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POWER SUPPLY SYSTEM

Abstract

A power supply system supplies alternating current power from a system power supply to a load of a house. A first electromagnetic switch is configured to switch electrical connection and disconnection between the leakage breaker and the overcurrent breaker. A second electromagnetic switch is configured to switch electrical connection and disconnection between the first electromagnetic switch and the power supply device and switch electrical connection and disconnection between the overcurrent breaker and the power supply device.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2024-019915 filed on Feb. 14, 2024, and to Japanese Patent Application No. 2024-109536 filed on Jul. 8, 2024. The disclosure of each of the above-identified applications, including the specification, drawings, and claims, is incorporated by reference herein in its entirety.

BACKGROUND

1. Technical Field

[0002] The present disclosure relates to a power supply system.

2. Description of Related Art

[0003] In a power supply system capable of supplying power from a system power supply to a power load of a house, power from a vehicle can be supplied to the power load mainly in an emergency (a power failure of the system power supply, a power shortage of the system power supply, and the like). In addition, a proposal has been made to perform power supply from the vehicle to the power load on a daily basis (such as a period in which an electricity charge of the system power supply is high). Japanese Unexamined Patent Application Publication No. 2019-71721 (JP 2019-71721 A) discloses a power supply system that can utilize power stored in an electrified vehicle in a power failure.

SUMMARY

[0004] A phase of alternating current power supplied from a system power supply and a phase of alternating current power supplied from a vehicle is different. Therefore, it is not preferable to simultaneously supply the alternating current power from the system power supply and the alternating current power from the vehicle to a power load. It is desirable that power supply from the vehicle to the power load is implementable with a system configuration as simple as possible.

[0005] The present disclosure provides a power supply system that can supply power from a vehicle to a power load with a simple system configuration.

[0006] A power supply system according to an aspect of the present disclosure supplies alternating current power from a system power supply to a power load of a house. The power supply system includes a current breaker, a load breaker, a power conversion device, a first switch, and a second switch. The current breaker receives the alternating current power from the system power supply to the house and disconnect the alternating current power during at least one of leakage or overcurrent. The load breaker is configured to electrically disconnect the current breaker and the power load from each other. The power conversion device is configured to supply, in a case where a vehicle is connected, alternating current power from the vehicle to the power load. The first switch is configured to switch electrical connection and disconnection between the current breaker and the load breaker. The second switch is configured to switch electrical connection and disconnection between the first switch and the power conversion device and switch electrical connection and disconnection between the load breaker and the power conversion device.

[0007] In the power supply system, the house may include a power conditioning system configured to receive generated power of a photovoltaic power generation device. The power conversion device may be configured to charge, in a case where the vehicle is connected, the vehicle with alternating current power from the power conditioning system. The power supply system may further include a third switch configured to switch electrical connection and disconnection between

the power conditioning system and the power conversion device.
[0008] In the power supply system, the power conversion device may be further configured to charge, in a case where the vehicle is connected, the vehicle with alternating current power from the current breaker. The power supply system may further include a third switch configured to switch electrical connection and disconnection between the current breaker and the power conversion device.
[0009] In the power supply system, in a case where the vehicle is connected to the power conversion device and a current electricity charge is higher than an electricity charge at a time when power currently charged in the vehicle is charged, the first switch may be opened and the second switch may be closed.
[0010] In the power supply system, in a case where the vehicle is connected to the power conversion device and the current electricity charge is higher than an electricity charge at a time when the vehicle is previously charged, the first switch may be opened and the second switch may be closed.
[0011] The power supply system may further include a control device configured to control the first switch and the second switch.
The control device may, in a case where power is supplied from the system power supply to the power load, close the first switch and open the second switch. The control device may, in a case where power is supplied from the vehicle to the power load, open the first switch and close the second switch.
[0012] The power supply system may further include a control device configured to control the first switch, the second switch, and the third switch.
The control device may, in a case where power is supplied form the vehicle, open the first switch, close the second switch, and open the third switch. The control device may, in a case where power is charged to the vehicle, close the first switch, open the second switch, and close the third switch. The control device may, in a case where power is not supplied from the vehicle and power is not charged to the vehicle, close the first switch, open the second switch, and open the third switch.
[0013] According to the present disclosure, it is possible to supply power from a vehicle to a power load with a simple system configuration.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0014] Features, advantages, and technical and industrial significance of exemplary embodiments of the present disclosure will be described below with reference to the accompanying drawings, in which like signs denote like elements, and wherein:
[0015] FIG. **1** is a circuit block diagram showing a first example of a configuration of a power supply system according to Embodiment 1;
[0016] FIG. **2** is a circuit block diagram showing a second example of the configuration of the power supply system according to Embodiment 1;
[0017] FIG. **3** is a flowchart showing a first example of a processing procedure related to control of an electromagnetic switch;
[0018] FIG. **4** is a circuit block diagram showing a first example of a configuration of a power supply system according to Embodiment 2;
[0019] FIG. **5** is a circuit block diagram showing a second example of the configuration of the power supply system according to Embodiment 2;
[0020] FIG. **6** is a circuit block diagram showing a third example of the configuration of the power supply system according to Embodiment 2;
[0021] FIG. **7** is a circuit block diagram showing a fourth example of the configuration of the

