－電極端子

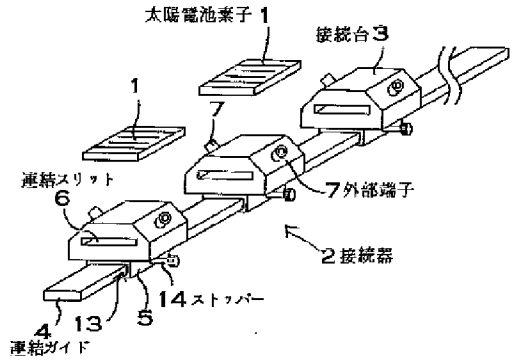
【図1】



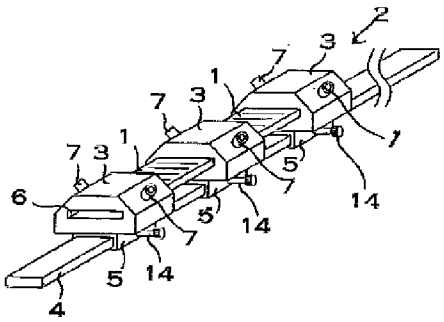
【図2】



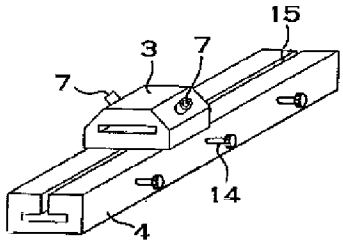
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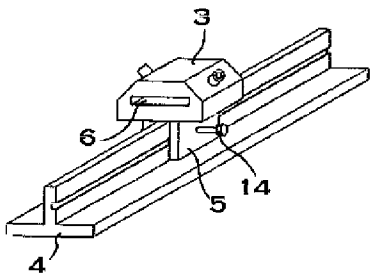
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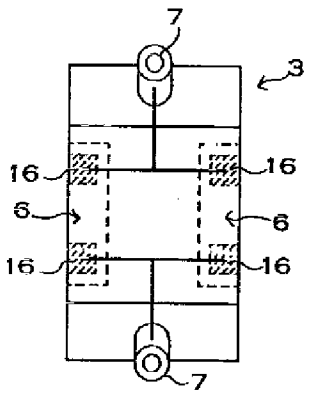
【図5】



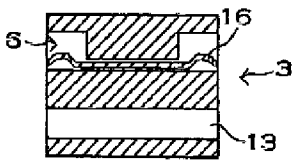
【図6】



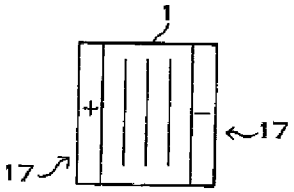
【図7】



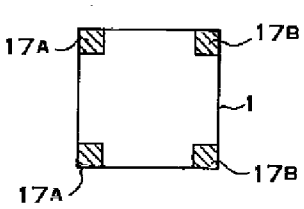
【図8】



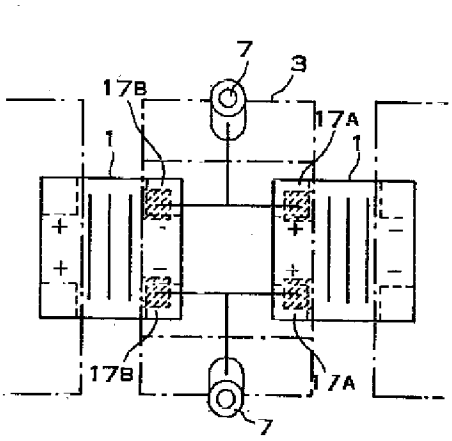
【図９】



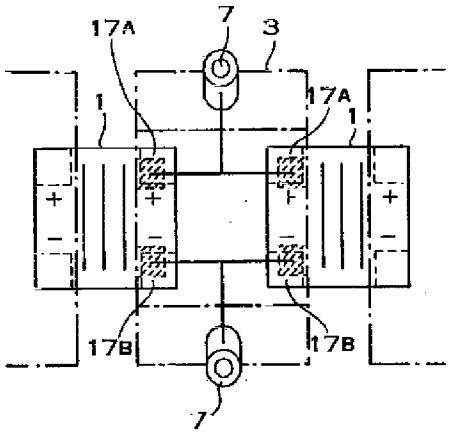
【図１０】



【図１１】



【図１２】

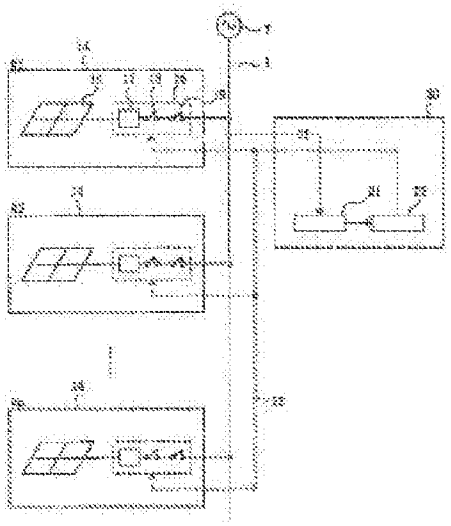


PHOTOVOLTAIC POWER GENERATING APPARATUS

Publication number: JP2000358330 (A)
Publication date: 2000-12-26
Inventor(s): MATSUKAWA MITSURU; SHIMOMURA YUKIO; SAKAE NORIO
Applicant(s): NISSIN ELECTRIC CO LTD
Classification:
- international: ***H01L31/04; H02J3/38; H02M7/48;*** **H01L31/04; H02J3/38; H02M7/48;** (IPC1-7): H02J3/38; H01L31/04; H02M7/48
- European:
Application number: JP19990166499 19990614
Priority number(s): JP19990166499 19990614

Abstract of **JP 2000358330 (A)**

PROBLEM TO BE SOLVED: To parallel off distributed power supplies at two points by providing a controller with a parallel-off control means, which transmits an open command for switches for parallel-off based on detection of a single operation of the distributed power supplies at times of system troubles. SOLUTION: N number of distributed power supplies #1 to #n 14 are provided with a solar cell 15 and a power conversion section 16, and the power conversion sections 16 are formed of inverters 17 as inversion devices. The inverters 17 are small-capacitance inverters and provided on the alternating-current output side with a first switch 18 for parallel-off. A first parallel-off point is formed at the switch 18. A second switch 19 for parallel-off, which forms a second parallel-off point, is installed in series with the first switch 19 for parallel-off, and the inverters 17 of the distributed power supplies 14 are connected with a power system 1 via the switches 18 and 19 for parallel-off. Thus the distributed power supplies 14 can be paralleled off from the power system 1.



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PATENT ABSTRACTS OF JAPAN

[*INFORMAL TRANSLATION*]

(11) Publication number : 2000-358330

(43) Date of publication of application : 26.12.2000

CLAIMS

[Claim 1] Two or more dispersed-type power sources of each characterized by comprising the following connected to a system are equipped with a solar cell and a stood [still] type electronic power inverter, A photovoltaic power generation apparatus which it concentrates with a common control device, operation of parallel off from a system of each of said dispersed-type power source and said electronic power inverter is controlled, link operation of said each dispersed-type power source is carried out to a system at the time of system normal, and parallel off of said each dispersed-type power source is carried out from a system at the time of a system abnormality, and carries out self sustaining.

The 1st switch for parallel off that consists of inner contact of said electronic power inverter, etc., and forms the 1st parallel-off point in the system side of said electronic power inverter of each of each of said dispersed-type power source.

A parallel-off control means which forms in series the 2nd switch for parallel off that forms the 2nd parallel-off point, and transmits open instructions of each of said switch for both parallel off to said common control device at said each dispersed-type power source by detection of individual operation of each of said dispersed-type power source at the time of a system abnormality.

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号
特開2000－358330
（P2000－358330A）
(43)公開日　平成12年12月26日(2000.12.26)

(51)Int.Cl.[7]	識別記号	ＦＩ		ﾃｰﾏｺｰﾄﾞ(参考)
Ｈ０２Ｊ　3/38		Ｈ０２Ｊ　3/38	Ｓ	５Ｆ０５１
Ｈ０１Ｌ　31/04		Ｈ０２Ｍ　7/48	Ｒ	５Ｇ０６６
Ｈ０２Ｍ　7/48			Ｍ	５Ｈ００７
		Ｈ０１Ｌ　31/04	Ｋ	

審査請求　未請求　請求項の数１　ＯＬ　（全　５　頁）

(21)出願番号　特願平11－166499

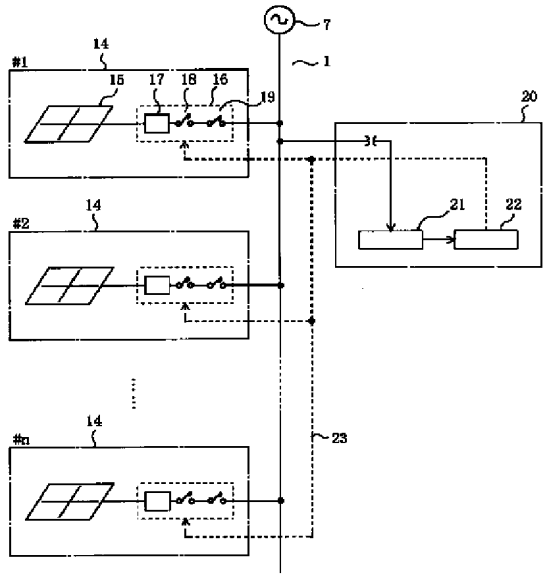
(22)出願日　平成11年６月14日(1999.6.14)

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最終頁に続く

(54)【発明の名称】　太陽光発電装置

(57)【要約】
【課題】　太陽電池構成の複数の分散型電源の運転を共通の制御装置で集中制御する際に、分散型電源の容量，台数によらず、系統連系保護装置の大型化等なく、しかも、盤配置の自由度を制限することなく、各分散型電源を２点で解列し得るようにする。
【解決手段】　各分散型電源１４それぞれの逆変換装置（インバータ１７）の系統側に、インバータ１７の内部コンタクト等からなり第１の解列点を形成する第１の解列用開閉器１８と、第２の解列点を形成する第２の解列用開閉器１９とを直列に設け、共通の制御装置２２に、系統異常時の各分散型電源１４の単独運転の検出により各分散型電源１４に開閉器１８，１９それぞれの解放指令を伝送する解列制御手段を備える。



１　電力系統
２，１４　分散型電源
３，１５　太陽電池
４，１７　インバータ
１０，２２　共通の制御装置
１８　第１の解列用開閉器
１９　第２の解列用開閉器

【特許請求の範囲】
【請求項１】　系統に接続された複数の分散型電源それぞれに太陽電池及び静止型の逆変換装置を備え、
前記各分散型電源の系統からの解列及び前記逆変換装置の運転を、共通の制御装置により集中して制御し、
系統正常時は前記各分散型電源を系統に連系運転し、系統異常時は前記各分散型電源を系統から解列して自立運転する太陽光発電装置において、
前記各分散型電源それぞれの前記逆変換装置の系統側に、前記逆変換装置の内部コンタクト等からなり第１の解列点を形成する第１の解列用開閉器と、第２の解列点を形成する第２の解列用開閉器とを直列に設け、
前記共通の制御装置に、系統異常時の前記各分散型電源の単独運転の検出により前記各分散型電源に前記両解列用開閉器それぞれの開放指令を伝送する解列制御手段を備えたことを特徴とする太陽光発電装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、電力系統に太陽電池の複数の分散型電源を連系し、これらの分散型電源の運転を１台の制御装置で集中制御する太陽光発電装置に関し、詳しくはその系統異常時の各分散型電源の解列に関する。
【０００２】
【従来の技術】従来、太陽光発電装置の分野においては、例えば本出願人の既出願（特願平８－３２７８５１号）の明細書，図面等に記載されているように、工場，ビル或いは一般住宅等の屋根や側壁等に大型，大電力出力の大規模の太陽電池を設置できない場合、この大規模の太陽電池を複数の小規模，小型の太陽電池とし、これらの小型の太陽電池と，静止型の逆変換装置としての小型，小容量のインバータとを組合せた太陽電池構成の複数の分散型電源を前記の屋根や側壁に分散設置することが行われる。
【０００３】そして、この複数の分散型電源構成の従来の太陽光発電装置は、ほぼ図２に示すように形成される。
【０００４】図２は電力系統１に＃１，＃２，…，＃ｎのｎ個の分散型電源２が連系した場合を示し、各分散型電源２は、それぞれ数ＫＷ程度の太陽電池３と、静止型の逆変換装置としての例えば１０ＫＷのインバータ４が形成する電力変換部５とを備える。
【０００５】そして、各分散型電源２のインバータ４は交流出力側（系統側）にそれぞれの内部コンタクタ等からなる解列用開閉器６が設けられ、この開閉器６を介して電力系統１に接続される。
【０００６】さらに、各分散型電源２と電力系統１の変電所等の系統電源７との間に各分散型電源２の共通の系統連系保護装置８が設けられ、この連系保護装置８は系統連系保護リレー９の系統電圧の検出結果等に基づき、各分散型電源２の共通の制御装置１０により系統停電等の系統異常の有無を監視・検出する。
【０００７】そして、制御装置１０は通信線１１を介した有線通信，又は無線通信により、各分散型電源２にインバータ４の駆動制御信号を伝送して各分散型電源２の運転を集中制御し、系統正常時は各分散型電源２のインバータ４を系統電圧に同期して連系運転する。
【０００８】ところで、この種の太陽光発電装置においては、系統停電等の系統異常が発生したときの各分散型電源２の単独運転を防止するため、いわゆる太陽光発電システムのガイドライン（系統連系技術要件ガイドライン）の規格に基づき、各分散型電源２それぞれの解列点を２点設ける必要がある。
【０００９】そして、各分散型電源２の解列用開閉器６がそれぞれの第１の解列点を形成することから、従来は系統連系保護装置８に第２の解列点を形成する共通の解列用開閉器１２が設けられ、各分散型電源２がそれぞれの解列用開閉器６と共通の解列用開閉器１２とを介して系統電源７に接続される。
【００１０】さらに、前記ガイドラインの規格によると、各分散型電源２の単独運転は、能動的方式と受動的方式とを組合せて検出して防止することが望ましいとされる。
【００１１】そのため、制御装置１０は能動的方式の単独運転検出により制御線１１を介して各分散型電源２にそれぞれの解列用開閉器６の開放指令を伝送し、これらの解列用開閉器６を開放するとともに、受動的方式の単独運転検出により内部の制御線１３を介して解列用開閉器１２に開放指令を伝送し、この解列用開閉器１２を開放する。
【００１２】なお、能動的方式の単独運転検出は、各分散型電源２のインバータ４の交流出力の周波数，有効電力又は無効電力を周期的に強制変動させ、有線又は無線で各分散型電源２から伝送されたそれぞれのインバータの交流出力の電圧，電流又は周波数の急変動を監視してそれらの急変動から単独運転への移行を検出するものである。
【００１３】また、受動的方式の単独運転検出は、系統電圧の位相，３次高調波又は周波数を監視し、それらの急変動から単独運転への移行を検出するものである。
【００１４】そして、系統異常が発生すると、単独運転移行の検出に基づく各分散型電源２の解列用開閉器６の開放，系統連系保護装置８の解列用開閉器１２の開放のいずれか一方又は両方により、各分散型電源２が電力系統１から解列される。
【００１５】このとき、各分散型電源２のインバータ４は交流出力側の接続が図示省略された非常負荷（重要負荷）に切換わるとともに、制御装置１０により運転モードが自立運転に切換わる。
【００１６】そして、系統停電中等は各分散型電源２の

自立運転出力が電力系統１から切離された非常負荷に給電される。

【００１７】

【発明が解決しようとする課題】前記図２の従来装置の場合、各分散型電源２の第２の解列点が系統連系保護装置８に設けた共通の解列用開閉器１２により形成されるため、各分散型電源２の容量，台数によっては解列用開閉器１２として、系統連系保護装置８の盤内に極めて大容量，大型の開閉器を設ける必要がある。

【００１８】この場合、解列用開閉器１２が大型，高価になるだけでなく、系統連系保護装置８の盤サイズが大きくなってこの装置８が大型，高価になる問題点がある。

【００１９】また、分散型電源２を増設等する際には、同時に系統連系保護装置８の解列用開閉器１２を容量アップしなければならず、場合によっては系統連系保護装置８の盤の取換え又は増設が必要になる問題点がある。

【００２０】さらに、分散型電源２の容量，台数によって系統連系保護装置８の盤サイズが変わるため、全体の盤サイズを統一して生産性の向上，コストダウン等を図ることができない問題点もある。

【００２１】その上、各分散型電源２の交流出力側の電力ケーブルを必ず系統連系保護装置８に引込まなければならないため、盤配置等の自由度が制限される等の問題点もある。

【００２２】本発明は、太陽電池構成の複数の分散型電源の運転を共通の制御装置で集中制御する際に、分散型電源の容量，台数によらず、系統連系保護装置の大型化等なく、しかも、盤配置の自由度を制限することなく、各分散型電源を２点で解列し得るようにすることを課題とする。

【００２３】

【課題を解決するための手段】前記の課題を解決するために、本発明の太陽光発電装置においては、各分散型電源それぞれの逆変換装置の系統側に、逆変換装置の内部コンタクト等からなり第１の解列点を形成する第１の解列用開閉器と、第２の解列点を形成する第２の解列用開閉器とを直列に設け、共通の制御装置に、系統異常時の各分散型電源の単独運転の検出により各分散型電源に両解列用開閉器それぞれの開放指令を伝送する解列制御手段を備える。

【００２４】したがって、各分散型電源にそれぞれ第１，第２の解列点の解列用開閉器が設けられ、系統異常時は、これらの開閉器が共通の制御装置から伝送されたそれぞれの開放指令によって開放され、各分散型電源が電力系統から解列される。

【００２５】この場合、各分散型電源は２解列点がそれぞれの両解列用開閉器により個別に形成される。

【００２６】そして、これらの解列用開閉器は、分散型電源の台数によらず、個々の分散型電源の容量に応じた小容量，小型の開閉器で形成される。

【００２７】しかも、従来の系統連系保護装置の大型の共通の解列用開閉器は省いて形成される。

【００２８】そのため、分散型電源の容量，台数によらず、系統連系保護装置等に大容量の大型の解列用開閉器を設けたりすることなく、各分散型電源にそれぞれの容量の小容量，小型の２個の解列用開閉器を設けて形成することができ、各盤サイズが大きくならず、分散型電源の増設による系統連系保護装置等の容量アップ，盤の取換え，増設が不要であり、しかも、各分散型電源の電力ケーブルを系統連系保護装置に引込む必要がなく、盤配置の自由度が制限されることもない。

【００２９】

【発明の実施の形態】本発明の実施の１形態につき、図１を参照して説明する。図１に示すように＃１～＃ｎのｎ台の分散型電源１４は、それぞれ図２の太陽電池３と同様の数ＫＷの小規模，小型の太陽電池１５と電力変換部１６とを備え、この電力変換部１６は静止型の逆変換装置としてのインバータ１７により形成される。

【００３０】このインバータ１７は図２の従来のインバータ４に相当し、例えば１０ＫＷの比較的小容量のインバータであり、その交流出力側（系統側）には、図２の解列用開閉器６に相当する内部コンタクタ等の第１の解列用開閉器１８が設けられ、この開閉器１８により第１の解列点が形成される。

【００３１】さらに、第１の解列用開閉器１８に直列に第２の解列点を形成する第２の解列用開閉器１９が設けられ、各分散型電源１４のインバータ１７はそれぞれの解列用開閉器１８，１９を介して電力系統１に接続される。

【００３２】このとき、両解列用開閉器１８，１９は、それぞれの分散型電源１４のインバータ１７に応じた容量，大きさの開閉器からなり、とくに解列用開閉器１９は図２の解列用開閉器１２の１／ｎの小容量，小型であり、しかも、分散型電源１４の台数が多くなっても大型化等することもない。

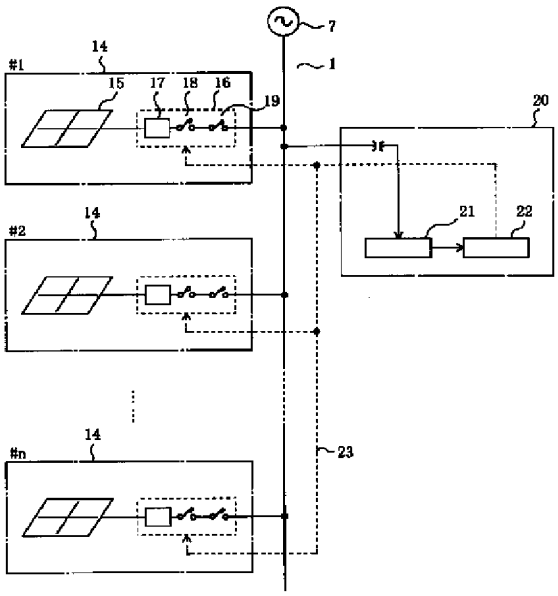
【００３３】一方、系統連系保護装置２０は例えば図２の同装置８から共通の解列用開閉器１２を省いた構成であり、系統連系保護リレー２１の系統電圧の検出結果等に基づき、共通の制御装置２２が通信線２３を介した有線通信，又は無線通信により、各分散型電源１４のインバータ１７の運転及び両解列用開閉器１８，１９の開閉を制御する。

【００３４】このとき、系統連系保護装置２０は図２の大型の解列用開閉器１２が設けられないため、分散型電源１４の容量，台数によらず、盤サイズが小さく、小型である。

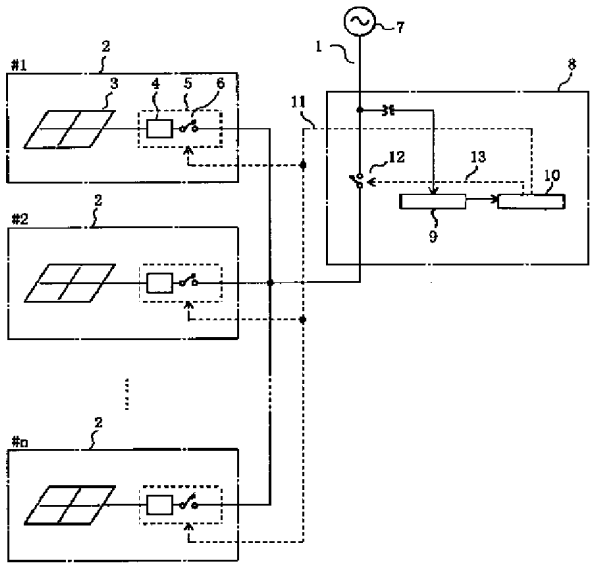
【００３５】そして、系統電源７の正常時（系統正常時）は、制御装置２２から各分散型電源１４に連系運転の制御指令が伝送され、各分散型電源１４のインバータ

１７が系統電源７に同期して連系運転される。
【００３６】また、系統異常時は図２の制御装置１０と同様の能動的方式，受動的方式の単独運転の検出に基づき、制御装置２２の解列制御手段から各分散型電源１４に、例えば制御コードを変えて両解列用開閉器１８，１９それぞれの開放指令が伝送される。
【００３７】そして、これらの開放指令の着信（受信）に基づき、各分散型電源１４の解列用開閉器１８，１９のいずれか一方又は両方が解放され、各分散型電源１４が電力系統１から解列される。
【００３８】このとき、各分散型電源１４のインバータ１７は交流出力側が例えば図示省略された非常給電用開閉器を介して共通の非常負荷に接続されるとともに、制御装置２２によって自立運転に制御され、各分散型電源１４の自立運転出力が非常負荷に給電される。
【００３９】そして、系統正常に戻ると、各分散型電源１４は非常負荷から切離されて解列用開閉器１８，１９が閉成し、連系運転に戻される。
【００４０】この場合、各分散型電源１４はそれぞれの容量に応じた小容量，小型の解列用開閉器１８，１９を設けて同一盤サイズに形成され、しかも、系統連系保護装置２０は従来の大容量，大型の共通の解列用開閉器１２が設けられず、分散型電源１４の容量，台数によらず小型である。
【００４１】そのため、分散型電源１４の台数が多くなっても系統連系保護装置２０等の盤サイズが大きくならず、その大型化等が生じない。
【００４２】また、分散型電源１４を増設する際に、系統連系保護装置２０等の容量アップか不要でそれらの取換えや増設は不要である。
【００４３】そして、分散型電源１４，系統連系保護装置２０等の盤サイズが分散型電源１４の台数によって変わらないため、それらの盤サイズを統一して規格化し、生産性の向上やコストダウン等を図ることができる。
【００４４】さらに、各分散型電源１４の電力ケーブルは電力系統１に直接接続され、それらの電力ケーブルを系統連系保護装置２０に引込む必要がないため、盤配置等の自由度が制限されることもない。
【００４５】そして、各分散型電源１４の太陽電池１５やインバータ１７の容量，制御装置２２の構成や運転制御手段及び単独運転検出方法等はどのようであってもよく、実施の形態のものに限られるものではない。
【００４６】また、制御装置２２から各分散型電源１４への制御指令等の伝送方式は、電力線を用いた配電線搬送方式，通信線２３を用いたスペクトラム拡散方式等の有線方式又は電波による無線方式等の種々の方式のいずれであってもよい。
【００４７】そして、制御装置２２が系統連系保護装置２０に設けられず、他の装置内に設けられたり、単独で設けられたりする場合にも、同様に適用できるのは勿論である。
【００４８】
【発明の効果】本発明は、以下に記載する効果を奏する。各分散型電源１４にそれぞれ第１，第２の解列点の解列用開閉器１８，１９が設けられ、系統異常時は、これらの開閉器１８，１９を、共通の制御装置２２から伝送されたそれぞれの開放指令によって開放し、各分散型電源１４を電力系統１から解列することができる。
【００４９】この場合、各分散型電源１４の２解列点がそれぞれの両解列用開閉器１８，１９により個別に形成され、これらの解列用開閉器１８，１９は、分散型電源１４の台数によらず、個々の分散型電源１４の容量に応じた小容量，小型の開閉器で形成される。
【００５０】そして、従来の系統連系保護装置の大型の共通の解列用開閉器は省いて形成される。
【００５１】したがって、分散型電源１４の容量，台数によらず、系統連系保護装置等に大容量，大型の解列用開閉器を設けたりすることなく、各分散型電源１４にそれぞれの容量の小型，小容量の２個の解列用開閉器１８，１９を設けて形成することができ、装置各部の盤サイズが大きくならず、それらの大型等が防止され、しかも、分散型電源１４の増設による系統連系保護装置等の他の盤の容量アップや取換え，増設等が不要で、全体の盤サイズを統一することができ、その上、各分散型電源１４の電力ケーブルを系統連系保護装置等に引込む必要がなく、盤配置の自由度が制限されることもない。
【図面の簡単な説明】
【図１】本発明の実施の１形態のブロック結線図である。
【図２】従来例のブロック結線図である。
【符号の説明】
１　電力系統
２，１４　分散型電源
３，１５　太陽電池
４，１７　インバータ
１０，２２　共通の制御装置
１８　第１の解列用開閉器
１９　第２の解列用開閉器

【図１】



【図２】



１　電力系統
２，１４　分散型電源
３，１５　太陽電池
４，１７　インバータ
１０，２２　共通の制御装置
１８　第１の解列用開閉器
１９　第２の解列用開閉器

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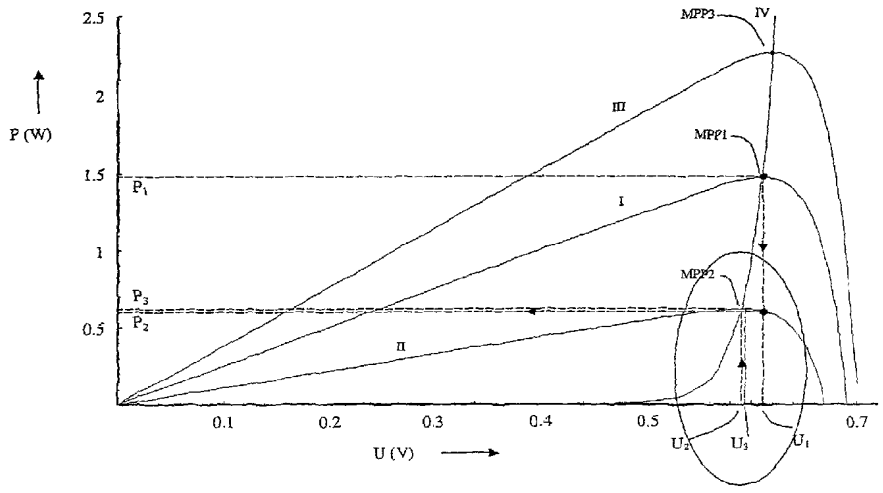
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Published:
— *with international search report*

[Continued on next page]

(54) Title: MAXIMUM POWERPOINT TRACKER



(57) Abstract: Maximum powerpoint tracker provided with memory means for storing information about the power produced by an energy source at a determined incoming power in this energy source depending as desired on the output voltage or the output current of this energy source, and with processor means for determining from this information the maximum power which can be produced by this energy source and the output voltage or output current required for this purpose, wherein the processor means are adapted to perform an algorithm according to which the maximum power which can be produced by an energy source and the output voltage or output current required for this purpose at a first incoming power in this energy source is determined from information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in this energy source.

WO 03/012569 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

MAXIMUM POWERPOINT TRACKER

The invention relates to a maximum powerpoint tracker provided with memory means for storing information about the power produced by an energy source at a determined incoming power in this energy source depending as desired on the output voltage or the output current of this energy source, and with processor means for determining from this information the maximum power which can be produced by this energy source and the output voltage or output current required for this purpose.

Such a maximum powerpoint tracker, generally designated with the abbreviation MPP-tracker, is a per se known circuit which is applied to maximize the power produced by an energy source with varying power. Examples of such an energy source are photovoltaic systems and wind turbines.

The known MPP-tracker "searches" for the maximum power in the power curve of an energy source, and sends this information to a control circuit which applies a voltage over the output of the energy source (or draws off a current from the energy source) such that it produces a greater output current (or has a higher output voltage) as the power increases, and produces a smaller output current (or has a lower output voltage) as the power decreases. The power curve is defined in the foregoing as the progression of the power produced by the energy source as a function of the output voltage or the output current of this energy source.

In the known MPP-tracker a search algorithm for a so-called extreme value adjustment is applied in order to determine the maximum power which can be drawn off at a given incoming power in the source, for instance incident sunlight or intercepted wind energy. In an extreme value adjustment the output voltage or the

output current of the energy source is changed in stepwise manner (increased or decreased), and the power produced is compared to power produced before the change. If the last-measured power is greater than the previously measured power, the output voltage or the output current is changed in stepwise manner in the same direction (i.e. increased or decreased). If the last-measured power is smaller than the previously measured power, the output voltage or the output current is changed in stepwise manner in opposing direction (i.e. decreased or increased).

It is a drawback of the known MPP-tracker that when the above described search algorithm is applied it responds relatively slowly to acute changes in the incoming power in the energy source. Such acute changes occur for instance in a photovoltaic system when cloud suddenly develops or clears away, and can occur in wind turbines in the case of local variations in wind-force. A slow response of the stepwise search algorithm results in a relatively long period in which the energy source does not produce its optimal power, and therefore in costly energy losses.

It is an object of the invention to provide an MPP-tracker which responds quickly to acute changes in the incoming power in an energy source for which this MPP-tracker is applied.

This objective is realized with a maximum powerpoint tracker of the type specified in the preamble, wherein according to the invention the processor means are adapted to perform an algorithm according to which the maximum power which can be produced by an energy source and the output voltage or output current required for this purpose at a first incoming power in this energy source is determined from information stored in the memory means about the maximum power which can be produced and the output voltage or

output current required for this purpose at at least a second and a third incoming power in this energy source.

In an embodiment of a maximum powerpoint tracker according to the invention, the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in this energy source is given by a coefficient U' of an exponential function $P_{mpp}=U'e^{u_{mpp}}$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} required for this purpose (expressed in a dimensionless unit).

The exponential function $P_{mpp}=U'e^{u_{mpp}}$ is based on an ideal solar cell, i.e. a solar cell which, in a simplified model, is represented by a voltage source with a resistance-free diode connected in parallel. It has been found that an exponential function forms a good approximation of the stated relation.

In a practical advantageous embodiment the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in this energy source is given by the coefficients a_i of an nth degree polynomial $P_{mpp}=\Sigma_{j=0}^{j=n}a_j u_{mpp}^j$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} required for this purpose (expressed in a dimensionless unit), wherein n is a whole number preferably equal to 2.

In a practical simple embodiment the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in this energy source comprises the parameters for describing a linear interdependence of the maximum power which can be produced and the output

voltage or output current required for this purpose at the incoming power.

A maximum powerpoint tracker according to the invention is preferably adapted to perform at predetermined time intervals a determination of the information about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in this energy source and to store this information in the memory means.

In an embodiment of an MPP-tracker according to the invention the algorithm comprises an iteration procedure.

