(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 778 824 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
17.09.2014 Bulletin 2014/38

(51) Int Cl.:
G05F 1/67 *(2006.01)*

(21) Application number: **13188790.3**

(22) Date of filing: **15.10.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **15.03.2013 JP 2013054146**

(71) Applicant: **OMRON CORPORATION**
Kyoto-shi, Kyoto 600-8530 (JP)

(72) Inventors:
- **Mabuchi, Masao**
  Kyoto-shi, Kyoto 600-8530 (JP)
- **Hirashima, Masahiro**
  Kyoto-shi, Kyoto 600-8530 (JP)

(74) Representative: **Kilian Kilian & Partner**
Aidenbachstraße 54
81379 München (DE)

(54) Power conditioner and program

(57) Accuracy of a determination whether a power conditioner (10) is started up is improved.

The power conditioner includes a start-up determination unit (106) and a cutoff controller (104). The start-up determination unit determines whether a startable power is obtained from a power supply (200) by causing a controller (102) to operate an inverter (40), when the voltage outputted from the power supply is greater than or equal to a reference voltage while the inverter is electrically cut off from a system power supply (300) or a load (310) through a cutoff unit (50). The cutoff controller electrically connects the inverter and the load or the system power supply through a cutoff unit when the start-up determination unit determines that the startable power is obtained from the power supply.

EP 2 778 824 A2

Description

TECHNICAL FIELD

[0001] The present invention relates to a power conditioner and a program.

RELATED ART

[0002] In a photovoltaic power system disclosed in Japanese Unexamined Patent Publication No. 2009-247184, a maximum power estimated value of a photovoltaic module is estimated based on power inputted to a converter and a voltage accumulated in a capacitor, the maximum power estimated value is compared to a start-up determination value, and whether a power conditioner is started up is determined based on a comparison result.

[0003] Nowadays, the number of types of the photovoltaic module connected to the power conditioner increases, and possibly photovoltaic modules having various specifications are connected to the power conditioner. Therefore, estimation accuracy of the power of the photovoltaic module is degraded, and determination accuracy of the start-up of the power conditioner is occasionally degraded. There is a demand to improve the determination accuracy of the start-up of the power conditioner.

SUMMARY

[0004] In accordance with one aspect of the present invention, a power conditioner includes: a boost circuit configured to boost a voltage outputted from a power supply; an inverter configured to convert a direct current outputted from the boost circuit into an alternating current and to output the alternating current to a load or a system power supply; a cutoff unit configured to switch whether the inverter is electrically cut off from the system power supply or the load; a controller configured to control operations of the inverter; a start-up determination unit configured to determine whether a startable power is obtained from the power supply when the voltage output from the power supply is greater than or equal to a reference voltage while the controller operates the boost circuit and the inverter and the inverter is electrically cut off from the system power supply or the load through the cutoff unit; and a cutoff controller configured to electrically connect the inverter and the load or the system power supply through the cutoff unit when the start-up determination unit determines that the startable power is obtained from the power supply.

[0005] In the power conditioner, the start-up determination unit may determine whether the startable power is obtained from the power supply by causing the controller to operate the inverter and the boost circuit, when the voltage outputted from the boost circuit is less than an upper-limit voltage higher than the reference voltage while the inverter is electrically cut off from the system power supply or the load through the cutoff unit.

[0006] In the power conditioner, the start-up determination unit may determine that the startable power is obtained from the power supply, when the voltage outputted from the boost circuit is greater than or equal to the startable voltage while power outputted from the boost circuit reaches reference power.

[0007] In accordance with another aspect of the present invention, a program configured to cause a computer to act as a control device making a start-up determination of a power conditioner, the power conditioner comprising: a boost circuit configured to boost a voltage outputted from a power supply; an inverter configured to convert a direct current output from the boost circuit into an alternating current and to output the alternating current to a load or a system power supply; and a cutoff unit configured to switch whether the inverter is electrically cut off from the system power supply or the load, the program causes the computer to act as: a controller configured to control operations of the boost circuit and the inverter; a start-up determination unit configured to determine whether a startable power is obtained from the power supply when the controller operates the inverter and the voltage outputted from the power supply is greater than or equal to a reference voltage while the inverter is electrically cut off from the system power supply or the load through the cutoff unit; and a cutoff controller configured to electrically connect the inverter and the load or the system power supply through the cutoff unit when the start-up determination unit determines that the startable power is obtained from the power supply.

[0008] All the features necessary for the present invention are not described in the summary of the present invention. A sub-combination of a feature group is also included in the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a system configuration diagram illustrating an example of an entire configuration of a photovoltaic system according to an embodiment;

Fig. 2 is a flowchart illustrating an example of a procedure of start-up processing performed by a control device;

Fig. 3 is a view illustrating an example of a functional block of the control device of the present embodiment; and

Fig. 4 is a flowchart illustrating a procedure of a power conditioner start-up determination made by the control device.

