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METHOD AND ARRANGEMENT FOR CONTROLLING A SOLAR POWERED PUMP

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ABSTRACT

A method of operating a pump in a pump system including a photo-voltaic panel system (1), an inverter (2) electrically connected to the photo-voltaic panel system and a motor (3) driving the pump and electrically con-
5 nected to the output of the inverter (2). The method includes 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 pro-
duced by the photovoltaic panel system is above the voltage limit, and dis-
abling the use of the inverter when the voltage of the photovoltaic system re-
10 mains below the voltage limit.

(Figure 1)

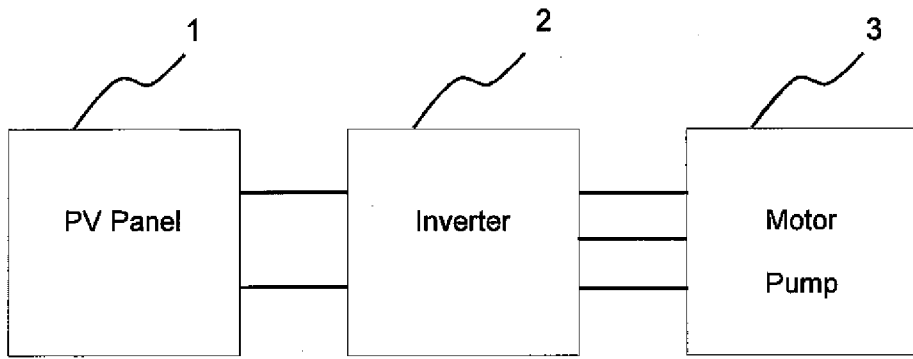


FIG 1

METHOD AND ARRANGEMENT FOR CONTROLLING A SOLAR POWERED PUMP

FIELD OF THE INVENTION

The present invention relates to pumping processes, and more particularly to pumping processes using power from a photovoltaic module.

BACKGROUND OF THE INVENTION

Photovoltaic modules or solar panels are widely used for generating electrical power. According to the purpose, 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.

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 of the power output. For extracting the maximum power from the photovoltaic panels a maximum power point tracker is often 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.

An AC motor, such as an induction motor, is a typical motor used in pumping processes. The induction motor requires 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 Pulse width modulation technique. The pumping systems with maximum power point trackers are complicated and expensive devices. A simpler structure is obtained by connecting an inverter directly to the output of the photovoltaic panel system or photovoltaic panel. The inverter obtains thus variable DC voltage as its input voltage. The inverter can be operated with variable DC voltage, but problems arise when 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.

BRIEF DESCRIPTION OF THE INVENTION

5 The present invention is aimed at providing a method and an arrangement for implementing the method so as to solve or at least ameliorate the abovementioned problem.

10 The invention is based on the idea of enabling the operation of the inverter when the output voltage from the photovoltaic panel system exceeds a settable voltage limit. As the inverter, that is 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 operates 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 up again. Thus the inverter does not have to be started again since it is not shut down for low input voltage.

15 According to a preferred embodiment of the invention, a user of the inverter can also set a minimum rotational speed limit for the pumping operation. When in a pumping system the rotational speed of the pump 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.

20 With the foregoing in view the invention in one aspect resides broadly in a method of operating a pump in a pump system including 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 including:

- 25 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
- 30 disabling the use of the inverter when the voltage of the photovoltaic system remains below the voltage limit.

30 In another aspect the invention resides broadly in a pump arrangement including 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 arrangement including:

- 35 means for setting a voltage limit for the inverter,
- means for monitoring the voltage produced by the photovoltaic

panel system, wherein

the inverter is adapted to operate for rotating the motor when the voltage produced by the photovoltaic panel system is above the voltage limit, and

5 the arrangement includes means for disabling the use of the inverter when the voltage of the photovoltaic system remains below the voltage limit.

BRIEF DESCRIPTION OF THE DRAWINGS

10 In the following the invention will be described in greater detail by means of preferred embodiments with reference to the accompanying drawings, in which

Figure 1 shows a simplified block diagram of a pumping system driven by an inverter.