In another embodiment the algorithm is followed after a predetermined instruction by a second algorithm for performing an extreme value adjustment, so that the maximum power which can be produced and the associated output voltage or output current can be determined with great accuracy. In a case where the first algorithm comprises an iteration procedure, the determined instruction comprises for instance of performing a predetermined number of iterations.

The invention will now be elucidated hereinbelow with reference to the drawings.

In the drawings

Fig. 1 is a diagram with three curves I-III which show the power P which can be produced by a solar cell as a function of the output voltage U, with a first curve IV which represents the maximum power P_{mpp} which can be produced by a solar cell as a function of the output voltage U_{mpp} at that maximum power which can be produced,

Fig. 2 shows a part of fig. 1 in enlarged view,

Fig. 3 shows a second curve IV' representing the maximum power P_{mpp} which can be produced by a solar cell as a function of the output voltage U_{mpp} at that maximum power which can be produced, and

Fig. 4 shows a third curve IV" representing the maximum power P_{mpp} which can be produced by a solar cell as a function of the output voltage U_{mpp} at that maximum power which can be produced.

Fig. 1 shows a diagram with three curves I-III representing the power P which can be produced by a solar cell as a function of the output voltage U at different incoming amounts of power, for instance as a result of different amounts of incident sunlight with varying cloud cover. The points MPP1, MPP2 and MPP3 in the respective curves I-III represent the maximum amounts of power which can be produced at the respective incoming amounts of power, and are connected by curve IV. The operation of the MPP-tracker according to the invention can be understood as follows. The power of a determined quantity of light incident in a solar cell corresponds for instance to a power which can be produced by this solar cell as according to curve I. The maximum power P1 which can be produced at an output voltage U1 is represented by the point MPP1 on curve I. In the case of a sudden fall in the quantity of incident sunlight, the power which can be produced corresponds to another curve, in the example curve II. At the original output voltage U1 a power P2 would be produced which is lower than the maximum power which can be produced in the conditions. According to the invention the MPP-tracker "searches" on the curve IV for the output voltage U2 corresponding to the power P2, then on curve II for the power P3 corresponding to the output voltage U2, on the curve IV for the output voltage U3 corresponding to the power P3, on curve II for the power P4 (not shown) corresponding to the output voltage U3 etc., until after a sufficient number of iterations there follows a search algorithm for an extreme value adjustment according to the prior art.

In practical situations, where the power curves of solar cells manufactured in accordance with a standard

process are known, the optimal power line IV can be predetermined and can be inputted into the memory of an MPP-tracker intended for that type of solar cells.

Fig. 2 shows an enlarged view of the part of fig. 1 enclosed by an ellipse.

Fig. 3 shows a curve IV' representing the maximum power P_{mpp} which can be produced by an ideal solar cell as a function of the output voltage U_{mpp} at that maximum power which can be produced. Curve IV' is calculated from the exponential function $P_{mpp}=U'e^{u_{mpp}}$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} required for this purpose (expressed in a dimensionless unit) for an ideal solar cell.

Fig. 4 shows a curve IV" representing the maximum power P_{mpp} which can be produced by a solar cell as a function of the output voltage U_{mpp} at that maximum power which can be produced, which curve IV" is calculated from a sixth degree polynomial $P_{mpp}=\Sigma_{j=0}^{j=6}a_j u_{mpp}^j$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} (expressed in a dimensionless unit).

An MPP-tracker according to the invention is particularly suitable for application in photovoltaic systems, in particular solar panels assembled from solar cells connected in series, where the shorter recovery time following a change in radiated power results in an increase in the produced power such that the extra investment cost of an MPP-tracker according to the invention is recouped in a relatively short time. The MPP-tracker according to the invention can however also be applied in other energy-generating systems, for instance wind turbines.

CLAIMS

1. Maximum powerpoint tracker provided with memory means for storing information about the power produced by an energy source at a determined incoming power in said energy source depending as desired on the output voltage or the output current of said energy source, and with processor means for determining from this information the maximum power which can be produced by said energy source and the output voltage or output current required for this purpose, **characterized in that** the processor means are adapted to perform an algorithm according to which the maximum power which can be produced by an energy source and the output voltage or output current required for this purpose at a first incoming power in said energy source is determined from information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in said energy source.

2. Maximum powerpoint tracker as claimed in claim 1, **characterized in that** the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in said energy source is given by a coefficient U' of an exponential function $P_{mpp}=U'e^{u_{mpp}}$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} required for this purpose.

3. Maximum powerpoint tracker as claimed in claim 1, **characterized in that** the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in said energy source is given by the coefficients a_i of an nth degree polynomial

$P_{mpp}=\Sigma_{j=0}^{j=n} a_j u_{mpp}^j$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} required for this purpose, wherein n is a whole number.

4. Maximum powerpoint tracker as claimed in claim 3, **characterized in that** n has the value 2.

5. Maximum powerpoint tracker as claimed in claim 1, **characterized in that** the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in said energy source comprises the parameters for describing a linear interdependence of the maximum power which can be produced and the output voltage or output current required for this purpose at the incoming power.

6. Maximum powerpoint tracker as claimed in any of the claims 1-5, **characterized in that** it is adapted to perform at predetermined time intervals a determination of the information about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in said energy source, and to store this information in the memory means.

7. Maximum powerpoint tracker as claimed in any of the claims 1-6, **characterized in that** the algorithm comprises an iteration procedure.

8. Maximum powerpoint tracker as claimed in any of the claims 1-7, **characterized in that** the algorithm is followed after a predetermined number of iterations by a second algorithm for performing an extreme value adjustment.

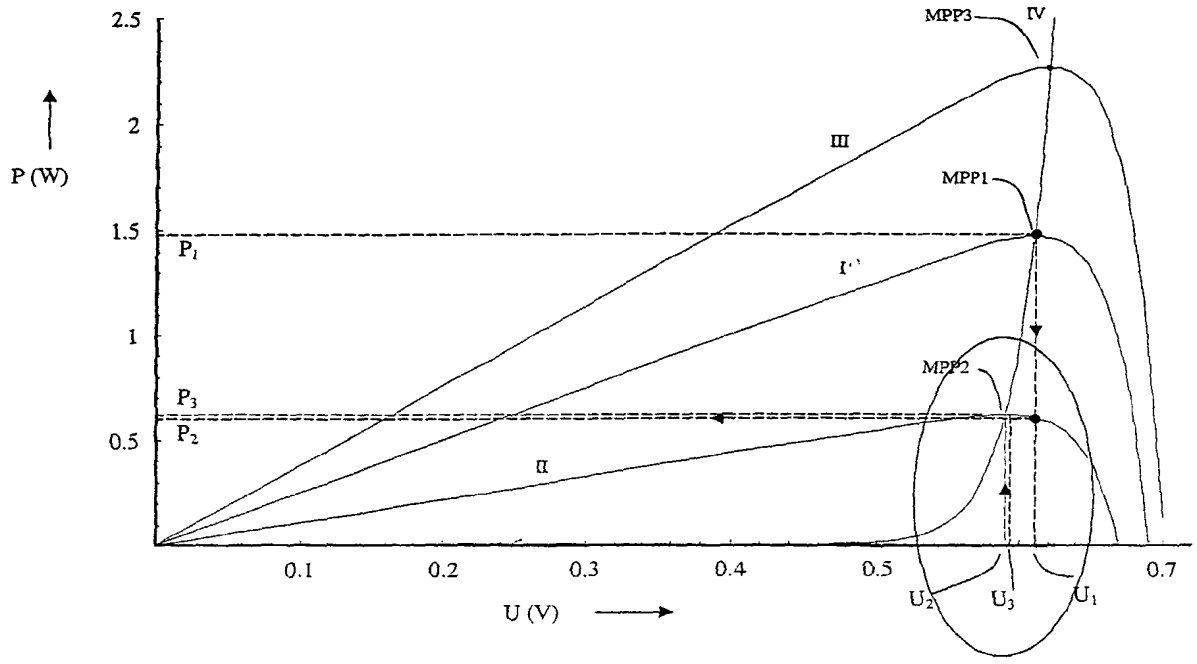

2.5
2
1.5
1
0.5
P (W)
P1
P3
P2
MPP3
IV
III
MPP1
I
MPP2
II
0.1
0.2
0.3
0.4
0.5
0.7
U (V)
U2
U3
U1

Fig. 1

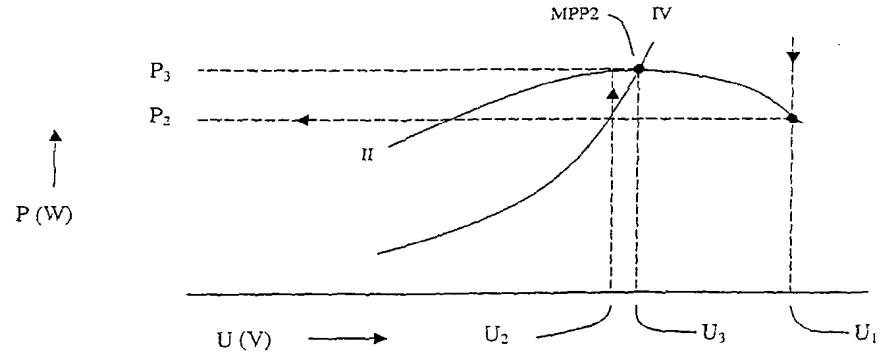

MPP2
IV
P3
P2
II
P (W)
U (V)
U2
U3
U1

Fig. 2

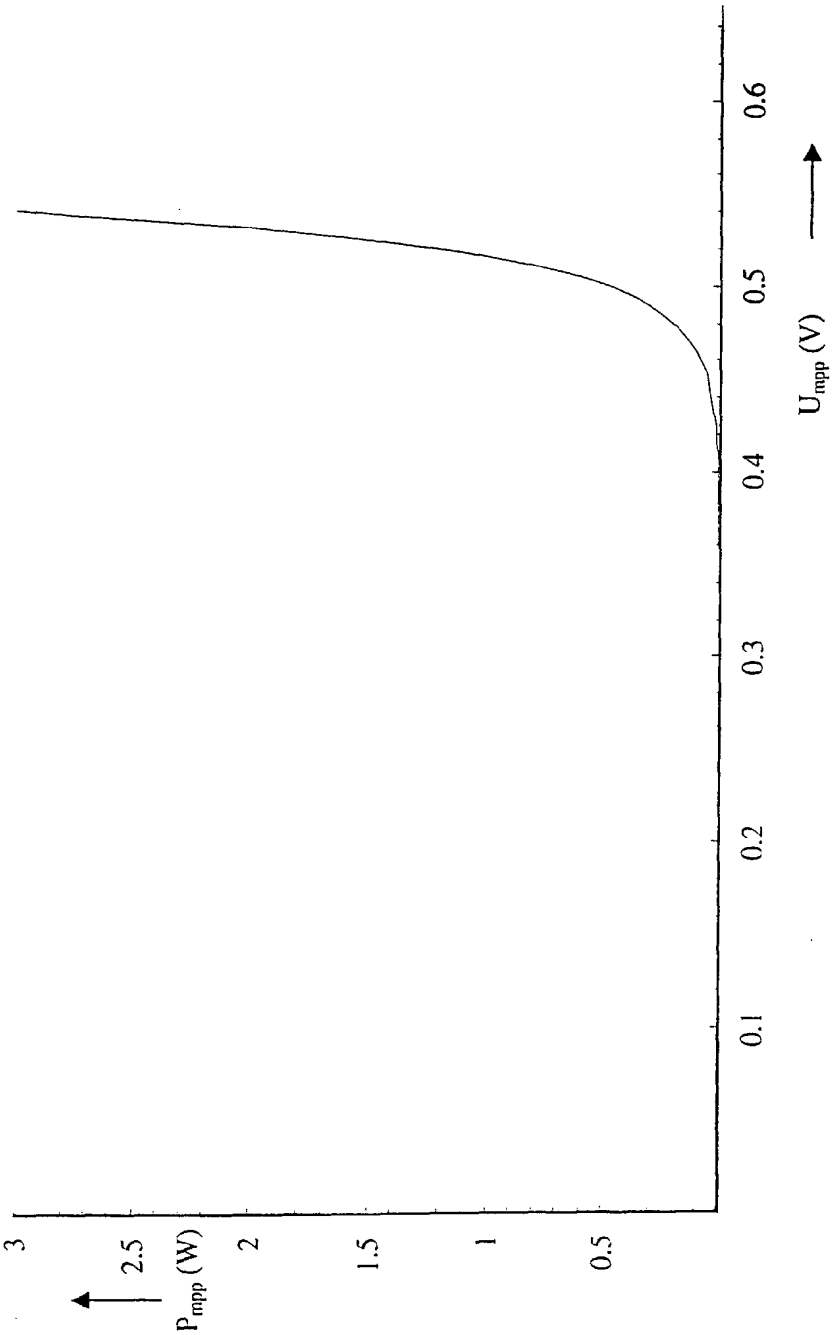


Fig. 3

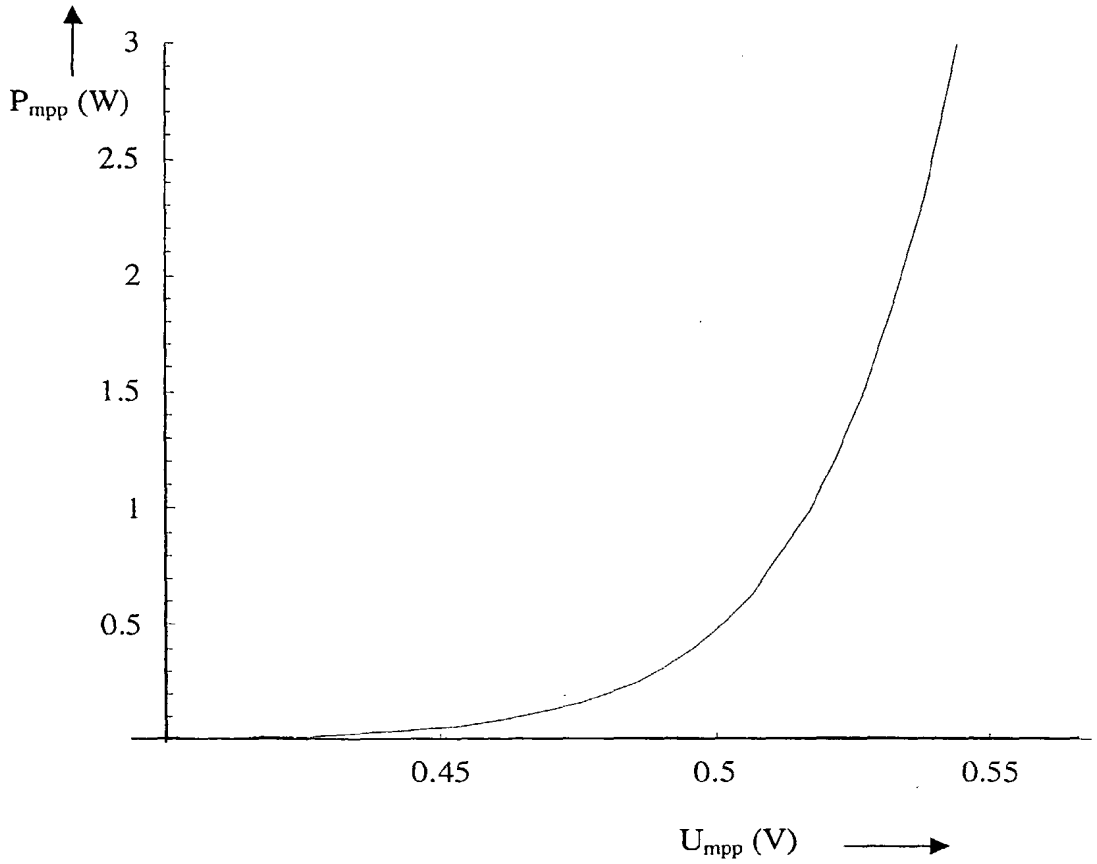


Fig. 4

INTERNATIONAL SEARCH REPORT

nal Application No
PCT/NL 02/00434

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G05F1/67 H02J7/35

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G05F H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 947 905 A (SANYO ELECTRIC CO) 6 October 1999 (1999-10-06)	1
A	the whole document	2-8

X	CHIHCHIANG HUA ET AL: "Comparative study of peak power tracking techniques for solar storage system" APPLIED POWER ELECTRONICS CONFERENCE AND EXPOSITION, 1998. APEC '98. CONFERENCE PROCEEDINGS 1998., THIRTEENTH ANNUAL ANAHEIM, CA, USA 15-19 FEB. 1998, NEW YORK, NY, USA,IEEE, US, 15 February 1998 (1998-02-15), pages 679-685, XP010263666 ISBN: 0-7803-4340-9	1
A	the whole document	2-8

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 October 2002	28/10/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Schobert, D

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	CHIHCHIANG HUA ET AL: "DSP-based controller application in battery storage of photovoltaic system" INDUSTRIAL ELECTRONICS, CONTROL, AND INSTRUMENTATION, 1996., PROCEEDINGS OF THE 1996 IEEE IECON 22ND INTERNATIONAL CONFERENCE ON TAIPEI, TAIWAN 5-10 AUG. 1996, NEW YORK, NY, USA,IEEE, US, 5 August 1996 (1996-08-05), pages 1705-1710, XP010203239 ISBN: 0-7803-2775-6	1
A	the whole document	2-8
X	HUA C ET AL: "IMPLEMENTATION OF A DSP-CONTROLLED PHOTOVOLTAIC SYSTEM WITH PEAK POWER TRACKING" IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, IEEE INC. NEW YORK, US, vol. 45, no. 1, 1 February 1998 (1998-02-01), pages 99-107, XP000735209 ISSN: 0278-0046	1
A	the whole document	2-8
A	US 5 869 956 A (FUKAE KIMITOSHI ET AL) 9 February 1999 (1999-02-09) abstract	1-8
A	US 5 604 430 A (DECKER DARWIN K ET AL) 18 February 1997 (1997-02-18) abstract	1-8

INTERNATIONAL SEARCH REPORT

information on patent family members

nal Application No
PCT/NL 02/00434

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0947905 A	06-10-1999	JP 11282553 A	15-10-1999
		JP 11282554 A	15-10-1999
		JP 11282555 A	15-10-1999
		CN 1230709 A	06-10-1999
		EP 0947905 A2	06-10-1999
		US 6046919 A	04-04-2000
US 5869956 A	09-02-1999	JP 10083223 A	31-03-1998
US 5604430 A	18-02-1997	NONE	

Form PCT/ISA/210 (patent family annex) (July 1992)

WANG/AMS

PCT/US2008/081827

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:

WANG LEHUA

GREENBERG TRAURIG LLP 2450 COLORADO AVENUE, SUITE 400 EAST SANTA MONICA CA 90404 USA

30th Month GT-LA
DUE DATE: 5.2.10
DEADLINE: 7.1.09
DOCKETED: 7.1.09
BY (INITIALS): RA

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference 108144200201 108144-200201/WO	Date of mailing *(day/month/year)* 24 JUNE 2009 (24.06.2009)
International application No. **PCT/US2008/081827**	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
Applicant **TIGO ENERGY, INC., et al**	International filing date *(day/month/year)* **30 OCTOBER 2008 (30.10.2008)**

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BY IP DEPARTMENT
GREENBERG TRAURIG LLP

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. These comments would also be made available to the public but not before the expiration of 30 months from the priority date.

Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

See the Annex to Form PCT/IB/301 and, for details about the applicable time limits, Office by Office, see the *PCT Applicant's Guide*, Volume II, National Chapters and the WIPO Internet site.

Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea	Authorized officer COMMISSIONER
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5207

Form PCT/ISA/220 (October 2005) *(See notes on accompanying sheet)*

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under Article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the *PCT Applicant's Guide*, a publication of WIPO.

In these Notes, "Article", "Rule" and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions, respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report and the written opinion of the International Searching Authority, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only (see *PCT Applicant's Guide*, Volume I/A, Annexes B1 and B2).

The attention of the applicant is drawn to the fact that ammendments to the claims under Article 19 are not allowed where the International Searching Authority has declared, under Article 17(2), that no international search report would be established (see *PCT Applicant's Guide*, Volume I/A, paragraph 296).

What parts of the international application may be amended ?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Preliminary Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When ? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments ?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How ? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments ?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below,under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

(i) the claim is unchanged;
(ii) the claim is cancelled;
(iii) the claim is new;
(iv) the claim replaces one or more claims as filed;
(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
   "Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
   "Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
   "Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
   "Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]:
   "Claims 1 - 10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under Article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be indentified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments and any accompanying statement, under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the time of filing the amendments (and any statement) with the International Bureau, also file with the International Preliminary Examining Authority a copy of such amendments (and of any statement) and, where required, a translation of such amendments for the proceduer before that Authority (see Rules 55.3(a) and 62.2, first sentence). For further information, see the Notes to the demand form (PCT/IPEA/401).

If a demand for international preliminary examination is made, the written opinion of the International Searching Authority will, except in certain cases where the International Preliminary Examining Authority did not act as International Searching Authority and where it has notified the International Bureau under Rule 66.1*bis*(b), be considered to be a written opinion of the International Preliminary Examining Authority. If a demand is made, the applicant may submit to the International Preliminary Examining Authority a reply to the written opinion together, where appropriate, with amendments before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later (Rule 43*bis*.1(c)).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to , the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see the *PCT Applicant's Guide*, Volume II.

* Attention

Copies of the documents cited in the international search report can be searched in the following Korean Intellectual Property Office English website for three months from the date of mailing of the international search report.

http://www.kipo.go.kr/en/ => Patent Search => PCT-Service

ID : PCT international application number
PW : **L02GHMBF**

Inquiries related to PCT International Search Report or Written Opinion prepared by KIPO as an International Searching Authority can be answered not only by KIPO but also through IPKC (Intellectual Property Korea Center), located in Vienna, VA, which functions as a PCT Help Desk for PCT applicants.

Homepage: http://www.ipkcenter.com
Email: ipkc@ipkcenter.com
Phone: +1 703 388 1066
Fax: +1 703 388 1064

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
WANG LEHUA

GREENBERG TRAURIG LLP 2450 COLORADO AVENUE, SUITE 400 EAST SANTA MONICA CA 90404
USA

RECEIVED
JUL -1 2009
BY IP DEPARTMENT
GREENBERG TRAURIG LLP

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**24 JUNE 2009 (24.06.2009)**
Applicant's or agent's file reference 108144200201	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2008/081827	**30 OCTOBER 2008 (30.10.2008)**	02 NOVEMBER 2007 (02.11.2007)

International Patent Classification (IPC) or both national classification and IPC

H01L 31/042(2006.01)i

Applicant

TIGO ENERGY, INC., et al

Written Opinion
GT-LA
DUE DATE: 9.24.09
DEADLINE: x
DOCKETED: 7.1.09
BY (INITIALS): RA

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	24 JUNE 2009 (24.06.2009)	MUN, Tae Jin Telephone No.82-42-481-8479

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2008/081827

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of :

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____ , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. type of material
   - ☐ a sequence listing
   - ☐ table(s) related to the sequence listing

   b. format of material
   - ☐ on paper
   - ☐ in electronic form

   c. time of filing/furnishing
   - ☐ contained in the international application as filed.
   - ☐ filed together with the international application in electronic form.
   - ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2008/081827

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-20	YES
	Claims	None	NO
Inventive step (IS)	Claims	2-15, 17-20	YES
	Claims	1, 16	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	None	NO

2. Citations and explanations :

Reference is made to the following document from the International Search Report(ISA)

D1 : JP 2000-358330 A

1. Novelty and Inventive Step

Claim 1 relates to a photovoltaic panel, comprising ① at least one photovoltaic cell, ② a connector to output energy from the photovoltaic panel, and ③ a switch coupled between the at least one photovoltaic cell and the connector, the switch configured to disconnect the at least one photovoltaic cell from the connector during installation of the photovoltaic panel, the switch configured to connect the at least one photovoltaic cell with the connector after installation of the photovoltaic panel.

Claim 16 relates to a photovoltaic module, comprising ① a voltage module to adjust an output of a plurality of photovoltaic cells, and ② a switch coupled the voltage module to selectively provide the output.

D1, which is the closest art to the present invention, relates to a photovoltaic power generating apparatus.

When D1 is compared with claim 1 and 16, the photovoltaic cell of claim 1 is corresponding to the solar cell(15) in D1, the switch of claim 1 and 16 is corresponding to the switches(16, 18) in D1, and the voltage module of claim 16 is corresponding to the inverters(17) in D1.

Hence, claims 1 and 16 are obvious over D1. Therefore, claims 1 and 16 lack an inventive step under PCT Article 33(3).

Claim 2-15 and 17-20 are dependent claims. But, additional features of claims 2-15 and 17-20 are not disclose in D1. So, an inventive step can be acknowledged for the subject matter of claims 2-15 and 17-20.

2. Industrial Applicability

Claims 1-20 meet the criteria set out in PCT Article 33(4).

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
108144200201		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US2008/081827	**30 OCTOBER 2008 (30.10.2008)**	02 NOVEMBER 2007 (02.11.2007)

Applicant

TIGO ENERGY, INC., et al

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of **3** sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

RECEIVED
JUL -7
BY IP DEPARTMENT
GREENBERG TRAURIG LLP

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of :
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:

ISR (File Amendment)
GT-LA
DUE DATE: 8.24.09
DEADLINE: X
DOCKETED: 7.1.09
BY (INITIALS): DA

5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. **1**
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2008/081827

A. CLASSIFICATION OF SUBJECT MATTER

H01L 31/042(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC8 H01L31/042

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and Applications for Utility models since 1975
Japanese Utility models and Applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKIPASS(KIPO Internal)
"Keywords: solar, photovoltaic, cell, switch, connector"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2000-358330 A (NISSIN ELECTRIC CO LTD) 26 December 2000 See the whole document	1, 16 2-15, 17-20
A	JP 1996-116628 A (NITTO KOGYO KK) 7 May 1996 See the whole document	1-20
A	JP 1997-148611 A (SANYO ELECTRIC CO LTD) 6 June 1997 See the whole document	1-20
A	JP 1999-103538 A (MY WAY GIKEN KK) 13 April 1999 See the whole document	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 JUNE 2009 (24.06.2009)	**24 JUNE 2009 (24.06.2009)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea	MUN, Tae Jin
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-8479

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2008/081827

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2000-358330 A	26.12.2000	None	
JP 1996-116628 A	07.05.1996	None	
JP 1997-148611 A	06.06.1997	None	
JP 1999-103538 A	13.04.1999	None	

Form PCT/ISA/210 (patent family annex) (July 2008)

Electronic Acknowledgement Receipt

EFS ID:	7582862
Application Number:	12628977
International Application Number:	
Confirmation Number:	6958
Title of Invention:	Systems and Methods for an Enhanced Watchdog in Solar Module Installations
First Named Inventor/Applicant Name:	Ron HADAR
Customer Number:	64494
Filer:	John Patrick Ward/Patricia Caldwell
Filer Authorized By:	John Patrick Ward
Attorney Docket Number:	108144-202701/US (TGY027)
Receipt Date:	10-MAY-2010
Filing Date:	01-DEC-2009
Time Stamp:	16:57:26
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed (SB/08)	202701_IDS.pdf	613697 3859a7cb15694669724a22d080a56145411 11cf7	no	9

Warnings:	
Information:	

2	Foreign Reference	AU_2005262278.pdf	1050806 bda96a04758e1f76854eaf5dc02d37fc4fbd52a0	no	33
Warnings:					
Information:					
3	Foreign Reference	DE_4232356.pdf	419969 baa62003b24ae498de551157556ea08d2e22f652	no	5
Warnings:					
Information:					
4	Foreign Reference	DE_19961705.pdf	675864 d28fed8719d8d91cb96cf7d02fcd3e30bf39e809	no	11
Warnings:					
Information:					
5	Foreign Reference	EP_1388774A1.pdf	844423 e951ca76db26515029068e73a438c8757d212cfd	no	15
Warnings:					
Information:					
6	Foreign Reference	ES_2249147.pdf	362368 5c0a0e3ad9f5be717ae857a6a8373fe6edc804d5	no	13
Warnings:					
Information:					
7	Foreign Reference	JP_4219982A.pdf	404256 8f59506dc3594e93d80da2b02c2c33b5c58a3bb1	no	6
Warnings:					
Information:					
8	Foreign Reference	JP_8097460A.pdf	769540 951b2478e78ae4e7fd5c8aaa00d0ea608b0b18de	no	8
Warnings:					
Information:					
9	Foreign Reference	JP_8116628A.pdf	526661 27f83a70ecddd9dae4573a9dc1c367eb816c8074	no	5
Warnings:					
Information:					
10	Foreign Reference	JP_8316517A.pdf	577476 338e25b4fe4cc6334e9e0134ed5882e41515dfdc	no	7
Warnings:					
Information:					

11	Foreign Reference	JP_9148611.pdf	1380088 8d670af6cae8fe8816f756bd6f4c48b758ac7e88	no	9
Warnings:					
Information:					
12	Foreign Reference	JP_2000358330A.pdf	432554 c40a1cb2cc3ef8565ec89dfb797a84c6ab6aabc8	no	7
Warnings:					
Information:					
13	Foreign Reference	WO_2003012569.pdf	546173 47f2c653a847407e88a712f9d35e413ffc30aa04	no	16
Warnings:					
Information:					
14	NPL Documents	Advanced_Energy.pdf	521680 cc5af2737bdd44ae45fda69af305a10809634203	no	6
Warnings:					
Information:					
15	NPL Documents	Websters_Removable.pdf	61958 ebcb51b152ebede06f3bcb1a9f772f7b8a97ccde	no	1
Warnings:					
Information:					
16	NPL Documents	Websters_Remove.pdf	116106 949b2f87714a109f0a00b019776ab1516af08f30	no	2
Warnings:					
Information:					
17	NPL Documents	Hewes.pdf	496380 dd282eb52a035fa832e51208488d7b3fcaa531ca	no	3
Warnings:					
Information:					
18	NPL Documents	PCTUS08_081827_ISR_WO.pdf	1316103 7b2be7b4c419da0fb9632fcee46fcec062cc7c36	no	10
Warnings:					
Information:					
19	NPL Documents	Palma.pdf	300372 d02e2ee50a6851b10f1c5384ae780d9c8f90045a	no	6
Warnings:					
Information:					

20	NPL Documents	Quaschning.pdf	443496 27d266a23d37c4483a86aa4fde2797688ebe6e90	no	6
Warnings:					
Information:					
21	NPL Documents	Uriarte.pdf	342846 82a6719419a9c146cd1266bc86e5d51e970b33f9	no	4
Warnings:					
Information:					
22	NPL Documents	Walker_Cascaded_2002.pdf	564877 2441bde60f00ad4a3bcc518a9106fee3f496a0d4	no	6
Warnings:					
Information:					
			Total Files Size (in bytes):	12767693	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/628,977	12/01/2009	Ron HADAR	108144-202701/US (TGY027)

CONFIRMATION NO. 6958

64494
GREENBERG TRAURIG, LLP (SV)
IP DOCKETING
2450 COLORADO AVENUE
SUITE 400E
SANTA MONICA, CA 90404

EARLY PUBLICATION REQUEST LETTER

OC000000040363227

Date Mailed: 03/02/2010

NOTICE REGARDING EARLY PUBLICATION REQUEST

The request for voluntary publication, amended publication, early publication, redacted publication, republication, corrected publication or revised publication has been received for this application. The request, including payment of any necessary fee(s), is in compliance with 37 CFR 1.215, 1.217, 1.219 or 1.221.

The projected publication date is 06/10/2010.

/tjkoontz/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/628,977	12/01/2009	Ron HADAR	108144-202701/US (TGY027)	6958

64494 7590 02/16/2010

GREENBERG TRAURIG, LLP (SV)
IP DOCKETING
2450 COLORADO AVENUE
SUITE 400E
SANTA MONICA, CA 90404

EXAMINER	
ART UNIT	PAPER NUMBER
1795	

NOTIFICATION DATE	DELIVERY MODE
02/16/2010	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

LAIPMAIL@GTLAW.COM
allenr@gtlaw.com
santosv@gtlaw.com

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

GREENBERG TRAURIG, LLP (SV)
IP DOCKETING
2450 COLORADO AVENUE
SUITE 400E
SANTA MONICA CA 90404

FEB 16 2010

In re Application of	:	
Hadar et al.	:	DECISION ON PETITION
Application No. 12/628,977	:	TO MAKE SPECIAL UNDER
Filed: 12/1/2009	:	THE GREEN TECHNOLOGY
Attorney Docket No. **108144-202701/US (TGY027)**	:	PILOT PROGRAM

This is a decision on the petition under 37 CFR 1.102, filed 1/19/2010, to make the above-identified application special under the pilot program for applications pertaining to Green Technologies as set forth 74 Federal Register Notice 64666 (December 8, 2009).

The petition is **GRANTED**.

A grantable petition to make an application special under 37 CFR 1.102 and the pilot program as set forth in 74 FR 64666 must be directed to a nonprovisional application filed under 35 USC 111(a) or be a national stage entry under 35 USC 371, exclusive of any reissue applications and be filed prior to the date of the notice, December 8, 2009.

