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(54) Title: CONTROL SYSTEM AND METHOD FOR POWERING VEHICLE WITH SOLAR ENERGY

(57) Abstract: A control system and a method for powering a vehicle with solar energy. The control system comprises a solar battery unit (1); a buck DC/DC converter (2); a boost DC/DC converter (3); an auxiliary power module (4) electrically connected with the solar battery unit (1); a control module (5) electrically connected with the solar battery unit (1), the buck DC/DC converter (2), and the boost DC/DC converter (3); a starting battery (7) electrically connected with the buck DC/DC converter (2); a power battery pack (9) electrically connected with the boost DC/DC converter (3) via a main contactor (K5); a battery manager (10) electrically connected with the control module (5), the power battery pack (9), the starting battery (7) via a third switch (K3), and the auxiliary power module (4) via a fourth switch (K4); and a photosensitive sensor (11) connected with the control module (5). The control system and the method can maximally use the solar energy to supply power to the vehicle load or charge the power battery pack.
CROSS-REFERENCE TO RELATED APPLICATIONS
The present application claims priority to and benefits of Chinese Patent Application No. 201010296994.8 filed with SIPO on September 30, 2010, the entirety of which is hereby incorporated by reference.

FIELD
The present disclosure relates to the field of powering a vehicle, more particularly to a control system and method of powering a vehicle with solar energy.

BACKGROUND
To settle problems of energy shortage and ever more severe environmental pollution, new energy, including electric energy and solar energy etc., has already been adopted in vehicles. The utilization of the solar energy to charge the vehicle not only reduces the environmental pollution but also increases the driving range of the vehicle.

At present, the application of the solar battery to electric vehicles is to provide power to the power battery after starting the vehicle. The disadvantage resides in that the solar energy is wasted for vehicles when the vehicle is stopping or parking. Thus, maximum utilization of the solar energy is not realized for charging the vehicle.

SUMMARY
In viewing thereof, the present invention is directed to solve at least one of the problems existing in the prior art. Accordingly, a control system of powering a vehicle with solar energy may need to provided, which may utilize solar energy maximally to power the vehicle. Further, a control method of powering a vehicle with solar energy may need to be provided.

Accordingly, according to an embodiment of the present disclosure, a system of powering a vehicle with solar energy may be provided, comprising: a solar battery unit for converting the solar energy; a buck DC/DC converter electrically connected with the solar battery unit with a first switch, which is electrically connected with a low-voltage load and a starting battery respectively; a boost DC/DC converter electrically connected with the solar
battery unit with a second switch, which is electrically connected with a high-voltage load; an auxiliary power module electrically connected with the solar battery unit; a control module connected with the solar battery unit, the buck DC/DC converter, the boost DC/DC converter; a power battery pack electrically connected with the boost DC/DC converter via a main contactor; a battery manager electrically connected with the control module, the power battery pack, the starting battery via a third switch, and the auxiliary power module via a fourth switch respectively; and a photosensitive sensor connected with the control module.

According to another embodiment of the present disclosure, a control method of the control system for powering a vehicle with solar energy as described herein above may be provided, which may comprise the steps of: powering the control module via the auxiliary power module by the solar battery unit when an output power of the solar battery unit has an output power greater than a predetermined start threshold P of the auxiliary power module; powering the low-voltage load and the starting battery with the solar battery unit via the buck DC/DC converter under the control of the control module when the vehicle is running; and powering the power battery pack with the solar battery unit via the boost DC/DC converter under the control of the control module when the vehicle is parking.

According to the present disclosure, when the vehicle is running or parking etc, the solar energy from the solar battery unit is always provided to the vehicle, realizing the maximum utilization of the solar energy so that unnecessary waste of the solar energy may be avoided.

Additional aspects and advantages of the embodiment of present invention will be given in part in the following descriptions, become apparent in part from the following descriptions, or be learned from the practice of the embodiment present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects and advantages of the invention will become apparent and more readily appreciated from the following descriptions taken in conjunction with the drawings in which:

Fig. 1 is a schematic diagram illustrating a control system of a solar power supply according to an embodiment of the present disclosure.

Fig. 2 is a schematic diagram illustrating a control system of a solar power supply according to another embodiment of the present disclosure.