power supply system according to Embodiment 2;

[0022] FIG. **8** is a flowchart showing a second example of the processing procedure related to the control of the electromagnetic switch;

[0023] FIG. **9** is a flowchart showing a third example of a processing procedure related to the control of the electromagnetic switch; and

[0024] FIG. **10** is a circuit block diagram showing a modification example of the first example of the configuration of the power supply system according to Embodiment 1.

DETAILED DESCRIPTION OF EMBODIMENTS

[0025] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the drawings. Note that, in the drawings, the same or equivalent parts are denoted by the same reference numerals, and description thereof will not be repeated.

Embodiment 1

System Configuration

[0026] FIG. **1** is a circuit block diagram showing a first example of a configuration of a power supply system according to Embodiment 1. A power supply system **101** supplies power from a system power supply **900** to a load of a house **101**A. The house **101**A is typically a house (a structure in which a person lives). Note that the house **101**A may include a structure that is not for residential use, such as a building or a facility that accommodates equipment. The load is, for example, various electrical devices, and may be disposed in an inside (interior) of the house **101**A or may be in an outside (exterior) of the house **101**A.

[0027] The power supply system **101** includes a leakage breaker **1**, overcurrent breakers **111** to **113**, **211**, **212**, and a power supply device **3**. The number of overcurrent breakers is not particularly limited.

[0028] The leakage breaker **1** receives alternating current power from the system power supply **900** to the house **101**A. A circuit PL**1** for transmitting AC 100 V of alternating current power and a circuit PL**2** for transmitting AC 200 V of alternating current power are connected to the leakage breaker **1**. The leakage breaker **1** electrically disconnects the system power supply **900** and the circuits PL**1**, PL**2** from each other at a time of detection of leakage. The leakage breaker **1** corresponds to a “current breaker” according to the present disclosure.

[0029] The overcurrent breakers **111** to **113** are electrically connected to the circuit PL**1** for AC 100 V. Although not shown, the house **101**A includes a plurality of rooms. For example, a load **121** is provided in a certain room, a load **122** is provided in another room, and a load **123** is provided in still another room. The overcurrent breakers **111** to **113** are provided corresponding to different rooms of the house **101**A. The overcurrent breakers **111** to **113** are configured to electrically disconnect the leakage breaker **1** and the loads **121** to **123** from each other at a time of detection of overcurrent. The overcurrent breaker **113** corresponds to a “load breaker” according to the present disclosure. Each load corresponds to a “power load” according to the present disclosure.

[0030] The overcurrent breakers **211**, **212** are electrically connected to the circuit PL**2** for AC 200 V. The overcurrent breakers **211**, **212** are provided in different rooms of the house **101**A, similarly to the overcurrent breakers **111** to **113** for the AC 100 V. The overcurrent breakers **211**, **212** are configured to electrically disconnect the leakage breaker **1** and the loads **221**, **222** from each other at the time of detection of overcurrent.