In order to qualify for special status, the following requirements must be met. 1) The application must be classified in one of the eligible US classifications listed in section VI of the notice. 2) The application must have no more than 3 independent claims and no more than 20 total claims. 3) The application must not contain any multiple dependent claims. 4) The petition must state the basis for seeking special status, i.e., the claimed invention either: A) materially enhances the quality of the environment or B) materially contributes to: i) the discovery or development of renewable energy resources, ii) the more efficient utilization and conservation of energy resources, or iii) greenhouse gas emission reduction. 5) If the disclosure is not clear on its face that the claimed invention materially contributes under category (A) or (B), the petition must be accompanied by a statement by the applicant, assignee, or an attorney/agent registered to practice before the Office explaining how the materiality standard is met. 6) A statement that applicant will agree to make an election without traverse in a telephonic interview if a restriction requirement is made by the examiner. 7) The petition to make special must be filed electronically. 8) The petition must be filed at least one day prior to the date that a first Office

Action appears in the Patent Application Information Retrieval (PAIR) system. 9) The petition must be accompanied by a request for early publication in compliance with 37 CFR 1.219 and include the publication fee as set forth in 37 CFR 1.18(d).

The requirement for a fee for consideration of the petition to make special for applications pertaining to Green Technologies has been waived.

The instant petition complies with items 1 – 9 above. Accordingly, the above-identified application has been accorded "special" status.

Telephone inquires concerning this decision should be directed to Tom Dunn at 571-272-1171.

The application is being forwarded to the Technology Center Art Unit 1795 for action on the merits commensurate with this decision.

/Tom Dunn/

Tom Dunn
Quality Assurance Specialist
Technology Center 1700

PTO/SB/420 (12-09)
Approved for use through 05/31/2010. OMB 0651-0062
U.S. Patent and Trademark Office; U. S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PETITION TO MAKE SPECIAL UNDER THE GREEN TECHNOLOGY PILOT PROGRAM

Attorney Docket Number: 108144-202701/US (TGY027)	Application Number (if known): 12/628,977	Filing date: December 1, 2009
First Named Inventor: Ron Hadar		
Title: Systems and Methods for an Enhanced Watchdog in Solar Module Installations		

APPLICANT HEREBY REQUESTS TO PARTICIPATE IN THE GREEN TECHNOLOGY PILOT PROGRAM FOR THE ABOVE-IDENTIFIED APPLICATION. See Instruction Sheet on page 2.

This petition must be timely filed electronically using the USPTO electronic filing system, EFS-Web.

1. By filing this petition:

   Applicant is requesting early publication: Applicant hereby requests early publication under 37 CFR 1.219 and the publication fee set forth in 37 CFR 1.18(d) accompanies this request. Applicant hereby rescinds under 37 CFR 1.213(b) any previous filed request that the above-identified application not be published under 35 U.S.C. 122(b).

   If the application has been published, the petition must still be accompanied by the publication fee set forth in 37 CFR 1.18(d) and a statement that the application has been published.

2. By filing this petition: applicant is agreeing to make an election without traverse in a telephonic interview and elect an invention that meets the eligibility requirement and classification requirement set forth in the notice entitled "Pilot Program for Green Technologies Including Greenhouse Gas Reduction" that was published in the Federal Register if the Office determines that the claims are not obviously directed to a single invention.

3. This request is accompanied by statements of special status for the eligibility requirement.

4. The application contains no more than three (3) independent claims and twenty (20) total claims.

5. The application does not contain any multiple dependent claims.

6. Other attachments: _____

Signature /John P. Ward/	Date January 19, 2010
Name (Print/Typed) John P. Ward	Registration Number 40,216

Note: *Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required in accordance with 37 CFR 1.33 and 11.18. Please see 37 CFR 1.4(d) for the form of the signature. If necessary, submit multiple forms for more than one signature, see below*.*

☐ *Total of _____ forms are submitted.

The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Ron Hadar et al.	**Examiner:**	***
Serial No.:	12/628,977	**Art Unit:**	1795
Filed:	December 1, 2009	**Confirmation:**	6958
Title:	SYSTEMS AND METHODS FOR AN ENHANCED WATCHDOG IN SOLAR MODULE INSTALLATIONS		

Mail Stop Petition
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

STATEMENT OF THE BASIS FOR SPECIAL STATUS

Sir/Madam:

The invention of the subject application, which is related to automatically or remotely rendering a solar energy array safe during an emergency or during maintenance, materially contributes to the development of renewable energy resources or energy conservation, and thus is eligible for special status under the Green Technology Pilot Program.

Respectfully submitted,

Date: January 19, 2010

/John P. Ward/
John P. Ward
Reg. No. 40,216

Customer Number 64494
GREENBERG TRAURIG, LLP
(650) 328-8500 Telephone
(650) 328-8508 Facsimile

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Ron Hadar et al.	**Examiner:**	***
Serial No.:	12/628,977	**Art Unit:**	1795
Filed:	December 1, 2009	**Confirmation:**	6958
Title:	SYSTEMS AND METHODS FOR AN ENHANCED WATCHDOG IN SOLAR MODULE INSTALLATIONS		

Mail Stop Petition
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REQUEST FOR EARLY PUBLICATION UNDER 37 CFR §1.219

Sir/Madam:

Applicant respectfully requests early publication of the above-referenced patent application in accordance with 37 CFR §1.219. The publication fee set forth in 37 CFR §1.18(d) is submitted herewith.

Respectfully submitted,

Date: January 19, 2010

/John P. Ward/
John P. Ward
Reg. No. 40,216

Customer Number 64494
GREENBERG TRAURIG, LLP
(650) 328-8500 Telephone
(650) 328-8508 Facsimile

Electronic Patent Application Fee Transmittal

Application Number:	12628977
Filing Date:	01-Dec-2009
Title of Invention:	Systems and Methods for an Enhanced Watchdog in Solar Module Installations
First Named Inventor/Applicant Name:	Ron HADAR
Filer:	John Patrick Ward/Anne Collette
Attorney Docket Number:	108144-202701/US (TGY027)

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Publ. Fee- early, voluntary, or normal	1504	1	300	300
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**300**

Electronic Acknowledgement Receipt

EFS ID:	6841342
Application Number:	12628977
International Application Number:	
Confirmation Number:	6958
Title of Invention:	Systems and Methods for an Enhanced Watchdog in Solar Module Installations
First Named Inventor/Applicant Name:	Ron HADAR
Customer Number:	64494
Filer:	John Patrick Ward/Anne Collette
Filer Authorized By:	John Patrick Ward
Attorney Docket Number:	108144-202701/US (TGY027)
Receipt Date:	19-JAN-2010
Filing Date:	01-DEC-2009
Time Stamp:	21:23:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$300
RAM confirmation Number	7428
Deposit Account	502638
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Petition for Green Tech Pilot	108144-202701US_Green_Technology_Petition.pdf	115563 a457a5d45efcf780e2a29a275c486b5482845539	no	1
Warnings:					
Information:					
2	Miscellaneous Incoming Letter	108144-202701US_Statement_of_Basis_for_Special_Status.pdf	21142 c545ddc2fc82cc71118ad65e52ba74a5b95428a4	no	1
Warnings:					
Information:					
3	Request for Early Publication	108144-202701US_Early_Publication_Request.pdf	22584 ebfcdc69610d2f6ed5468bcb969623b6c4319c18	no	1
Warnings:					
Information:					
4	Fee Worksheet (PTO-875)	fee-info.pdf	30446 727fd8d0d00d22ec704b4b52312edab388f9dfc2	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	189735		

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/08a (07-09)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	12628977
Filing Date	2009-12-01
First Named Inventor	Ron Hadar
Art Unit	1795
Examiner Name	
Attorney Docket Number	108144-202701/US(TGY027)

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4580090		1986-04-01	Bailey et al.	
	2	4604567		1986-08-05	Chetty	
	3	4873480		1989-10-10	Lafferty	
	4	5027051		1991-06-25	Lafferty	
	5	5504418		1996-04-02	Ashley	
	6	5648731		1997-07-15	Decker et al.	
	7	5747967		1998-05-05	Muljadi et al.	
	8	5932994		1999-08-03	Jo et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Art Unit	1795
	Examiner Name	
	Attorney Docket Number	108144-202701/US(TGY027)

	9	7259474		2007-08-21	Blanc	
	10	7336004		2008-02-26	Lai	
	11	7394237		2008-07-01	Chou et al.	
	12	7462955		2008-12-09	McNamara	
	13	7518266		2009-04-14	Eckroad	
	14	7538451		2009-05-26	Nomoto	
	15	7545053		2009-06-09	Yoshikawa	
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	1	20050172995		2005-08-11	Rohrig et al.	

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	Filing Date	2009-12-01
	First Named Inventor	Ron Hadar
	Art Unit	1795
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	Attorney Docket Number	108144-202701/US(TGY027)

	2	20080036440		2008-02-14	Garmer	

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	1	0178757	EP		1986-04-23	TRW Inc.		☐
	2	11103538	JP		1999-04-13	My Way Giken KK		☐
	3	2005069096	WO		2005-07-28	Koninklijke Philips Electronics		☐
	4	2005112551	WO		2005-12-01	Hansung Engineering Co. LTD		☐

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	ALONSO, R. et al., "A New Distributed Converter Interface for PV Panels," 20th European Photovoltaic Solar Energy Conference, Barcelona, Spain, pp. 2288-2291, June 6-10, 2005.	☐
	2	ALONSO, R. et al., "Experimental Results of Intelligent PV Module for Grid-Connected PV Systems," 21st European Photovoltaic Solar Energy Conference, Dresden, Germany, pp. 2297-2300, September 4-8, 2006.	☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	12628977
	Filing Date	2009-12-01
	First Named Inventor	Ron Hadar
	Art Unit	1795
	Examiner Name	
	Attorney Docket Number	108144-202701/US(TGY027)

	3	BASSO, Tim, "IEEE Standard for Interrconnecting Distributed Resources With the Electric Power System," IEEE PES Meeting, June 9, 2004.	☐
	4	Boostbuck.com, "The Four Boostbuck Topologies," located at http://www.boostbuck.com/TheFourTopologies.html, 2003.	☐
	5	ENSLIN, Johan H.R., et al., "Integrated Photovoltaic Maximum Power Point Tracking Converter," IEEE Transactions on Industrial Electronices, Vol. 44, No. 6, pp. 769-773, December 1997.	☐
	6	GAUTAM, Nalin K. et al., "An Efficient Algorithm to Simulate the Electrical Performance of Solar Photovoltaic Arrays," Energy, Vol. 27, No. 4, pp. 347-361, 2002.	☐
	7	LINARES, Leonor et al., "Improved Energy Capture in Series String Photovoltaics via Smart Distributed Power Electronics," 24th Annual IEEE Applied Power Electronics Conference and Exposition, pp. 904-910, February 15, 2009.	☐
	8	NORDMANN, T. et al., "Performance of PV Systems Under Real Conditions," European Workshop on Life Cycle Analysis and Recycling of Solar Modules, The "Waste" Challenge, Brussels, Belgium, March 18-19, 2004.	☐
	9	ROMAN, Eduardo, et al., "Intelligent PV Module for Grid-Connectred PV Systems," IEEE Transactions on Industrial Electronics, Vol. 53, No. 4, pp. 1066-1073, August 2006.	☐
	10	WALKER, Jeffrey R. et al., "Cascaded DC-DC Converter Connection of Photovoltaic Modules," IEEE Transactions on Power Electronics, Vol. 19, No. 4, pp. 1130-1139, July 2004.	☐

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	12628977
	Filing Date	2009-12-01
	First Named Inventor	Ron Hadar
	Art Unit	1795
	Examiner Name	
	Attorney Docket Number	108144-202701/US(TGY027)

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John P. Ward/	Date (YYYY-MM-DD)	2009-12-23
Name/Print	John P. Ward	Registration Number	40216

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

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(19) Europäisches Patentamt
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(11) Publication number: 0 178 757
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 85305606.7

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(30) Priority: 15.10.84 US 660811

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23.04.86 Bulletin 86/17

(84) Designated Contracting States:
DE FR GB IT

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(54) Solar array regulator.

(57) Apparatus for regulating the voltage output of a solar cell array by selectively actuating individual cells that have been constructed to include a light control valve capable of being rendered opaque or transparent under electrical control. By automatically controlling selected cells in the array in this manner, the output characteristics of the array can be regulated to compensate for variations caused by temperature or other changes.

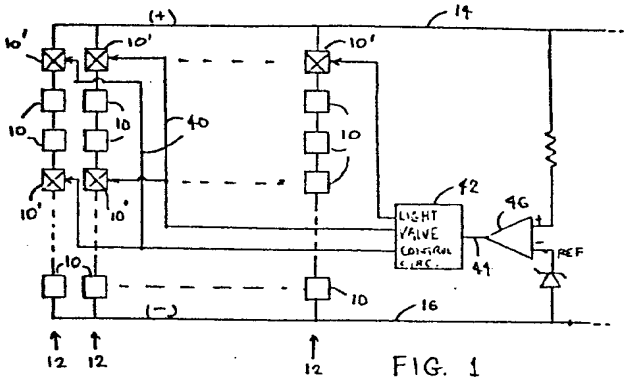


FIG. 1

EP 0 178 757 A2

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SOLAR ARRAY REGULATOR

BACKGROUND OF THE INVENTION

This invention relates generally to solar cell arrays, and more particularly, to techniques for regulating the electrical output of an array in varying conditions. Arrays of semiconductor solar cells are frequently used as the principal power source in spacecraft and terrestrial application, to power battery charging circuits, or to power other electical equipment directly.

Although solar cell arrays are an efficient and reliable power source, there are some commonly encountered conditions that vary the operating characteristics of such arrays. Variations in temperature can produce wide variations in the output voltage of a solar cell array, and some form of voltage regulation is therefore necessary. More specifically, the maximum or open-circuit voltage available from an array is significantly increased when the temperature of the cells making up the array is relatively low. When a spacecraft emerges from a shadow condition, as when eclipsed by the earth or some other body, the temperature of the array may be as low as approximately -176 degrees C. After exposure to direct sunlight for some minutes, the temperature may rise by as much as 200 degrees C. The voltage output from an array that has just emerged from shadow may be almost double the value obtained after the array reaches its equlibrium temperature in sunlight.

Unless the electrical load on the array can be increased during periods when the temperature is low, the output voltage must be regulated down to a

lower value. The technique normally used is to bypass or short-circuit strings of cells by means of high-power switching transistors. If each string of cells in the array is shortened by appropriate switching, the output of the array is reduced, but only at the expense of power dissipation in the switching transistors. Consequently, the power dissipation of the transistors is greatly increased during periods that the voltage is being regulated in this manner.

It will be appreciated from the foregoing that there is a need for an alternative technique for regulating the electrical output of a solar cell array during conditions of increased voltage. This need is especially accute in spacecraft power supply applications, but is also present in terrestrial applications in which arrays are subject to wide temperature fluctuations.

SUMMARY OF THE INVENTION

The present invention resides in the use of an electrically controlled optical device to regulate the output from a solar cell array having multiple solar cells. Basically, and in general terms, the apparatus of the invention comprises means for providing control signals indicative of a desired change in electrical output of the array, and electrically operated light valve means installed on selected cells of the array and operable by the control signals to control the amount of radiation reaching the selected cells, and therefore the total electrical output of the array. The means for providing control signals includes means for monitoring the output voltage of the solar cell array, means for comparing

the monitored output voltage with a desired reference value and generating a difference signal, and control means responsive to the difference signal, to generate control signals to regulate the output of the array.

More specifically, the light valve means may take the form of cover panels that include a liquid crystal element. The control signals are then effective to render the cover panels relatively opaque to at least some portion of the solar radiation spectrum.

The control means of the invention may be constructed to provide a plurality of control signals, the number of which is dependent on the magnitude of the difference signal. For larger differences between the actual voltage and the desired reference voltage, a larger number of control signals will be generated, each being coupled to separate cells or groups of cells in the array. Alternatively, the light valve means is responsive to an analog signal to provide varying degrees of opaqueness, and the control means then produces a single analog control signal, the magnitude of which determines the degree to which all of the light valve means are rendered opaque.

Although liquid crystal displays provide the necessary characteristics to function as a light valve, other materials under development may prove to have superior characteristics. For example, a ceramic material referred to as PLZT (lead lanthanate zirconate titanate) has electrically controllable light transmission properties.

It will be appreciated from the foregoing that the present invention represents a significant advance in the field of solar cell arrays. In par-

ticular, the invention provides an efficient technique for modulating the voltage output from a solar array without bypassing cells in the array. Other aspects and advantages of the invention will become apparent from the following more detailed description, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a simplified schematic diagram of a solar cell array, the voltage output of which is regulated in accordance with the invention;

FIG. 2 is a graph showing the current-versus-voltage characteristics of a solar cell array; and

FIG. 3 shows the comparative current-versus-voltage characteristics of a typical solar cell having a liquid crystal display (LCD) light valve installed and either activated or inactivated.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in the drawings for purposes of illustration, the present invention is concerned with a novel technique for regulating the output voltage of an array of solar cells. A single solar cell is a diode of silicon or other semiconductor material, having the property that an electrical current is generated as a result of the incidence of light on the cell. A single cell can generate an open-circuit voltage of about 0.5 volt, i.e. when no load is connected to the cell, and has a short-circuit current of about 50 milliamperes (mA) or less, i.e. the current that flows when the output terminals of the cell

are connected together in a short-circuit condition. Because the electrical output of a single cell is of little practical application, cells are typically connected together in an array having multiple strings of series-connected cells. Each string has a combined voltage output of many times that of a single cell. Increased current output is provided by connecting multiple strings in parallel to form the array.

Such an array is shown in fragmentary and diagrammatic form in FIG. 1. Multiple cells, indicated by reference numeral 10, are connected in series strings 12, which are connected together in parallel between two output buses 14 and 16. A typical current-versus-voltage characteristic for an array is shown in FIG. 2. If the output buses are open-circuited, the output current is zero and the output voltage is the open-circuit voltage, which is indicated as approximately 38 volts. If the output buses are connected together, the output voltage is zero and the current generated is the short-circuit current, indicated as I_{sc}. At the short-circuit current condition, the load impedance is zero. If the load impedance is gradually increased, the output voltage also increases, but the current initially remains relatively constant, as indicated by the curve 20. As the voltage approaches its open-circuit value, the current begins to drop off rapidly.

The characteristic has a limiting operating point, indicated at 22, at which the output power, the product of current and voltage, will be at a maximum. When the array is not electrically loaded, the open-circuit output voltage will be generated. As electrical load is added to the array, the voltage will fall off slightly, and the current will in-

crease, providing increasing power output from the array. However, when the maximum power output point 22 is reached, further attempts to increase the load will result in significant reduction in the voltage and the output power. A typical, partly loaded condition is indicated by the load line 24.

The problem with which the invention is concerned arises because the current-voltage characteristic 20 changes significantly when the array is at a lower operating temperature, as when a spacecraft on which the array is installed has just emerged from a shadow. The characteristic for such a reduced temperature condition is shown at 20'. The curve 20' has the same general shape as curve 20, but the short-circuit current is reduced and the open-circuit voltage is increased. Typically, a single solar cell has a temperature coefficient of 2 millivolts (mv) per degree C, i.e., the voltage output of the cell changes by 2mv for each degree of temperature change. For a string of a hundred cells exposed to temperature differences of 200 degrees, the overall voltage variation can be as high as 40 volts, or a 100-percent variation. Unless the electrical load can be increased, some means must be provided to regulate this increased voltage down to the normal level. In the past, this has been done by selectively short-circuiting sub-strings of cells by means of high-power switching transistors, in which power must be dissipated.

In accordance with the invention, selected cells, indicated at 10', are provided with a light control valve, to "shadow" these cells from radiation and thereby reduce the total voltage generated by each series string 12. Electrically actuated light valves have been known for some time, but not applied

to the problem of solar array voltage regulation. United States Pat. No. 2,185,379 to Meyers et al. discloses an electrically controlled light valve proposed for use in a projection television system. The use of electric fields to control a diffraction grating is disclosed in United States Pat. No. 3,813,142 to Buhrer. Moreover, the properties of liquid crystal cells for use as optical switches in a general sense is well known. There are many patents and publications concerning liquid crystals and liquid crystal displays (LCDs). For example, United States Pat. No. 4,385,799 to Soref and United States Pat. No. 3,791,716 to Borel et al.

Each of the selected cells 10' includes a cover panel having an electrically controllable element, by means of which the transmission of light to the cell is controlled. Basically, the controllable element must be able to render the cover panel relatively opaque to radiation over some portion of the spectrum to which the cell is responsive.

One controllable element that satisfies this requirement is the liquid crystal display (LCD) element. As is well known, the application of an electric field to the liquid crystal element results in an arrangement of the crystalline structure that renders the element relatively opaque and black in appearance. A suitable LCD element is liquid crystal Model No. CIN-6-ITC manufactured by UCE Inc., of Norwalk, Connecticut 06855.

FIG. 3 shows how the output characteristic of a solar cell is effected by activation of the electrically controllable element. Curve 30 shows the I-V characteristic when the LCD element is inactive and relatively transparent, and curve 32 shows the same characteristic after activation of the ele-

ment to render it relatively opaque. The output current is reduced by about half and the voltage reduced by a lesser amount. A more ideal light valve element would effectively collapse the output characteristic and produce zero output contribution to a string of cells.

Another possible material for use as a light valve is an optical ceramic material referred to as PLZT (lead lanthanate zirconate titanate). This and related materials have been investigated for various applications, such as in aircraft cockpit windows and protective eye shields. These ceramic materials can be controlled to provide good reflectivity properties, suitable for reflecting incident radiation from selected solar cells in an array.

In a practical application of the principles of the invention, each of the selected cells 10' is connected by control lines 40 to a control circuit 42. The control circut 42 receives on line 44 a signal indicative of the difference between the actual output voltage of the array and a reference voltage. The difference signal is provided by a diffenece amplifier 46 to which are connected two input lines 48 and 50 carrying signals indicative of the actual and reference voltages, respectively. The function of the control circuit 42 is to produce control signals on lines 40 to "shadow" selected ones of the cells 10'. It will be apreciated that the nature of the control signals on lines 40 will depend on the nature of the light control valve elements used in the cells 10'. If the control valves are binary in nature, that is either on or off, the control signals will also be binary and will be distributed in such a manner as to effect the desired reduction in output from the array, by actuating an appropriate number of

the cells 10' in each array string 12. If the control valves are analog in nature, providing a continuously variable tranmissivity of light, then the control signals on line 40 will also be analog signals, varying the transmissivity of all of the selected cells 10' by an appropriate amount to regulate the output voltage to its desired level.

One difficulty with selective shadowing of cells in an array, is that each shadowed cell that produces no output, or a reduced output, functions as an electrical load on the array. If a single cell in a string is selected for shadowing, the voltage across the cell can be high enough that significant power is dissipated in the cell in the form of heat. This creates a "hot spot" in the array, which can have a significant effect on the mechanical design of the array. The problem can be minimized by ensuring that cells selected for shadowing are spaced apart by no more than some minimum amount in each cell string.

It will be appreciated from the foregoing that the present invention represents a significant advance in the field of solar cell arrays. In particular, the invention provides a novel technique for regulating the electrical output of an array without using switching transistors to selectively short-circuit strings of cells. The advantages of the technique are that it uses a small number of additional parts, it is light in weight, and it consumes very little power to effect control of the array.

It will be also appreciated that, although a specific embodiment of the invention has been described in detail for purposes of illustration, various modifications may be made without departing from the spirit and scope of the invention. Accordingly, the invention is not to be limited except as by the appended claims.

CLAIMS

1. Apparatus for regulating the electrical output of a solar cell array having multiple solar cells, the apparatus comprising:

means for providing control signals indicative of a desired change in electrical output of the array; and

electrically actuated light valve means installed on selected cells of the array and operable by the control signals to control the amount of radiation reaching the selected cells, and therefore the total electrical output of the array.

2. Apparatus as set forth in claim 1, wherein the means for providing control signals includes:

means for monitoring the output voltage of a solar cell array;

means for comparing the monitored output voltage with a desired reference value and generating a difference signal; and

control means responsive to the difference signal, to generate the control signals to regulate the output of the array.

3. Apparatus as set forth in claim 1, wherein:

the electrically actuated light valve means includes a cell cover panel having a liquid crystal element switchable between a relatively transparent condition and a relatively opaque condition.

4. Apparatus as set forth in claim 2, wherein:

the electrically actuated light valve means includes a cover panel having a liquid crystal element switchable between a relatively transparent condition and a relatively opaque condition.

5. Apparatus as set forth in claim 1, wherein:

the electrically actuated light valve means includes a cover panel of an optical ceramic material.

6. Apparatus as set forth in claim 2, wherein:

the electrically actuated light valve means includes a cover panel of an optical ceramic material.

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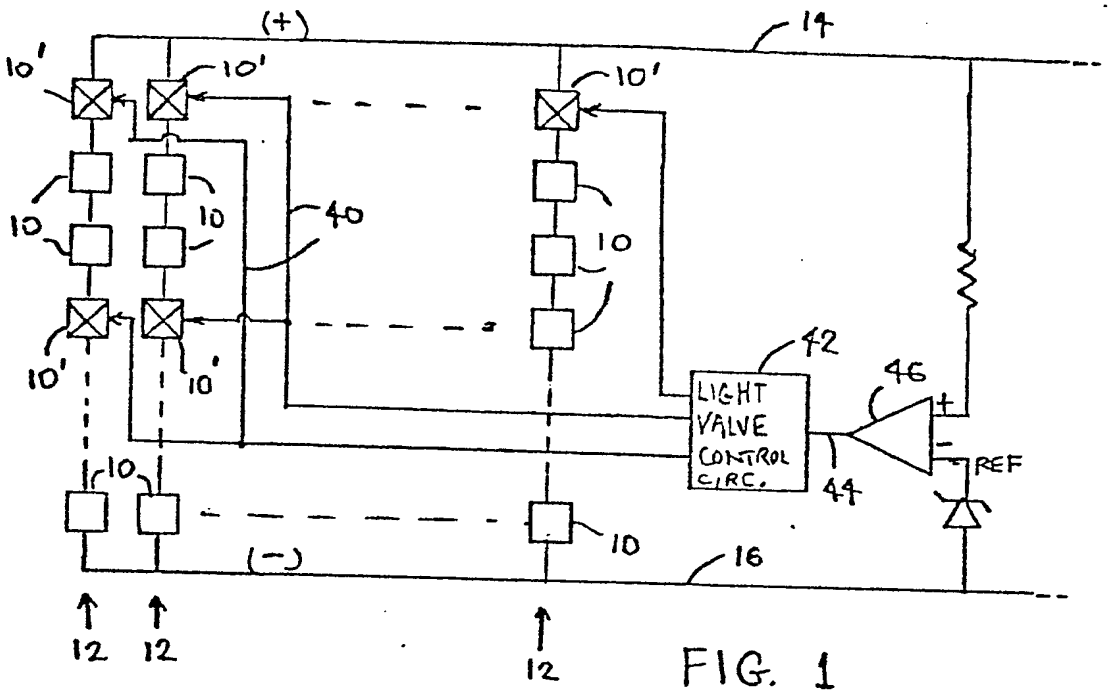


FIG. 1

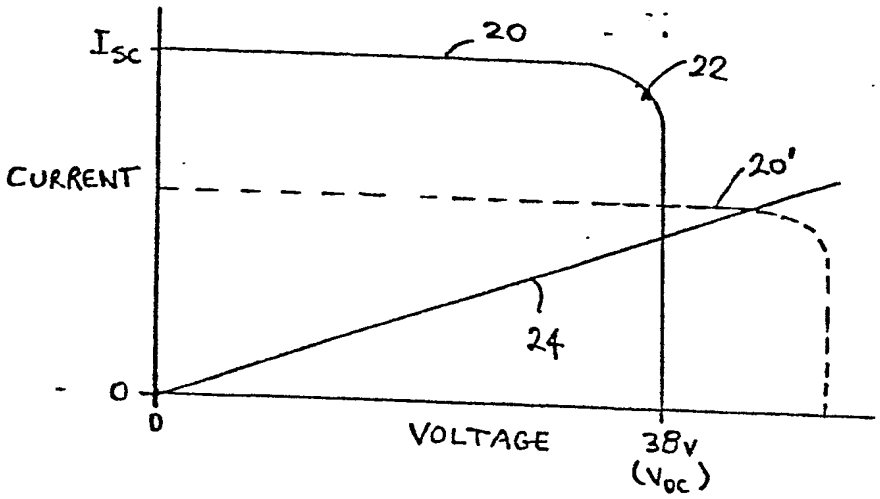


FIG. 2

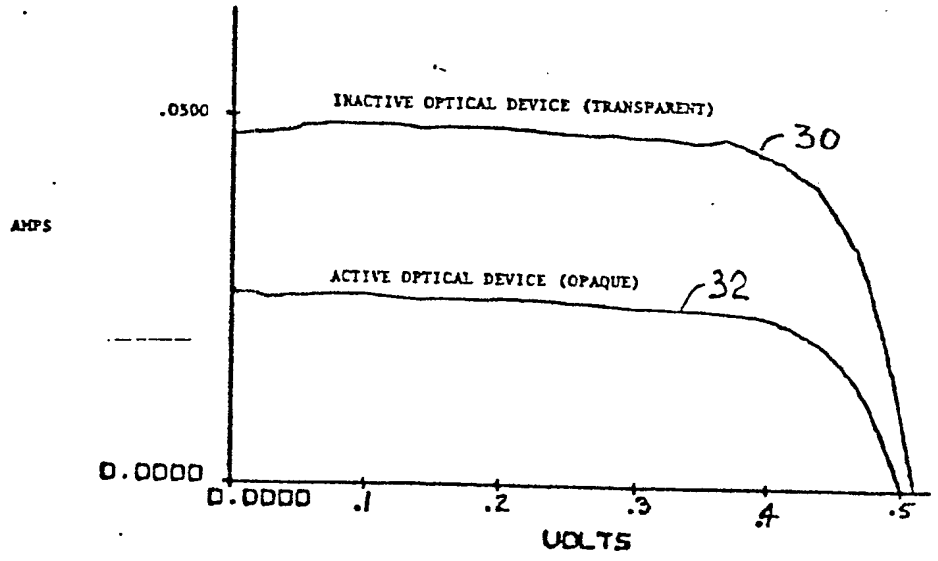


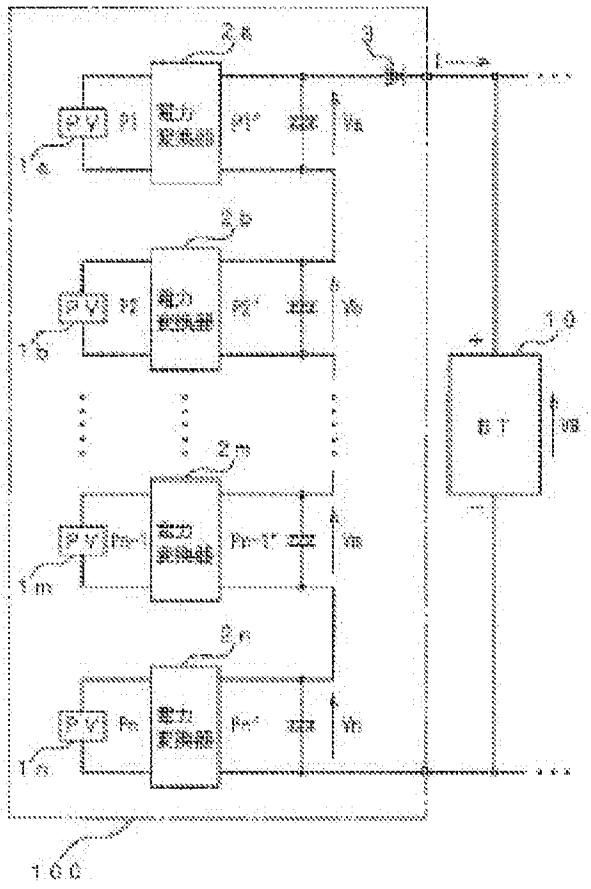
FIG. 3

OPTICAL POWER GENERATING SYSTEM

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Publication date: 1999-04-13
Inventor(s): HAYASHI YOICHI; YOU CHIYUUKEI
Applicant(s): MY WAY GIKEN KK
Classification:
- international: ***H01L31/042; H02J7/35;*** **H01L31/042; H02J7/35;** (IPC1-7): H02J7/35; H01L31/042
- European:
Application number: JP19970279497 19970927
Priority number(s): JP19970279497 19970927

Abstract of **JP 11103538 (A)**

PROBLEM TO BE SOLVED: To provide an optical power generating system that can prevent decrease of power generating efficiency of the whole system. SOLUTION: An optical power generating system 100 comprises a plurality of solar battery modules 1a to 1n, and a plurality of power converters 2a to 2n respectively connected to the modules 1a to 1n and having maximum solar energy pursuing functions. The converters 2a to 2n are connected in series to one another. The modules 1a to 1n have their output current and output voltage controlled by the maximum solar energy pursuing functions of the converters 2a to 2n, so that the maximum power generating efficiency can be always obtained. Further, a common output current flows through the output terminals of the converters 2a to 2n, and the output voltages are automatically adjusted, so that the ratio of any two voltages becomes equal to the ratio of the maximum powers of the corresponding two of the modules 1a to 1n.