Fig. 3 is a flow chart illustrating a control method of a control system for powering a vehicle with solar energy according to an embodiment of the present disclosure.
DETAILED DESCRIPTION

Reference will be made in detail to embodiment of the present disclosure. The embodiment described herein with reference to drawings are explanatory, illustrative, and used to generally understand the present disclosure. The embodiment shall not be construed to limit the present disclosure. The same or similar elements and the elements having same or similar functions are denoted by like reference numerals throughout the descriptions.

As shown in Fig. 1, a control system of powering a vehicle with solar energy is schematically shown. The control system may comprise a solar battery unit 1, such as for example a solar battery pack, a buck DC/DC converter 2, a boost DC/DC converter 3, a control module 5, a low-voltage load 6, a starting battery 7, a high-voltage load 8, a power battery pack 9, an auxiliary power module 4, a photosensitive sensor 11, a main contactor K5, a first switch K1, a second switch K2, a third switch K3, and a fourth switch K4. The solar battery unit 1 is connected to the auxiliary power module 4 and the control module 5 respectively, which is connected to the DC/DC buck 2 converter via the first switch K1 and connected to the boost DC/DC converter 3 via the second switch K2. The buck DC/DC converter 2 is connected to the low-voltage load 6, the starting battery 7 and the control module 5 respectively. The boost DC/DC converter 3 is connected to the high-voltage load 8 and the control module 5 respectively, which is connected to the power battery pack 9 via the main contactor K5. As shown in Fig. 1, the power battery pack 1 is connected to a battery manager 10. The control module 5 is connected to the auxiliary power module 4, the battery manager 10 and a photosensitive sensor 11. The auxiliary power module 4 is connected to the battery manager 10 via the fourth switch K4. The battery manager 10 is connected to the starting battery 7 via the third switch K3.

The low-voltage load 6 may be the load connected in series to the starting battery 7 comprising, for example, lamps, instrument panels and wipers etc.

The high-voltage load 8 may be the load to which the power battery pack 9 directly supplies power, comprising, for example but not limited hereto, air conditioner, steering electromotor, air compressors and wheel motors etc.

In some embodiment, the first switch K1, the second switch K2, the third switch K3 and the fourth switch K4 may be electric control relays or manual switches respectively. In some embodiment, the control module 5 may be a DSP chip.

Fig. 2 is a schematic diagram illustrating a control system of powering a vehicle with
solar energy according to another embodiment of the present disclosure, which is substantially
the same with the aforementioned embodiment of the present disclosure except those as
described hereinafter.

A service switch K6 is electrically connected with an output of the solar power battery 1
which is configured for switching on/off circuits between the solar power battery 1 and the
buck DC/DC converter 2, between the solar power battery 1 and the boost DC/DC converter 3,
between the solar power battery 1 and the control module 5 and between the solar power
battery 1 and the auxiliary power module 4. When the entire control system is needed for
maintenance, the service switch K6 is switched off to ensure the operation safety of the entire
control system.

A host computer display 12 may be provided between the auxiliary module 4 and the
control module 5. The host computer display 12 may display the operation state of the entire
control system. The operation states of the entire control system may comprise, but not limited
hereto, module operating states, such as the buck DC/DC converter 2 or the boost DC/DC
converter 3, the output voltages and currents of the solar battery unit 1, the buck DC/DC
converter 2 or the boost DC/DC converter 3, warning lamps for over-voltage, rectification
efficiency, over-current and over-temperature etc, for example. In actual operation, the host
computer display 12 is convenient for user to check the operation state of the entire control
system and cope with the faults timely. Certainly, the host computer display 12 may display
any states to users as condition may require.

The output of the solar battery unit 1 may be electrically connected with a voltmeter for
detecting the output voltage of the solar battery unit 1 and an ammeter for detecting the output
current of the solar battery unit 1. An output of the buck DC/DC converter 2 may have a
voltmeter for detecting the output voltage of the buck DC/DC converter 2 and an ammeter for
detecting the output current of the buck DC/DC converter 2. And an output of the boost
DC/DC converter 3 may have a voltmeter for detecting the output voltage of the boost DC/DC
converter 3 and an ammeter for detecting the output current of the boost DC/DC converter 3.
Thus, the control module 5 may sample the output voltages and currents of the solar battery
unit 1, the buck DC/DC converter 2 and the boost DC/DC converter 3. Based on the sampled
voltages and currents thereof, maximum power point tracking (MPPT) may be utilized
performed, and output PWM waves to adjust the buck DC/DC converter 2 and the boost
DC/DC converter 3 respectively. In result, the utilization of the solar energy is improved and
the MPPT is commonly used in the art, the detailed description of which is hereby omitted for
clarity purpose.