DETAILED DESCRIPTION

[0010] Hereinafter, an embodiment of the present invention will be described. However, the present invention

according to the claims is not limited to the embodiment. All combinations of features described in the embodiment are not necessary for the means for solving the problem.

[0011] Fig. 1 is a system configuration diagram illustrating an example of an entire configuration of a photovoltaic system of the present embodiment. The photovoltaic system includes a photovoltaic array 200 and a power conditioner 10. A plurality of photovoltaic strings in which a plurality of photovoltaic modules are connected in series are connected in parallel in the photovoltaic array 200. The plurality of photovoltaic arrays 200 are examples of the power supply that outputs a DC voltage.

[0012] The power conditioner 10 boosts the DC voltage outputted from the photovoltaic array 200, converts the boosted DC voltage into an AC voltage, and outputs the AC voltage onto a side of a system power supply 300. The power conditioner 10 includes a capacitor C1, a boost circuit 20, a capacitor C2, an inverter 40, a coil L2, a capacitor C3, a relay 50, a power supply 60, and a control device 100.

[0013] Both ends of the capacitor C1 are electrically connected to a positive electrode terminal and a negative electrode terminal of the photovoltaic array 200, respectively, and the capacitor C1 smoothes the DC voltage outputted from the photovoltaic array 200. The boost circuit 20 includes a coil L1, a switch Tr, and a diode D1. The boost circuit 20 may be what is called a chopper switching regulator. The boost circuit 20 boosts the voltage outputted from the photovoltaic array 200.

[0014] For example, the switch Tr is an Insulated Gate Bipolar Transistor (IGBT). One end of the coil L1 is connected to one end of the capacitor C1, and the other end of the coil L1 is connected to a collector of the switch Tr. The collector of the switch Tr is connected to an anode of the diode D1, and an erraitter of the switch Tr is connected to the other end of the capacitor C1. The coil L1 accumulates energy based on power outputted from the photovoltaic array 200 during an on period of the switch Tr, and discharges the energy during an off period of the switch Tr. Therefore, the boost circuit 20 boosts the DC voltage outputted from the photovoltaic array 200. The diode D1 rectifies the output from the coil L1. The diode D1 prevents the boosted DC voltage from flowing onto an input side from an output side of the boost circuit 20.

[0015] The boost circuit 20 is not limited to the above configuration. For example, the boost circuit 20 may be constructed by insulation type boost circuits, such as a half-bridge boost circuit and a full-bridge boost circuit, which have a transformer winding.

[0016] The capacitor C2 smoothes the DC voltage outputted from the boost circuit 20. The inverter 40 includes a switch, and converts the DC voltage outputted from the boost circuit 20 into the AC voltage by turning on and off the switch to output to the system power supply 300 or a load 310. For example, the inverter 40 may be constructed by a single-phase full-bridge PWM inverter including four bridge-connected semiconductor switches. In one pair out of the four semiconductor switches, the semiconductor switches are connected in series. In the other pair out of the four semiconductor switches, the semiconductor switches are connected in series. The other pair of the semiconductor switches is connected in parallel to the one pair of the semiconductor switches.

[0017] The coil L2 and the capacitor C3 are provided between the inverter 40 and the system power supply 300. The coil L2 and the capacitor C3 remove a noise from the AC voltage outputted from the inverter 40. The relay 50 is provided between the capacitor C3 and the system power supply 300. The relay 50 switches whether the inverter 40 is electrically cut off from the system power supply 300 or the load 310. The power conditioner 10 is electrically connected to the system power supply 300 or the load 310 by turning on the relay 50, and the power conditioner 10 is electrically cut off from the system power supply 300 or the load 310 by turning off the relay 50. The relay 50 is an example of the cutoff unit.

[0018] For example, the power supply 60 is constructed by a power supply IC chip. The power supply 60 is connected onto an output side of the boost circuit 20. The power supply 60 generates power, which indicates a predetermined voltage supplied to the control device 100, from the DC voltage taken out from the boost circuit 20, and the power supply 60 supplies the generated power to the control device 100. The power supply 60 is started up, when the voltage outputted from the boost circuit 20 reaches a reference voltage while the switch Tr of the boost circuit 20 is in an off state. After the start-up, the power supply 60 generates driving power driving the control device 100 using the power outputted from the boost circuit 20, and supplies the driving power to the control device 100. The power supply 60 may directly use the power from the system power supply 300 to generate the power supplied to the control device 100.

[0019] In order to obtain the maximum power from the photovoltaic array 200, the control device 100 controls the switching operation of the boost circuit 20, boosts the DC voltage outputted from the photovoltaic array 200, converts the boosted DC voltage into the AC voltage, and outputs the AC voltage onto the side of the system power supply 300.

[0020] The power conditioner 10 also includes voltage sensors 12 and 16 and current sensors 14 and 18. The voltage sensor 12 detects a voltage Vin corresponding to a potential difference between both the ends of the photovoltaic array 200. The voltage sensor 16 detects a voltage Vout corresponding to the potential difference between both the ends on the output side of the boost circuit 20. The current sensor 14 detects a current Iin, which is outputted from the photovoltaic array 200 and passes onto the input side of the boost circuit 20. The current sensor 18 detects a current Iout outputted from the boost circuit 20.