[0031] The power supply device **3** is configured to be connected to a vehicle **4** via a power supply cable (not shown). The vehicle **4** is an electrified vehicle on which a traveling battery is mounted and that can receive power from and transmit power to an outside of the vehicle, and specifically is a battery electric vehicle (BEV) or a plug-in hybrid electric vehicle (PHEV). The power supply device **3** includes an AC-DC conversion device, and is configured to supply alternating current power from the vehicle **4** to a load (in this example, the load **123**) in a case where the vehicle **4** is connected. The power supply device **3** is an example of a “power conversion device” according to the present disclosure.

[0032] The power supply system **101** further includes a first electromagnetic switch **51**, a second electromagnetic switch **52**, and a controller **10**.
[0033] A first end of the first electromagnetic switch **51** is electrically connected to the circuit PL**1** for AC 100 V. A second end of the first electromagnetic switch **51** is electrically connected to the overcurrent breaker **113**. As a result, the first electromagnetic switch **51** is configured to switch electrical connection and disconnection between the leakage breaker **1** and the overcurrent breaker **113** in response to a control command from the controller **10**.
[0034] A first end of the second electromagnetic switch **52** is electrically connected to the second end of the first electromagnetic switch **51** and is electrically connected to the overcurrent breaker **113**. A second end of the second electromagnetic switch **52** is electrically connected to the power supply device **3**. As a result, the second electromagnetic switch **52** is configured to switch electrical connection and disconnection between the first electromagnetic switch **51** and the power supply device **3** and switch electrical connection and disconnection between the overcurrent breaker **113** and the power supply device **3** in response to the control command from the controller **10**.
[0035] Although not shown, the leakage breaker **1** and the overcurrent breakers **111** to **113**, **211**, **212** are provided in a distribution board (may be a switch board depending on a type of the house **101**A). In a case of a distribution board having a large size, the first electromagnetic switch **51** and the second electromagnetic switch **52** may be disposed inside the distribution board. In a case of a distribution board having a small size, the first electromagnetic switch **51** and the second electromagnetic switch **52** may be disposed in a housing that is externally attached to the distribution board and is provided near the distribution board.
[0036] The first electromagnetic switch **51** corresponds to a “first switch” according to the present disclosure, and the second electromagnetic switch **52** corresponds to a “second switch” according to the present disclosure. The first electromagnetic switch **51** and the second electromagnetic switch **52** are also collectively referred to as an “electromagnetic switch”.
[0037] The controller **10** is computer equipment including a processor **11** and a memory **12**, and is, for example, a home energy management system (HEMS) controller. The controller **10** outputs the control command for opening and closing (turning on and off) each of the first electromagnetic switch **51** and the second electromagnetic switch **52**. As will be described later, the controller **10** may acquire power information (information on power trading, information on electricity charge, and the like) of the system power supply **900** from an energy management server (not shown), and open and close the first electromagnetic switch **51** and the second electromagnetic switch **52** or control the power supply device **3** according to the acquired power information (that is, supply power from the vehicle **4**). The controller **10** corresponds to a “control device” according to the present disclosure.
[0038] A phase of the alternating current power supplied from the system power supply **900** and the alternating current power supplied from the vehicle **4** is different. Therefore, it is not preferable to simultaneously supply the alternating current power from the system power supply **900** and the alternating current power from the vehicle **4** to the loads **121** to **123**. According to Embodiment 1, which of the two pieces of alternating current power is supplied to the loads **121** to **123** can be selected by using the first electromagnetic switch **51** and the second electromagnetic switch **52**.
[0039] FIG. **2** is a circuit block diagram showing a second example of the configuration of the power supply system according to Embodiment 1. In order to avoid complication of the drawings, the illustrations of the house **101**A and the controller **10** are omitted in FIG. **2** and subsequent drawings.
[0040] A power supply system **102** shown in FIG. **2** is different from the power supply system **101** shown in FIG. **1** in that the first electromagnetic switch **51** is electrically connected to the circuit PL**1** for AC 100 V, and in that the second electromagnetic switch **52** is electrically connected to the circuit PL**1** for AC 100 V.
[0041] In the power supply system **101** shown in FIG. **1**, the first electromagnetic switch **51** is

provided at a position corresponding to upstream of the overcurrent breaker **113**. Therefore, solely the overcurrent breaker **113** is disconnected from the leakage breaker **1** by the opening and closing of the first electromagnetic switch **51**. On the other hand, the first electromagnetic switch **51** shown in FIG. **2** is provided not at a position corresponding only to the upstream of the overcurrent breaker **113**, but at a position corresponding also to upstream of the overcurrent breakers **111**, **112** of the other rooms. Therefore, in a case where the first electromagnetic switch **51** is turned off, all of the three overcurrent breakers **111** to **113** are disconnected from the leakage breaker **1**.