Fig. 3 shows a flow chart illustrating a control method of the control system for powering a vehicle with solar energy as described above. The method may comprise: powering the control module 5 via the auxiliary power module 4 by the solar battery unit 1 when an output power of the solar battery unit 1 has an output power greater than a predetermined start threshold P of the auxiliary power module 4;

powering the low-voltage load 6 and the starting battery 7 with the solar battery unit 1 via the buck DC/DC converter 2 under the control of the control module 1 when the vehicle is running; and

powering the power battery pack 9 with the solar battery unit 1 via the boost DC/DC converter 3 under the control of the control module 5 when the vehicle is parking.

Furthermore, the step of powering the low-voltage load 6 and the starting battery 7 when the vehicle is running may further comprise the steps of:

switching on the third switch K3 under the control of the control module 5, powering the battery manager 10 with the starting battery 7, with the main contactor K5 being switched on and the high-voltage load 8 being powered by the power battery pack 9 if the self-inspection of the battery manager 10 is successful, also sending an instruction of switching on the main contactor K5 to the control module 5;

sampling an output voltage of the solar battery unit 1 by the control module 5, sampling sunlight with the photosensitive sensor 11, and switching on the first switch K1 when the output voltage of the solar battery unit 1 is greater than or equal to a predetermined voltage C4 and the photosensitive voltage sampled by the photosensitive sensor 11 is greater than or equal to a predetermined voltage CI in a first predetermined time; and

sampling the output voltage and current of the solar battery unit 1 and/or sampling the output voltage and current of the buck DC/DC converter 2 by the control module 5 for maximum power point tracking, and outputting a PWM wave to adjust the buck DC/DC converter 2 for controlling the solar battery unit 1 to provide power to the low-voltage load 6 and the starting battery 7 via the buck DC/DC converter 2.

Furthermore, when the vehicle is parking, the solar battery unit 1 provides power to the power battery pack 9 via the boost DC/DC converter 3 under the control of the control module 5. The process includes following steps of:

switching off the third switch K3 and switching on the fourth switch K4 under the control of the control module 5, powering the battery manager 10 with the auxiliary power module 4,
switching on the main contactor K5 if the self inspection of the battery manager 10 is successful and sending an instruction of closing the main contactor K5 to the control module 5;
sampling the output voltage of the solar battery unit 1 by the control module 5, sampling sunlight with the photosensitive sensor 11, and switching on the second switch K2 when the output voltage of the solar battery unit 1 is greater than or equal to the predetermined voltage C4 and the sunlight voltage sampled by the photosensitive sensor 11 is greater than or equal to the predetermined voltage CI; and
sampling the output voltage and current of the solar battery unit 1 and/or sampling the output voltage and current of the boost DC/DC converter 3 by the control module 5 for maximum power point tracking, and outputting a PWM wave to adjust the boost DC/DC converter 3 for controlling the solar battery unit 1 to provide power to the power battery pack 9 via the boost DC/DC converter 3.

As shown in Fig. 3, the control method may comprise the following steps.

S10: powering the control module 5 by the solar battery unit 1 via the auxiliary power module 4 when the output power of the solar battery unit 1 is greater than a predetermined start threshold P of the auxiliary power module 4;

S11: detecting the state of the vehicle and when the vehicle is running, performing the step S12, when the vehicle is parking, performing the step S15;

S12: when the vehicle is running, the third switch K3 is switched on by the control module 5, the battery manager 10 is powered by the solar battery unit 7, and the battery manager 10 performs self inspection; if the self inspection thereof is successful, the main contactor K5 is switched on and the high-voltage load 8 is powered by the power battery pack 9, also the instruction of switching on the main contactor K5 is sent to the control module 5;

S13: the control module 5 samples the output voltage of the solar battery unit 1 and the photosensitive sensor 11 samples the sunlight; when the output voltage of the solar battery unit 1 is greater than or equal to the predetermined voltage C4 and the photosensitive voltage sampled by the photosensitive sensor 11 is greater than or equal to the predetermined voltage CI in a first predetermined time, the first switch K1 is switched on;