[0021] Fig. 2 is a flowchart illustrating an example of a processing procedure performed during the start-up of the control device 100.

[0022] The power supply 60 is started up, when an

output voltage Vout, which is inputted from the photovoltaic array 200 and outputted from the boost circuit 20, is greater than or equal to a reference voltage Vth1 while the boost circuit 20, the inverter 40, the power supply 60, and the control device 100 are stopped (S10). The power supply 60 generates the driving power driving the control device 100 using the power outputted from the photovoltaic array 200. The control device 100 is started up by receiving the power from the power supply 60 (S12).

[0023] The control device 100 starts the operation of the boost circuit 20 while the inverter 40 is electrically cut off from the system power supply 300 or the load 310 through the relay 50 (S14). The control device 100 estimates power Wa that can be outputted from the boost circuit 20 with an amount of change in power, which is outputted from the boost circuit 20 when the voltage input to the boost circuit 20 is changed, as a parameter (S16).

[0024] The control device 100 determines whether the power Wa is greater than or equal to power Wt necessary to operate the control device 100, the boost circuit 20, and the inverter 40 (S18). When the power Wa is less than the power Wt, the control device 100 determines that the power obtained from the photovoltaic array 200 does not satisfy the power necessary to start up the power conditioner 10, and stops the operation of the boost circuit 20 (S20). The control device 100 starts the operation of the boost circuit 20 again when a predetermined waiting period elapses (S22).

[0025] On the other hand, when the estimated power Wa is greater than or equal to the power Wt, the control device 100 turns on the relay 50 (S24), and starts the operation of the inverter 40 to start grid interconnection with the system power supply 300 (S26).

[0026] According to the processing procedure, the control device 100 turns on the relay 50 to operate the inverter 40, when the estimated power satisfies the power that can operate the control device 100, the boost circuit 20, and the inverter 40. In this case, when the power is inaccurately estimated, the actual power is insufficiently obtained from the photovoltaic array, and occasionally the inverter 40 cannot be operated by the power obtained from the photovoltaic array. In such cases, after the processing in Step S26, the control device 100 stops the operations of the boost circuit 20 and the inverter 40 to tentatively turn off the relay 50. Then the control device 100 starts the operation of the boost circuit 20 to estimate the power again. That is, occasionally the relay 50 is repeatedly turned on and off by repeating the estimation of the power during the start-up of the power conditioner 10. Because occasionally the obtained power changes depending on the type of the photovoltaic array connected to the power conditioner 10, it is further difficult that the control device 100 accurately estimates the power for many types of the photovoltaic arrays that can be connected to the power conditioner 10.

[0027] According to the present embodiment, when the inverter 40 is operated in addition to the boost circuit 20 while the relay 50 is turned off, the control device 100 determines whether a startable power corresponding to the minimum power necessary to start up the power conditioner 10 is obtained from the photovoltaic array 200 based on the power outputted from the boost circuit 20. Therefore, the accuracy of the start-up determination of the power conditioner 10 can be improved. Additionally, the turn-on and -off repetitions of the relay 50, which are caused by repeating the estimation of the power during the start-up of the power conditioner 10, can be prevented. Therefore, a generation frequency of an operating sound caused by turning on and off the relay 50 can be decreased. Additionally, progression of degradation of the relay 50 due to the turn-on and -off of the relay 50 can be reduced.

[0028] Fig. 3 illustrates an example of a functional block of the control device 100 of the present embodiment. The control device 100 includes a controller 102, a relay controller 104, and a start-up determination unit 106. The controller 102 controls the operations of the boost circuit 20 and the inverter 40. The controller 102 controls a boost ratio by turning on and off the switch Tr included in the boost circuit 20 based on PWM control, and controls an input voltage Vin at the boost circuit 20 such that the maximum pr peak power is obtained from the photovoltaic array 200. The controller 102 controls the input voltage at the inverter 40 by turning on and off each switch included in the inverter 40 based on the PWM control, and converts the direct current outputted from the boost circuit 20 into the alternating current synchronized with the voltage at the system power supply 300.

[0029] The relay controller 104 turns on and off the relay 50 to perform the electric connection and cutoff between the inverter 40 and the system power supply 300 or the load 310. When the voltage outputted from the photovoltaic array 200 is greater than or equal to the reference voltage Vth1, the start-up determination unit 106 causes the controller 102 to operate the boost circuit 20 and the inverter 40 while the inverter 40 is electrically cut off from the system power supply 300 or the load 310 through the relay 50.

[0030] The start-up determination unit 106 determines whether the startable power is obtained from the photovoltaic array 200 while the boost circuit 20 and the inverter 40 are operated. The start-up determination unit 106 may determine that the startable power is obtained from the photovoltaic array 200 when the voltage outputted from the boost circuit 20 is greater than or equal to a startable voltage Vth3 while the power outputted from the boost circuit 20 reaches the reference power Wth (Step S110 in Fig. 3).