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PATENT ABSTRACTS OF JAPAN

[INFORMAL TRANSLATION]

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CLAIMS

[Claim 1] Two or more power converters which have a maximum dissipation tailing function which takes out the maximum dissipation from two or more optical power generation bodies which transform light energy into electrical energy, and said optical power generation body which is connected to each of two or more of said optical power generation bodies, and corresponds, A preparation, an optical power generation system connecting said two or more power converters in series.

[Claim 2] An optical power generation system which carried out multiple connection of two or more power generation modules, comprising:
Two or more optical power generation bodies from which each of said power generation module transforms light energy into electrical energy.
Two or more power converters which have a maximum dissipation tailing function which takes out the maximum dissipation from said optical power generation body which an input edge is connected to each of two or more of said optical power generation bodies, and the series connection of the outgoing end of each other is carried out, and corresponds.

[Claim 3] An optical power generation system characterized by said optical power generation body being the solar cell module which combined a photovoltaic cell in claim 1 or 2.

[Claim 4] An optical power generation system characterized by said optical power generation body being the solar panel which combined a solar cell module in claim 1 or 2.

[Claim 5] An optical power generation system characterized by said power converter being a direct current to direct current converter in either of claims 1-4.

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Ｈ０１Ｌ　31/042		Ｈ０１Ｌ　31/04	Ｒ

審査請求　未請求　請求項の数５　ＦＤ　（全　７　頁）

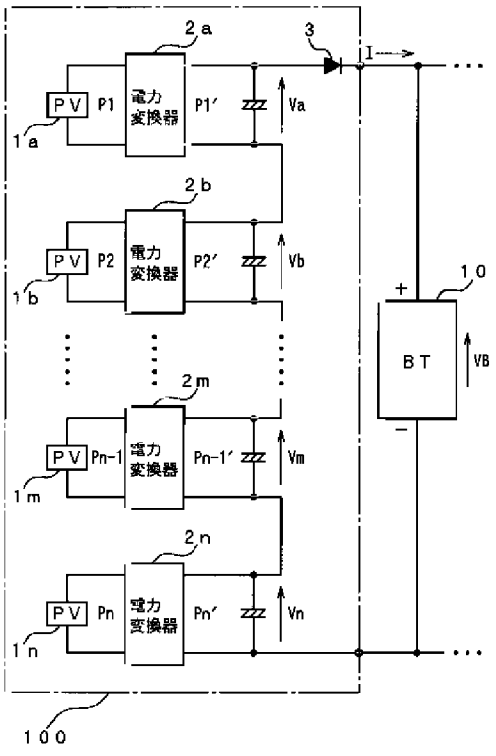
(21)出願番号　特願平9－279497

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(54)【発明の名称】　光発電システム

(57)【要約】
【課題】　システム全体の発電効率の低下を防止することができる光発電システムを提供すること。
【解決手段】　光発電システム１００は、複数の太陽電池モジュール１ａ～１ｎと各陽電池モジュール１ａ～１ｎに接続された最大電力追尾機能を有する複数の電力変換器２ａ～２ｎとを含んで構成されており、各電力変換器２ａ～２ｎは直列に接続されている。各太陽電池モジュール１ａ～１ｎは、電力変換器２ａ～２ｎの最大電力追尾機能によって、常に最大の発電効率となるように出力電流および出力電圧が制御される。また、電力変換器２ａ～２ｎの各出力端には共通の出力電流が流れており、各出力電圧はそれぞれの比が各太陽電池モジュール１ａ～１ｎの最大電力の比となるように自動調整される。



【特許請求の範囲】
【請求項１】　光エネルギーを電気エネルギーに変換する複数の光発電体と、
前記複数の光発電体のそれぞれに接続され、対応する前記光発電体から最大電力を取り出す最大電力追尾機能を有する複数の電力変換器と、
を備え、複数の前記電力変換器を直列に接続することを特徴とする光発電システム。
【請求項２】　複数の発電モジュールを並列接続した光発電システムであって、前記発電モジュールのそれぞれは、
光エネルギーを電気エネルギーに変換する複数の光発電体と、
入力端が前記複数の光発電体のそれぞれに接続され、出力端が互いに直列接続され、対応する前記光発電体から最大電力を取り出す最大電力追尾機能を有する複数の電力変換器と、
を備えることを特徴とする光発電システム。
【請求項３】　請求項１または２において、
前記光発電体は、太陽電池セルを組み合わせた太陽電池モジュールであることを特徴とする光発電システム。
【請求項４】　請求項１または２において、
前記光発電体は、太陽電池モジュールを組み合わせた太陽電池パネルであることを特徴とする光発電システム。
【請求項５】　請求項１～４のいずれかにおいて、
前記電力変換器は、直流／直流変換器であることを特徴とする光発電システム。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、光発電体から出力される電圧、電流を電力変換して負荷やバッテリに出力する光発電システムに関する。
【０００２】
【従来の技術】近年、光発電体の応用技術として太陽光発電が普及しつつある。太陽光発電においては、日射強度や周囲温度などの自然条件や太陽電池の経年変化などにより太陽電池の出力電圧－出力電流特性が変化する。したがって、太陽電池の出力電圧および出力電流を最大電力が取り出せる動作点（最適動作点）に保つためには、いわゆる最大電力追尾制御（ＭＰＰＴ制御）が不可欠である。
【０００３】図４は、従来の光発電システムの構成を示す図である。同図に示すように、複数個の太陽電池モジュール１０１ａ～１０１ｎを直列に接続して太陽電池パネル１０５が構成され、その出力がＭＰＰＴ制御機能を有する電力変換器１０２を介して負荷に接続されている。また、それぞれの太陽電池モジュール１０１ａ～１０１ｎには、太陽電池モジュール１０１ａ等の表面の汚れや日陰などによる日光の遮断あるいは故障等によって発電能力が低下したり発電しなくなったりしたときに、正常に作動している他の太陽電池モジュール１０１ａ～１０１ｎから出力される電流を流すために、バイパス素子としてのダイオード（バイパスダイオード）１０４ａ～１０４ｎが接続されている。
【０００４】
【発明が解決しようとする課題】ところで、図４に示したように各太陽電池モジュール１０１ａ～１０１ｎを直列接続して太陽電池パネル１０５から電力を取り出す場合には全ての太陽電池モジュール１０１ａ～１０１ｎに同じ電流が流れる。これは、ＭＰＰＴ制御を行った場合も同様であり、太陽電池パネル１０５の全体として最大電力が得られるように所定の出力電流値が設定される。しかし、各太陽電池モジュール１０１ａ～１０１ｎの最適動作点は、光の入射条件や特性の違いなどからそれぞれ異なっており、同一の出力電流値で全ての太陽電池モジュール１０１ａ～１０１ｎを最適動作点で動作させることはできない。すなわち、太陽電池パネル１０５を構成するすべての太陽電池モジュール１０１ａ～１０１ｎから最大電力を取り出すことができるように最適動作点を定めることはできないため、それぞれの太陽電池モジュール１０１ａ～１０１ｎの最大発電能力を同時に引き出すことができなかった。
【０００５】このような発電効率の低下を防止するためには、太陽電池モジュール１０１ａ～１０１ｎの各出力電圧Ｖ１～Ｖｎを、各太陽電池モジュール１０１ａ～１０１ｎにおいて最適動作点になるように制御すればよい。図５は、直列接続された複数個の太陽電池モジュール１０１ａ～１０１ｎの出力電圧Ｖａ～Ｖｎを可変に制御する発電制御装置の構成を示す図である。同図に示すように、太陽電池モジュール１０１ａ～１０１ｎには、スイッチング素子１０６ａ～１０６ｎのそれぞれが接続されている。この発電制御装置は、各スイッチング素子１０６ａ～１０６ｎのオフデューティ（スイッチング素子のオンオフ周期とオフ期間の比率）Ｄａ～Ｄｎを変えることで出力電圧の比が制御可能であり、出力電圧とオフデューティの間には、
Ｖ１：Ｖ２：…：Ｖｎ＝Ｄａ：Ｄｂ：…：Ｄｎ
の関係が成立する。すなわち、オフデューティＤａ～Ｄｎの比を制御して、全ての太陽電池モジュール１０１ａ～１０１ｎが最適動作点で動作できるようにそれぞれの出力電圧Ｖ１～Ｖｎを設定することにより、各太陽電池モジュール１０１ａ～１０１ｎから最大電力を取り出すことが可能となる。
【０００６】しかし、上述した発電制御装置は、スイッチング素子１０６ａ～１０６ｎのそれぞれのオフデューティを異なる値に制御しなければならないため、制御方法が複雑になる。また、各太陽電池モジュール１０１ａ～１０１ｎを最適動作点で動作させようとすると、予め太陽電池モジュール１０１ａ等の数を決めておく必要があり、太陽電池モジュール１０１ａ等の数を変更した光

発電システムにおいては、その都度オフデューティの比も変更しなければならず、構成の柔軟性に欠けるという問題点があった。

【０００７】本発明は、このような点に鑑みて創作されたものであり、その目的は、システム全体の発電効率の低下を防止することができる光発電システムを提供することにある。

【０００８】

【課題を解決するための手段】上述した課題を解決するために、本発明の光発電システムは、光エネルギーを電気エネルギーに変換する複数の光発電体と、この光発電体のそれぞれに接続される最大電力追尾機能を有する複数の電力変換器とを有しており、これらの電力変換器が直列に接続されて構成されている。それぞれの電力変換器は、最大電力追尾機能により、接続された光発電体から最大電力を取り出すことができるように、光発電体から出力される電圧や電流の制御を行っている。上述したように、それぞれの光発電体から最大電力を取り出すことができる動作点（最適動作点）は、光発電体ごとに異なるが、このように、光発電システムを構成するそれぞれの光発電体が別個に常に最大電力を発生するように制御されるため、光発電システム全体の発電効率の低下を防止することができる。さらに、それぞれの光発電体の発電効率は、電力変換器の最大追尾機能によって制御されており、他の光発電体の発電効率の変動によって何ら影響を受けるものではないため、負荷容量等に応じて光発電体の数を変更するような場合であっても常に各光発電体を最適動作点で動作させることができ、柔軟性のある光発電システムを実現することができる。

【０００９】また、上述した構成を有する発電モジュールを並列に接続して、より大きな発電電力を得る光発電システムを構築することもできる。このような光発電システムにおいて各発電モジュールは別々に発電動作を行っており、各発電モジュール内の光発電体は最適動作点で動作するため、光発電システム全体としての発電効率の低下を防止することができる。

【００１０】上述した光発電体は、具体的には太陽電池セルを組み合わせた太陽電池モジュールであり、あるいはこれをさらに複数個組み合わせた太陽電池パネルであって、これらを単位として最大電力が取り出せるように制御が行われる。特に、太陽電池モジュールごとに最適動作点で動作させることにより、光発電システム全体での発電効率の低下を最小限に抑えることができる。また、それよりも大きな太陽電池パネルごとに最適動作点で動作させることにより構成の簡略化が可能となる。

【００１１】また、上述した電力変換器は最大電力追尾機能を有する直流／直流変換器であり、各光発電体を最適動作点で動作させた状態で、負荷に印加する全体の出力電圧（各電力変換器の出力電圧の総和）を一定に保ちながら、最大の出力電流を流すことができる。したがって、光発電システムの発電量が常に個々の光発電体の最大発電量の総和になり、各光発電体の特性や日照状態の相違による発電効率の低下を防止することができる。

【００１２】

【発明の実施の形態】本発明を適用した一実施形態の光発電システムは、複数の太陽電池モジュールのそれぞれにＭＰＰＴ制御機能を有する電力変換器を接続して、それぞれの太陽電池モジュールが最適動作点で動作（発電）するように制御を行うことに特徴がある。以下、本発明を適用した一実施形態の光発電システムについて、図面を参照しながら具体的に説明する。

【００１３】（１）光発電システムの全体構成

図１は、本発明を適用した一実施形態の光発電システムの全体構成を示す図である。同図に示すように、光発電システム１００は、複数個の太陽電池モジュール１ａ～１ｎ、複数の電力変換器２ａ～２ｎ、逆電流防止ダイオード３を含んで構成されている。なお、同図に示す光発電システム１００には、バッテリ装置１０とその他の電気機器（図示せず）が電気負荷として接続されており、これらの電気負荷が充分大きくて、ＭＰＰＴ制御を行って発生した最大の出力電流が常にこれらの電気負荷に流れるものとして説明を行う。

【００１４】太陽電池モジュール１ａ～１ｎのそれぞれは、直列または並列に接続された複数の太陽電池セル（ＰＶセル）から構成されている。ＰＶセルは、例えば、薄いＰ型シリコン半導体の層に薄いＮ型半導体の層を積み上げた形をしており、光が当たると、Ｐ型層側にプラス、Ｎ型層側にマイナスの起電力が発生する。この電力は、層の表面・裏面に形成された電極を通して集められる。

【００１５】また、太陽電池モジュール１ａ～１ｎは、それぞれ電力変換器２ａ～２ｎと接続されている。初段の電力変換器２ａは、一方の出力端子は逆電流防止ダイオード３を介してバッテリ装置１０のプラス端子に接続されており、他方の出力端子は次段の電力変換器２ｂの出力端子に接続されている。電力変換器２ｂ～２ｍのそれぞれは、一方の出力端子が前段の出力端子に接続されており、他方の出力端子が次段の出力端子に接続されている。最終段の電力変換器２ｎは、一方の出力端子は前段の電力変換器２ｍの出力端子に接続されており、他方の出力端子はバッテリ装置１０のマイナス端子に接続されている。

【００１６】逆電流防止ダイオード３は、日光の遮断や故障等によって光発電システム１００の発電能力が低下してその出力電圧がバッテリ装置１０の端子間電圧よりも低くなったときに、逆流する電流を防止するためのものである。

【００１７】（２）電力変換器の詳細構成および動作

次に、図１に示した電力変換器２ａ～２ｎの詳細な構成および動作について説明する。各電力変換器２ａ～２ｎ

は同じ構成を有しており、代表して電力変換器２ａについて説明する。図２は、電力変換器２ａの構成を示す図である。同図に示すように、電力変換器２ａは、電流センサ２１、電圧センサ２２、ＭＰＰＴ制御部２３、降圧型チョッパ回路部２４を含んで構成されている。

【００１８】電流センサ２１は、電力変換器２ａに接続された太陽電池モジュール１ａから流れ込む電流値をＭＰＰＴ制御部２３に出力し、電圧センサ２２は、電力変換器２ａに接続された太陽電池モジュール１ａから印加される電圧値をＭＰＰＴ制御部２３に出力する。ＭＰＰＴ制御部２３は、一定時間間隔で降圧型チョッパ回路部２４内部のスイッチング素子２５のオン時間とオフ時間の比を変更する。

【００１９】降圧型チョッパ回路部２４は、直流／直流コンバータであり、ＭＰＰＴ制御部２３からの指示に応じてスイッチング素子２５のオン時間とオフ時間の比を制御することにより、出力電圧が入力電圧以下の範囲で設定される。また、降圧型チョッパ回路部２４の入力電流は、スイッチング素子２５のオン時間とオフ時間の比を変更することにより制御可能であり、太陽電池モジュール１ａが最適動作点近傍で動作している場合にはこの入力電流を変えることにより入力電圧（太陽電池モジュール１ａの出力電圧）もこれに連動して変化する。これらの入力電流の変化は、電流センサ２１によって検出されてＭＰＰＴ制御部２３に伝えられ、また、入力電圧の変化は、電圧センサ２２によって検出されてＭＰＰＴ制御部２３に伝えられる。

【００２０】ＭＰＰＴ制御部２３は、これらの入力電流および入力電圧に基づいて太陽電池モジュール１ａから電力変換器２ａに入力される電力を算出し、前回（スイッチング素子２５のオン時間とオフ時間の比を変更する前）の電力の算出値との比較を行い、電力が大きくなる方向にスイッチング素子２５のオン時間とオフ時間の比を変更する。具体的には、以下のようにして、入力電力の比較を行い、スイッチング素子２５のオン時間とオフ時間の比を変更する。

【００２１】図３は、太陽電池モジュール１ａの出力電圧と出力電力の関係を示す特性図である。例えば、同図に示すＡ点で動作しているときに、ＭＰＰＴ制御部２３がスイッチング素子２５を制御することにより、動作点がＢ点に移った場合には、出力電力は増加したのであるから、より電力値が大きなＢ点での動作状態を維持する。また、Ｂ点で動作しているときに、ＭＰＰＴ制御部２３がスイッチング素子２５を制御することにより、動作点がＣ点に移った場合は、出力電力は減少したのであるから、ＭＰＰＴ制御部２３は、動作点をＢ点に戻すために再度スイッチング素子２５を制御する。

【００２２】このように、ＭＰＰＴ制御部２３は、一定時間間隔でスイッチング素子２５のオン時間とオフ時間の比を変更して、その都度、太陽電池モジュール１ａの入力電力の増減を監視することにより、太陽電池モジュール１ａの出力電力が常に最大となるように、つまり、太陽電池モジュール１ａが最適動作点で動作するように制御を行っている。また、電力変換器２ａに入力される電力が最大となるため、電力変換器２ａから出力される電力も最大となる。

【００２３】次に、電力変換器２ａ～２ｎから出力される電圧および電流について検討する。図１において、太陽電池モジュール１ａ～１ｎから出力される最大電力をそれぞれＰ１～Ｐｎ、電力変換器２ａ～２ｎから出力される電力をそれぞれＰ１′～Ｐｎ′、電力変換器２ａ～２ｎから出力される電圧をそれぞれＶ１～Ｖｎ、バッテリ装置１０の端子電圧をＶＢ、バッテリ装置１０等の電気負荷に流れる電流をＩとする。

【００２４】各電力変換器２ａ～２ｎにおける電力損失を零とすると、

$$P1=P1',\ P2=P2',\ \cdots,\ Pn=Pn' \qquad \cdots(1)$$

の関係が成り立つ。また、電圧ＶＢと電流Ｉは、次式で示される。

【００２５】

$$VB=V1+V2+\cdots+Vn \qquad \cdots(2)$$

$$I=P1/V1=P2/V2=\cdots=Pn/Vn \qquad \cdots(3)$$

この（３）式は、電力変換器２ａ～２ｎを直列に接続することによって、電力変換器２ａ～２ｎの各出力電圧Ｖ１～Ｖｎは、対応する太陽電池モジュール１ａ～１ｎの出力電力Ｐ１～Ｐｎに比例し、しかも各出力電圧Ｖ１～Ｖｎの比が各太陽電池モジュール１ａ～１ｎの比に等しくなるように制御されることを示している。

【００２６】例えば、太陽電池モジュール１ａのみが日陰に入って出力電力Ｐ１が低下した場合には、それまで太陽電池モジュール１ａが分担していた電圧および電流を維持できないため、各太陽電池モジュール１ａ～１ｎの出力電流が一定になるという条件の下で、上述した（１）式～（３）式を満たすように、各電力変換器２ａ～２ｎの出力電圧Ｖ１～Ｖｎとこれらに共通の出力電流Ｉが自動的に設定される。実際には、発電能力が低下した太陽電池モジュール１ａに接続された電力変換器２ａの出力電圧Ｖ１が低下し、それ以外の電力変換器２ｂ等の出力電圧Ｖ２等が上昇する。また、太陽電池モジュール１ａ以外の各出力電圧Ｖ２等が高くなることからも分かるように、共通の出力電流Ｉは低下する。また、このようにして各電力変換器２ｂ等の出力電圧と出力電流は変化するが、それぞれの入力側に接続されている太陽電池モジュール１ｂ等は別々にＭＰＰＴ制御されているため、常に最適動作点での動作を維持しており、その時点における最大電力が得られる。

【００２７】このように、本実施形態の光発電システム１００は、太陽電池モジュール１ａ～１ｎのそれぞれにＭＰＰＴ制御機能を有する電力変換器２ａ～２ｎを接続し、しかも各電力変換器２ａ～２ｎの出力端を直列接続して全体の出力電圧としている。したがって、各太陽電池モジュール１ａ～１ｎを別々にＭＰＰＴ制御して最適動作点で動作させることができ、光発電システム１００全体としての発電効率の低下を防止することができる。

【００２８】また、電力変換器２ａ～２ｎの出力端には共通の出力電流Ｉが流れ、各太陽電池モジュール１ａ～１ｎから出力される最大電力の比と等しくなるように各電力変換器２ａ～２ｎの出力電圧Ｖａ～Ｖｎが自動的に調整されるため、複雑な制御を行う必要がない。また、太陽電池モジュール１ａ～１ｎのいずれかに影や汚れによる、あるいは経年変化やもともとの特性のばらつきによる発電能力の低下が生じても、各太陽電池モジュール１ａ～１ｎにおいて最大電力が得られるように、各電力変換器２ａ～２ｎの出力電圧や出力電流が自動的に調整されるため、他の太陽電池モジュールへの影響がなく、光発電システム１００全体としての発電電力の低下を最小限に抑えることができる。

【００２９】これは、太陽電池モジュールおよび電力変換器の数が増加あるいは減少した場合も同様であり、各太陽電池モジュールを最適動作点で動作させながら、電力変換器の各出力電圧、出力電流が自動的に調整されるため、電気負荷の大きさに応じたシステム構成の変更が容易であり、柔軟性のある光発電システムを実現することができる。

【００３０】また、上述したように各太陽電池モジュール１ａ～１ｎは、互いに発電能力が異なるようにしてもよいため、太陽電池モジュール１ａ～１ｎのそれぞれの設置条件を意識的に変えて、光発電システム１００全体の発電特性の時間変化を調整することも容易である。

【００３１】また、大規模な光発電システムにおいては、複数の太陽電池モジュールを直列接続した太陽電池パネルの数を増やすとともに、各太陽電池パネルごとに電力変換器を設置し、その出力側を並列接続することにより、本実施形態の光発電システム１００と同様の効果が得られるが、光発電システム１００は太陽電池モジュール１ａ等の数が少ない家庭用の小規模システムにも適している。

【００３２】なお、本発明は、上記実施形態に限定されるものではなく、本発明の要旨の範囲内で種々の変形実施が可能である。例えば、上述した実施形態では、太陽電池モジュール１ａ～１ｎのそれぞれごとに電力変換器２ａ～２ｎを接続したが、複数の太陽電池モジュールによって太陽電池パネルを構成し、この太陽電池パネルごとに電力変換器を接続し、各電力変換器を直列に接続して電気負荷に接続するようにしてもよい。

【００３３】また、図１に示した光発電システム１００を単独でバッテリ装置１０等の電気負荷に接続するのではなく、図１に示した光発電システム１００と同じ構成を有する発電モジュールを複数備え、これを並列接続した光発電システムを構築して電気負荷に接続するようにしてもよい。この場合には、各発電モジュールは独立に動作するため、それぞれに含まれる太陽電池モジュール１ａ等を最適動作点で動作させることができるため、光発電システム全体の発電効率の低下を防止することができる。

【００３４】また、上述した実施形態では、太陽電池モジュール１ａ等から出力される電圧や電流を監視してＭＰＰＴ制御を行い、太陽電池モジュール１ａ等が最大効率で発電することができるように制御したが、他の方法によって制御してもよい。例えば、電力変換器２ａ等から出力される電圧および電流を監視してＭＰＰＴ制御を行ってもよい。この場合は、電流センサ２１および電圧センサ２２を電力変換器の出力段に備えるようにすればよい。また、太陽電池モジュール１ａ等から出力される電圧の変動が少ないことや出力される電流が周囲の温度によって大きく変動することに着目して、あらかじめ太陽電池モジュール１ａ等の出力電流－温度特性を記憶しておいて、太陽電池モジュール１ａ等の周囲の温度を監視することによって、ＭＰＰＴ制御を行うようにしてもよい。また、上述した実施形態では、電力変換器２ａ等に降圧型チョッパ回路部２４を用いたが、昇圧型のチョッパ回路を用いてもよい。

【００３５】また、上述した実施形態では、直列接続された複数の電力変換器２ａ～２ｎの後段にバッテリ装置１０を接続するようにしたが、バッテリ装置１０の前段に昇圧型の電力変換器（直流／直流変換器）を接続するようにしてもよい。上述したように、本実施形態の光発電システムでは、各太陽電池モジュール１ａ等の発電能力が低下したときに、対応する電力変換器２ａ等の出力電圧が相対的に低下するが、このようにして出力電圧が低下する電力変換器２ａ等の数が増えると、バッテリ装置１０に印加する電圧が低下して電力の供給が停止するおそれがある。ところが、昇圧型の電力変換器を挿入することにより、この出力電圧の低下を補うことができるため、動作範囲を広げることができる。

【００３６】

【発明の効果】上述したように、本発明によれば、光発電システムを構成するそれぞれの光発電体ごとに最大電力追尾機能を有する電力変換器が接続されており、これらの電力変換器は直列に接続されている。このため、電力変換器の最大電力追尾機能によって、それぞれの光発電体が別個に常に最大電力を出力するように制御されるため、光発電システム全体の発電効率の低下を防止することができる。さらに、それぞれの光発電体の発電効率は、電力変換器の最大追尾機能によって制御されており、他の光発電体の発電効率の変動によって何ら影響を

受けるものではないため、負荷容量等に応じて光発電体の数を変更するような場合であっても常に各光発電体を最適動作点で動作させることができ、柔軟性のある光発電システムを実現することができる。

【図面の簡単な説明】

【図１】本発明を適用した一実施形態の光発電システムの構成を示す図である。

【図２】電力変換器の構成を示す図である。

【図３】太陽電池モジュールの出力電圧－出力電力特性を示す図である。

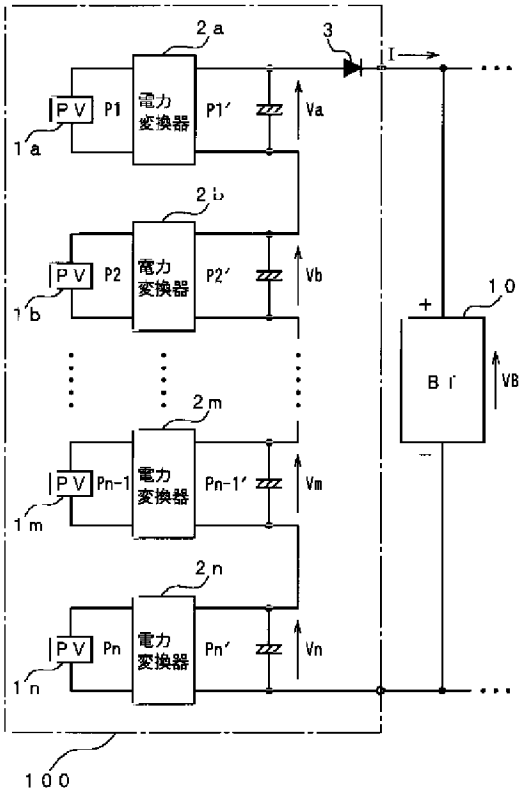
【図４】従来の光発電システムの構成を示す図である。

【図５】スイッチング素子が接続された太陽電池モジュールを用いた発電制御装置の構成を示す図である。

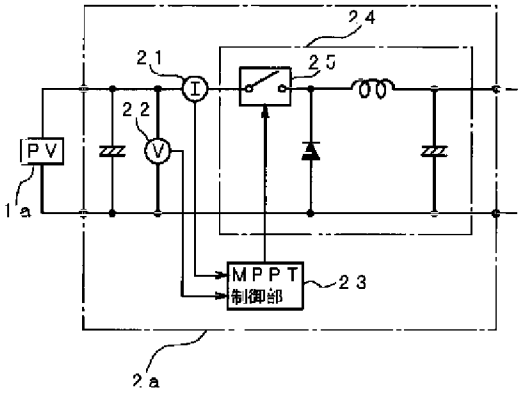
【符号の説明】

１ａ～１ｎ　太陽電池モジュール
２ａ～２ｎ　電力変換器
３　逆電流防止ダイオード
１０　バッテリ装置
２１　電流センサ
２２　電圧センサ
２３　ＭＰＰＴ制御部
２４　降圧型チョッパ回路部
２５　スイッチング素子
１００　光発電システム

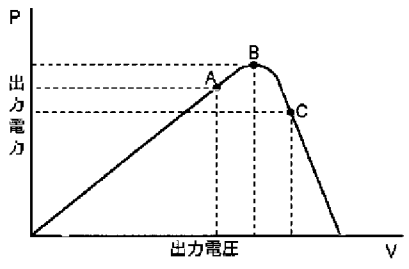
【図１】



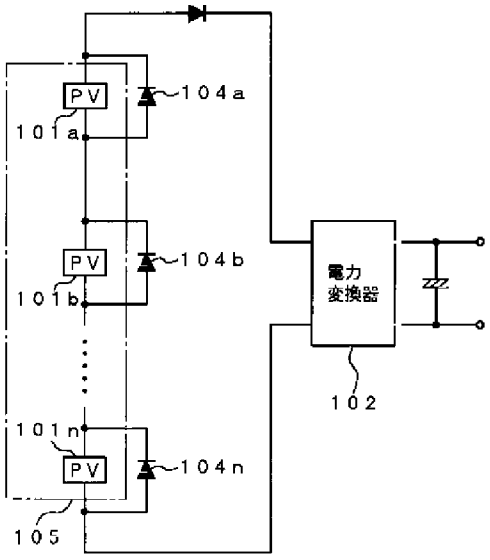
【図２】



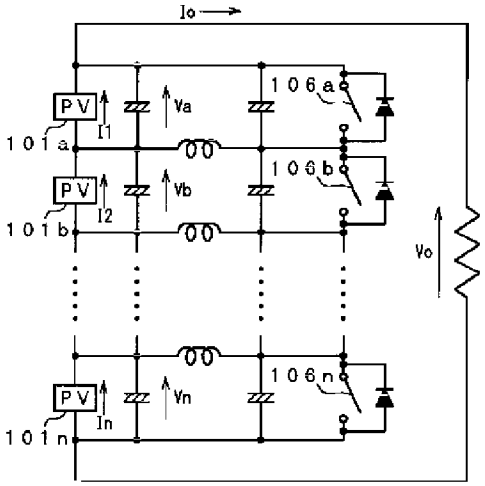
【図３】



【図４】



【図５】



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(74) Common Representative: **KONINKLIJKE PHILIPS ELECTRONICS, N.V.**; c/o Robert J. Kraus, P.O. Box 3001, Briarcliff Manor, NY 10510-8001 (US).

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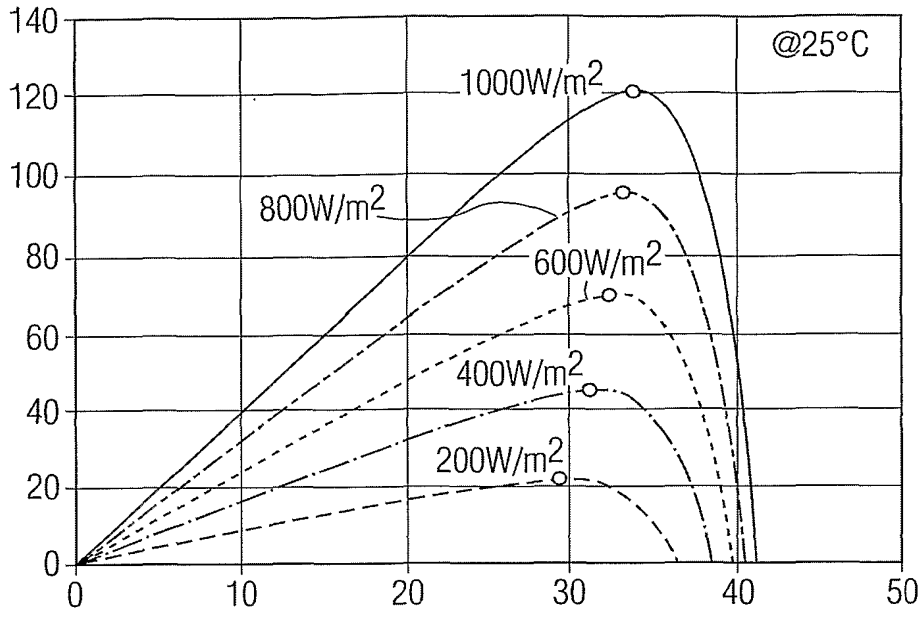
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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM,*

[Continued on next page]

(54) Title: SOLAR POWER SOURCE WITH MAXIMUM POWER-POINT TRACKING



(57) Abstract: A solar array power source is provided that automatically operates at its maximum power point despite changes in irradiance and array temperature.

WO 2005/069096 A1

PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations*

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SOLAR POWER SOURCE WITH MAXIMUM POWER-POINT TRACKING

This invention relates to maximum power point tracking to enable the maximum extraction of power from solar cell apparatus.

With continuing increases in efficiency and decreases in cost of solar cell devices, their use for providing electrical power is becoming ever more practical. To facilitate the extraction of the maximum power output, it is desirable to perform maximum power point tracking (MPPT) for varying levels of irradiance. This can be better understood with reference to Figure 1, which shows output power versus output voltage curves for a typical photovoltaic (PV) solar cell array operating at a number of different irradiance levels of light impinging on the array, at an array temperature of 25°C. Note that, for each different irradiance level, there is only one operating point on the respective curve where the output power from the solar array is at a maximum. This maximum power point is marked by a small circle on each of the curves.

