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(54) **METHOD AND ARRANGEMENT FOR CONTROLLING A SOLAR POWERED PUMP**

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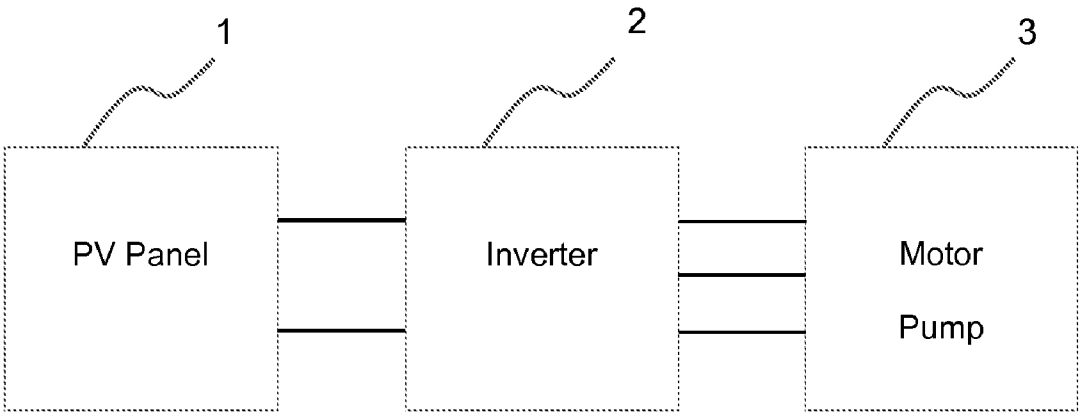
(57) **ABSTRACT**

A method and arrangement are disclosed for operating a pump in pump system having a photovoltaic panel system, an inverter electrically connected to the photovoltaic panel system, and a motor driving the pump and electrically connected to the output of the inverter. The method can include setting a voltage limit for the inverter, monitoring the voltage produced by the photovoltaic panel system, operating the inverter for rotating of the motor when the voltage produced by the photovoltaic panel system is above the voltage limit, and disabling use of the inverter when the voltage of the photovoltaic system remains below the voltage limit.



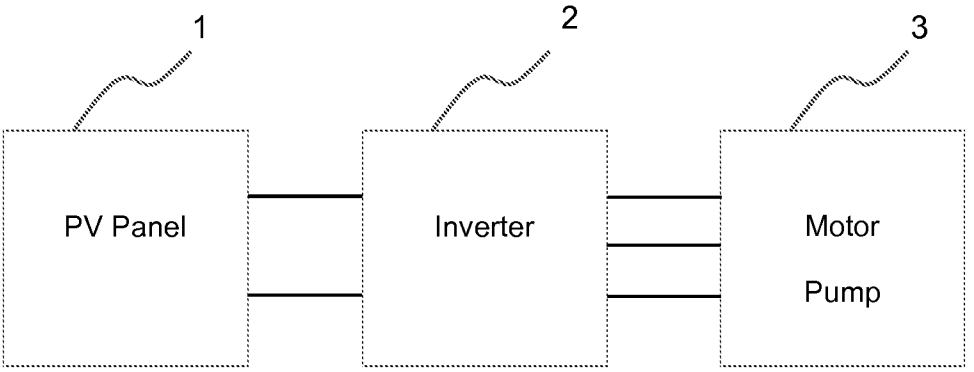


FIG 1

METHOD AND ARRANGEMENT FOR CONTROLLING A SOLAR POWERED PUMP

RELATED APPLICATION

[0001] This application claims priority under 35 U.S.C. §119 to Indian Patent Application No. 4397/CHE/2013 filed in India on Sep. 27, 2013, the entire content of which is hereby incorporated by reference in its entirety.

FIELD

[0002] The present disclosure relates to pumping processes, such as pumping processes using power from a photovoltaic module.

BACKGROUND INFORMATION

[0003] Photovoltaic modules or solar panels are widely used for generating electrical power. To this end, electrical power from the photovoltaic panels can be consumed directly, stored in a battery or fed to electrical grid. When the energy is consumed directly, the load may be for example a motor for a specific purpose, such as pumping. In such a case the motor rotates the pump if power is available from the photovoltaic panel system.

[0004] The output of photovoltaic panels depends on atmospheric conditions. Clouds in the sky may temporarily shadow the photovoltaic panels from sunlight which immediately affects the output from the photovoltaic panels. Further, the temperature of the photovoltaic panels has an effect on the power output. For extracting the maximum power from the photovoltaic panels a maximum power point tracker can be employed. Such a tracker operates to change the operation point of the photovoltaic panel so that as much power as possible is obtained. For changing the operation point of the photovoltaic panel, the output voltage or current from the photovoltaic panel is changed.

[0005] An AC motor, such as an induction motor, is an exemplary motor used in pumping processes. The induction motor uses alternating voltage and for that purpose an inverter is connected to feed the motor. As known, inverters are converter devices which are able to produce alternating voltage from a DC voltage source using a pulse width modulation technique. The pumping systems with maximum power point trackers can be complicated and expensive devices.