DETAILED DESCRIPTION OF THE INVENTION

15 Figure 1 shows a simplified block diagram of a pumping arrangement according to the invention. In the block diagram a photovoltaic (PV) panel system is connected to the input of an inverter. The term photovoltaic panel system refers 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 preferably an induction motor. A pump is further mechanically connected to the motor such that the pump is rotated together with the motor.

25 When the pumping system is operated according to the method of the invention, 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 and corresponding speed. If the pump is unable to reach the minimum speed as defined 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.

35 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, known constant volts per hertz scheme, in which the ratio between the output voltage of the inverter and the frequency of the output voltage is kept constant. As the start of the modulation is made automatically, the user of the system typically has set a certain program on 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.

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.

According to an embodiment of the invention, the method includes setting a minimum rotational speed limit. When this limit is set, the inverter continuously monitors 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 voltages 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. 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 are checked. Whenever the voltage of the inverter falls below the voltage limit, a predefined set restart time gap is given for the automatic restart of the inverter. Whereas in case of dry run function a longer settable restart time is allowed. This time depends on the area of pump installation considering the water recovery in that particular area and the user can set time for restart accordingly.

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 the range of 50 to 80 % of the nominal value of the open circuit voltage. It is understood, that the voltage limit affects 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 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.

5 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.

10 The arrangement of the present invention comprises 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 further includes means for setting a voltage limit for the inverter. This voltage limit may be set directly to the inverter as a parameter.

15 According to the invention, the arrangement includes means for monitoring the voltage produced by the photovoltaic panel system. Typically, the inverter includes measurement circuits that are used for determining the inputted voltage. The inverter is 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 is required. 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.

20 The arrangement further includes means for disabling the use of the inverter when the voltage of the photovoltaic system remains below the voltage limit. The means for disabling the use of the inverter is preferably circuitry in the inverter that stops the modulation of the inverter. For determining whether the voltage is below a limit for period of a time interval, a clock circuit is required in the inverter. The output of the clock circuit is compared with the time interval in the inverter. As known, inverters include certain amount of calculation capacity for the purposes of simple comparisons and calculations. Other
30 embodiments of the method of the invention may also be implemented using an inverter.

35 It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of operating a pump in a pump system including 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 including:
- 5 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
- 10 disabling the use of the inverter when the voltage of the photovoltaic system remains below the voltage limit.
2. A method according to claim 1, including:
- setting a rotational speed limit,
 monitoring the rotational speed of the motor connected to the output
- 15 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, further including restarting of the inverter by
- 20 checking whether the monitored voltage is above the set voltage limit,
 starting the 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
- 25 speed, then starting the operation of the inverter after a settable time delay.
4. A pump arrangement including 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 arrangement including:
- 30 means for setting a voltage limit for the inverter,
 means for monitoring the voltage produced by the photovoltaic panel system, wherein
- the inverter is adapted to operate for rotating the motor when the voltage produced by the photovoltaic panel system is above the voltage limit,
- 35 and

the arrangement includes means for disabling the use of the inverter when the voltage of the photovoltaic system remains below the voltage limit.

EDITORIAL NOTE

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- There is 1 page of Drawings which is not page numbered

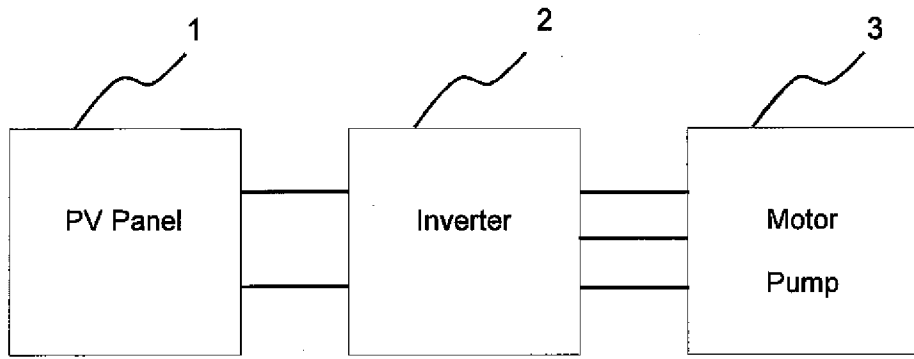


FIG 1