One known type of maximum power point tracking employs an active searching algorithm. If changes in the irradiance level occur slowly or infrequently, a static approach may be employed whereby the power output at different operating points along a given curve for a fixed irradiance level is measured until the maximum power point is found. If a more dynamic approach is desired, to better track quickly changing irradiance levels, additional computational speed and complexity is required.

Two other types of known maximum power point tracking, which are generally simpler and require less computational speed, utilize a fixed voltage or current approach:

- The fixed voltage approach measures the open-circuit voltage of a solar cell array and sets the operating voltage of the array at a fixed percentage of the measured voltage. This, however, requires intermittent interruption of the power generation by the array to take the necessary measurement. Further, the relationship between the open-circuit voltage and the maximum power point is not perfectly linear.
- The fixed current approach measures the short-circuit current of a solar cell array and sets the operating current of the array at a fixed percentage of the measured current. This is generally more accurate than the open-circuit voltage approach, but

only if there are not substantial variations in the temperature of the array. Also, this approach still requires intermittent interruption of the power generation.

It is desirable to have a maximum power point measurement approach which is accurate and can be implemented in a simple and low cost manner without adversely affecting operation of solar cell power generation.

In accordance with the invention, a solar cell power source includes a solar cell array having a characteristic maximum power point output current that varies substantially with changes of the irradiance of light impinging on the array, but does not vary substantially with temperature changes of the array over an operating temperature range of the array. A photo-detector device which produces an output signal that varies with changes in the irradiance of impinging light is disposed for detecting the irradiance of light impinging on the solar cell array. A load electrically connected to an output of the solar cell array has an input impedance which varies in response to the photo-detector output signal to effect drawing from the array that output current which is characteristic of the maximum power point of the array at the irradiance of the light impinging on the array. With this simple approach, the solar array can be automatically operated approximately at its maximum power point despite substantial changes in irradiance and temperature of the array.

The principle of the invention can be better understood by referring to Figures 2 and 3. Figure 2 illustrates output current versus output voltage curves for the solar cell array of Figure 1, when operating at a number of different array temperatures and at an irradiance level of 1000 Watts/m^2. The curves for the other irradiance levels shown in Figure 1 are similar, but are not included in Figure 2 to keep this figure simple. The maximum power point current for each of the irradiance levels can be determined from the plot of Figure 3. Note from Figure 2 that while the output voltage produced by the array at the maximum power point (indicated by the small circle on each curve) varies significantly with array temperature, the output current does not. In fact, the current at the maximum power point varies by less than 1% over the operating temperature range -25°C to +75°C. For all of the irradiance levels for which curves are shown in Figure 1, the current at the maximum power point varies by less than 2% over the operating temperature range -25°C to +75°C. In other words, the maximum power point can be maintained by measuring the solar irradiance of light impinging on the array and loading the output of the array to draw the corresponding characteristic current indicated on the current-voltage plot for the particular array in use. For the array having the characteristic

curves shown in Figure 2, the output current to be drawn to maintain the maximum power point at an irradiance level of 1000 Watts/m^2 would be approximately 3.5 amps, as indicated in Figure 3.

Figure 1 is a plot of the characteristic output power versus output voltage curves for a particular solar cell array.

Figure 2 is a plot of the characteristic output current versus output voltage curves for the solar cell array.

Figure 3 is a plot of the maximum power point current versus irradiance for the solar cell array.

Figure 4 is a block diagram of an exemplary embodiment of a solar power source in accordance with the invention.

Figures 5-8 are schematic diagrams illustrating exemplary embodiments of solar power sources in accordance with the invention.

Figure 4 schematically illustrates an exemplary embodiment of a solar cell power source in accordance with the invention. This embodiment includes a solar-array module M, a control circuit C and a load L. The module M includes an array S of solar cells and a photo-detector P arranged for receiving impinging light radiation. DC power produced by the array S is made available at output terminals 1,2 of the array. An output signal produced by the photo-detector P in response to the impinging light radiation is applied to an input of the control circuit C. The control circuit is also electrically connected to the load L. The load L includes input terminals 3,4 that are electrically connected to the output terminals of the array and output terminals 5,6 for providing power to a user apparatus. In operation, the control circuit controls an input impedance of the load L in response to light radiation impinging on the photo-detector P and the solar array S to draw maximum power from the array, in accordance with the invention.

In one particularly useful embodiment, the load L is an inverter for converting the DC power produced by the array to AC power provided at the output terminals 5,6. Figure 5 illustrates one such embodiment as including a solar-array module M, the inverter load L having a conventional boost converter input section B and a DC-to-AC converter section, and control circuitry. The control circuitry includes a maximum power point tracker (MPPT), a difference generator Σ, an error amplifier A, and a duty cycle ratio controller R.

The MPPT produces a reference current signal I_{ref} representative of the average or DC current that should be drawn from the solar array to achieve the maximum power point at the irradiance of the array. This is done by sensing the current through the photo-detector P to detect the irradiance level and producing a reference signal corresponding to the maximum power point current that is characteristic of the array at that level.

This can be achieved with relatively simple circuitry if a photo-diode having a current-irradiance characteristic that varies with temperature similarly with that of the solar cells in the array S is employed for the photo-detector P. In fact, for typical silicon solar array a silicon photo-diode may be utilized which produces a current that is proportional to the maximum power point current of the array itself over the operating temperature range. In this case, a trans-impedance amplifier which will produce an output voltage that is proportional to the current through the photo-detector may be used for the MPPT circuitry.

The difference generator Σ compares the magnitude of the reference current signal I_{ref} with a current signal I_{solar} representing the current from the solar array S. In the exemplary embodiment of Figure 5, the current from the solar array is measured by sensing the current passing through one of the inputs of the load L. Any difference between these magnitudes is applied to an input of an error amplifier A, which drives a duty cycle ratio unit R that controls the switching of a transistor Q in the boost converter input section B. The unit R produces a square-wave signal that switches the transistor on and off at a ratio of on time to off time that effects production of an average solar array current I_{solar} equal to the reference current I_{ref}, thereby drawing the maximum power from the solar array.

Figure 6 illustrates an embodiment that is similar to that of Figure 5, but which utilizes peak current control rather than average current control. In this embodiment, cyclical switching of the transistor Q is controlled by a peak current mode controller PK such that the current drawn from the solar array by the load L is equivalent to the DC maximum power point current required at the irradiance sensed by the photo-detector P. This is done by switching the transistor off, during each cycle, at that peak current which results in the desired average current. The MPPT produces a reference signal I_{ref} (peak) representative of this peak current. Controller PK determines when this peak current is reached by comparing the peak magnitude of the sensed solar array current I_{solar} with I_{ref} (peak).

Figure 7 illustrates an embodiment similar to that of Figure 5, but employing a MPPT including a microprocessor μP. In this embodiment, data representing the maximum power

point currents for the solar array at a variety of irradiance levels can be stored in one or more look-up tables. The reference current I_{ref} would be looked up by the microprocessor in response to a sensed array irradiance.

Figure 8 illustrates an embodiment where all of the control functions are included in a MPPT including a microprocessor. This embodiment could be used to replace any or all of the embodiments of Figures 5-7, and a variety of other embodiments. It could also store the characteristic data needed to operate a number of different solar arrays at their characteristic power point currents and to power a number of different loads, thereby providing a universal solar power source.

While exemplary embodiments of the invention are described, various modifications and changes can be made without departing from the spirit and scope of the invention. It is therefore to be understood that the invention includes all embodiments that fall within the scope of the appended claims.

Claims

What is claimed is:

1. A solar cell power source comprising:

a. a solar cell array (S) having a characteristic maximum power point output current that varies substantially with changes in irradiance of light impinging on the array, but does not vary substantially with temperature changes of the array over an operating temperature range;

b. a photo-detector device (P) disposed for detecting the irradiance of light impinging on the solar cell array, said device producing an output signal that varies with changes of said detected irradiance;

c. a load (L) electrically connected to an output of the solar cell array and which is controlled in response to the photo-detector output signal to effect drawing from said array that output current which is characteristic of the maximum power point of the array at the irradiance of the light impinging on the array.

2. A solar cell power source as in claim 1 where the load comprises an inverter for converting DC power produced by the solar cell array to AC power.

3. A solar cell power source comprising:

a. a solar cell array (S) having a characteristic maximum power point output current that varies substantially with changes in irradiance of light impinging on the array, but does not vary substantially with temperature changes of the array over an operating temperature range;

b. photo-detector device (P) disposed for detecting the irradiance of light impinging on the solar cell array, said device producing an output current that varies with changes of said detected irradiance;

c. a load (L) electrically connected to an output of the solar cell array and having an input impedance which varies in response to the photo-detector output current to effect drawing from said array that output current which is characteristic of the maximum power point of the array at the irradiance of the light impinging on the array.

4. A solar cell power source as in claim 3 where the photo-detector device output current varies linearly with changes of the detected irradiance.

5. A solar cell power source comprising:

a. a solar cell array (S) having a characteristic maximum power point output current that varies substantially with changes in irradiance of light impinging on the array, but does not vary substantially with temperature changes of the array over an operating temperature range;

b. a photo-detector device (P) disposed for detecting the irradiance of light impinging on the solar cell array, said device producing an output signal that varies with changes of said detected irradiance;

c. a load (L) electrically connected to an output of the solar cell array and having a controllable input impedance;

d. control circuitry (C) coupled to the photo-detector and to the load for effecting variation of the input impedance in response to the photo-detector output signal to such that the load draws from the array that output current which is characteristic of the maximum power point of the array at the irradiance of the light impinging on the array.

6. A solar cell power source as in claim 5 where the control circuitry comprises:

a. a maximum power point tracker (MPPT) responsive to the photo-detector output signal for producing a reference signal representative of the maximum power point current that should be drawn from the solar cell array at the detected irradiance;

b. circuitry for cyclically varying the controllable input impedance such that the output current drawn from the array by the load tracks the maximum power point current represented by the reference signal.

7. A solar cell power source as in claim 6 where the reference signal represents an average value of the maximum power point current.

8. A solar cell power source as in claim 6 where the reference signal represents a peak value of the maximum power point current.

9. A solar cell power source as in claim 6 where the maximum power point tracker comprises a processor.

10. A solar cell power source as in claim 9 where data representative of the characteristic maximum power point output currents of the array for different irradiances is stored in at least one look-up table.

11. A solar cell power source as in claim 5 where the control circuitry comprises a processor.

12. A solar cell power source as in claim 11 where data representative of the characteristic maximum power point output currents of the array for different irradiances is stored in at least one look-up table.

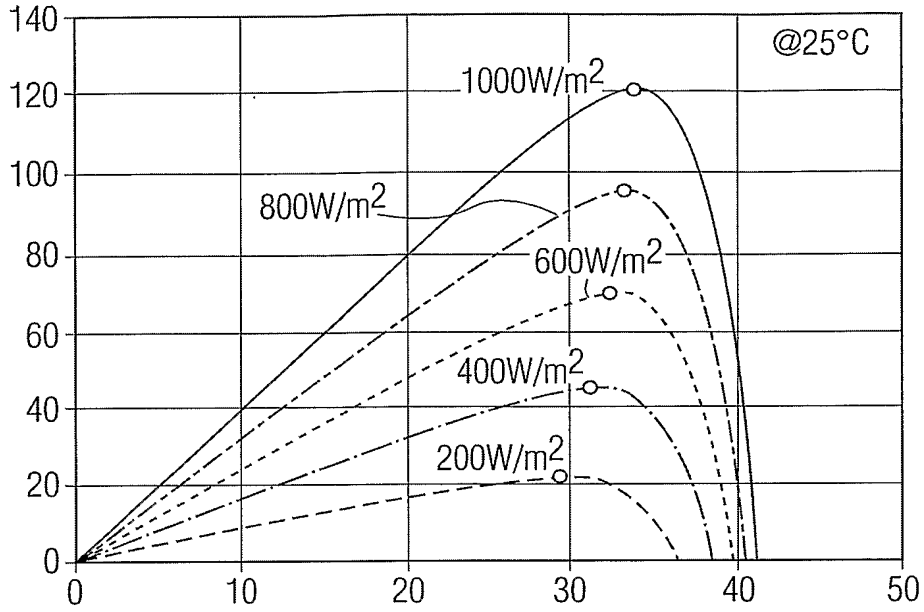

@25°C
1000W/m2
800W/m2
600W/m2
400W/m2
200W/m2
140
120
100
80
60
40
20
0
0
10
20
30
40
50

FIG. 1

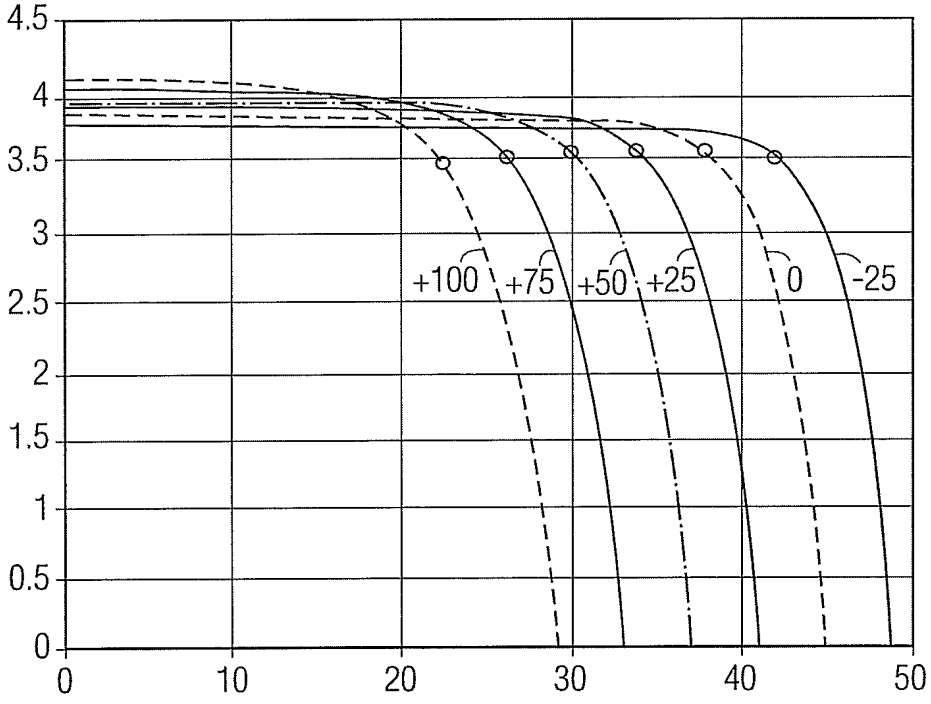

4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
+100
+75
+50
+25
0
-25

FIG. 2

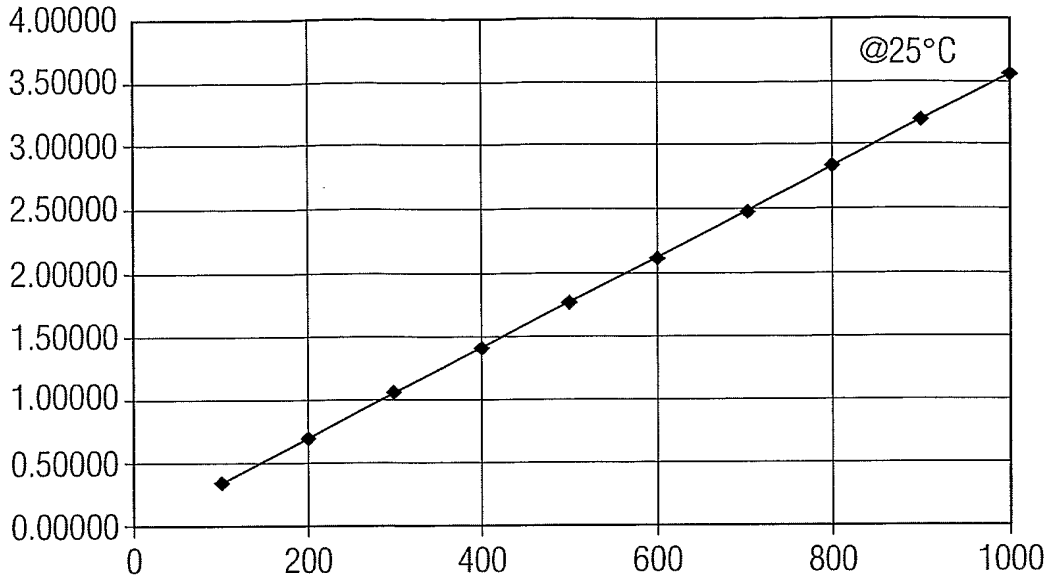

4.00000
3.50000
3.00000
2.50000
2.00000
1.50000
1.00000
0.50000
0.00000
0
200
400
600
800
1000
@25°C

FIG. 3

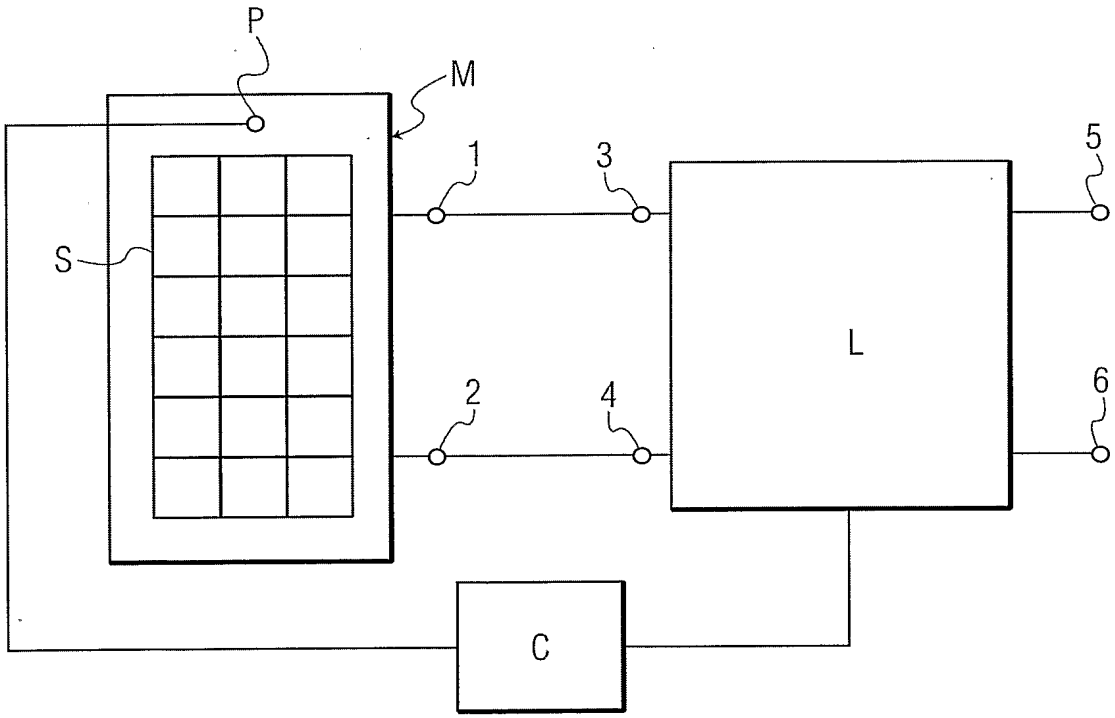

P
M
1
3
5
S
L
2
4
6
C

FIG. 4

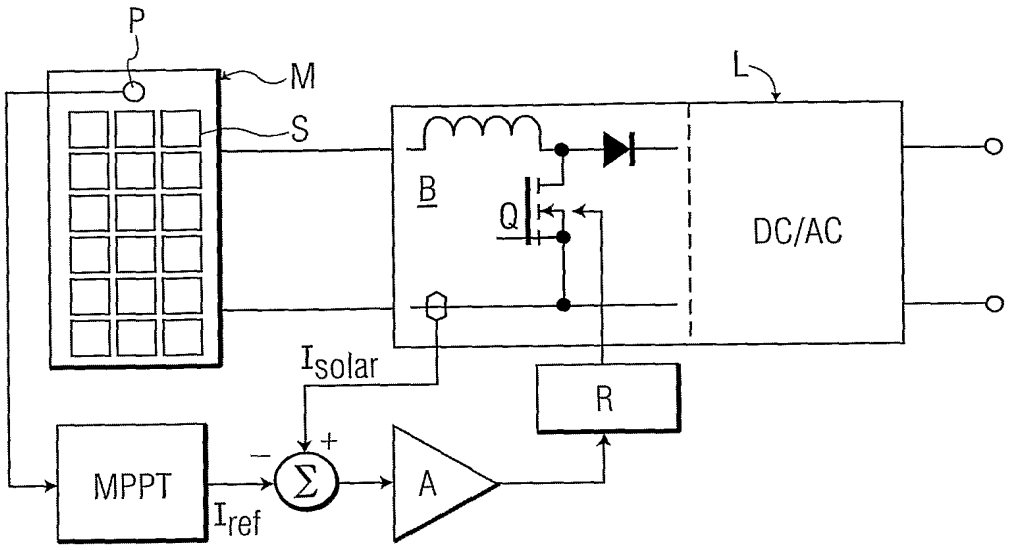

P
M
S
L
B
Q
DC/AC
I_{solar}
R
MPPT
I_{ref}
−
+
Σ
A

FIG. 5

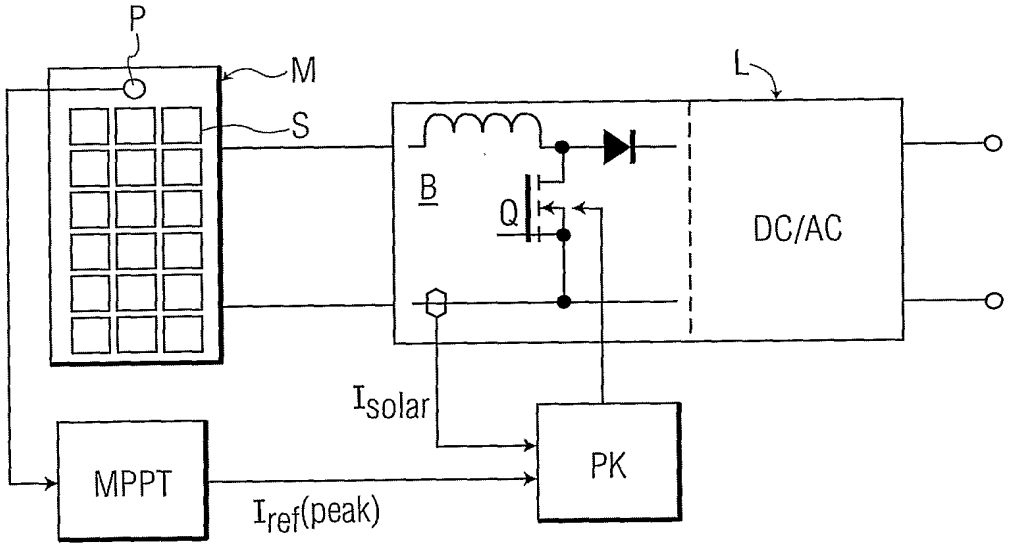

P
M
S
L
B
Q
DC/AC
I_{solar}
PK
MPPT
$I_{ref(peak)}$

FIG. 6

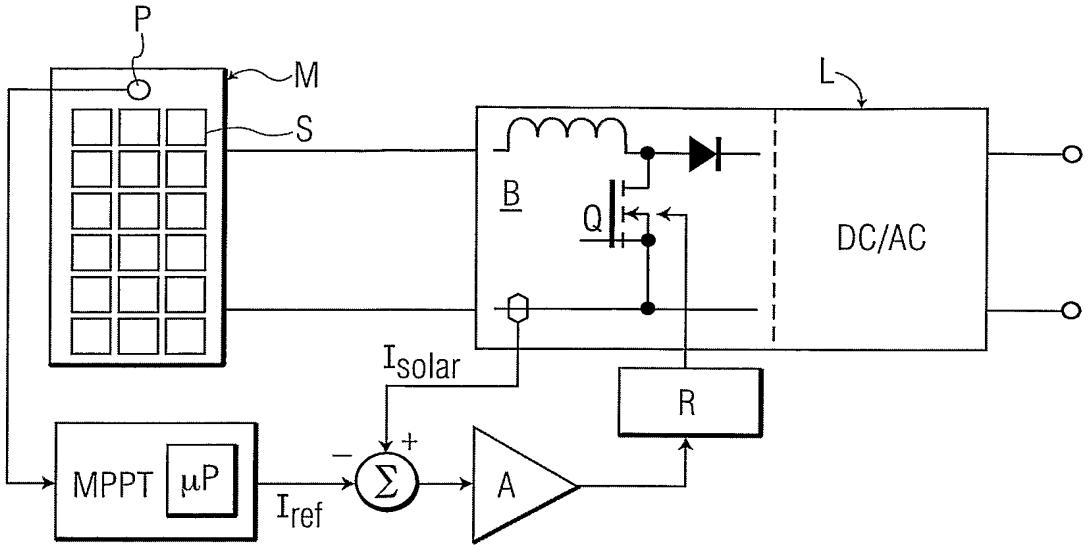

P
M
S
L
B
Q
DC/AC
I_{solar}
R
MPPT
μP
I_{ref}
Σ
A

FIG. 7

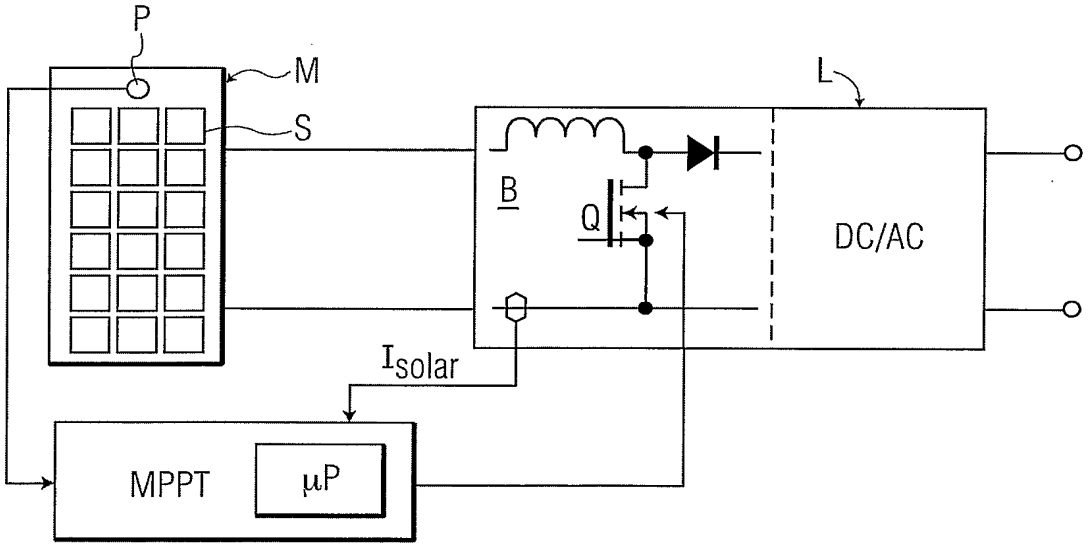

P
M
S
L
B
Q
DC/AC
I_{solar}
MPPT
μP

FIG. 8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2005/050127

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G05F1/67 H01L31/042

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G05F H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 873 480 A (LAFFERTY ET AL) 10 October 1989 (1989-10-10) column 3, line 12 - column 6, line 16; figures 1,2	1-12
X	US 5 293 447 A (FANNEY ET AL) 8 March 1994 (1994-03-08) column 3, line 33 - column 7, line 27; figures 1-3,5	1-12
X	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 15, 6 April 2001 (2001-04-06) & JP 2000 347753 A (MITSUBISHI ELECTRIC CORP; KAKEI GAKUEN), 15 December 2000 (2000-12-15) abstract; figure 1	1-12

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
5 April 2005	21/04/2005

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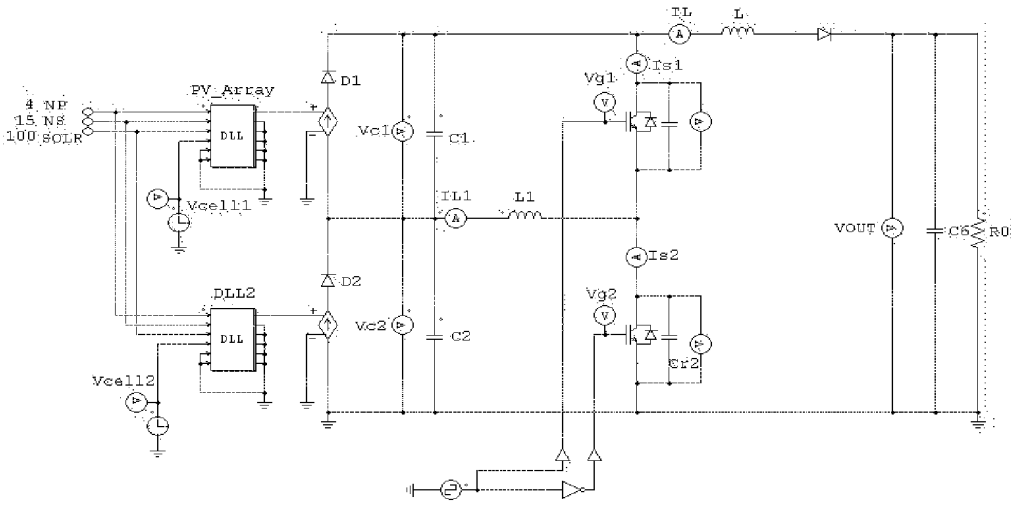
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[Continued on next page]

(54) Title: METHOD FOR COMPENSATING FOR PARTIAL SHADE IN PHOTOVOLTAIC POWER SYSTEM



(57) Abstract: There is provided a method for compensating for partial shade using a photovoltaic power system, in which a plurality of serial-connected arrays of solar cell modules are connected in parallel, the arrays are connected to a converter, and a final power is outputted from the converter. The method includes the steps of: connecting an auxiliary power source to each solar cell module; if a low solar radiation is detected by an MPPT controller, supplying a necessary power through the auxiliary power source at a time, thereby maintaining constant voltage and preventing a temporarily shutdown; connecting in parallel the solar cell modules of the serial- connected arrays in multi-stages; and varying an operating voltage ratio of the solar cell module by controlling an off duty cycle of each chopper at the MPPT controller, thereby generating maximum output from the serial-connected array of each solar cell module.

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Description

METHOD FOR COMPENSATING FOR PARTIAL SHADE IN PHOTOVOLTAIC POWER SYSTEM

Technical Field

[1] The present invention relates to a method for compensating for a partial shade in a photovoltaic power system, and more particularly, to a method for compensating for a partial shade in a photovoltaic power system, in which a constant voltage can be maintained by supplying an insufficient voltage of a solar cell module in a low solar radiation, a temporary shutdown of the system can be prevented, and a maximum power can be generated at a serial-connected array of each solar cell module.

[2]

Background Art

[3] Korea established an alternative energy resource development/usage/ distribution promotion policy for promoting an expanded distribution of new regeneration energy and supported its development of technology.

[4] Since a solar photovoltaic power generation utilizes a natural energy, many researches on it have been made for a long time. In recent years, home power generators are available.

[5] In such a photovoltaic power generation system, a plurality of solar cell modules are connected in serial/parallel fashion and are connected to a power conversion device. The reason is that since a solar cell module alone has a low output voltage of below 30 V, a serial connection of the module and a boost converter are required for boosting the low output voltage to an input voltage of a grid-tie inverter. A finial power is obtained by connecting the serial-connected arrays in parallel.

[6] In an output characteristic of each module, however, an operating point of the solar cell module array is changed depending on solar radiation, temperature, load variation, etc. Accordingly, in the solar cell, a maximum power point tracking (MPPT) control method capable of always providing a maximum output should be applied to the converter. Several MPPT control algorithms have been studied. There are an analog MPPT algorithm and a digital MPPT algorithm using a microprocessor. In view of a control object, the MPPT control algorithms are also classified into an MPPT control algorithm using a constant voltage control method, a P&O (Perturbation and Observation Method) MPPT control algorithm, an Inc Cond (Incremental Conductance) MPPT algorithm, and a current feedback algorithm. Although the conventional MPPT control algorithms operate well in a high solar radiation, the MPPT control does not operate well in a low solar radiation. Thus, an amount of power generation is reduced.

Accordingly, a lot of improved algorithms have been studied.

[7] Also, in an installation of the photovoltaic power system, considering that the solar cells are used in places such as general home or places where the installation area is small, generation power is greatly reduced when the solar cells are connected in series, because solar radiation is different depending on the shade of the adjacent buildings or the installation place. In order to partially solve this problem, bypass diodes are connected to the solar cells. Also, in order to increase the generation efficiency, MPPT control algorithm is installed in each module, or a temporary voltage reduction is compensated using hardware.