[0006] A simpler structure can be obtained by connecting an inverter directly to the output of the photovoltaic panel system or photovoltaic panel. The inverter obtains variable DC voltage as its input voltage. The inverter can be operated with variable DC voltage, but problems can arise when an actual DC voltage level falls below the low voltage level of the inverter. This will stop the operation of the inverter. This may happen when, for example, clouds are shadowing the panels temporarily. When the inverter stops modulation for the reason of low input voltage, the operation is not continued automatically, and the user has to manually start the inverter again.

SUMMARY

[0007] A method is disclosed for operating a pump in a pump system having a photovoltaic panel system, an inverter electrically connected to the photovoltaic panel system, and a motor driving the pump and electrically connected to an output of the inverter, the method comprising: setting a voltage limit for the inverter; monitoring voltage produced by the photovoltaic panel system; operating the inverter for rotating of the motor when the voltage produced by the photovoltaic panel system is above the voltage limit; and disabling use of the inverter when the voltage of the photovoltaic system is below the voltage limit.

[0008] A pump arrangement is disclosed comprising: a photovoltaic panel system; an inverter electrically connected to the photovoltaic panel system; a motor driving a pump and electrically connected to an output of the inverter; means for setting a voltage limit for the inverter; means for monitoring voltage produced by the photovoltaic panel system such that the inverter will be controlled to operate for rotating the motor when a voltage produced by the photovoltaic panel system is above the voltage limit; and means for disabling use of the inverter when a voltage produced by the photovoltaic system is below the voltage limit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] In the following discussion, disclosed features and advantages will be described in greater detail by way of exemplary embodiments with reference to the accompanying drawing, in which:

[0010] FIG. **1** shows a simplified block diagram of an exemplary pumping system driven by an inverter.

DETAILED DESCRIPTION

[0011] Methods, and arrangements for implementing the methods, are disclosed herein so as to solve the aforementioned issues.

[0012] Exemplary embodiments are based on an idea of enabling operation of an inverter when an output voltage from a photovoltaic panel system exceeds a settable voltage limit. As the inverter, directly connected to the output of the photovoltaic panel system, is operated only after the voltage has risen to a certain level, the operation of the inverter can operate more reliably. Once the voltage sinks below the limit, the inverter can set itself to an operation mode in which it waits for the voltage to rise again. Thus, the inverter does not have to be started again since it does not shut down for low input voltage.

[0013] According to an exemplary embodiment disclosed herein, a user of the inverter can also set a minimum rotational speed limit for the pumping operation. When the rotational speed of the pump in a pumping system is low, the pump is not necessarily capable of producing flow. This may wear the pump excessively since the pumped liquid is not cooling the pump.

[0014] FIG. **1** shows a simplified block diagram of an exemplary pumping arrangement as disclosed herein. In the block diagram a photovoltaic (PV) panel system is connected to the input of an inverter. The term photovoltaic panel system refers, for example, to any combination of photovoltaic panels, modules or strings, and can also be a single panel. As known, the PV panels produce DC voltage, and thus the output from the PV panels is directly connected to the input of the inverter. The output of the three phase inverter is further connected to a three phase AC motor, which is for example an induction motor. A pump is further mechanically connected to the motor such that the pump is rotated together with the motor.

[0015] When the pumping system is operated according to an exemplary method as disclosed herein, a voltage limit is set. Once the voltage of PV panel system connected to the voltage input of the inverter exceeds or reaches the set limit,

the inverter is started and it starts modulating; i.e., producing output voltage to the motor. The inverter will produce the output voltage for a corresponding motor speed. If the pump is unable to reach the minimum speed as defined for example by the user, then the inverter will shutoff and wait for set restart time before restarting once again. This process will continue until the pumps starts working above the speed limit set.

[0016] Once the voltage from the PV panel system reaches the limit, the inverter starts controlling the motor according to the control scheme of the inverter. The motor may be controlled with any known control method for rotating the motor. The inverter may employ, for example, a known constant volts per hertz scheme, in which a ratio between the output voltage of the inverter and the frequency of the output voltage is kept constant. As the start of the modulation can be made automatically, the user of the system can set a certain program in the inverter. This program may, for example, maximise the pumping process outcome by driving the motor and the pump at a maximum available rotational speed without exceeding the maximum rotational speed limit.

[0017] Once the motor and the pump are rotating and the voltage is above the set limit, the voltage may drop below the set limit for some reason. The voltage may drop, for example, due to temporary clouding. As the voltage drops below the set limit, the use of the inverter is disabled. Once the use of the inverter is disabled, it does not produce output voltage, but it actively monitors the input DC voltage. If the DC voltage rises again above the limit, then the inverter starts its modulation again. The use of the voltage limit saves the motor from being run with a low voltage.