S14: the control module 5 samples the output voltages and currents of the solar battery unit 1 and/or the buck DC/DC converter 2, then maximum power point tracking is performed based on the sampled voltages and currents, and outputs the PWM wave to adjust the buck DC/DC converter 2 for controlling the solar battery unit 1 to provide power to the low-voltage load 6 and the starting battery 7 via the buck DC/DC converter 2;
S15: when the vehicle is parking, the third switch K3 is switched off by control module 5, and the fourth switch K4 is switched on, the battery manager 10 is powered by the auxiliary power module 4; if the self inspection of the battery manager 10 is successful, the main contactor K5 is switched on and the instruction of switching on the main contactor K5 is sent to the control module 5;

S16: the control module 5 samples the output voltage of the solar battery unit 1 and the photosensitive sensor 11 samples the sunlight, when the output voltage of the solar battery unit 1 is greater than or equal to the predetermined voltage C4 and the photosensitive voltage sampled by the photosensitive sensor 11 is greater than or equal to the predetermined voltage CI in the first predetermined time, the second switch K2 is switched on;

S17: the control module 5 samples the output voltages and currents of the solar battery unit 1 and/or the boost DC/DC converter 3, then maximum power point tracking is performed based on the sampled voltages and currents, and outputs the PWM wave to adjust the boost DC/DC converter 3 for controlling the solar battery unit 1 to provide power to the power battery pack 9 via the boost DC/DC converter 3.

In one embodiment, the predetermined start threshold P of the auxiliary power module 4 may be about 30W to about 35W. In one embodiment, the first predetermined time may be about 5s to about 10s. In one embodiment, the predetermined voltage C1 may be about 1V to about 3V. In one embodiment, the predetermined voltage C4 may be about 84V to about 126V.

In one embodiment, for step S10, when the output power of the solar battery unit 1 is greater than the predetermined start threshold P of the auxiliary power module 4, the control module 5 is powered by the solar battery unit 1 via the auxiliary power module 4. The predetermined start threshold P of the auxiliary power module 4 is defined by the design parameters of the auxiliary power module 4 and may be, for example, 30W. From aforementioned description, the step S10 may be performed only if the output power of the solar battery unit 1 is greater than the predetermined start threshold P of the auxiliary power module 4, if not, the entire control system does not work, that is, the control module 5 powered by the solar battery unit 1 via the auxiliary power module 4 is not performed.

In one embodiment, for step S11, the control method may further comprise a step of detecting the state of the vehicle, which may further comprise the steps of: detecting whether the battery manager 10 sends an instruction of switching on the main contactor K5 in the second predetermined time, such as 20s-30s; and determining that the vehicle is running or parking based on whether the instruction of switching on the main contactor K5 is sent within
the second predetermined time. Certainly, the description in step S11 is only one method for detecting the state of the vehicle, the vehicle state may also be determined by detecting the ignition switch position (ON or OFF position).

In one embodiment, for step S12, when the vehicle is running, the control module 5 switches on the switch K3, the battery manager 10 is powered by the solar battery unit 7, the battery manager 10 performs self inspection. The step of self inspection performed by the battery manager 10 may include: 1) detecting whether the voltage of each cell in the power battery pack 9 is over-voltage or under-voltage; detecting if each cell in the power battery pack 9 has a temperature within a first predetermined range; detecting whether the pre-charge of the main contactor K5 is finished or not; and detecting whether leakage current of the vehicle has a leakage current within a second predetermined range. It should be noted that the self inspection of the battery manager 10 is not limited to the four steps as described herein above.

If the self inspection performed by the battery manager 10 is successful, the main contactor K5 is switched on, the high-voltage load 8 is powered by the power battery 9 and the instruction of switching on the main contactor K5 is sent to the control module 5; if the self inspection performed by the battery manager 10 is not successful, the self inspection is performed in loop until the self inspection is successful, then a next step may be continued.

In one embodiment, for step S13, the control module 5 samples the output voltage of the solar battery unit 1 and the photosensitive sensor 11 samples the sunlight; when the output voltage of the solar battery unit 1 is greater than or equal to the predetermined voltage C4 and the photosensitive voltage sampled by the photosensitive sensor 11 is greater than or equal to the predetermined voltage CI in a first predetermined time, such as, for example 5s, the first switch K1 is switched on. When the output voltage of the solar battery unit 1 is less than the predetermined voltage C4 and the photosensitive voltage is less than the predetermined voltage CI in a first predetermined time such as, for example, 5s, the step is performed in loop until the output voltage of the solar battery unit 1 is greater than or equal to the predetermined voltage C4 and the photosensitive voltage sampled by the photosensitive sensor 11 is greater than or equal to the predetermined voltage CI in a first predetermined time, then a next step may be continued.