[8]

Disclosure of Invention

Technical Problem

[9] In order to solve problems of an installation situation and temporary reduction of power generation, the present invention provides a system that can always supply maximum power by applying choppers to each module in multi-stage and controlling power generation of each serial-connected array. Also, the present invention provides an improved method using an auxiliary circuit to which a digital controller and a switching topology are applied. By configuring simulation and small-capacity circuit, efficiency of the compensation for partial shade and low solar radiation can be increased.

[10] An object of the present invention is to maintain constant voltage and prevent temporary shutdown by connecting an auxiliary power source to an output terminal of each solar cell module and supplying necessary power through the auxiliary power source when a low solar radiation is detected by an MPPT controller.

[11] Another object of the present invention is to provide generate maximum output from the serial-connected array of each solar cell module by connecting in parallel the solar cell modules of the serial-connected arrays in multi-stages and varying an operating voltage ratio of the solar cell module by controlling an off duty cycle of each chopper at the MPPT controller.

[12]

Technical Solution

[13] According to an aspect of the present invention, there is provided a method for compensating for partial shade using a photovoltaic power system, in which a plurality of serial-connected arrays of solar cell modules are connected in parallel, the arrays are connected to a converter, and a final power is outputted from the converter, the method comprising the steps of: connecting an auxiliary power source to each solar cell module; if a low solar radiation is detected by an MPPT controller, supplying a

necessary power through the auxiliary power source at a time, thereby maintaining constant voltage and preventing a temporarily shutdown; connecting in parallel the solar cell modules of the serial-connected arrays in multi-stages; andvarying an operating voltage ratio of the solar cell module by controlling an off duty cycle of each chopper at the MPPT controller, thereby generating maximum output from the serial-connected array of each solar cell module.

[14] The auxiliary power source includes: a switch for performing a switching operation according to a control of the MPPT controller; and a capacitor or small-capacity battery for discharging charged voltage according to the switching of the switch.

[15] The MPPT controller sets a reference voltage (Vref) as a lowest operating voltage of an MPPT control range of the serial-connected array, increases the reference voltage (Vref) and detects an output voltage (V(k)) of the serial-connected array. If the output voltage (V(k)) is greater than the reference voltage, the MPPT controller does not operate the switch. If the output voltage (V(k)) decreases due to an amount of the solar radiation or a change of load after the reference voltage (Vref) increases to the maximum, the MPPT controller decreases the reference voltage (Vref).

[16] The MPPT controller alternately switches each chopper.

[17]

Advantageous Effects

[18] In the method for compensating for the partial shade in the photovoltaic power system, multi-stage choppers are applied to every solar cell module, and maximum power is always supplied at the serial-connected array by controlling power generation of the serial-connection array of each module. A maximum power point is obtained by connecting multi-stage choppers in parallel. Therefore, it is possible to compensate for the partial shade and obtaining constant output by controlling maximum power point even when the partial shade occurs.

[19]

Brief Description of the Drawings

[20] FIG. 1 is a circuit diagram of a generation control circuit according to an embodiment of the present invention;

[21] FIG. 2 illustrates a switching sequence and a reactor current waveform in a generation control circuit according to an embodiment of the present invention;

[22] FIG. 3 is a flowchart illustrating a method for compensating for a partial shade in a photovoltaic power system according to an embodiment of the present invention;

[23] FIG. 4 is a circuit diagram of a power point control circuit according to an embodiment of the present invention;

[24] FIG. 5 is a current waveform of an inductor and each part in a power point control

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circuit according to an embodiment of the present invention;

[25] FIG. 6 is a circuit diagram of a photovoltaic power system to which a method for compensating for a partial shade is applied;

[26] FIG. 7 is an operation waveform of each part in a rapid change of a solar radiation in a photovoltaic power system according to an embodiment of the present invention;

[27] FIG. 8 is a test circuit of a photovoltaic power system according to an embodiment of the present invention; and

[28] FIG. 9 is a graph illustrating an output characteristic before and after a control of each solar cell in a photovoltaic power system according to an embodiment of the present invention.

[29]

Best Mode for Carrying Out the Invention

[30] Hereinafter, the preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[31] In the embodiments of the present invention, multi-stage chopper is applied to each solar cell module, and a power generation in a serial-connected array of each module is controlled, such that a maximum power is always supplied from the serial-connected array. Also, using an MPPT controller, a maximum output voltage is always supplied. In this manner, by solving a problem that an output of an entire array is reduced in a low solar radiation or a partial shade is solved, a maximum power point can be obtained. Thus, a compensation for the partial shade is possible and a constant output can be obtained by the control of the maximum power point even at the partial shade. However, the present invention is not limited to the above-described system, but it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention.

[32] First, a shape-compensation MPPT technique will be described below.

[33] FIG. 1 is a circuit diagram of a generation control circuit in which two solar cells are connected in series. The generation control circuit is provided for solving a problem of a power-generation unbalanced state. FIG. 2 illustrates a switching sequence of switches SW1 and SW2 and reactor current waveform. Here, the switching sequence controls to alternately operate the switches SW1 and SW2, instead of turning off them at the same time.

[34] Meanwhile, an off duty cycle of the switches SW1 and SW2 can be obtained by Equation 1 below.

[35] (Equation 1)

[36]

$$\overline{D_1}:\overline{D_2}$$

[37] A relationship between the off duty cycle and an operating voltage of each solar cell can be expressed as Equations 2 to 6 below.

[38] (Equation 2)

[39]

$$\begin{cases} V_1 = -L\dfrac{di_L}{dt} \\ V_2 = L\dfrac{di_L}{dt} \end{cases} \Rightarrow \begin{cases} V_1 = -L\dfrac{\Delta i_L}{T_{2OFF}} \\ V_2 = L\dfrac{\Delta i_L}{T_{1OFF}} \end{cases}$$

[40] (Equation 3)

[41]

$$L\Delta i_L = V_1 T_{2OFF} = V_2 T_{1OFF}$$

[42] (Equation 4)

[43]

$$V_1 \frac{T_{2OFF}}{T_S} = V_2 \frac{T_{1OFF}}{T_S}$$

[44] (Equation 5)

[45]

$$\therefore V_1 \overline{D_2} = V_2 \overline{D_1}$$

[46] (Equation 6)

[47]

$$V_1 : V_2 = \overline{D_1} : \overline{D_2}$$

[48] It can be seen from Equations 2 to 6 that a ratio (V1:V2) of the operating voltage in each solar cell can be freely set by changing the off duty cycle of each switch.

[49] Unlike the conventional method, when a low solar radiation is detected in a state that the MPPT control is not performed, an auxiliary power source configured with a switch and a capacitor is operated. A large-capacity super capacitor or a small-capacity battery can be used as the capacitor of the auxiliary power source. By charging as an input voltage using the voltage charged in the capacitor or the battery, an insufficient voltage is supplemented for a predetermined time, such that a temporary power generation is possible.

[50] At this point, after a reference voltage Vref is set as a lowest operating voltage of the MPPT control range and is increased, an output voltage V(k) is detected. When the output voltage V(k) is greater than the reference voltage Vref, the switches of the auxiliary power source do not operate. Instead, when the output voltage V(k) decreases

due to an amount of the solar radiation or a change of load after the reference voltage Vref increases to the maximum, the reference voltage Vref is reduced.

[51] In other words, the power P(k) and P(k-1) detected by the algorithm are compared with each other. If the two powers are identical to each other, the MPPT is not executed. When two powers are different, the power is reduced while following an array voltage, and an operation of reducing the reference voltage is executed. During this process, the reference voltage is maintained for a predetermined time, but the meaning of the increase/decrease value of the reference voltage Vref is different, although it is similar to the conventional P&O MPPT.

[52] FIG. 3 is a flowchart illustrating a method for compensating for a partial shade in a photovoltaic power system according to an embodiment of the present invention.

[53] FIG. 4 is a circuit diagram of a power point control circuit using PSIM according to an embodiment of the present invention. In FIG. 4, ms_user6.dll is a solar cell model to which a characteristic of a solar cell is applied, ms_user7.dll is applied for making an environment where solar radiation varied with time, and ms_user8.dll is an algorithm program.

[54] FIG. 5 is a current waveform of an inductor and each part in the power point control circuit according to an embodiment of the present invention. It can be seen that characteristic identical to ideal waveform is obtained.

[55] FIG. 6 is a circuit diagram of a photovoltaic power system to which a method for compensating for a partial shade is applied. In FIG. 6, there is shown a circuit for applying an improved IncCon control method.

[56] FIG. 7 is an operation waveform of each part in a rapid change of a solar radiation in a photovoltaic power system according to an embodiment of the present invention. Compared with the conventional control method, an error in a fast following speed, an actual power and a generated power is reduced.

[57] FIG. 8 is a test circuit of the photovoltaic power system according to an embodiment of the present invention. A solar cell used in the test is GMG01531, a characteristic of the solar cell is a rated maximum output of 53 W, an open circuit voltage of 21.7 V, a short circuit voltage of 3.25 V, a maximum operating voltage of 17.4 V, and a maximum operating current of 3.05 A.

[58] FIG. 9 is a graph illustrating an output characteristic before and after a control of each solar cell in a photovoltaic power system according to an embodiment of the present invention. Due to a partial shade at PV2 before the control, a current flows through bypass diode, causing the power generation to be reduced. However, due to the power point control operation, the amounts of power generation PV1 and PV2 are identical to each other.

[59] In order to solve the problem of the conventional MPPT control algorithm in that

power generation is impossible at a low solar radiation and a response speed is slow at a rapid change of solar radiation, an improved MPPT control algorithm is proposed. This method is implemented with a simple structure. A low solar radiation is detected and the switches of the auxiliary power source connected to the output terminal of the solar cell is operated. In this manner, an insufficient power is temporarily supplied, thereby maintaining a constant voltage and preventing a temporary shutdown of the system.

[60] Also, in order to solve a problem in that an output of an entire array is greatly lowered when a partial shade occurs in the serial/parallel connection of the system, a maximum power point is obtained by connecting multi-stage choppers in parallel. Therefore, it is possible to compensate for the partial shade and obtaining constant output by controlling maximum power point even when the partial shade occurs.

[61] It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

[62]

Industrial Applicability

[63] In the method for compensating for the partial shade in the photovoltaic power system, multi-stage choppers are applied to every solar cell module, and maximum power is always supplied at the serial-connected array by controlling power generation of the serial-connection array of each module. A maximum power point is obtained by connecting multi-stage choppers in parallel. Therefore, it is possible to compensate for the partial shade and obtaining constant output by controlling maximum power point even when the partial shade occurs.

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Claims

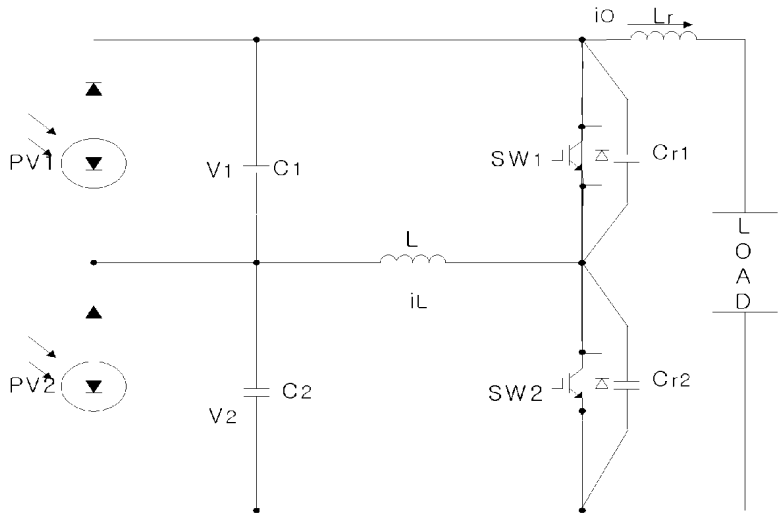
[1] A method for compensating for partial shade using a photovoltaic power system, in which a plurality of serial-connected arrays of solar cell modules are connected in parallel, the arrays are connected to a converter, and a final power is outputted from the converter, the method comprising the steps of:
connecting an auxiliary power source to each solar cell module;
if a low solar radiation is detected by an MPPT controller, supplying a necessary power through the auxiliary power source at a time, thereby maintaining constant voltage and preventing a temporarily shutdown;
connecting in parallel the solar cell modules of the serial-connected arrays in multi-stages; and
varying an operating voltage ratio of the solar cell module by controlling an off duty cycle of each chopper at the MPPT controller, thereby generating maximum output from the serial-connected array of each solar cell module.

[2] The method of claim 1, wherein the auxiliary power source includes:
a switch for performing a switching operation according to a control of the MPPT controller; and
a capacitor or small-capacity battery for discharging charged voltage according to the switching of the switch.

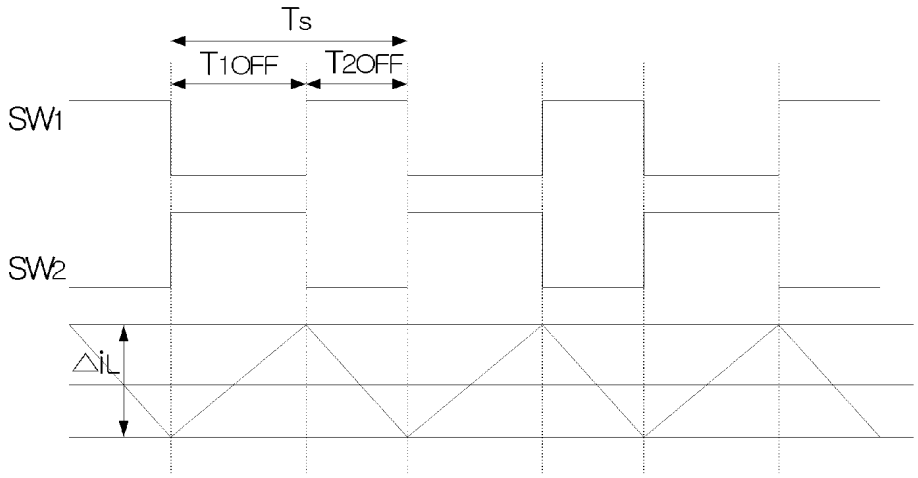
[3] The method of claim 1, wherein the MPPT controller sets a reference voltage (Vref) as a lowest operating voltage of an MPPT control range of the serial-connected array, increases the reference voltage (Vref) and detects an output voltage (V(k)) of the serial-connected array,
if the output voltage (V(k)) is greater than the reference voltage, the MPPT controller does not operate the switch, and
if the output voltage (V(k)) decreases due to an amount of the solar radiation or a change of load after the reference voltage (Vref) increases to the maximum, the MPPT controller decreases the reference voltage (Vref).

[4] The method of claim 1, wherein the MPPT controller alternately switches each chopper.

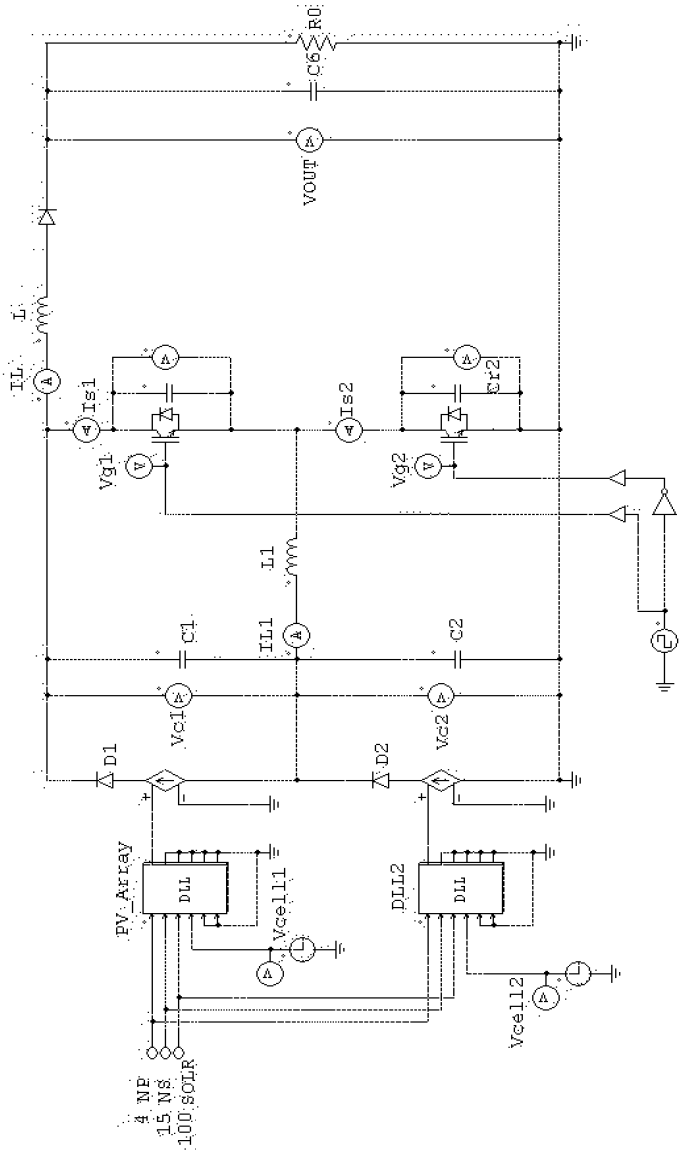
[Fig. 1]


iO
Lr
PV1
V1
C1
SW1
Cr1
L
iL
LOAD
PV2
C2
V2
SW2
Cr2

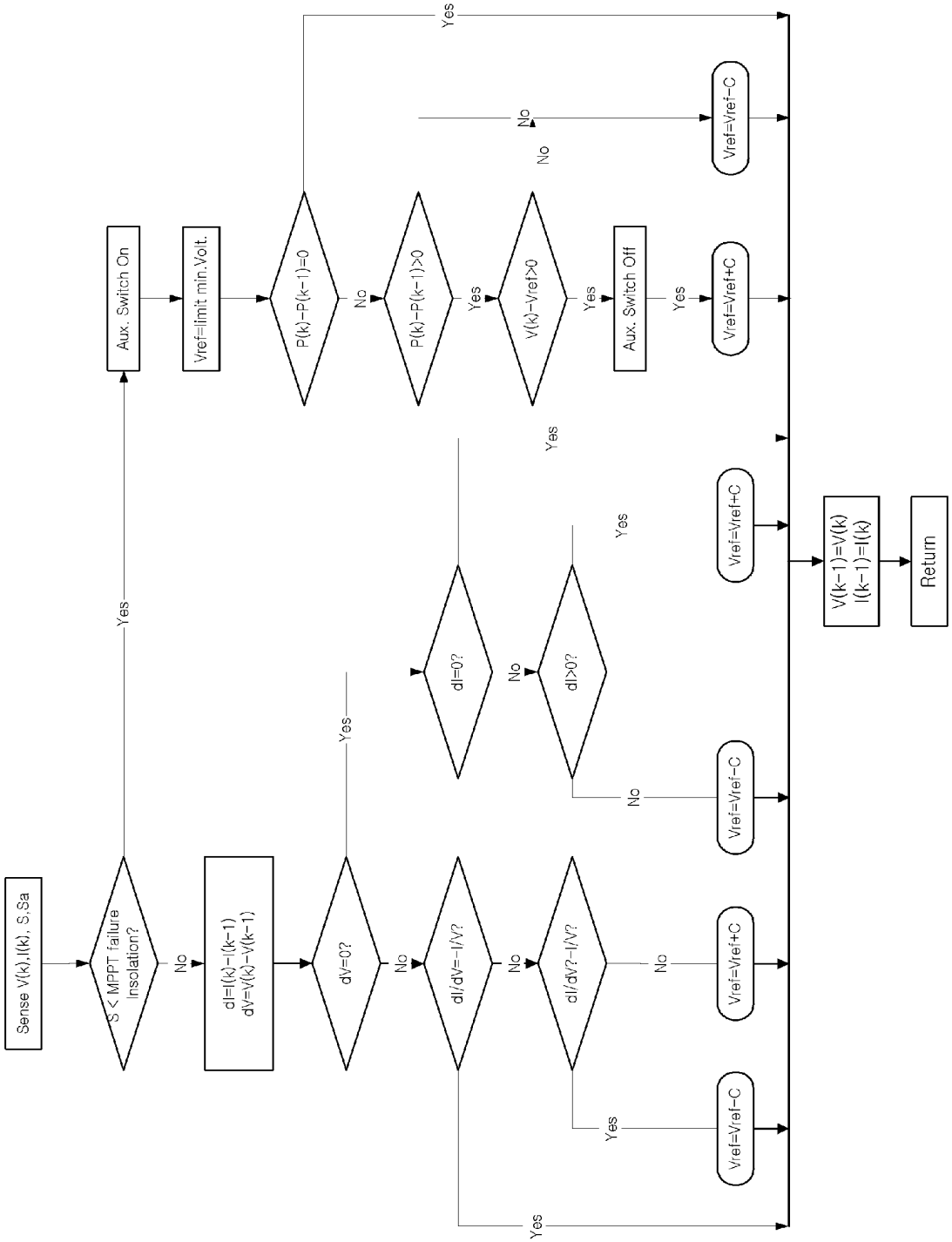
[Fig. 2]


Ts
T1OFF
T2OFF
SW1
SW2
△iL

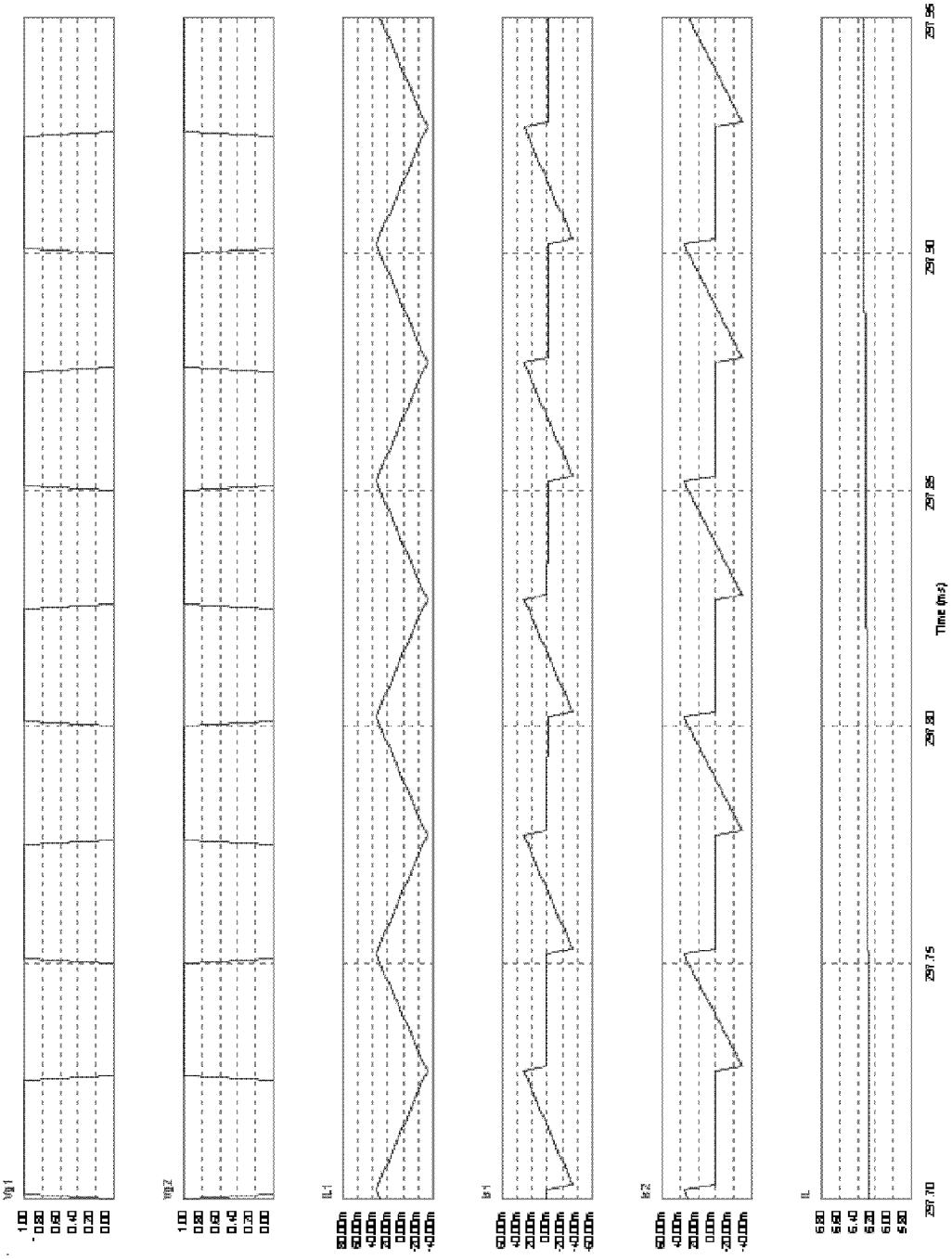
[Fig. 3]


R0
C6
VOUT
L
IL
Is1
Vg1
Is2
Cr2
Vg2
L1
IL1
C1
C2
Vc1
Vc2
D1
D2
PV_Array
DLL
DLL2
Vcell1
Vcell2
4 NP
15 NS
100 SOLR

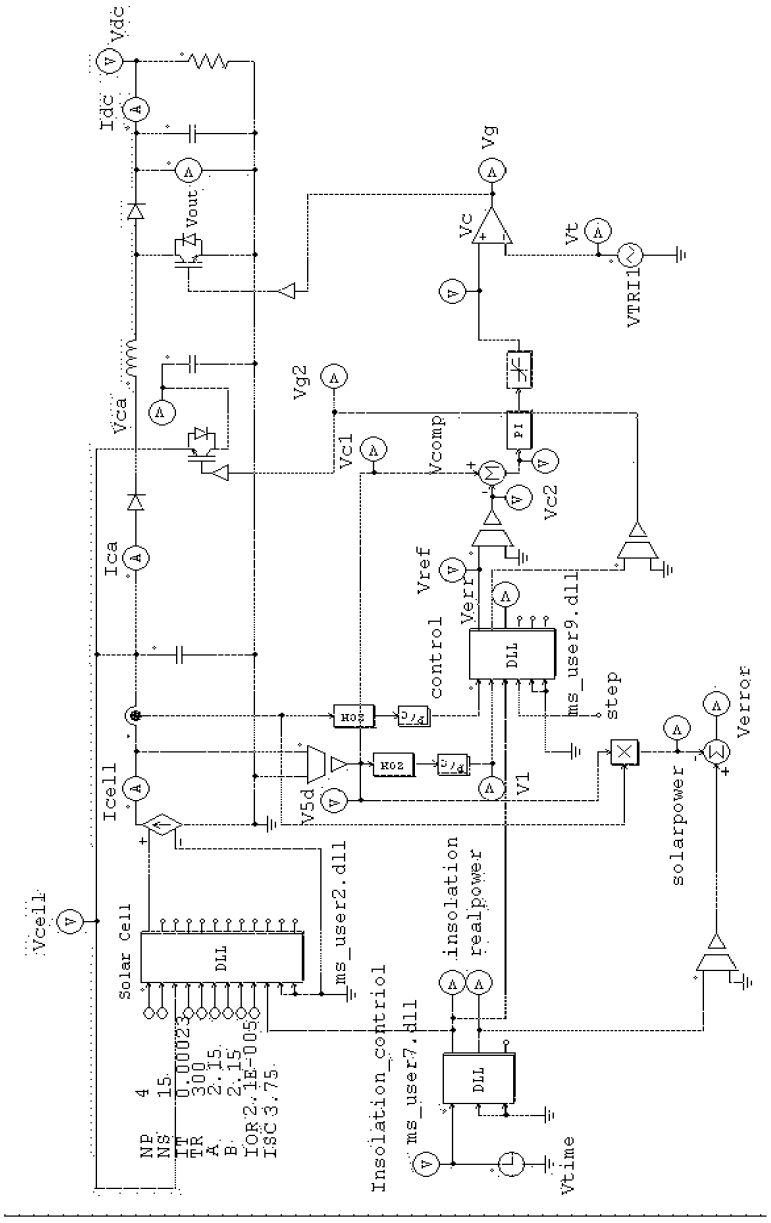
[Fig. 4]


Sense V(k),I(k), S,Sa
S < MPPT failure Insolation?
Yes
No
Aux. Switch On
dI=I(k)-I(k-1)
dV=V(k)-V(k-1)
Vref=limit min.Volt.
dV=0?
Yes
No
dI=0?
Yes
No
dI>0?
Yes
No
dI/dV=-I/V?
Yes
No
dI/dV?-I/V?
Yes
No
P(k)-P(k-1)=0
Yes
No
P(k)-P(k-1)>0
Yes
No
V(k)-Vref>0
Yes
No
Aux. Switch Off
Yes
Vref=Vref+C
Vref=Vref-C
V(k-1)=V(k)
I(k-1)=I(k)
Return

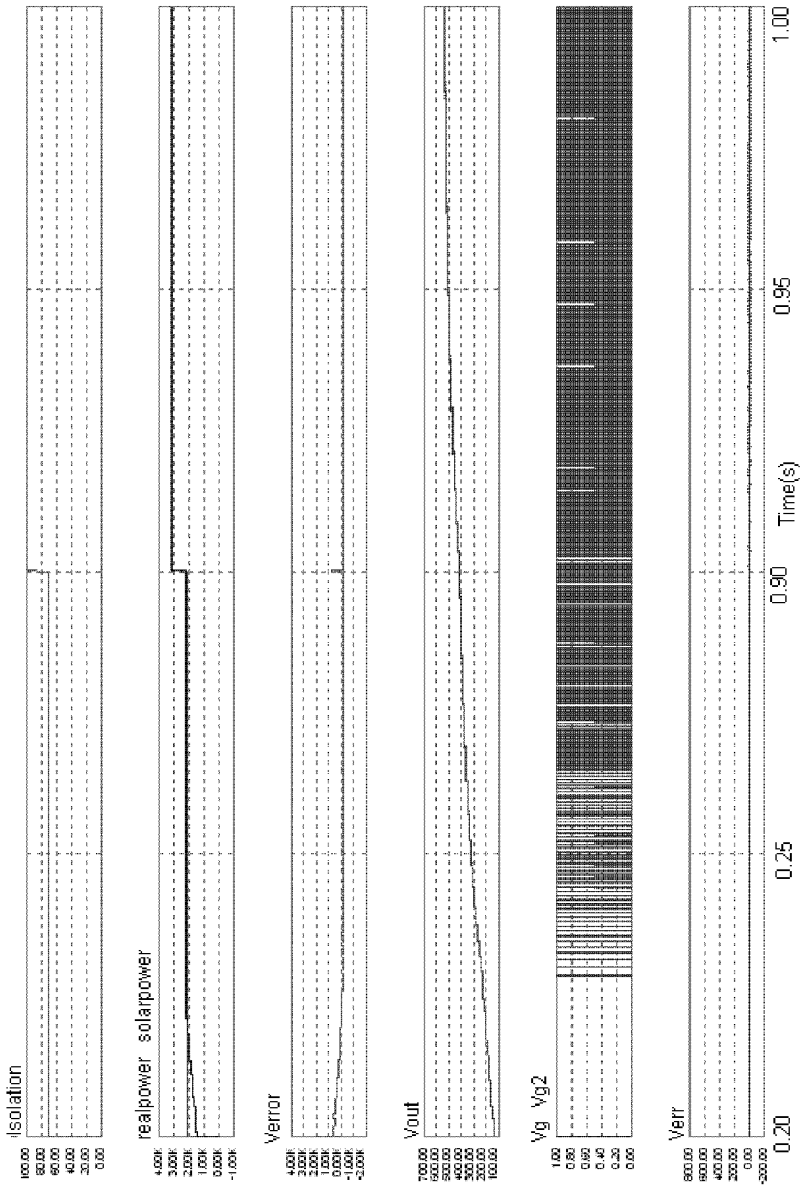
[Fig. 5]



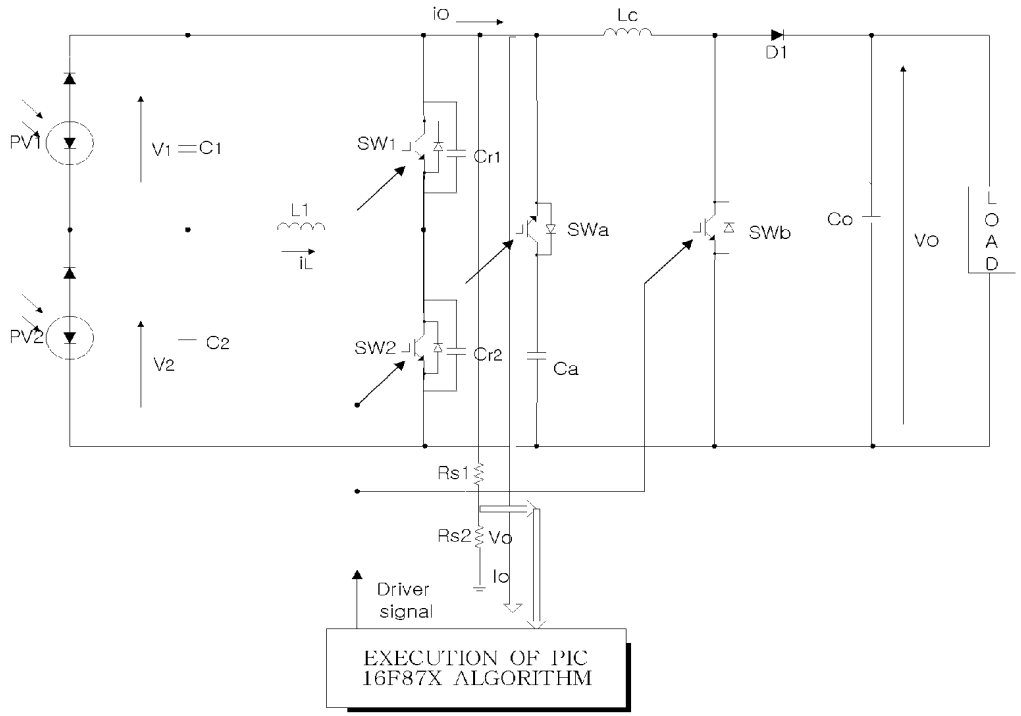
[Fig. 6]