[0031] The controller 102 operates the inverter 40 while the relay 50 is turned off in order that the start-up determination unit 106 more accurately determines whether the power necessary to start up the inverter 40, in addition to the control device 100 and the boost circuit 20, is obtained from the photovoltaic array 200. Accordingly, the controller 102 may control each switch of the inverter 40 to operate the inverter 40 on an arbitrary con-

dition. For example, the controller 102 may operate the inverter 40 by controlling each switch of the inverter 40 at a duty ratio of 50%. A processing burden on the control device 100 can be reduced by controlling each switch of the inverter 40 at the duty ratio of 50%.

[0032] The relay controller 104 electrically connects the inverter 40 and the system power supply 300 or the load 310 through the relay 50 in response to the result that the start-up determination unit 106 determines that the startable power is obtained from the photovoltaic array 200.

[0033] When the photovoltaic array 200 outputs the high voltage, occasionally the voltage outputted from the boost circuit 20 is excessively high in the case where the boost circuit 20 is operated. In such cases, possibly elements, such as the capacitor C2, which are provided on the output side of the boost circuit 20 are adversely affected.

[0034] Therefore, when the voltage output from the boost circuit 20 is greater than or equal to an upper-limit voltage Vth2 higher than the reference voltage Vth1 while the boost operation of the boost circuit 20 is stopped, the start-up determination unit 106 may cause the controller 102 to operate the inverter 40 while the inverter 40 is electrically cut off from the system power supply 300 or the load 310 through the relay 50 (Steps S104 and S108 in Fig. 4). The start-up determination unit 106 may determine whether the startable power is obtained from the photovoltaic array 200, in the state in which the boost operation of the boost circuit 20 is stopped while the on and off operations of the switch of the inverter 40 are performed (Step S110 in Fig. 3). That is, when the voltage outputted from the boost circuit 20 is greater than or equal to the supper-limit voltage Vth2 higher than the reference voltage Vth1, the start-up determination unit 106 may stop the boost operation of the boost circuit 20 while performing only the on and off operations of the switch of the inverter 40, and the start-up determination unit 106 may determine whether the startable power is obtained from the photovoltaic array 200.

[0035] Fig. 4 is a flowchart illustrating a procedure in which the control device 100 makes the start-up determination of the power conditioner 10.

[0036] The power supply 60 is started up, when the output voltage Vout, which is inputted from the photovoltaic array 200 and outputted from the boost circuit 20, is greater than or equal to the reference voltage Vth1 while the boost circuit 20, the inverter 40, the power supply 60, and the control device 100 are stopped. The power supply 60 generates the driving power driving the control device 100 using the power output from the photovoltaic array 200. The control device 100 is started up by receiving the power from the power supply 60 (S102).

[0037] When the control device 100 is started up, the start-up determination unit 106 determines whether the output voltage Vout at the boost circuit 20 is greater than or equal to the upper-limit voltage Vth2 (S104). When the output voltage Vout is less than the upper-limit voltage Vth2, the start-up determination unit 106 causes the controller 102 to start the operations of the boost circuit 20 and the inverter 40 while the inverter 40 is electrically cut off from the system power supply 300 or the load 310 through the relay 50 (S106). The controller 102 may start the on and off operations of each of the switches included in the boost circuit 20 and the inverter 40.

[0038] The start-up determination unit 106 calculates the power Wout outputted from the boost circuit 20 based on the voltage Vout and the current Iout, which are outputted from the boost circuit 20. The start-up determination unit 106 determines whether the output voltage Vout at the boost circuit is greater than or equal to the startable voltage Vth3 when the power Wout reaches the reference power Wth(S110). When the output voltage Vout is greater than or equal to the startable voltage Vth3, the start-up determination unit 106 determines that the startable power is obtained from the photovoltaic array 200, the controller 102 tentatively stops the operation of the inverter 40 (S112), and the relay controller 104 turns on the relay 50 (S114). After the relay controller 104 turns on the relay 50, the controller 102 starts the operation of the inverter 40 again (S116). In the case where the power conditioner 10 is not interconnected with the system power supply 300, the controller 102 may not tentatively stop the inverter 40 before the relay 50 is turned on.

[0039] On the other hand, when the output voltage Vout is greater than or equal to the upper-limit voltage Vth2, the start-up determination unit 106 causes the controller 102 to start the operation of the inverter 40, in the state in which the boost circuit 20 is stopped while the inverter 40 is electrically cut off from the system power supply 300 or the load 310 through the relay 50 (S108). The start-up determination unit 106 determines whether the output voltage Vout at the boost circuit is greater than or equal to the startable voltage Vth3 when the power Wout reaches the reference power Wth (S110).

[0040] When the output voltage Vout is less than the startable voltage Vth3, the start-up determination unit 106 causes the controller 102 to stop the operations of the boost circuit 20 and the inverter 40 or the operation of the inverter 40 (S118). When a predetermined waiting period elapses after the operations of the boost circuit 20 and the inverter 40 or the operation of the inverter 40 is stopped (S120), the start-up determination unit 106 performs the pieces of processing from Step S104 again.