In one embodiment, for step S14, the control module 5 samples the output voltages and currents of the solar battery unit 1 and/or the buck DC/DC converter 2, then maximum power point tracking may be performed based on the sampled voltages and currents, and outputs the PWM wave to adjust the buck DC/DC converter 2 for controlling the solar battery unit 1 to
power the low-voltage load 6 and the starting battery 7 via the buck DC/DC converter 2. Due to the adoption of MPPT, the utilization of the solar energy may be further improved.

In one embodiment, for the step S15, the self inspection of the battery manager 10 is the same as that in step 12. Therefore, the detailed description is not exemplified herein for clarity purpose.

In one embodiment, for the step S16, the control module 5 samples the output voltage of the solar battery unit 1 and the photosensitive sensor 11 samples the sunlight, when the output voltage of the solar battery unit 1 is greater than or equal to the predetermined voltage C4 and the photosensitive voltage sampled by the photosensitive sensor 11 is greater than or equal to the predetermined voltage C1 in the first predetermined time such as, for example, 5s, the second switch K2 is switched on. When the output voltage of the solar battery unit 1 is less than the predetermined voltage C4 and the sunlight voltage is less than the predetermined voltage C1 in a first predetermined time such as, for example, 5s, the process is performed in loop until the output voltage of the solar battery unit 1 is greater than or equal to the predetermined voltage C4 and the photosensitive voltage is greater than or equal to the predetermined voltage C1 in a first predetermined time, then a next step may be continued.

In one embodiment, for the step S17, the control module 5 samples the output voltages and currents of the solar battery unit 1 and/or the boost DC/DC converter 3, then maximum power point tracking may be performed based on the sampled voltages and currents, and outputs the PWM wave to adjust the boost DC/DC converter 3 for controlling the solar battery unit 1 to power the power battery pack 9 via the boost DC/DC converter 3. At this moment, the power battery pack 9 storages the power converted from solar energy by the solar energy unit 1to power the high-voltage load 8 when the vehicle is running.

In one embodiment, when the vehicle is running, when the sunlight voltage sampled by the photosensitive sensor is less than the predetermined voltage C1 in the first predetermined time such as 5s~10s, the switch K1 is switched off by the control module 5, and when the sunlight voltage sampled by the photosensitive sensor is greater than the predetermined voltage C3 in the third predetermined time such as 4s~5s, the control switch K1 may be switched on by the control module 5.

When the vehicle is parking and if the sunlight voltage sampled by the photosensitive sensor is less than the predetermined voltage C1 in the first predetermined time such as 5s~10s, the switch K2 is switched off by the control module 5, and if the photosensitive voltage sampled by the photosensitive sensor is greater than the predetermined voltage C3 in the third
predetermined time such as 4s~5s, the switch K2 may be switched on by the control module 5.

In one embodiment, when there are failure in the buck DC/DC converter 2 and/or the boost DC/DC converter 3, such as under-voltage input, an over-voltage output, an over-current output, an over-temperature or the starting battery being filled with power, the first switch K1 or the second switch K2 may be switched off by the control module 5 to protect the entire control system. To be specific, the buck DC/DC converter 2 has the following failures:

under-voltage input: when the output voltage of the solar battery unit 1, that is the input voltage of the buck DC/DC converter 2 is less than the predetermined voltage C2, the first switch K1 may be switched off by the control module 5;

over-voltage output: when the output voltage of the buck DC/DC converter 2 is greater than the predetermined voltage C5, the first switch K1 may be switched off by the control module 5;

over-current output: when the output current of the buck DC/DC converter 2 is greater than the predetermined current C6, the first switch K1 may be switched off by the control module 5;

over-temperature: when a voltage corresponding to the inner temperature of the buck DC/DC converter 2 is greater than a predetermined voltage C7 corresponding to a threshold temperature of the DC/DC converter 2, the first switch K1 may be switched off by the control module 5. In one embodiment, the voltage corresponding to the inner temperature of the buck DC/DC converter 2 may be determined by a thermistor provided inside the buck DC/DC converter 2;

starting battery being filled with power: when the output voltage of the buck DC/DC converter 2 is greater than the predetermined voltage C5, the first switch K1 may be switched off by the control module 5.