[0042] As described above, in a case where the electrical connection and disconnection between the leakage breaker **1** and at least one overcurrent breaker can be switched, the disposition of the first electromagnetic switch **51** is not limited. The first electromagnetic switch **51** may be disposed anywhere as long as it is possible to switch the connection and disconnection between the leakage breaker **1** and at least one overcurrent breaker of the overcurrent breakers **111** to **113**.

[0043] In addition, in the second example, the first end of the second electromagnetic switch **52** is electrically connected to the circuit PL**1** (that is, single-phase three wires) for AC 100 V. As a result, the alternating current power from the vehicle **4** can be supplied not only to the load **123** but also to other loads **121**, **122**.

[0044] Since the configuration of the power supply system **102** except for the disposition of the first electromagnetic switch **51** and the second electromagnetic switch **52** is the same as the corresponding configuration of the power supply system **101**, a detailed description thereof will not be repeated.

[0045] Another electromagnetic switch (not shown) in place of the first electromagnetic switch **51** may be electrically connected to, for example, between the overcurrent breaker **113** and the load **123** (in other words, a position corresponding to downstream of the load **123**).

Processing Flow

[0046] FIG. **3** is a flowchart showing a first example of a processing procedure related to control of the electromagnetic switch. Processing shown in the flowchart is executed when a predetermined condition is satisfied (for example, every predetermined period). Each step is implemented by software processing by the controller **10** (processor **11**), but may be implemented by hardware (electric circuit) disposed in the controller **10**. Hereinafter, step is abbreviated as S. The same applies to other flowcharts described below.

[0047] Here, the power supply system **101** shown in FIG. **1** will be described as an example. At start of serial processing, it is assumed that the first electromagnetic switch **51** is turned on (closed) and the second electromagnetic switch **52** is turned off (opened).

[0048] With reference to FIGS. **1** and **3**, in S**100**, the controller **10** determines whether or not the power supply device **3** is connected to the vehicle **4**. In a case where the power supply device **3** is connected to the vehicle **4** (YES in S**100**), the controller **10** proceeds with the processing to S**101**. In a case where the power supply device **3** is not connected to the vehicle **4** (NO in S**100**), the controller **10** ends the processing. The processing of S**100** may be omitted.

[0049] In S**101**, the controller **10** acquires power information of the system power supply **900** (in this example, information on current electricity charge) from, for example, the energy management server (not shown).

[0050] In S**102**, the controller **10** determines whether or not a current electricity charge acquired in S**101** is higher than a reference price (for example, an average price of an electricity charge of the day). In a case where the current electricity charge is higher than the reference price (YES in S**102**), the controller **10** proceeds with the processing to S**103**.

[0051] In S**103**, the controller **10** acquires a state of charge (SOC) of the battery mounted on the vehicle **4** through communication with the vehicle **4** or the like. Then, the controller **10** determines whether or not the acquired SOC is higher than a needed value (S**104**). The needed value is, for example, a value corresponding to a power amount needed for the vehicle **4** to travel the next day. The needed value may be a predetermined fixed value or may be a variable value determined according to a usage record of the vehicle **4**.

[0052] In a case where the SOC is higher than the needed value (YES in S**104**), the controller **10** proceeds with the processing to S**105**. In a case where the SOC is equal to or less than the needed value (NO in S**104**), the controller **10** proceeds with the processing to S**109**.