[0041] As described above, according to the present embodiment, when the power conditioner 10 makes the start-up determination, the power output from the photovoltaic array 200 is estimated while the inverter 40 is operated, and the start-up determination can be made from the estimated power. Accordingly, the start-up determination can accurately be made irrespective of the type of the photovoltaic array 200 connected to the power conditioner 10.

Therefore, the turn-on and -off repetitions of the relay 50, which are caused by repeating the estimation of the power during the start-up of the power conditioner 10, can

be prevented. Additionally, the generation frequency of the operating sound caused by turning on and off the relay 50 can be decreased, and progression of degradation of the relay 50 due to the turn-on and -off of the relay 50 can be reduced.

[0042] Each unit included in the control device 100 of the present embodiment may be constructed by installing a program, which is recorded in a computer-readable recording medium to perform various pieces of processing related to the start-up determination of the power conditioner 10, and by causing the computer to execute the program. That is, the computer acts as each unit included in the control device 100 by causing the computer to execute the program, which performs various pieces of processing related to the start-up determination of the power conditioner 10, whereby the control device 100 may be constructed.

[0043] The computer includes a CPU, various memories such as a ROM, a RAM, and an EEPROM (registered trademark), a communication bus, and an intorface, and the CPU reads and executes sequentially the processing program previously stored in the ROM as firmware, whereby the computer acts as the control device 100.

[0044] Although the embodiment of the present invention is described above, the technical scope of the present invention is not limited to the scope of the embodiment. It is clear for those skilled in the art that various changes and modifications can be made in the present invention. It is clear from the claims that the changes and modifications are also included in the technical scope of the present invention.

[0045] In the performance sequence of pieces of processing such as the operations, the procedures, the steps, and the stages in the device, the system, the program, and the method in the claims, the description, and the drawings, "before" or "prior to" is not described unless otherwise noted, and it is noted that the pieces of processing are performed in any performance sequence as long as the output of the preceding processing is used in the subsequent processing. In the operation flow of the claims, the description, and the drawings, for the sake of convenience, it is not always necessary that the pieces of processing be performed in this order even if "at first" or "then" is used.

Claims

1. A power conditioner (10) comprising:

a boost circuit (20) configured to boost a voltage output from a power supply (200);
an inverter (40) configured to convert a direct current outputted from the boost circuit into an alternating current and to output the alternating current to a load (310) or a system power supply (300);
a cutoff unit (50) configured to switch whether the inverter is electrically cut off from the system power supply or the load;
a controller (102) configured to control operations of the boost circuit and the inverter;
a start-up determination unit (106) configured to determine whether a startable power is obtained from the power supply, when the voltage outputted from the power supply is greater than or equal to a reference voltage while the controller operates the inverter and the inverter is electrically cut off from the system power supply or the load through the cutoff unit; and
a cutoff controller (104) configured to electrically connect the inverter and the load or the system power supply through the cutoff unit when the start-up determination unit determines that the startable power is obtained from the power supply.

2. The power conditioner (10) according to claim 1, wherein the start-up determination unit (106) determines whether the startable power is obtained from the power supply (200) when the voltage output from the boost circuit is less than an upper-limit voltage higher than the reference voltage while the controller (102) operates the inverter (40) and the boost circuit (20) and the inverter is electrically cut off from the system power supply (300) or the load (310) through the cutoff unit (50).

3. The power conditioner (10) according to claim 1 or 2, wherein the start-up determination unit (106) determines that the startable power is obtained from the power supply (200), when the voltage outputted from the boost circuit (20) is greater than or equal to the startable voltage while power outputted from the boost circuit reaches a reference power.

4. A program configured to cause a computer to act as a control device (100) making a start-up determination of a power conditioner (10), the power conditioner comprising:

a boost circuit (20) configured to boost a voltage outputted from a power supply (200); an inverter (40) configured to convert a direct current outputted from the boost circuit into an alternating current and to output the alternating current to a load (310) or a system power supply (300); and a cutoff unit (50) configured to switch whether the inverter is electrically cut off from the system power supply or the load,
the program causing the computer to act as: a controller (102) configured to control operations of the boost circuit and the inverter;
a start-up determination unit (106) configured to determine whether a startable power is obtained from the power supply when the voltage output-

ted from the power supply is greater than or equal to a reference voltage while the controller operates the inverter and the inverter is electrically cut off from the system power supply or the load through the cutoff unit; and
a cutoff controller (104) configured to electrically connect the inverter and the load or the system power supply through the cutoff unit when the start-up determination unit determines that the startable power is obtained from the power supply.