Similarly, the boost DC/DC converter 3 may have the following failures which may be coped with as following:

under-voltage input: when the output voltage of the solar battery unit 1, i.e. the input voltage of the boost DC/DC converter 3 is less than predetermined voltage C2, the second switch K2 may be switched off by the control module 5;

over-voltage output: when the output voltage of the boost DC/DC converter 3 is greater than the predetermined voltage C8, the second switch K2 may be switched off by the control module 5;
over-current output: when the output current of the boost DC/DC converter 3 is greater than the predetermined voltage C6, the second switch K2 may be switched off by the control module 5;

over-temperature: when a voltage corresponding to the inner temperature of the boost DC/DC converter 3 is greater than a predetermined voltage C7 corresponding to a threshold temperature of the boost DC/DC converter 3, the second switch K2 may be switched off by the control module 5. In one embodiment, the voltage corresponding to the inner temperature of the boost DC/DC converter 3 may be determined by a thermistor provided inside the boost DC/DC converter 3;

power battery pack being filled with power: when the output voltage of the boost DC/DC converter 3 is greater than the predetermined voltage C8, the second switch K2 may be switched off by the control module 5.

In one embodiment, the predetermined voltage C1 is 1V~3V, the predetermined voltage C2 is 80V~200V, the predetermined voltage C3 is 1.2V~3.6V, the predetermined voltage C4 is 84V~126V and the predetermined voltage C5 is 11*120% where U is the rated voltage of the starting battery 7, the predetermined current C6 is 1*120% where I is the rated output current of the buck DC/DC converter 2, the predetermined voltage C7 is 1V~3V and the predetermined voltage C8 is the rated voltage or protecting voltage at which the power battery 9 is filled with. Obviously, the predetermined time, voltage and/or current of the present disclosure, rather than limiting hereto, may be designed as condition may require.

Although explanatory embodiment have been shown and described, it would be appreciated by those skilled in the art that changes, alternatives, and modifications can be made in the embodiment without departing from spirit and principles of the disclosure. Such changes, alternatives, and modifications all fall into the scope of the claims and their equivalents.
WHAT IS CLAIMED IS:

1. A control system of powering a vehicle with solar energy, comprising:
   a solar battery unit;
   a buck DC/DC converter electrically connected with the solar battery unit with a first switch, which is electrically connected with a low-voltage load and a starting battery respectively;
   a boost DC/DC converter electrically connected with the solar battery unit with a second switch, which is electrically connected with a high-voltage load;
   an auxiliary power module electrically connected with the solar battery unit;
   a control module connected with the solar battery unit, the buck DC/DC converter, the boost DC/DC converter;
   a power battery pack electrically connected with the boost DC/DC converter via a main contactor;
   a battery manager electrically connected with the control module, the power battery pack, the starting battery via a third switch, and the auxiliary power module via a fourth switch respectively; and
   a photosensitive sensor connected with the control module.

2. The control system of claim 1, wherein the first switch, second switch, third switch and fourth switch are electric control relays.

3. The control system of claim 1, further comprising:
   a service switch electrically connected with an output of the solar battery unit for switching on/off circuits between the solar battery unit and the buck DC/DC converter, between the solar battery unit and the boost DC/DC converter, between the solar battery unit and the control module and between the solar battery unit and the auxiliary power module.

4. The control system of claim 1, wherein a host computer display is provided between the auxiliary module and the control module.

5. The control system of any one of claims 1 to 4, wherein the output of the solar battery unit also has a voltmeter for detecting the output voltage of the solar battery unit and an ammeter for detecting the output current of the solar battery unit.

6. The control system of each one of claim 1 to claim 4, wherein an output of the buck DC/DC converter has a voltmeter for detecting the output voltage of the buck DC/DC
converter and an ammeter for detecting the output current of the buck DC/DC converter.

7. The control system of each one of claim 1 to claim 4, wherein an output of the boost DC/DC converter has a voltmeter for detecting the output voltage of the boost DC/DC converter and an ammeter for detecting the output current of the boost DC/DC converter.

8. The control system of any one of claims 1-4, wherein the control module is a DSP chip.

9. A control method of the control system for powering a vehicle with solar energy of claim 1, comprising the steps of:

powering the control module via the auxiliary power module by the solar battery unit when an output power of the solar battery unit has an output power greater than a predetermined start threshold P of the auxiliary power module;

powering the low-voltage load and the starting battery with the solar battery unit via the buck DC/DC converter under the control of the control module when the vehicle is running; and

powering the power battery pack with the solar battery unit via the boost DC/DC converter under the control of the control module when the vehicle is parking.