[0018] According to an exemplary embodiment disclosed herein, a method can include setting a minimum rotational speed limit. When this limit is set, the inverter can continuously monitor the rotational speed of the motor and the pump. When the speed drops below the set limit, the modulation of the inverter is disabled; i.e., the inverter does not produce voltage to the motor. The pumping system is stopped for the reason of low rotational speed for ensuring that the pump will not be damaged. After the rotational speed has fallen below the limit, the inverter checks whether the voltage from the panel system is above the set limit.

[0019] If the voltage is above the voltage limit, then the operation of the inverter is started. For starting the inverter, voltage level and dry run functionality for example can be checked. Whenever the voltage of the inverter falls below the voltage limit, a predefined set restart time gap can be provided for the automatic restart of the inverter. Whereas in the case of a dry run function, a longer settable restart time can be allowed. This time can depend on, for example, an area of pump installation considering the water recovery in that particular area and the user can set a time for restart accordingly.

[0020] The voltage limit can be chosen such that the voltage limit corresponds to a certain percentage of the nominal value of the open circuit voltage of the PV panel system. The selected percentage may be in an exemplary range of 50 to 80% of a nominal value of the open circuit voltage.

[0021] It should be understood that the voltage limit can affect the operation of the inverter in such a way that, as the limit value is lower, the pump is driven with a lower voltage, and an output from the pump is obtained with lower voltages. The limit value may also be selected based on the nominal values of the motor driving the pump.

[0022] The rotational speed limit may be chosen such that when operating near the voltage limit, the power obtainable from the PV panel system is enough to rotate the pump with speeds higher than the limit.

[0023] An exemplary arrangement disclosed herein can include a photovoltaic panel system **1**, an inverter **2** electrically connected to the photovoltaic panel system and a motor **3** driving the pump and electrically connected to the output of the inverter **2**. The arrangement can include means (e.g., a user interface) for setting a voltage limit for the inverter. This voltage limit may be set directly to the inverter as a parameter.

[0024] According to an exemplary embodiment disclosed herein, the arrangement can include means for monitoring the voltage produced by the photovoltaic panel system (e.g., a voltage sensor). For example, the inverter can include measurement circuits that are used for determining the input voltage.

[0025] The inverter can be further adapted to operate for rotating the motor when the voltage produced by the photovoltaic panel system is above the voltage limit. For this purpose, a simple comparison logic circuit or software module can be included. The set limit and the monitored voltages are compared, and when the inverter detects that the monitored voltage is above the limit, the inverter is operational to rotate the motor.

[0026] The arrangement can include means for disabling the use of the inverter when the voltage of the photovoltaic system remains below the voltage limit (e.g., a disable switch). The means for disabling the use of the inverter can include circuitry in the inverter that stops the modulation of the inverter.

[0027] For determining whether the voltage is below a limit for a period of a time interval, a clock circuit can be included in the inverter. The output of the clock circuit can be compared with the time interval in the inverter. As known, inverters can include a certain amount of calculation capacity for the purpose of simple comparisons and calculations. Other embodiments of the method disclosed herein may also be implemented using an inverter.

[0028] It will be apparent to those skilled in the art that, as technology advances, the inventive concepts can be implemented in various ways. The invention and its embodiments are not limited to the examples described herein but may vary within the scope of the claims.

[0029] Thus, it will be appreciated by those skilled in the art that the present invention can be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are therefore considered in all respects to be illustrative and not restricted. The scope of the invention is indicated by the appended claims rather than the foregoing description and all changes that come within the meaning and range and equivalence thereof are intended to be embraced therein.

1. A method of operating a pump in a pump system having a photovoltaic panel system, an inverter electrically connected to the photovoltaic panel system, and a motor driving the pump and electrically connected to an output of the inverter, the method comprising:

setting a voltage limit for the inverter;

monitoring voltage produced by the photovoltaic panel system;

operating the inverter for rotating of the motor when the voltage produced by the photovoltaic panel system is above the voltage limit; and

disabling use of the inverter when the voltage of the photovoltaic system is below the voltage limit.

2. A method according to claim **1**, comprising:

setting a rotational speed limit;

monitoring a rotational speed of the motor connected to the output of the inverter; and

disabling the use of the inverter when the rotational speed of the motor is below the set rotational speed limit.

3. A method according to claim **2**, comprising:

restarting of the inverter by checking whether the monitored voltage is above the set voltage limit;

starting operation of the inverter if the voltage is above the set limit; and

if the inverter is disabled due to dry run fault or due to low rotational speed, then starting the operation of the inverter after a settable time delay.

4. A pump arrangement comprising:

a photovoltaic panel system;

an inverter electrically connected to the photovoltaic panel system;

a motor driving a pump and electrically connected to an output of the inverter;

means for setting a voltage limit for the inverter;

means for monitoring voltage produced by the photovoltaic panel system such that the inverter will be controlled to operate for rotating the motor when a voltage produced by the photovoltaic panel system is above the voltage limit; and

means for disabling use of the inverter when a voltage produced by the photovoltaic system is below the voltage limit.

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