[0053] In S**105**, the controller **10** acquires information on an electricity charge when the vehicle **4** is previously charged from, for example, the energy management server (not shown). Then, in S**106**, the controller **10** calculates a difference between the current electricity charge acquired in S**101** and the electricity charge at the time of the previous charging acquired in S**105**, and determines whether or not the difference is larger than a threshold value a. In a case where the difference is larger than the threshold value a (YES in S**106**), the controller **10** proceeds with the processing to S**107**. In a case where the difference is equal to or less than the threshold value a (NO in S**106**), the controller **10** proceeds with the processing to S**109**. In the present embodiment, the threshold value a is a positive value, but the threshold value a may be zero. Further, although an example of calculating the difference has been described in the embodiment, determination equivalent to S**106** may be made based on, for example, a ratio (b/a) between b and a instead of the difference.

[0054] Here, for the sake of description, the current electricity charge and the electricity charge at the time of the previous charging are respectively denoted by the a and the b. In addition, an empty capacity of power in the load **123** is denoted by x. Further, a power amount consumed by an ECU or the like when the vehicle **4** is charged (loss of the power amount) is denoted by L. In this case, a profit obtained by the user when the vehicle **4** discharges to the load **123** is denoted by $bx-ax-aL$. In order for a value of $bx-ax-aL$ to be larger than zero, a relationship of $(b-a)>aL/x$ needs to be satisfied. That is, as the difference between b and a is smaller, a threshold value of the x for the user to obtain the profit is larger. The controller **10** may set a value of aL/x to the threshold value α, or may set a value obtained by adding a certain value to the value of aL/x to the threshold value α. As a result, it is possible to reduce occurrence of a financial loss due to the power supply from the vehicle **4** to the load **123**. The controller **10** may acquire information on the x from the load **123**. In addition, the L may be a fixed value stored in the memory **12** (FIG. **1**).

[0055] In S**105**, the information on the electricity charge at the time of the previous charging is acquired, but the present disclosure is not limited thereto. For example, in a case where the power currently stored in the vehicle **4** has been stored by a plurality of times of charging in the past, information on an average value of electricity charges in the times of charging in the past may be acquired.

[0056] The controller **10** turns off the first electromagnetic switch **51** and turns on the second electromagnetic switch **52** (S**107**). Then, the controller **10** controls the power supply device **3** such that the power supply from the vehicle **4** to the load **123** is started (S**108**), and returns the processing to S**103**.

[0057] When the power supply from the vehicle **4** is continued, the SOC decreases with the passage of time. When the SOC is equal to or less than the needed value (NO in S**104**), the controller **10** controls the power supply device **3** such that the power supply from the vehicle **4** to the load **123** is ended (S**109**). Then, the controller **10** turns on the first electromagnetic switch **51** and turns off the second electromagnetic switch **52** (S**110**). As a result, the serial processing is terminated.

[0058] As will be described in Embodiment 2 to be described later, in a case where a charging device is provided in addition to the power supply device **3** or a bidirectional power conversion device is provided instead of the power supply device **3** (refer to FIGS. **4** and **5**), the controller **10** may control the charging device or the bidirectional power conversion device such that the vehicle **4** is charged in a case where the electricity charge is equal to or less than the reference price (NO in S**102**) (S**111**, S**112**).

[0059] In FIG. **3**, an example in which the subsequent processing is changed depending on whether or not the electricity charge is higher than the reference price has been described. Alternatively, the controller **10** may switch the processing in response to whether or not a current time is a nighttime period (a period in which a nighttime charge is applied). As a result, the electricity charge can be saved.

[0060] Alternatively, the controller **10** may switch the processing according to whether or not the current time is a period in which power demand of the house **101**A reaches a peak. By performing power supply from the vehicle **4** in the period in which the power demand reaches the peak, it is possible to cover the peak of the power demand even when the maximum supply current from the system power supply **900** is low, and thus it is possible to reduce so-called contracted amperes. Therefore, the electricity charge can be saved.

[0061] As described above, in Embodiment 1, the power supply systems **101**, **102** include the first electromagnetic switch **51** and the second electromagnetic switch **52**. By using the first electromagnetic switch **51** and the second electromagnetic switch **52**, it is possible to select whether to supply the alternating current power from the system power supply **900** and the alternating current power from the vehicle **4** to the loads **121** to **123**. More specifically, the alternating current power from the system power supply **900** is selected by turning on the first electromagnetic switch **51** and turning off the second electromagnetic switch **52**. On the other hand, the alternating current power from the vehicle **4** is selected by turning off the first electromagnetic switch **51** and turning on the second electromagnetic switch **52**. Therefore, according to Embodiment 1, the power from the vehicle **4** can be supplied to the load with a simple system configuration in which the two electromagnetic switches are merely added.