10. The control method of claim 9, wherein the step of powering the low-voltage load and the starting battery when the vehicle is running further comprises the steps of:

switching on the third switch under the control of the control module, powering the battery manager with the starting battery, with the main contactor being switched on and the high-voltage load being powered by the power battery pack if the self-inspection of the battery manager is successful, sending an instruction of switching on the main contactor to the control module;

sampling an output voltage of the solar battery unit by the control module, sampling sunlight with the photosensitive sensor, and switching on the first switch when the output voltage of the solar battery unit is greater than or equal to a predetermined voltage C4 and the sunlight voltage sampled by the photosensitive sensor is greater than or equal to a predetermined voltage CI in a first predetermined time; and

sampling the output voltage and current of the solar battery unit and/or sampling the output voltage and current of the buck DC/DC converter by the control module for maximum power point tracking, and outputting a PWM wave to adjust the buck DC/DC converter for controlling the solar battery unit to provide power to the low-voltage load and the starting battery via the buck DC/DC converter.
11. The control method of claim 10, further comprising the steps of:
switching off the first switch under the control of the control module when the photosensitive voltage sampled by the photosensitive sensor is less than the predetermined voltage C1 in a third predetermined time;
switching on the first switch under the control of the control module when the photosensitive voltage sampled by the photosensitive sensor is greater than the predetermined voltage C3 in a fourth predetermined time; and/or
switching off the first switch when the input under-voltage, output over-voltage, output over-current or over-temperature occurs in the buck DC/DC converter, or the starting battery is filled with power.

12. The control method of claim 9, wherein the step of powering the power battery pack when the vehicle is parking comprises the steps of:
switching off the third switch and switching on the fourth switch under the control of the control module, powering the battery manager with the auxiliary power module, switching on the main contactor if the self inspection of the battery manager is successful and sending an instruction of closing the main contactor to the control module;
sampling an output voltage of the solar battery unit by the control module, sampling sunlight with the photosensitive sensor, and switching on the second switch when the output voltage of the solar battery unit is greater than or equal to the predetermined voltage C4 and the photosensitive voltage sampled by the photosensitive sensor is greater than or equal to the predetermined voltage C1; and
sampling the output voltage and current of the solar battery unit and/or sampling the output voltage and current of the boost DC/DC converter by the control module for maximum power point tracking, and outputting a PWM wave to adjust the boost DC/DC converter for controlling the solar battery unit to provide power to the power battery pack via the boost DC/DC converter.

13. The control method of claim 12, further comprising:
switching off the second switch when the photosensitive voltage sampled by the photosensitive sensor is less than the predetermined voltage C1 in the third time;
switching on the second switch when the photosensitive voltage sampled by the photosensitive sensor is greater than the predetermined voltage C3 in the fourth time; and/or
switching off the second switch when the input under-voltage, output over-voltage, output over-current or over-temperature occurs in the boost DC/DC converter, or the power battery
pack is filled with power.

14. The control method of any one of claims 10-13, wherein the step of self inspection performed by the battery manager further comprises the steps of:
   - detecting whether the voltage of each cell in the power battery pack is over-voltage or under-voltage;
   - detecting if each cell in the power battery pack has a temperature within a first predetermined range;
   - detecting whether the pre-charge of the main contactor is finished or not; and
   - detecting whether leakage current of the vehicle has a leakage current within a second predetermined range.

15. The control method of any one of claims 10-13, wherein the predetermined start threshold $P$ of the auxiliary power module is about $30\text{W}$ to about $35\text{W}$, the first predetermined time is about $5\text{s}$ to about $10\text{s}$, the third predetermined time is about $2\text{s}$ to about $3\text{s}$, the fourth predetermined time is about $4\text{s}$ to about $5\text{s}$, the predetermined voltage $C_1$ is about $1V$ to about $3V$, the predetermined voltage $C_3$ is about $1.2V$ to about $3.6V$, and the predetermined voltage $C_4$ is about $84V$ to about $126V$.

16. The control method of any one of claims 10-13, further comprising:
   - if the self inspection performed by the battery manager is not successful, performing the step of self inspection in loop until the self inspection is successful.