Vdc
Idc
Vout
Vca
Ica
Icell
Vcell
Solar Cell
DLL
ms_user2.dll
NP 4
NS 15
IF 0.00023
TR 300
A 2.15
B 2.15
IOR 2.1E-005
ISC 3.75
Vg
Vc
Vt
VTRI1
Vg2
Vc1
Vcomp
PI
Vc2
Vref
Verr
control
ms_user9.dll
step
Verror
V5d
V1
solarpower
insolation
realpower
Insolation_control
ms_user7.dll
Vtime

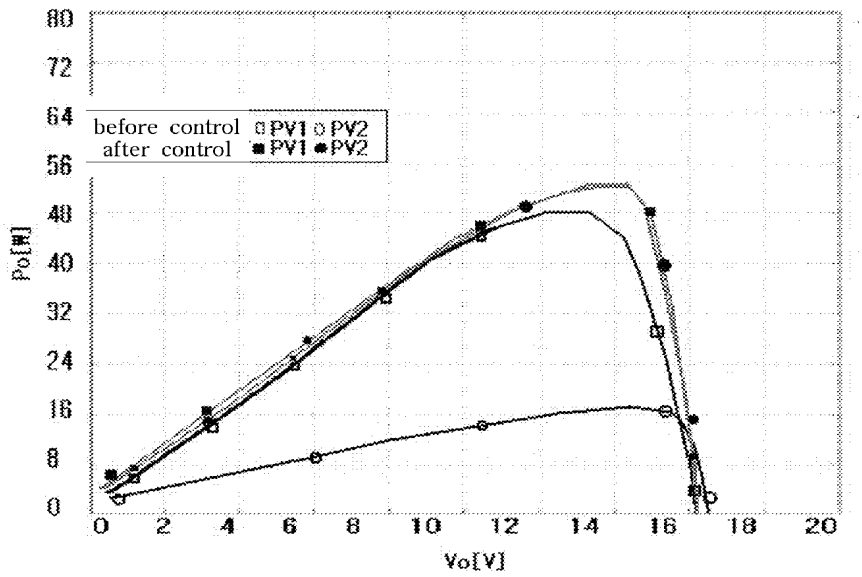
[Fig. 7]


Isolation
realpower solarpower
Verror
Vout
Vg Vg2
Verr
0.20
0.25
0.90
0.95
1.00
Time(s)

[Fig. 8]


Io
Lc
D1
PV1
V1 =C1
SW1
Cr1
L1
iL
SWa
SWb
Co
Vo
L
O
A
D
PV2
C2
V2
SW2
Cr2
Ca
Rs1
Rs2
Vo
Io
Driver
signal
EXECUTION OF PIC
16F87X ALGORITHM

[Fig. 9]


before control PV1 PV2
after control PV1 PV2
Po[W]
Vo[V]
0
8
16
24
32
40
48
56
64
72
80
0
2
4
6
8
10
12
14
16
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Electronic Acknowledgement Receipt

EFS ID:	6701944
Application Number:	12628977
International Application Number:	
Confirmation Number:	6958
Title of Invention:	Systems and Methods for an Enhanced Watchdog in Solar Module Installations
First Named Inventor/Applicant Name:	Ron HADAR
Customer Number:	64494
Filer:	John Patrick Ward/Patricia Caldwell
Filer Authorized By:	John Patrick Ward
Attorney Docket Number:	108144-202701/US (TGY027)
Receipt Date:	23-DEC-2009
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Application Type:	Utility under 35 USC 111(a)

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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed (SB/08)	108144-202701_IDS.pdf	610031 a9c1828a5445c0e26c598d18ed1ede7376082cec	no	6

Warnings:	
Information:	

2	Foreign Reference	EP0178757A2.pdf	337089 927ffe730f9d2f2c093c659934d94d0015e3051e	no	13
Warnings:					
Information:					
3	Foreign Reference	JP_11103538A.pdf	1262287 b96a9f7a171531f77130e067359e71269b7202c4	no	9
Warnings:					
Information:					
4	Foreign Reference	WO2005069096.pdf	558298 6b2ea1aea92e45d580bff7a97d129e2786ddee35	no	16
Warnings:					
Information:					
5	Foreign Reference	WO2005112551.pdf	770721 7a2a6a44f1aa23b3b46d47fde4afcf68d77205f5	no	17
Warnings:					
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6	NPL Documents	Alonso_Distributed.pdf	316381 bd912fa51bb4928ef3f81333f9c90b06de0bb7c6	no	4
Warnings:					
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7	NPL Documents	Alonso_Experimental.pdf	248866 5f6be18061d8ab4a0030ef3f285ad210e6b4a67f	no	4
Warnings:					
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8	NPL Documents	Basso.pdf	1376968 4f29b54421bf214457ff3985134ccf3beaffb8af	no	56
Warnings:					
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9	NPL Documents	Boostbuck.pdf	68958 a0bdf852811024495d444f923e8f894d034c9398	no	3
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10	NPL Documents	Enslin.pdf	450731 d6b6ef36fdc94bd6d4c3ad7f53056299b3bcef80	no	5
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11	NPL Documents	Gautam.pdf	177477 e0ebf6227917253fb87cfccd0b1747d0bfe1741e	no	15
Warnings:					
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12	NPL Documents	Linares.pdf	1041332 d0053aa44bc0f443d28e3bb9abcd1feed2edf8da	no	7
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13	NPL Documents	Nordmann.pdf	24716128 d34915b168042169aacaa93ac6e0a94471b8613d	no	20
Warnings:					
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14	NPL Documents	Roman.pdf	768186 b2a52443fc6f5e6f9f7652e09e1041bbba918bca	no	8
Warnings:					
Information:					
15	NPL Documents	Walker.pdf	823250 2984cf6c5be1dfa83611ebd822e2041f3757a8d8	no	10
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New International Application Filed with the USPTO as a Receiving Office

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
12/628,977	12/01/2009	1795	462	108144-202701/US (TGY027)	20	3

CONFIRMATION NO. 6958

64494
GREENBERG TRAURIG, LLP (SV)
IP DOCKETING
2450 COLORADO AVENUE
SUITE 400E
SANTA MONICA, CA 90404

FILING RECEIPT

OC000000039189655

Date Mailed: 12/15/2009

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Ron HADAR, Cupertino, CA;
Shmuel ARDITI, Los Gatos, CA;

Assignment For Published Patent Application

TIGO ENERGY, Los Gatos, CA

Power of Attorney: The patent practitioners associated with Customer Number 64494

Domestic Priority data as claimed by applicant

This appln claims benefit of 61/275,977 09/03/2009
and claims benefit of 61/276,753 09/16/2009

Foreign Applications

If Required, Foreign Filing License Granted: 12/10/2009

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/628,977**

Projected Publication Date: 03/03/2011

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****

Title

Systems and Methods for an Enhanced Watchdog in Solar Module Installations

Preliminary Class

136

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	108144-202701/US (TGY027)
	Application Number	
Title of Invention	Systems and Methods for an Enhanced Watchdog in Solar Module Installations	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

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☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Ron		HADAR	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Cupertino	State/Province	CA	Country of Residence [i]	US

Citizenship under 37 CFR 1.41(b) [i] IL

Mailing Address of Applicant:

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Address 2			
City	Cupertino	State/Province	CA
Postal Code	95014	Country [i]	US

Applicant 2 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Shmuel		ARDITI	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Los Gatos	State/Province	CA	Country of Residence [i]	US

Citizenship under 37 CFR 1.41(b) [i] US

Mailing Address of Applicant:

Address 1	104 Las Uvas Court		
Address 2			
City	Los Gatos	State/Province	CA
Postal Code	95032	Country [i]	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	108144-202701/US (TGY027)
	Application Number	
Title of Invention	Systems and Methods for an Enhanced Watchdog in Solar Module Installations	

☐ An Address is being provided for the correspondence Information of this application.			
Customer Number	64494		
Email Address	LAIPMAIL@GTLAW.COM	Add Email	Remove Email

Application Information:

Title of the Invention	Systems and Methods for an Enhanced Watchdog in Solar Module Installations		
Attorney Docket Number	108144-202701/US (TGY027)	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)		**Suggested Figure for Publication (if any)**	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)
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Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	64494		

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Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61275977	2009-09-03
Prior Application Status	Pending		Remove

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	108144-202701/US (TGY027)
	Application Number	
Title of Invention	Systems and Methods for an Enhanced Watchdog in Solar Module Installations	

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61276753	2009-09-16

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

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This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

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Application Number	Country [i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			(•) Yes ( ) No

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Assignee 1 Remove

If the Assignee is an Organization check here. [X]

Organization Name	Tigo Energy		
Mailing Address Information:			
Address 1	170 Knowles Drive, Suite 203		
Address 2			
City	Los Gatos	**State/Province**	CA
Country [i] US		Postal Code	95032
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the **Add** button. Add

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/John P. Ward/			Date (YYYY-MM-DD)	2009-12-01
First Name	John P.	Last Name	Ward	Registration Number	40216

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	108144-202701/US (TGY027)
	Application Number	
Title of Invention	Systems and Methods for an Enhanced Watchdog in Solar Module Installations	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

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UNITED STATES PATENT APPLICATION

FOR

SYSTEMS AND METHODS FOR AN ENHANCED WATCHDOG IN SOLAR MODULE INSTALLATIONS

INVENTORS:

RON HADAR
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PREPARED BY:

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SYSTEMS AND METHODS FOR AN ENHANCED WATCHDOG IN SOLAR MODULE INSTALLATIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of Provisional U.S. Application Serial No. 61/275,977, filed September 3, 2009, entitled "SYSTEM AND METHOD FOR ENHANCED WATCH DOG IN SOLAR PANEL INSTALLATIONS," and Provisional U.S. Application Serial No. 61/276,753, filed September 16, 2009, entitled "SYSTEM AND METHOD FOR ENHANCED WATCH DOG IN SOLAR PANEL INSTALLATIONS," the disclosures of which are hereby incorporated herein by reference.

[0002] The following applications are also incorporated herein by reference: U.S. Patent Application Serial No. 12/366,597, filed February 5, 2009, entitled "APPARATUSES AND METHODS TO REDUCE SAFETY RISKS ASSOCIATED WITH PHOTOVOLTAIC SYSTEMS," and U.S. Patent Application Serial No. 12/411,317, filed March 25, 2009, entitled "ENHANCED SYSTEM AND METHOD FOR BALANCING SOLAR PANELS IN A MULTI-PANEL SYSTEM."

FIELD OF THE TECHNOLOGY

[0003] At least some embodiments of the disclosure relate to photovoltaic systems in general, and more particularly but not limited to, improving the safety of photovoltaic systems.

BACKGROUND

[0004] First responders, solar array installers, and maintenance personnel operating near solar arrays can be exposed to dangerous or lethal voltages. The danger can be even higher if certain wires are disconnected through theft, vandalism, accident, natural forces, or other causes. To protect first responders, solar array installers, and maintenance personnel, solar arrays can be turned off in an emergency. However, the systems used to turn off a solar array in an emergency can also be disabled by the emergency (e.g., fire).

SUMMARY OF THE DESCRIPTION

[0005] Systems and methods in accordance with the present invention are described herein. Some embodiments are summarized in this section. The present disclosure relates to systems, methods, and apparatus for shutting down a photovoltaic energy generating unit when communication with a central controller is interrupted. In one approach a solar array may include a watchdog unit able to disconnect a solar module from a power bus, or lower the solar module voltage to a safe level, when communication from the central controller is interrupted. Disconnecting the solar module, or lowering the solar module voltage, may be performed by opening a switchable connection or lowering a duty cycle of the switchable connection. Either of these operations can be controlled by a controller within the watchdog unit. In an embodiment, the watchdog unit may lose power or not have access to its primary energy source (e.g., due to fire, vandalism, or malfunction, to name a few). In such an instance the watchdog unit may turn to a backup energy source (e.g., battery or capacitor).

[0006] One aspect of the disclosure is a system comprising a watchdog unit coupled between a solar module and a power bus. The watchdog unit may be configured to monitor communication from a central controller. The watchdog unit may also be configured to determine that the communication is interrupted. The watchdog unit may also be configured to disconnect the solar module from the power bus when the communication is interrupted.

[0007] Another aspect of the disclosure is a system comprising a watchdog device coupled between a solar module and a power bus. The watchdog device may be configured to verify communication with a central controller. The watchdog device may also be configured to shutdown the solar module if communication with the central controller cannot be verified.

[0008] Another aspect of the disclosure is a computer-implemented method. The method includes monitoring, via a computing device, a signal from a central controller. The method includes determining, via the computing device, if the signal has been lost. The method includes disconnecting, via the computing device, one or more solar modules from a power bus if the signal has been lost. The method includes determining, via the computing device, if the signal includes a shutdown command. The method includes disconnecting, via the computing device, the one or more solar modules from the power bus if the signal includes a shutdown command. The method includes waiting, via the computing device, for a restart signal. The method includes

connecting, via the computing device, the one or more solar modules to the power bus when the restart signal is received.

[0009] Other embodiments and features of the present invention will be apparent from the accompanying drawings and from the detailed description which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The embodiments are illustrated by way of example and not limitation in the figures of the accompanying drawings in which like references indicate similar elements.

[0011] **Figure 1** illustrates an embodiment of an energy production system including a plurality of junction boxes each coupled between a solar module and a power bus.

[0012] **Figure 2** illustrates a solar module and a detail view of an embodiment of a junction box.

[0013] **Figure 3** illustrates an embodiment of a junction box.

[0014] **Figure 4** illustrates an embodiment of a method of controlling the output of a solar module.

[0015] **Figure 5** illustrates another embodiment of a method of controlling the output of a solar module.

DETAILED DESCRIPTION

[0016] The following description and drawings are illustrative and are not to be construed as limiting. Numerous specific details are described to provide a thorough understanding. However, in certain instances, well known or conventional details are not described in order to avoid obscuring the description. References to one or an embodiment in the present disclosure are not necessarily references to the same embodiment; and, such references mean at least one.

[0017] Solar arrays can be shutdown during an emergency, maintenance, or installation in order to protect first responders, solar array installers, and maintenance personnel from shock or electrocution. However, systems used to shutdown a solar array can also be damaged in an emergency. The systems and methods herein disclosed can shutdown a solar array or lower the voltages to safe levels even when the solar array is damaged or when an active shutdown signal is sent to the solar array. Specifically, a watchdog unit is disclosed that monitors communication from a central controller, and upon interruption of that communication, disconnects a solar module from a power bus. Alternatively, when communication is interrupted, the watchdog unit can lower the solar module voltage to a safe level. The systems and methods also describe a watchdog unit able to receive a shutdown signal, which would allow first responders, solar array installers, and maintenance personnel to remotely render the solar array safe before approaching the solar array. In the event that the watchdog unit loses power, backup sources of power are also described.

[0018] **Figure 1** illustrates an embodiment of an energy production system 100 including a plurality of junction boxes 104 each coupled between a solar module 102 and a power bus 108. The solar modules 102 generate power from absorbed photons and provide this power to the power bus 108. The junction boxes 104 control the voltage provided by the solar modules 102 to the power bus 108. In an embodiment, this is done via control of one or more switchable connections within the junction boxes 104. Junction boxes 104 can disconnect the solar modules 102 from the power bus 108 or lower the voltage provided to the power bus 108. The junction boxes 104 may each comprise a watchdog unit. Each watchdog unit can monitor a communication (or signal) from a central controller 106 via wireless or wired connection. When the communication is interrupted, each watchdog unit can render its associated solar module 102 safe by disconnecting the solar module 102 from the power bus 108 or by lowering the solar module 202 voltage to a safe level.

[0019] Power from the solar modules 102 can be converted to alternating current (AC) power via an optional inverter 140, and then provided to the power grid, a battery, or other load. Given a direct current (DC) load, the inverter may be left out. The power bus 108 may be connected in parallel or series with other power buses in a combiner box (not illustrated) before the combined power is provided to the inverter 140 or a (DC) load.

[0020] Watchdog units may also be configured to respond to a shutdown signal. Upon receiving a shutdown signal from the central controller 106, the watchdog units may disconnect the solar modules 102 from the power bus 108, or they may lower the solar module 102 voltages to a safe level. The shutdown signal can be automatically generated within the central controller 106 or some other controller in communication with the central controller 106. Alternatively, the shutdown signal can be manually generated. For instance, a solar array maintenance worker may push a button connected to the central controller initiating shutdown of all solar modules so that the worker can do maintenance on the solar array without worrying about shock or electrocution.

[0021] The location of the central controller 106 is non-limiting. The central controller 106 may be remote. The central controller 106 may be a part of a combiner box or inverter 140. The central controller 106 may be a part of one of the junction boxes 104.

[0022] Although Figure 1 illustrates a junction box 104 for each solar module 102, other embodiments may have solar modules 102 that are coupled directly to the power bus without a junction box 104. Furthermore, even where there is a junction box 104 coupled between each solar module 102 and the power bus 108, there may not be a watchdog unit in every junction box 104.

[0023] A "solar cell" is a photovoltaic device configured to absorb photons and convert them into electrical energy. A "solar module" is a device that includes at least one or more solar cells, wherein the solar cells are connected in series or in parallel. The solar cells absorb photons and convert the photons into electrical energy. A "power bus" is a conductive path connecting one or more solar modules 102 in series. A "watchdog unit" is a device or software implemented in hardware configured to monitor a communication from a central controller 106 and shut down, or disconnect from the power bus 108, a solar module 102 when the communication from the central controller 106 is interrupted or when a shutdown signal is received. A "signal" is an electric quantity (voltage or current or field strength) whose modulation represents coded information.

[0024] **Figure 2** illustrates a solar module 202 and a detail view of an embodiment of a junction box 204. The junction box 204 may be coupled between a solar module 202 and a power bus 208. The junction box 204 may include a controller 212 and may include a switchable connection 216 (or two or more switchable connections 216). The junction box 204 optionally includes a converter/adaptor 218 and/or optionally includes a diode 220. The junction box 204 may include a watchdog unit 210. The watchdog unit 210 may be configured to monitor a communication from the central controller 106, determine that the communication has been interrupted, and disconnect the solar module 202 from the power bus 208 or lower the solar module 202 voltage to a safe level.

[0025] The watchdog unit 210 may be configured to monitor a communication from the central controller 106 via a connection 214. The connection 214 can be wired or wireless. For a wireless communication, the watchdog unit 210 may be implemented in software. For a communication arriving via a wired connection, the watchdog 210 may be implemented in hardware. However, the watchdog unit 210 for monitoring the wired communication may also be implemented in software or in a hardware-software combination. The watchdog unit 210 for monitoring the wireless communication may also be implemented in hardware or in a hardware-software combination. The communication can take any form that can be recognized by the watchdog unit 210. For instance, the communication can be continuous or pulsed, or periodic or non-periodic.

[0026] There are numerous reasons that communication may be interrupted. For instance, the central controller 106 may fail to send a communication or the connection 214 (wired or wireless) between the central controller 106 and the watchdog unit 210 may be severed by fire, accident, or malfunction, to name a few. Whatever the cause of the interruption (or interrupted fault), the watchdog unit 210 can determine that the communication has been interrupted. In response to determining that the communication has been interrupted, the watchdog unit 210 can render its associated solar module 202 safe by disconnecting the solar module 202 from the power bus 208 or by lowering the solar module 202 voltage to a safe level. Disconnecting the solar module 202 can be performed by, for instance, forcing the switchable connection 216 to operate in an open state. Lowering the solar module 202 voltage to a safe level can be performed by, for example, lowering the duty cycle of the switchable connection 216.

[0027] There are numerous ways to determine that a communication has been interrupted. For instance, given a pulsed communication, the watchdog unit 210 may look for loss of the pulses. The watchdog unit 210 may also look for an irregular periodicity to the pulses. The watchdog unit 210 may look for a decrease in the amplitude of the pulses. Whichever one or more of these the watchdog unit 210 looks for, it will also look to see that the irregular behavior has surpassed a threshold. For example, irregularity in the periodicity of the pulses may be identified when less than a threshold number of pulses are received that have an abnormal period. As another example, an interrupted communication may be one that has dropped below a certain threshold amplitude. As another example, an interrupted communication may be one that has been irregular for longer than a threshold period of time. In an embodiment, the watchdog unit 210 may look for a threshold of irregularity to be surpassed. These limited examples merely scratch the surface of the numerous qualities or parameters that can be monitored in order to determine that a communication has been interrupted.

[0028] While the watchdog unit 210 can be triggered by an interrupted communication, it can also be triggered by an instruction or other affirmative signal. For instance, the same communication that the watchdog unit 210 monitors for interruption, could also carry an indication (or instructions) to limit the voltage or disconnect (or shutdown) the solar module 202 from the power bus 208. In other words, the central controller 106 can be configured to transmit a repeated or continuous communication, but it can also be configured to transmit a limited-duration shutdown signal. The watchdog unit 210 can monitor the communication for an interruption or for a shutdown signal. The shutdown signal can be initiated by an automatic control in or of the central controller 106. The shutdown signal can also be manually initiated. The manually-initiated shutdown signal may be used by first responders, solar array installers, and maintenance personnel to remotely render the solar array safe. The manual input can be connected to the central controller 106 or can be remotely transmitted to the central controller 106.

[0029] The watchdog unit 210 can also be triggered by detecting a fault in: the power bus 208 wiring, wiring internal to the watchdog unit 210, or wiring internal to the junction box 204. A fault can be detected by comparing relevant voltages, or the absence of voltages between any one or more of the following: solar modules 202, power buses 208, or ground, to name a few. For instance, a fault can be detected by comparing relevant voltages, or the absence thereof,

between the solar module 202 and the power bus 208. In another example, the relevant voltages, or absence thereof, could be compared between the solar module 202 and the ground.

[0030] As illustrated, the watchdog unit 210 is a part of the junction box 204. Alternatively, the watchdog unit 210 can be located outside the junction box 204. For instance, the watchdog unit 210 can be a part of the combiner box, the inverter 140, or any other location downstream from the junction box 204. The watchdog unit 210 can include any one or more of the following: the controller 212; one or more switchable connections 216; the converter/adaptor 218; and the diode 220. The watchdog unit 210 may lose power. For instance, the watchdog unit 210 may become disconnected from a primary power source (e.g., via fire). In an embodiment, the primary power source may include, for example, one or more of the following: the solar module 202, the power bus 206, a battery (not illustrated), or a capacitor (not illustrated). For instance, the watchdog unit 210 may be wired to draw power from either or both of the solar module 202 and the power bus 206. A backup power source can therefore provide the watchdog unit 210 with power when the watchdog unit's 210 primary power source is not available. In other words, the watchdog unit 210 can draw energy from a backup energy source when a primary energy source is not available.

[0031] The junction box 204 may include the controller 212. The controller 212 may monitor a communication from the central controller 106 via the wired/wireless connection 214. The wired/wireless connection 214 can also be seen in Figure 1 as the dashed line leading from the central controller 106 to the solar modules 102. If the communication is interrupted, then the controller 204 may render the solar module 202 safe by either limiting the solar module 202 voltage or by disconnecting the solar module 202 from the power bus 208. The controller 204 can control the switchable connection 216 via a wired or wireless connection (not illustrated). The controller 204 can control the duty cycle of the switchable connection 216. Thus, the controller 204 can control the voltage that the solar module 202 provides to the power bus 208. The controller 204 can also disconnect the solar module 202 from the power bus 208 by leaving the switchable connection 216 in an open state. The controller 204 can be implemented in hardware, software, or a hardware-software combination. The controller 204 may derive instructions from a storage medium such as a non-volatile storage medium (e.g., electrically erasable programmable read-only memory (EEPROM), read-only memory (ROM), flash, to

name a few). This allows the controller 204 to obtain instructions even when power has been lost.

[0032] The junction box 204 may include the switchable connection 216. The switchable connection 216 may connect and disconnect the solar module 202 to/from the power bus 208. The switchable connection 216 may be normally closed. When the switchable connection 216 is closed, the solar module 202 is connected to the power bus 208, and the entire voltage of the solar module 202 can be provided to the power bus 208. However, when the switchable connection 216 is opened, the solar module 202 may be disconnected from the power bus 208 and cannot provide voltage to the power bus 208. By opening and closing the switchable connection 216 at a particular duty cycle, a portion of the solar module's 202 voltage can be provided to the power bus 208, in essence lowering the solar module 202 voltage to a safe level. The switchable connection 216 can be mechanical or electrical (e.g., transistors). Non-limiting examples of electrical switches include field-effect transistors (FET), metal-oxide-semiconductor FETs (MOSFET), and insulated gate bipolar-type transistors (IGBT). The function of the switchable connection 216 may be carried out elsewhere (e.g., by the inverter 140).

[0033] The junction box 204 may include a converter/adaptor 218. The converter/adapter 218 acts as a local management unit ("LMU"). The LMUs may be configured to balance voltages and currents between solar modules 202 and between power buses 208. The converter/adapter can be implemented serially (as illustrated) or in parallel (not illustrated).

[0034] The junction box 204 may include an optional diode 220. The diode 220 can be coupled in series with the power bus 208 and coupled in parallel with the solar module 202. The diode 220 may be forward biased in the direction of the flow of current. As such, the diode 220 can reverse bias the solar module 202, should the solar module 202 stop producing power. The diode 220 can prevent reversal of the solar module 202 if there are one or more weak solar modules 202 on the power bus 208. Weak solar modules 202 are those that provide a lower current than other solar modules 202. The diode 220 may not be desired for an AC configuration since the diode 220 can rectify an AC power signal and thus reduce the power generated by the solar module 202.

[0035] **Figure 3** illustrates an embodiment of a junction box 304. This embodiment of a junction box 304 is similar to the junction box 204 illustrated in Figure 2, but with the addition of optional switchable connections 322, 324 and optional lines 326, 328, 330.

[0036] The junction box 304 may include a bypass circuit such as the one formed by switchable connection 322. Since current may have to pass through the solar module 302 in order to pass downstream on the power bus 308, current may stop flowing in the power bus 308 if the watchdog unit 310 disconnects one of the solar modules 302 from the power bus 308. A bypass circuit, using the switchable connection 322, shorts the power bus 308 through the junction box 304 such that current in the power bus 308 can bypass the solar module 302. The switchable connection 322 may normally be open, but may close when the solar module 302 is disconnected from the power bus 308. The bypass circuit can be used in combination with a diode 320. The bypass circuit also allows current to pass through the junction box 304 without having to pass through the diode 320 or the solar module 302. The switchable connection 322 can be a mechanical or electronic switch. Non-limiting examples of electronic switches include FETs, MOSFETs, and IGBTs. The switchable connection 322 may not be desired in a high voltage system.

[0037] The junction box 304 may include a switchable connection 324, which can be used to increase the longevity of the solar module 302. The switchable connection 324 may be normally open. When closed, the switchable connection 324 can short the solar module 302 to itself. This may be done when the solar module 302 is disconnected from the power bus 308. In doing so, the solar module 302 can produce current, which may increase the solar module's 302 longevity. Shorting the solar module 302 is described in more detail in related U.S. Patent Application Serial No. 12/542,632, filed August 17, 2009, entitled "SYSTEMS AND METHODS FOR PREVENTION OF OPEN LOOP DAMAGE DURING OR IMMEDIATELY AFTER MANUFACTURING," which is incorporated herein by reference.

[0038] The junction box 304 may include a feed line 326 connecting the solar module 302 and the controller 312. The feed line 326 may be configured to provide the controller 312 with power when power is lost (e.g., when the controller 312 cannot obtain power from its primary power source). The junction box 304 may include a line 328 configured to provide power to the controller 312 from the solar module 302. The junction box 304 may include a line 330 configured provide power to the controller 312 from the power bus 308. The controller 312 may also be powered by a batter or capacitor (not illustrated).

[0039] **Figure 4** illustrates an embodiment of a method of controlling the output of a solar module. The method 400 may be computer-implemented, and each of the operations discussed

below can be carried out via a computing device. The method 400 begins by initializing parameters in an initialize parameters operation 402. System checks are then performed in a perform system checks operation 404. The method 400 then verifies communication with a central controller via a verify communication decision 406. If communications with the central controller are verified, then the method 400 looks for a shutdown signal in a shutdown signal received decision 408. If a shutdown signal is not received, then the method returns to the perform system checks operation 404. If a shutdown signal is received, then the method 400 shuts down the solar module in shutdown operation 410. The method 400 then waits for a restart signal from the central controller in the wait for restart signal operation 412. Once the restart signal is received, the method returns to the initialize parameters operation 402.

[0040] Turning back to the verify communication decision 406, if communication with the central controller is not verified, then the method 400 waits to verify communication. If communication is verified in less than an allowed number of "skips," as determined by a number of allowed skips exceeded decision 414, then the method 400 looks for a shutdown signal in the shutdown decision 408. The method 400 then continues from the shutdown decision 408 as previously described. However, if communication is not verified by the time the number of skips is exceeded, as determined by the number of allowed skips exceeded decision 414, then the method 400 turns to the shutdown operation 410 and shuts the solar module down (disconnects one or more solar modules from the power bus or lowers one or more solar module voltages to safe levels). The method 400 then continues from the shutdown operation 410 as previously described.

[0041] The method 400 begins with the initialize parameters operation 402. Parameters are used in the perform system checks operation 404, as reference points for the system checks. Parameters can thus include values describing any of the systems or devices that the perform system checks operation 404 may look at. For instance, the types of wiring, proper voltages in the wires, proper currents in transistors, expected signals from the central controller, number of allowed skips, what the shutdown signal looks like, and how much time can elapse before an irregular signal is considered interrupted are just some of the parameters that can be used. Parameters can be stored in a storage medium, preferably a non-volatile storage medium such as electrically erasable programmable read-only memory (EEPROM), read-only memory (ROM), and flash.

[0042] The method 400 then performs system checks in the perform operation 404. System checks compare the parameters to measured values. Some non-limiting examples of things that can be measured include, types of wiring, voltages in the wires, currents in transistors, signals from the central controller, number of skips, the shutdown signal, and elapsed time of interrupted signals, to name a few. For instance, a parameter initialized in the initialize operation 402 may indicate that the voltage produced by the panel should be around 30V plus or minus 5V. If the system check finds the voltage to be 29V, then everything is acceptable. However, if the voltage were 24V or any other value below 25V, then the system check might provide a warning to the central controller or take some other remedial action.

[0043] Once system checks have been performed, the method 400 tries to verify communication with the central controller in the verify decision 406. Verifying communication includes monitoring a communication from the central controller and ensuring that there are no problems with the communication. For instance, ensuring that the voltage of the communication is above a certain threshold (e.g., within 10% of maximum power), ensuring that a certain number of pulses are received within a certain period of time (e.g., at least one hundred pulses per second), or ensuring that communication is not lost for longer than a threshold period of time (e.g., communication is not verified if lost for more than three seconds), to name a few. In an embodiment, verifying communication can include receiving a communication within a set time from when a last communication was received. For instance, if communications are supposed to be received every two seconds, and there is a three second gap between receipt of two consecutive communications, the method 400 may determine that communication has not been verified. The signal or communication from the central controller can be transmitted via wireless or wired means. In an embodiment, verifying communication can be an active rather than passive operation. For example, a signal such as a challenge can be sent to the central controller, and the communication is not verified until a response is received.

[0044] If communication is verified, then the method 400 determines if a shutdown signal has been received in the shutdown signal received operation 408. A shutdown signal can replace the signal that is being monitored. Alternatively, the shutdown signal can be overlaid or multiplexed onto the signal being monitored. The shutdown signal can be initiated by automatic means, such as a fire alarm. The shutdown signal can be initiated by manual means, such as a fireman pushing an emergency shutdown button at the breaker box on a house that is burning.

[0045] If the shutdown signal is not received, then the method 400 can loop back to the perform system checks operation 402 as illustrated. Alternatively, the method 400 can continue to verify communication with the central controller via the verify decision 406. If the shutdown signal is received, then the method 400 shuts the solar module down in the shutdown operation 410. Shutdown may include using a watchdog and/or switchable connection to disconnect the solar module from the power bus. Shutdown may include using a watchdog and/or switchable connection to lower the solar module voltage to a safe level.