5. Method for making a start-up determination of a power conditioner (10), the power conditioner comprising:

a boost circuit (20) configured to boost a voltage outputted from a power supply (200); an inverter (40) configured to convert a direct current outputted from the boost circuit into an alternating current and to output the alternating current to a load (310) or a system power supply (300); and a cutoff unit (50) configured to switch whether the inverter is electrically cut off from the system power supply or the load,
the method comprising the steps of:

controlling operations of the boost circuit and the inverter;
determining whether a startable power is obtained from the power supply when the voltage outputted from the power supply is greater than or equal to a reference voltage while the inverter is operated and the inverter is electrically cut off from the system power supply or the load through the cutoff unit; and
connecting the inverter and the load or the system power supply through the cutoff unit when determining that the startable power is obtained from the power supply.

FIG. 1

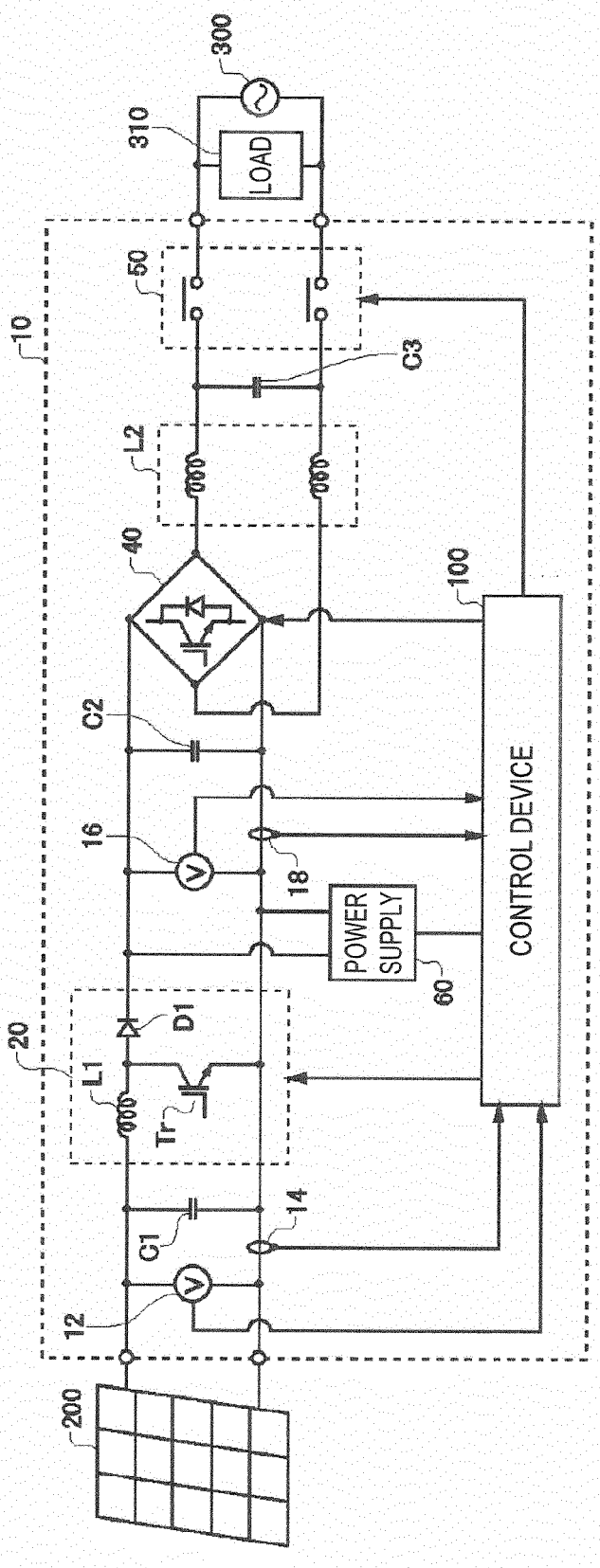

300
310
LOAD
50
10
C3
L2
40
100
C2
16
18
POWER SUPPLY
60
CONTROL DEVICE
20
D1
L1
Tr
14
C1
12
200

FIG. 2

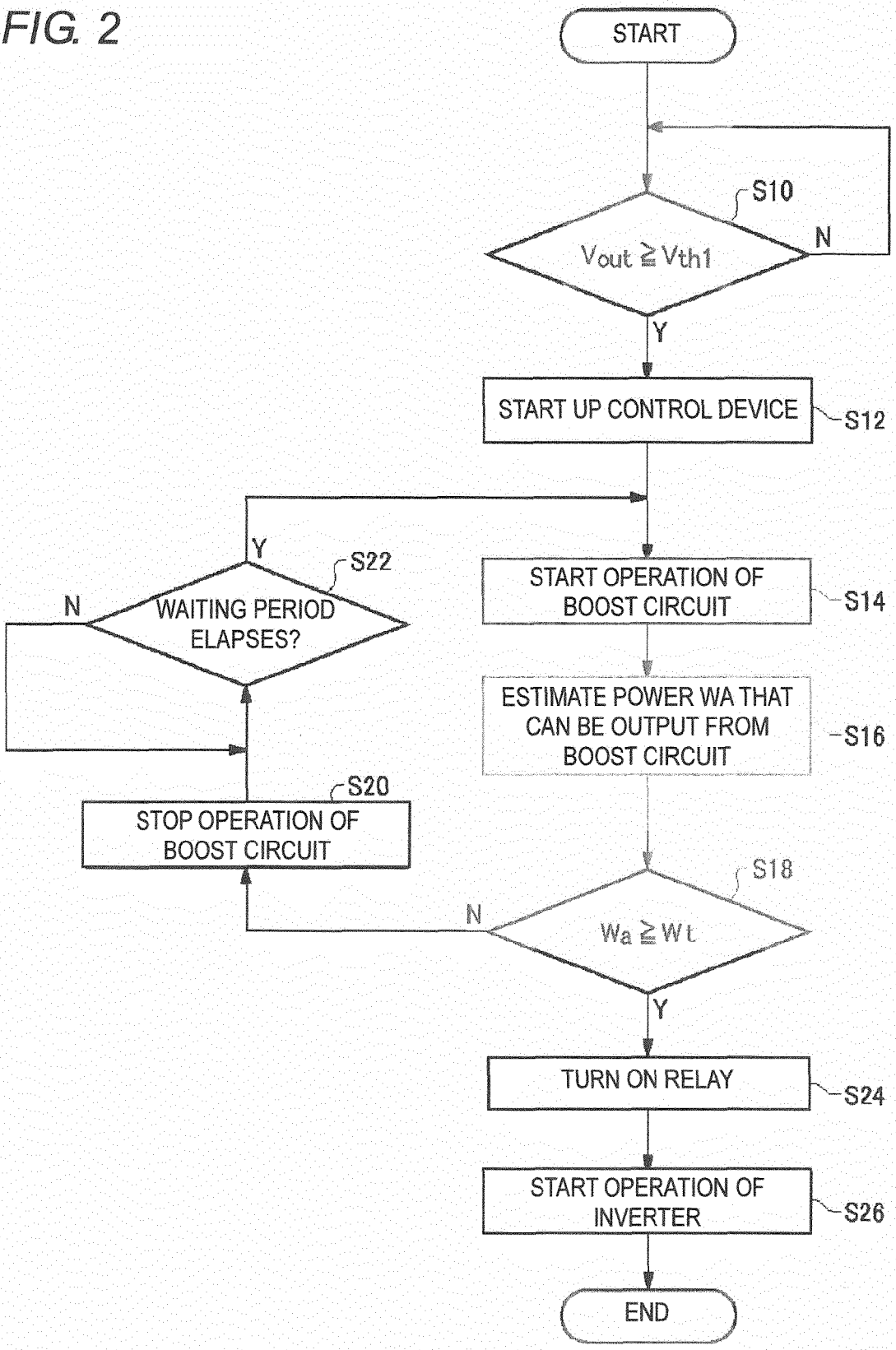

START
S10
Vout ≧ Vth1
N
Y
START UP CONTROL DEVICE
S12
START OPERATION OF BOOST CIRCUIT
S14
ESTIMATE POWER WA THAT CAN BE OUTPUT FROM BOOST CIRCUIT
S16
S18
Wa ≧ Wt
N
Y
TURN ON RELAY
S24
START OPERATION OF INVERTER
S26
END
Y
S22
N
WAITING PERIOD ELAPSES?
S20
STOP OPERATION OF BOOST CIRCUIT