17. The control method of any one of claims 10-12, further comprising:
   - when the output voltage of the solar battery unit is less than a predetermined voltage $C_4$ and the photosensitive voltage sampled by the photosensitive sensor is less than or equal to a predetermined voltage $C_1$ in a first predetermined time, performing this step in loop until the output voltage of the solar battery unit is greater than or equal to a predetermined voltage $C_4$ and the photosensitive voltage sampled by the photosensitive sensor is greater than or equal to the predetermined voltage $C_1$.

18. The control method of claim 9, further comprising the step of detecting the state of the vehicle.

19. The control method of claim 18, wherein the step of detecting the state of vehicle further comprises the steps of:
   - detecting whether the battery manager sends out an instruction of switching on the main contactor in the second predetermined time;
   - determining that the vehicle is running or parking based on whether the instruction of
switching on the main contactor is sent within the second predetermined time.

20. The control method of claim 19, wherein the second predetermined time is about 20s to about 30s.
Fig. 2
When output power of the solar battery pack 1 is greater than preset start power P of auxiliary power module 4, control module 5 is powered by solar battery unit 1 via auxiliary power module 4.

Vehicle is running or parking? (If yes, go to S12, if no, go to S10)

Third switch K3 is switched off, battery manager 10 is powered by starting battery 7, battery manager 10 performs self inspection; if successful, main contactor K5 is switched on and high-voltage load 6 is powered by power battery pack 9, also sending instruction of switching on main contactor K5 to control module 5.

Control module 5 samples output voltage of solar battery pack 1 and photosensitive sensor 11 samples sunlight, when output voltage of solar battery pack 1 is greater than or equal to a predetermined voltage C4 and photosensitive voltage sampled by photosensitive sensor 11 is greater than or equal to predetermined voltage C1 in a first preset time, first switch K1 is switched off and maximum power point tracking is performed based on sampled output voltages and currents of solar battery pack 1 and buck DC/DC converter 2 for controlling solar battery pack 1 to power low-voltage load 6 and starting battery 7 via DC/DC buck converter 2.

Third switch K3 is switched off and fourth switch K4 is switched on, battery manager 9 is powered by auxiliary power module 4. If the self inspection is successful, main contactor K5 is switched on and sending instruction of switching on main contactor K5 to control module 5.

Control module 5 samples output voltage of solar battery pack 1 and photosensitive sensor 11 sampling sunlight, when output voltage of solar battery pack 1 is greater than or equal to predetermined voltage C4 and photosensitive voltage sampled by photosensitive sensor 11 is greater than or equal to predetermined voltage C1 in first preset time, second switch K2 is switched on and MPPT is performed based on sampled voltages and currents of solar battery pack 1 and/or boost DC/DC converter 3, and outputting PWM wave to adjust buck DC/DC converter 2 for controlling solar battery pack 1 to power the power battery pack 9 via boost DC/DC converter 3.
INTERNATIONAL SEARCH REPORT

INTERNATIONAL APPLICATION NO.
PCT/CN201 1/079973

A. CLASSIFICATION OF SUBJECT MATTER

See the extra sheet
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: 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 practicable, search terms used)

IWPI, EPODOC, CNPAT, CNTXT, CNKI: vehicle, car, solar, buck, boost, power, supply, DC, battery, cell, converter

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category* Citation of document, with indication, where appropriate, of the relevant passages Relevant to claim No.
A CN201113461Y (LIU WANG, Yongjie) 10 Sep. 2008 (10.09.2008) see the whole document 1-20
A JP6-78474A (JAPAN STORAGE BATTERY CO LTD et al.) 18 Mar. 1994 (18.03.1994) 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:
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"&" document member of the same patent family

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<th>Patent Documents referred in the Report</th>
<th>Publication Date</th>
<th>Patent Family</th>
<th>Publication Date</th>
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<tr>
<td>WO2008127016A1</td>
<td>23.10.2008</td>
<td>CN101663765A</td>
<td>03.03.2010</td>
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<tr>
<td></td>
<td></td>
<td>DE1 12008000930T5</td>
<td>04.03.2010</td>
</tr>
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<td></td>
<td>US2010116565A1</td>
<td>13.05.2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN101663765B</td>
<td>17.08.2011</td>
</tr>
<tr>
<td>CN201 113461Y</td>
<td>10.09.2008</td>
<td>None</td>
<td></td>
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<td>09.04.2002</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>JP6-78474A</td>
<td>18.03.1994</td>
<td>None</td>
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</tbody>
</table>
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

H02J 7/00 (2006.01) i
H02J 7/35 (2006.01) i