[0046] After shutdown, the method 400 waits for a restart signal. The restart signal is a signal from the central controller that is transmitted via the same wireless or wired means that communicates the originally monitored signal. The restart signal may be automatically transmitted when certain conditions are met or may be manually initiated. For instance, at the end of a fire or after a home has been fixed after a fire, maintenance personnel may flip a manual switch near the fuse box to initiate the restart signal. In an embodiment where the system is running off of a limited backup power source, the backup power source may run down while the method 400 waits for the restart signal. In this case, the method 400 can initiate a full shutdown. The full shutdown may include turning off all systems which are still operational. When the restart signal is received, the method 400 can loop back to the initialize parameters operation 402.

[0047] Returning now to the verify communication decision 406, if communication with the central controller cannot be verified, then the method 400 may continue trying to verify communication until a threshold is surpassed. This continued attempt to verify takes place via the number of skips allowed decision 414. Skips refers to the event of missing a communication or pulse. If a communication or pulse should be received every second, but one pulse is not received, then a skip has occurred. For example, if a communication or pulse is not received for five seconds, then four skips have occurred. Additionally, the threshold can take many forms. For instance, the threshold can be a number of skips. The threshold can be a time period in which communication cannot be verified. The threshold can be a number of missed pulses or a number of pulses having less-than-expected amplitude. These are just a few non-limiting examples of the plethora of thresholds that can be used in the number of allowed skips decision 414. The threshold values can be extracted from or read from a storage medium. The storage medium can be the same one that stores parameters, or it can be a separate storage medium. In either case,

non-volatile memory can be used so that the threshold values can still be accessed even after power is lost.

[0048] When the threshold is surpassed (or number of skips is exceeded) the method 400 moves to the shutdown and wait operations 410, 412. However, if the threshold is not surpassed (e.g., communication with the central controller is lost, but resumes before the threshold is surpassed), then the method 400 determines if the communication (or signal) includes a shutdown signal via the shutdown decision 408.

[0049] One skilled in the art will recognize that the order of operations of the method 400 can be varied without departing from the spirit of the disclosure. At the bare minimum the method 400 requires the verify communication decision 406 along with the shutdown operation 410. Thus, in the broadest sense, the method 400 is about monitoring communication from the central controller, verifying the communication, and shutting the solar module down when the communication cannot be verified. Any one or more of the other operations and decisions can be added to this basic set of decision 406 and operation 410. As for different orders of operation, the method 400 can look for the shutdown signal via the shutdown decision 408 concurrently with the verify decision 406 or before the verify decision 406. The number of allowed skips exceeded decision 414 may also operate before, after, or concurrently with the shutdown decision 408. Furthermore, once a restart signal has been received, the method 400 may loop back to the verify decision 406 rather than the initialize and perform operations 402, 404.

[0050] **Figure 5** illustrates another embodiment of a method of controlling the output of a solar module. The method 500 may be computer-implemented, and each of the operations discussed below can be carried out via a computing device. The method 500 monitors a signal from a central controller in a monitor operation 502. The method 500 determines if the signal has been lost via a signal lost decision 504. If the signal is lost, then one or more solar modules are disconnected from a power bus via a disconnect operation 508. Disconnect means that a switchable connection has a reduced duty cycle such that the voltage provided to the power bus by the solar module is reduced. In an embodiment, the switchable connection can have a duty cycle of 0%, always open, such that no voltage is provided to the power bus. The method 500 may also determine if the signal includes a shutdown signal via a shutdown signal received decision 506. If the signal includes a shutdown signal, then the method 500 disconnects one or more solar modules from the power bus via the disconnect operation 508. If a shutdown signal is

not received, then the method 500 continues to monitor the signal from the central controller via the monitor operation 502. When the one or more solar modules are disconnected from the power bus, the method 500 may optionally enable a bypass circuit via an enable bypass circuit operation 510. The bypass circuit allows current to continue to flow in the power bus when the one or more solar modules are disconnected from the power bus. The method 500 may then wait for a restart signal via a wait operation 512. The method 500 continues to wait for the restart signal until the restart signal is received or until a backup power source (e.g., battery or capacitor) runs out, assuming the primary power source is not available. If the backup power source runs out, then the method 500 initiates a full shutdown. If the restart signal is received, then the method 500 can connect the one or more solar modules to the power bus via a connect operation 516.

[0051] By lost signal, it is meant that the signal amplitude is not great enough to surpass an amplitude threshold or that the signal has become so irregular as to surpass an irregularity threshold. For instance, if only ten out of a hundred pulses have been received (assuming a pulsed signal), then the signal may be considered lost.

[0052] In an embodiment, watchdog units can be coupled between each solar module and the power bus. The watchdog units can be configured to monitor a signal from a central controller and disconnect the solar modules from the power bus if the signal is lost or if the signal includes a shutdown signal. However, there may not be a watchdog unit for each solar module. In such an embodiment, solar modules that are not coupled to a watchdog unit may not be disconnected from the power bus.

[0053] Disconnecting one solar module from the power bus may include a complete disconnection, as for example performed via the opening of a mechanical or electronic switch. However, disconnecting can also include lowering the voltage (e.g., lowering a duty cycle of a switch). One skilled in the art will recognize that the order of operations of the method 500 can be varied without departing from the spirit of the disclosure.

[0054] It is clear that many modifications and variations of these embodiments may be made by one skilled in the art without departing from the spirit of the novel art of this disclosure. For example, instead of including the watchdog units with the junction boxes, the watchdog units can be a part of local management units (LMU's) that are also responsible for balancing the currents between solar modules in a power bus and are responsible for balancing the voltages between

power buses in a solar array. These modifications and variations do not depart from the broader spirit and scope of the invention, and the examples cited herein are to be regarded in an illustrative rather than a restrictive sense.

CLAIMS

What is claimed is:

1. A system comprising:
a watchdog unit coupled between a solar module and a power bus and configured to:
monitor a communication from a central controller;
determine that the communication is interrupted; and
disconnect the solar module from the power bus when the communication is interrupted.

2. The system of claim 1, further comprising a switchable connection configured to disconnect the solar module from the power bus.

3. The system of claim 2, wherein the switchable connection is controlled by a controller.

4. The system of claim 3, further comprising a feed line from the solar module to the controller, and configured to provide the controller with power from the solar module when a primary power source is unavailable.

5. The system of claim 1, further comprising a bypass circuit configured to enable current in the power bus to bypass the solar module.

6. The system of claim 1, further comprising a backup power source configured to provide the watchdog unit with power when a primary power source is unavailable.

7. The system of claim 1, wherein the communication is interrupted when a threshold of irregularity is surpassed.

8. The system of claim 1, wherein the communication is interrupted when the central controller fails to send a communication.

9. The system of claim 1, wherein the watchdog unit resides in a junction box.

10. The system of claim 1, further configured to disconnect the solar module from the power bus when the watchdog unit receives a shutdown signal.

11. The system of claim 1, wherein the watchdog unit wirelessly communicates with the central controller.

12. A system comprising:

a watchdog device coupled between a solar module and a power bus, the watchdog device configured to:

verify communication with a central controller; and

shutdown the solar module if communication with the central controller cannot be verified.

13. The system of claim 12, wherein to shutdown the solar module entails disconnecting the solar module from the power bus.

14. The system of claim 12, wherein to verify communication:

a challenge is sent to the central controller; and

a response to the challenge is received.

15. The system of claim 12, wherein to verify communication, a communication is received within a set time from when a last communication was received.

16. The system of claim 12, further configured to shutdown the solar module if a shutdown signal is received.

17. The system of claim 12, further configured to wait for a restart signal.

18. The system of claim 12, further configured to draw energy from a backup energy source when a primary energy source is not available.

19. A computer-implemented method comprising:

monitoring, via a computing device, a signal from a central controller;

determining, via the computing device, if the signal has been lost;

disconnecting, via the computing device, one or more solar modules from a power bus if the signal has been lost;

determining, via the computing device, if the signal includes a shutdown command;

disconnecting, via the computing device, the one or more solar modules from the power bus if the signal includes a shutdown command;

waiting, via the computing device, for a restart signal; and

connecting, via the computing device, the one or more solar modules to the power bus when the restart signal is received.

20. The method of claim 19, further comprising:

enabling, via the computing device, a bypass circuit when the one or more solar modules are disconnected from the power bus, so that current continues to flow in the power bus.

ABSTRACT

Systems and methods are disclosed for automatically or remotely rendering a solar array safe during an emergency or maintenance. A watchdog unit is disclosed for monitoring a signal from a central controller. If the signal is lost, interrupted, or becomes irregular, or if a shutdown signal is received, then the watchdog unit can shutdown one or more solar modules. Shutting down a solar module can mean disconnecting it from a power bus of the solar array or lowering the solar module voltage to a safe level.

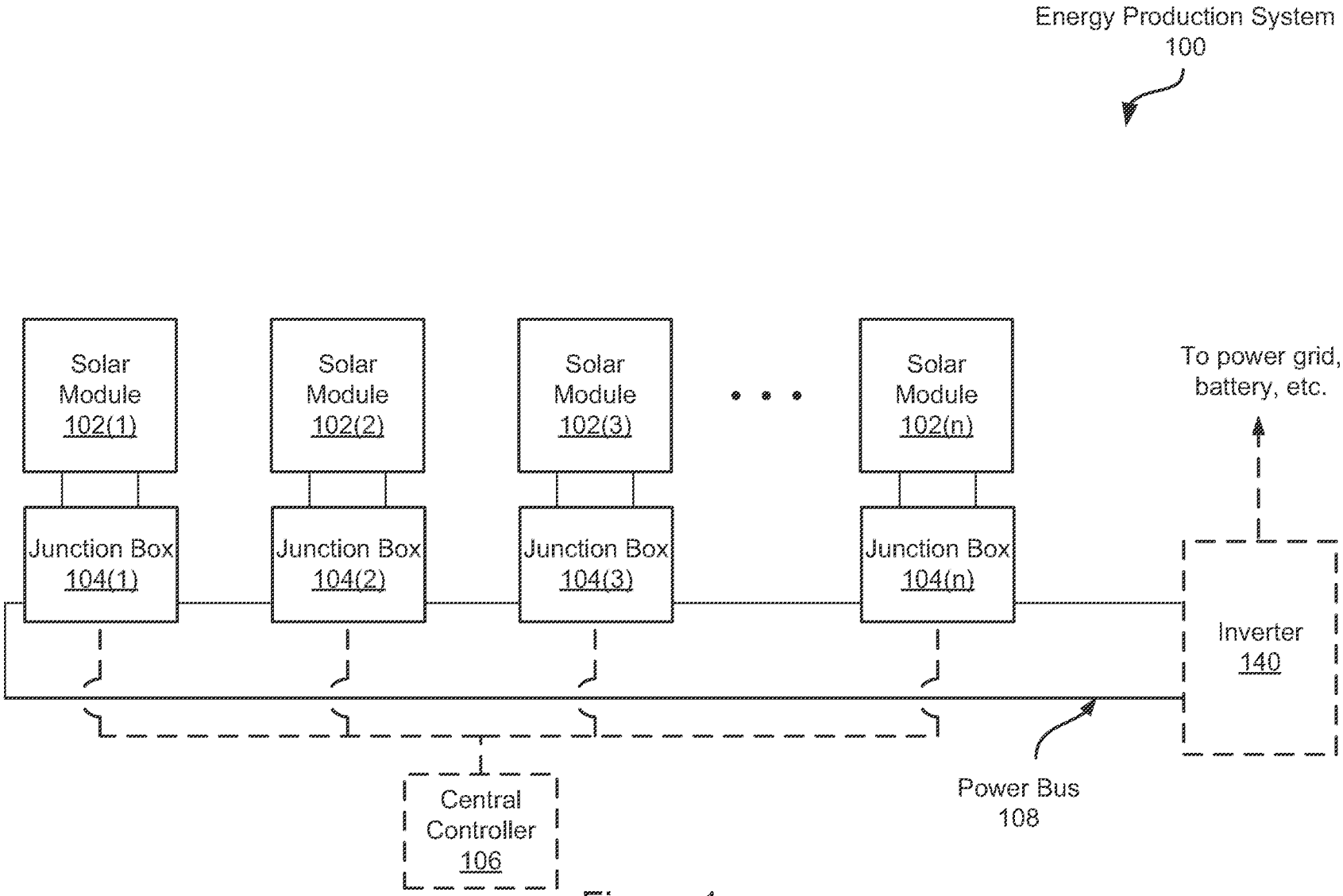

Energy Production System
100
Solar Module 102(1)
Solar Module 102(2)
Solar Module 102(3)
Solar Module 102(n)
To power grid, battery, etc.
Junction Box 104(1)
Junction Box 104(2)
Junction Box 104(3)
Junction Box 104(n)
Inverter 140
Central Controller 106
Power Bus 108

Figure 1

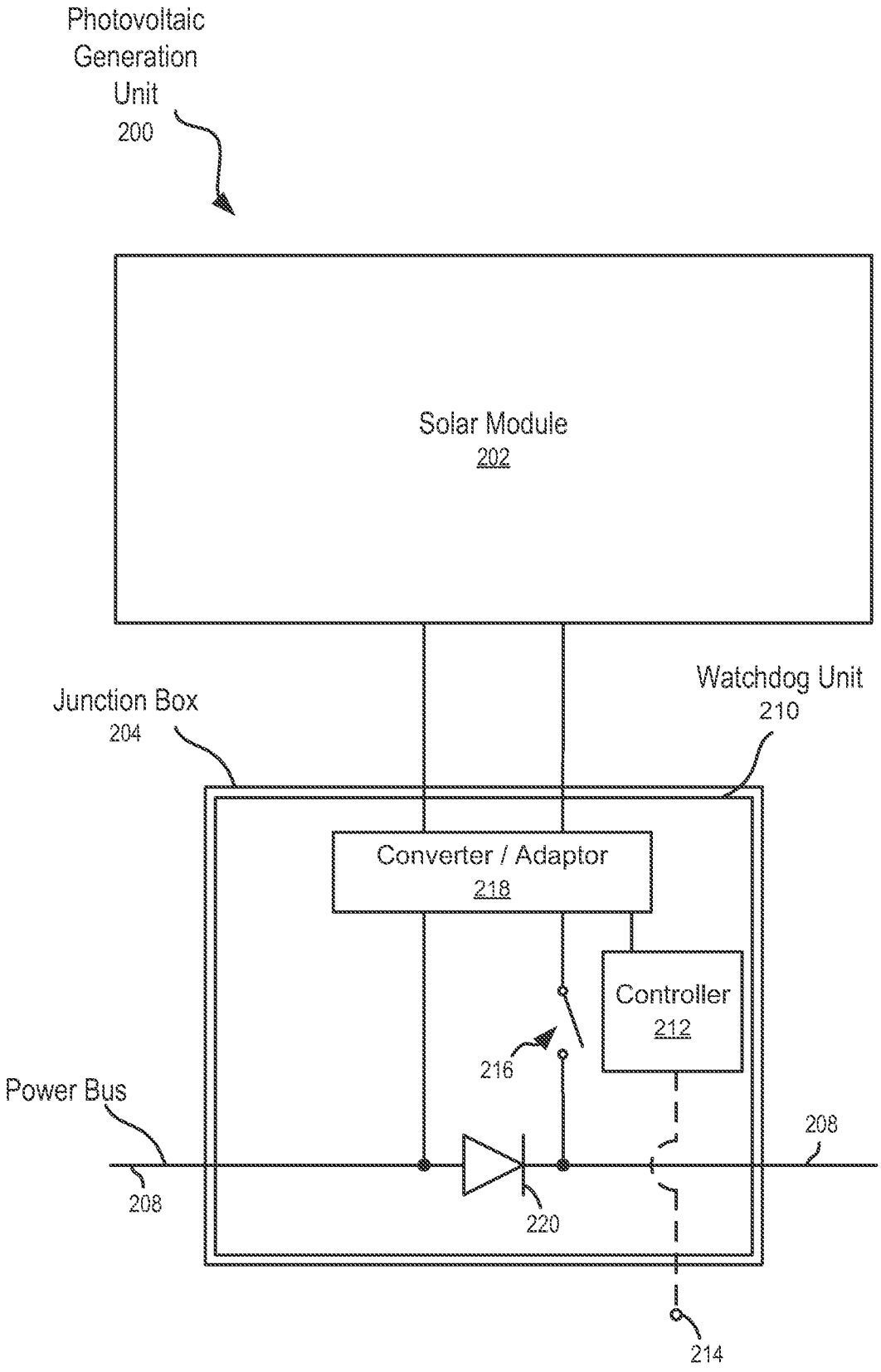

Photovoltaic Generation Unit
200
Solar Module
202
Junction Box
204
Watchdog Unit
210
Converter / Adaptor
218
Controller
212
216
Power Bus
208
208
220
214

Figure 2

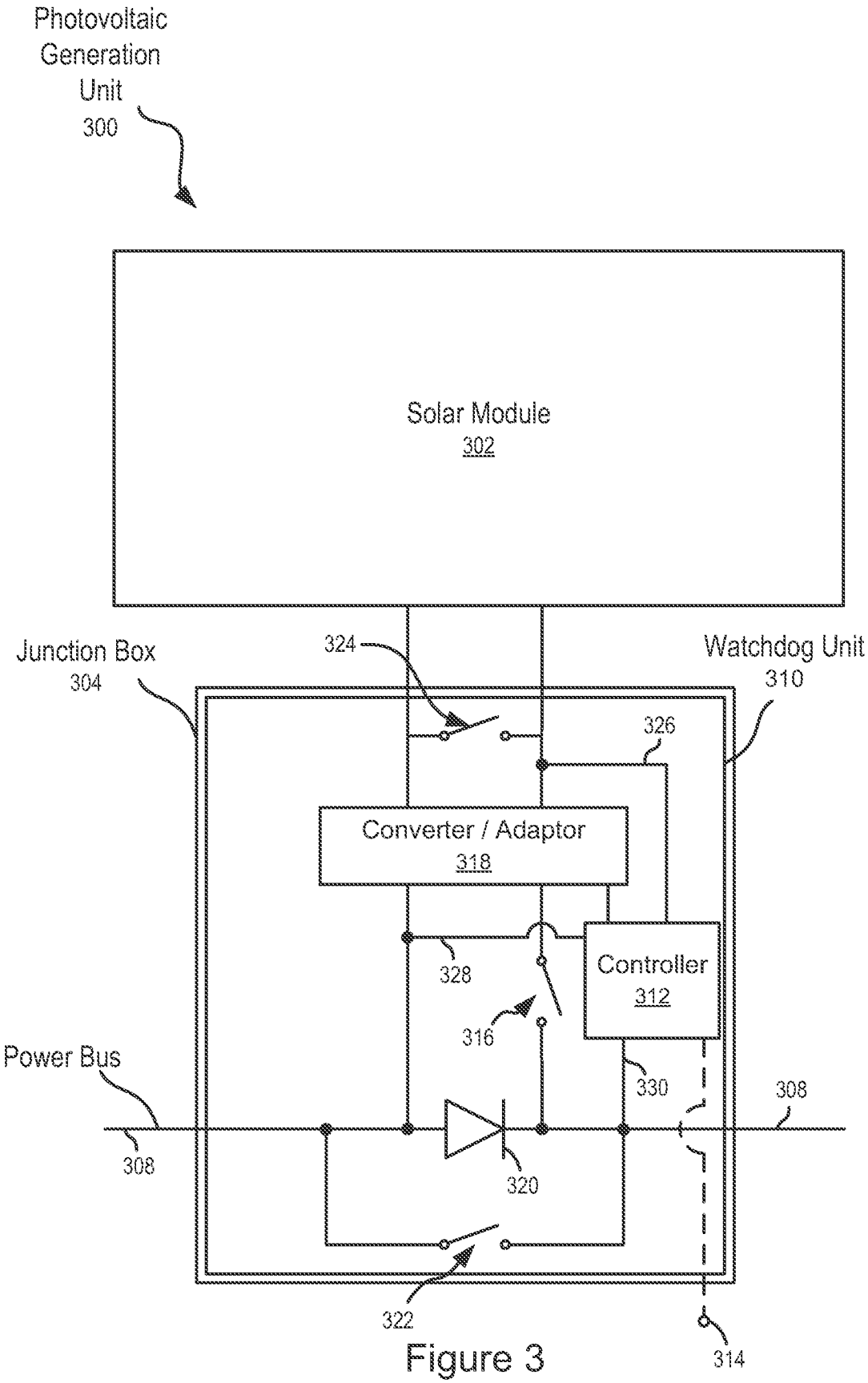

Photovoltaic Generation Unit
300
Solar Module
302
Junction Box
304
324
Watchdog Unit
310
326
Converter / Adaptor
318
328
Controller
312
316
Power Bus
330
308
308
320
322
314

Figure 3

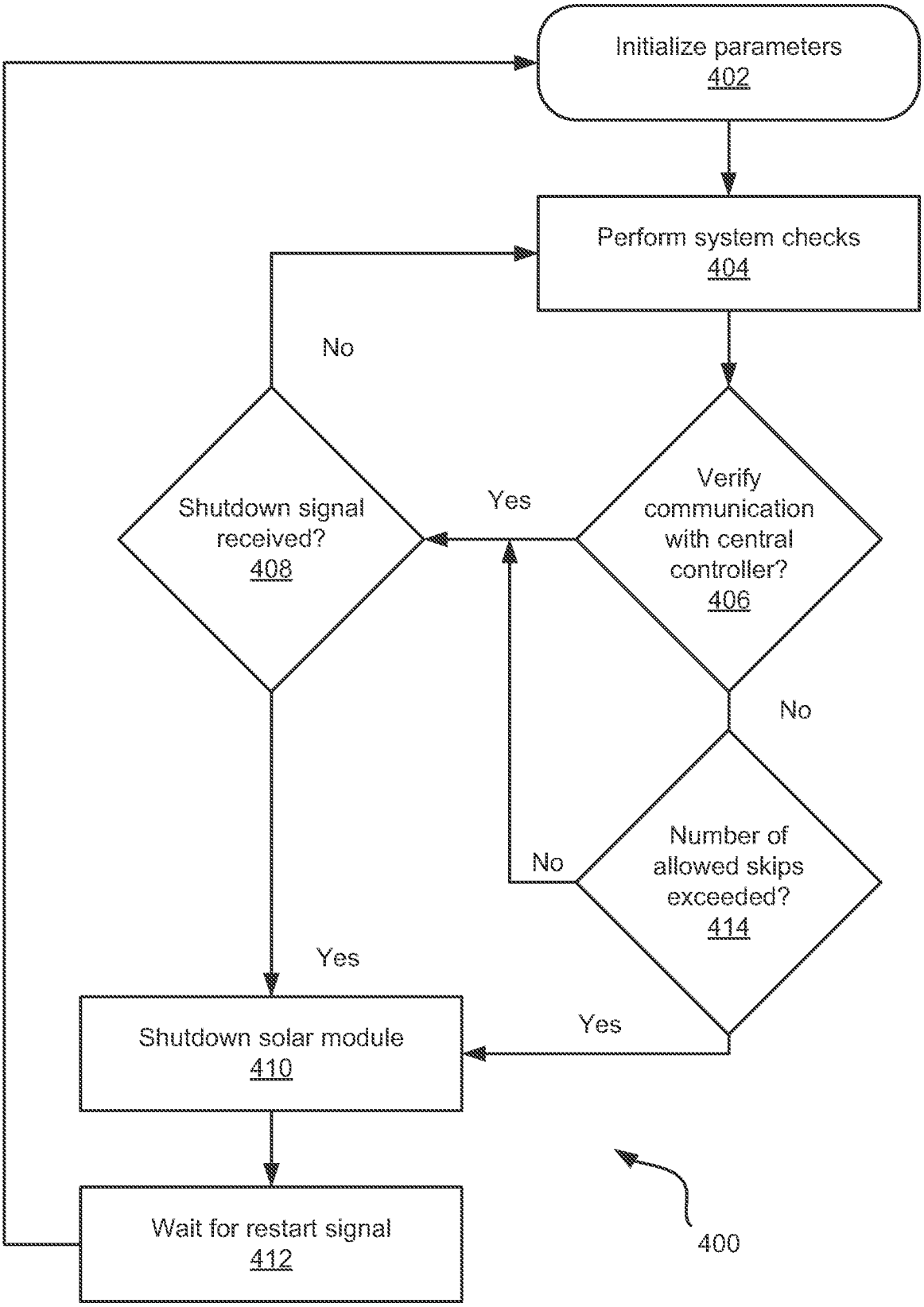

Initialize parameters
402
Perform system checks
404
No
Shutdown signal received?
408
Yes
Verify communication with central controller?
406
No
Number of allowed skips exceeded?
414
No
Yes
Yes
Shutdown solar module
410
Wait for restart signal
412
400

Figure 4

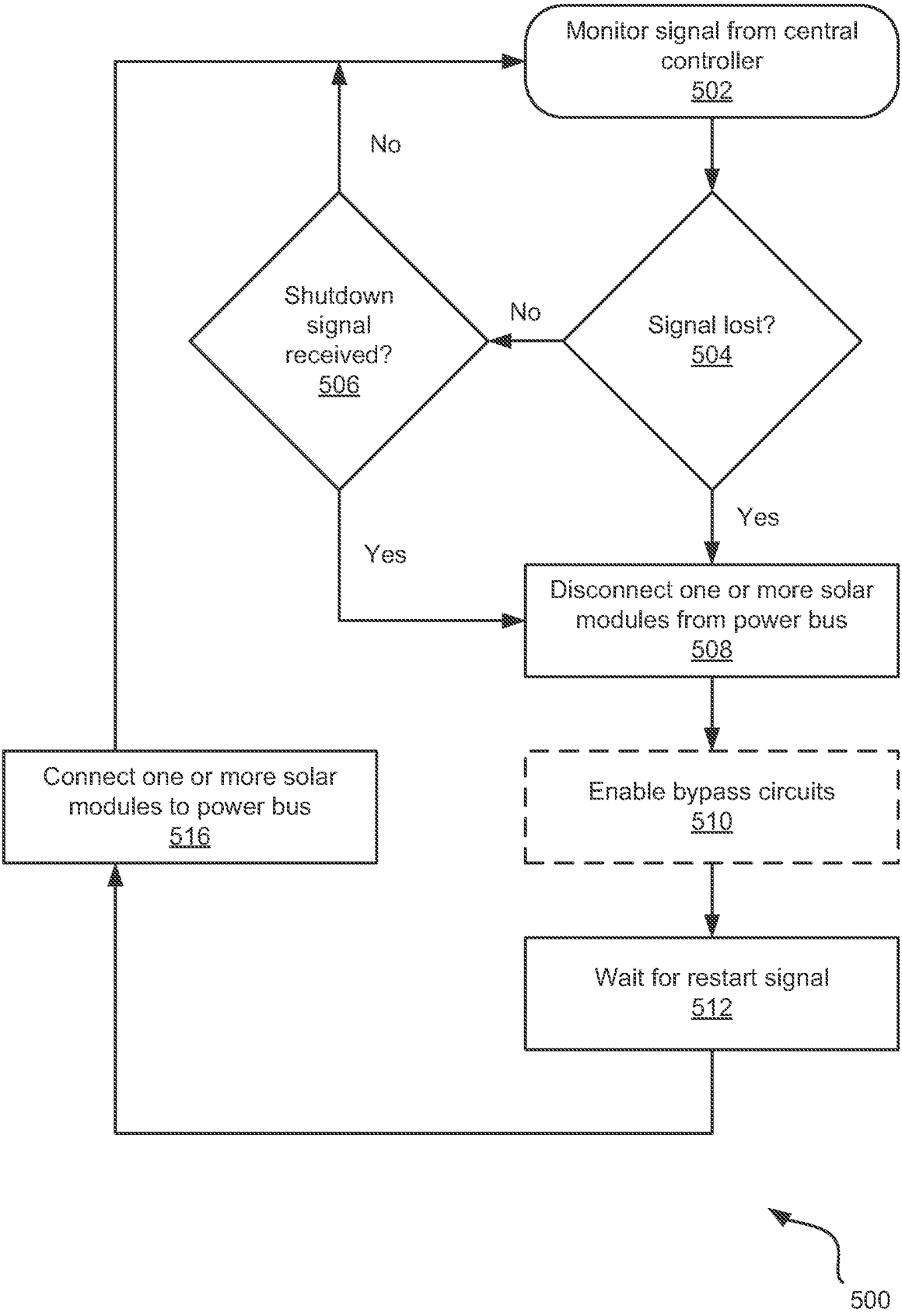

Monitor signal from central controller
502
No
Shutdown signal received?
506
No
Signal lost?
504
Yes
Yes
Disconnect one or more solar modules from power bus
508
Enable bypass circuits
510
Wait for restart signal
512
Connect one or more solar modules to power bus
516
500

Figure 5

UNITED STATES PATENT APPLICATION

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SYSTEMS AND METHODS FOR AN ENHANCED WATCHDOG IN SOLAR MODULE INSTALLATIONS

The specification of which
a. ☒ is attached hereto
b. ☐ was filed on _____, as Application Serial no. _____, which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

a. ☒ no such applications have been filed.
b. ☐ such applications have been filed as follows:

FOREIGN APPLICATION(S), IF ANY, CLAIMING PRIORITY UNDER 35 USC § 119			
COUNTRY	**APPLICATION NUMBER**	**DATE OF FILING (day, month, year)**	**DATE OF ISSUE (day, month, year)**
ALL FOREIGN APPLICATION(S), IF ANY, FILED BEFORE THE PRIORITY APPLICATION(S)			
COUNTRY	**APPLICATION NUMBER**	**DATE OF FILING (day, month, year)**	**DATE OF ISSUE (day, month, year)**

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose to the Office all information known which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

a. ☒ no such applications have been filed.
b. ☐ such applications have been filed as follows:

For Continuation-in-Part (CIP) Applications, complete

U.S. APPLICATION NUMBER	DATE OF FILING (day, month, year)	STATUS (patented, pending, abandoned)

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below:

a. ☐ no such applications have been filed.
b. ☒ such applications have been filed as follows:

U.S. PROVISIONAL APPLICATION NUMBER	DATE OF FILING (Day, Month, Year)
61/275,977	3 September 2009
61/276,753	16 September 2009

I hereby appoint all attorneys and/or patent agents associated with the following customer number, to prosecute this application and to transact all business in the Patent and Trademark Office and before competent International Authorities including the World Intellectual Property Organization, connected herewith:

Customer Number 64494

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Greenberg Traurig, LLP to the contrary.

Please direct all correspondence in this case to Greenberg Traurig, LLP at the customer number indicated below:

Customer Number 64494

Phone: 650-328-8500
Fax: 650-328-8508
svip@gtlaw.com

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

COMBINED DECLARATION AND POWER OF ATTORNEY CONTINUED

Full Name of Inventor	Last Name	First Name	Middle Name
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Signature of Inventor:			**Date: MM/DD/YYYY** 11/30/2009

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Signature of Inventor:			**Date: MM/DD/YYYY** 11/30/2009

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	Systems and Methods for an Enhanced Watchdog in Solar Module Installations
First Named Inventor/Applicant Name:	Ron HADAR
Filer:	John Patrick Ward/Anne Collette
Attorney Docket Number:	108144-202701/US (TGY027)

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility filing Fee (Electronic filing)	4011	1	82	82
Utility Search Fee	2111	1	270	270
Utility Examination Fee	2311	1	110	110
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**462**

Electronic Acknowledgement Receipt

EFS ID:	6552333
Application Number:	12628977
International Application Number:	
Confirmation Number:	6958
Title of Invention:	Systems and Methods for an Enhanced Watchdog in Solar Module Installations
First Named Inventor/Applicant Name:	Ron HADAR
Customer Number:	64494
Filer:	John Patrick Ward/Anne Collette
Filer Authorized By:	John Patrick Ward
Attorney Docket Number:	108144-202701/US (TGY027)
Receipt Date:	01-DEC-2009
Filing Date:	
Time Stamp:	20:22:45
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$462
RAM confirmation Number	6957
Deposit Account	502638
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	108144-202701US_ADS.pdf	1229750 85290dd0a31d87a4b38ad71e10142f2feaae69ce	no	5
Warnings:					
Information:					
2		108144-202701US_Application.pdf	145786 09624a163860f18c281b1ff447d3532ca67e5e35	yes	22

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Specification	1	18
	Claims	19	21
	Abstract	22	22

Warnings:					
Information:					
3	Drawings-only black and white line drawings	108144-202701US_Drawings.pdf	29494 63d7f5a058310d123b2f037246f0c070f3ddf7e0	no	5
Warnings:					
Information:					
4	Oath or Declaration filed	108144-202701US_Declaration.pdf	123877 a287a53c56bd34da217e4b3c58eeb174ea562082	no	3
Warnings:					
Information:					
5	Fee Worksheet (PTO-875)	fee-info.pdf	32879 61a109669823458f26095d1ba9552d1689174e1a	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1561786		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Filing Date: 12/01/09

Approved for use through 7/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 12/628,977

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	82		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	270		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	110		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =		x$26		OR	x$52	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x$110			x$220	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $270 ($135 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			195			390	
			TOTAL	462		TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
						TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
						TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**