FIG. 3

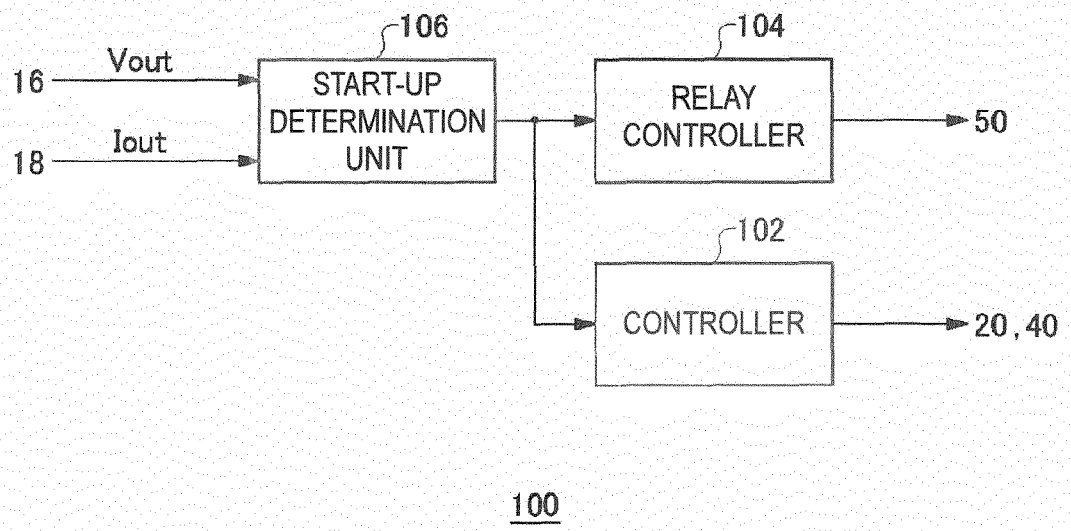
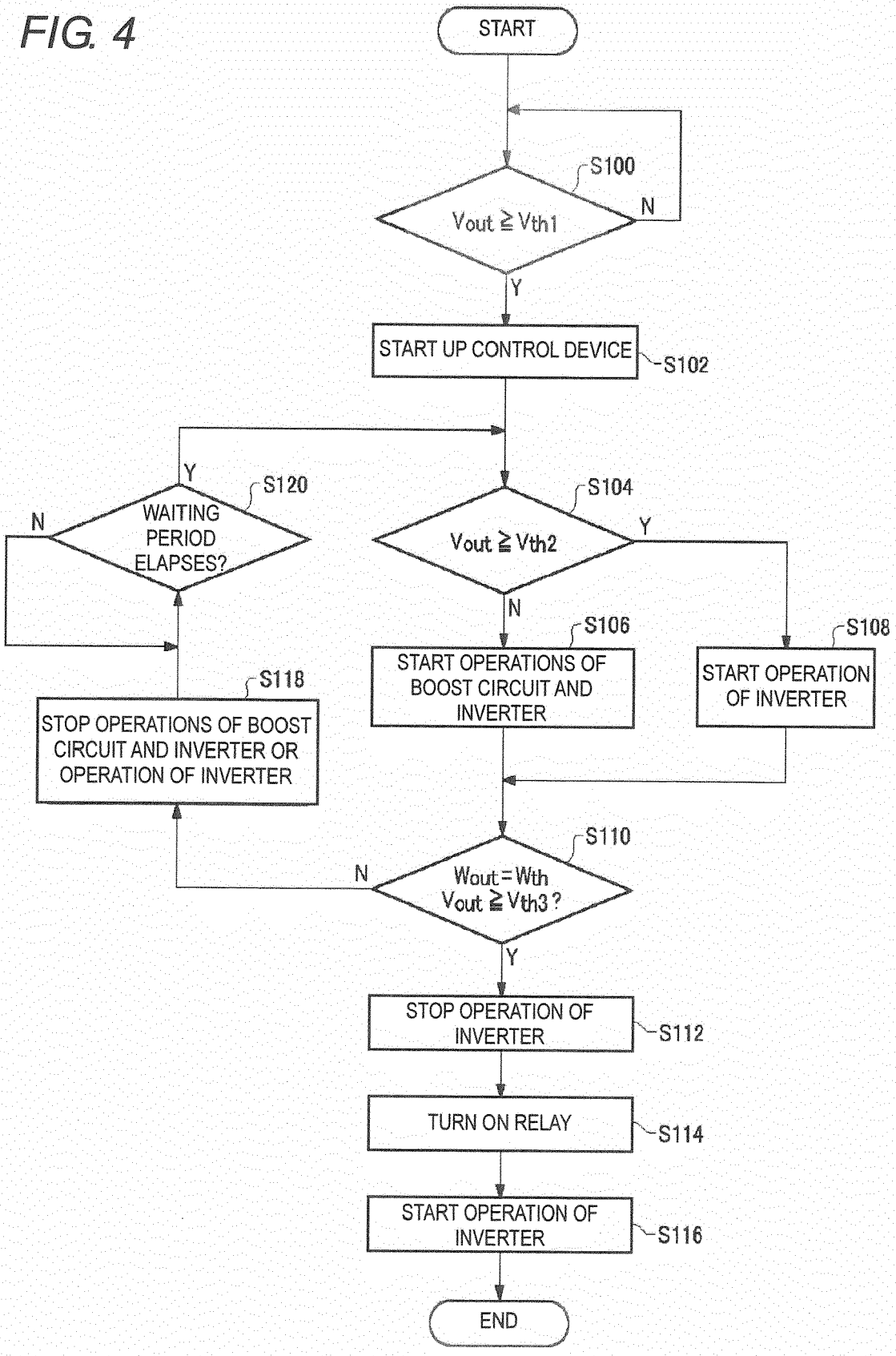

106
104
16
Vout
18
Iout
START-UP DETERMINATION UNIT
RELAY CONTROLLER
50
102
CONTROLLER
20, 40
100

FIG. 4


START
S100
Vout ≧ Vth1
N
Y
START UP CONTROL DEVICE
S102
Y
S120
N
WAITING PERIOD ELAPSES?
S104
Vout ≧ Vth2
Y
N
S106
START OPERATIONS OF BOOST CIRCUIT AND INVERTER
S108
START OPERATION OF INVERTER
S118
STOP OPERATIONS OF BOOST CIRCUIT AND INVERTER OR OPERATION OF INVERTER
S110
N
Wout = Wth
Vout ≧ Vth3 ?
Y
STOP OPERATION OF INVERTER
S112
TURN ON RELAY
S114
START OPERATION OF INVERTER
S116
END

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2009247184 A **[0002]**