Embodiment 2

[0062] In Embodiment 2, a configuration in which a vehicle can be charged with power generated by a photovoltaic power generation device will be described.

System Configuration

[0063] FIG. **4** is a circuit block diagram showing a first example of a configuration of a power supply system according to Embodiment 2. A power supply system **201** shown in FIG. **4** is different from the power supply systems **101**, **102** (refer to FIGS. **1** and **2**) according to Embodiment 1 in that a third electromagnetic switch **53**, a charging device **6**, a power conditioning system (PCS) **7**, and a photovoltaic power generation device **8** are further included.

[0064] A first end of the third electromagnetic switch **53** is electrically connected to the power conditioning system **7**. A second end of the third electromagnetic switch **53** is electrically connected to the charging device **6**. As a result, the third electromagnetic switch **53** is configured to switch electrical connection and disconnection between the power conditioning system **7** and the charging device **6** in response to the control command from the controller **10** (refer to FIG. **1**). The third electromagnetic switch **53** corresponds to a “third switch” according to the present disclosure.

[0065] The charging device **6** is configured to be connected to the vehicle **4** via a charging cable (the charging cable and the power supply cable may be used in common) (not shown). The charging device **6** includes an AC-DC conversion device, and is configured to charge the vehicle **4** with alternating current power from the power conditioning system **7** in a case where the vehicle **4** is connected. In this example, the power supply device **3** and the charging device **6** correspond to the “power conversion device” according to the present disclosure.

[0066] The power conditioning system **7** receives direct current power from the photovoltaic power generation device **8** and converts the direct current power into alternating current power. The power conditioning system **7** outputs the alternating current power to the leakage breaker **1** and outputs the alternating current power to the charging device **6** via the third electromagnetic switch **53**.

[0067] Since the configuration of the power supply system **201** except for the third electromagnetic switch **53**, the charging device **6**, the power conditioning system **7**, and the photovoltaic power generation device **8** is the same as the corresponding configuration of the power supply systems **101**, **102**, a detailed description thereof will not be repeated.

[0068] FIG. **5** is a circuit block diagram showing a second example of the configuration of the power supply system according to Embodiment 2. A power supply system **202** shown in FIG. **5** is different from the power supply system **201** (refer to FIG. **4**) in that a bidirectional power conversion device **9** is included instead of the power supply device **3** and the charging device **6** (in other words, the power supply device **3** and the charging device **6** are integrated into one).

[0069] FIG. **6** is a circuit block diagram showing a third example of the configuration of the power supply system according to Embodiment 2. A power supply system **203** shown in FIG. **6** is different from the power supply system **201** (refer to FIG. **4**) in that the first end of the third electromagnetic switch **53** is electrically connected to the leakage breaker **1** (the circuit PL**2** for AC 200 V) instead of the power conditioning system **7**. In FIG. **6**, the bidirectional power conversion device **9** may be provided instead of the power supply device **3** and the charging device **6**.

[0070] FIG. **7** is a circuit block diagram showing a fourth example of the configuration of the power supply system according to Embodiment 2. A power supply system **204** shown in FIG. **7** is different from the power supply system **202** (refer to FIG. **5**) in the following two points. A first difference is that the bidirectional power conversion device **9** is electrically connected to the leakage breaker **1** (the circuit PL**2** for AC 200 V). A second difference is that the power supply system **204** does not include the third electromagnetic switch **53** and the bidirectional power conversion device **9** can switch between the power supply and the charging of the vehicle **4**.

[0071] Since the configurations of the power supply systems **202** to **204** shown in FIGS. **5** to **7** except for the above are the same as the corresponding configurations of the power supply system **201** shown in FIG. **4**, a detailed description will not be repeated.

Processing Flow

[0072] FIG. **8** is a flowchart showing a second example of the processing procedure related to the control of the electromagnetic switch. Here, the power supply system **201** shown in FIG. **4** will be described as an example. At start of serial processing, it is assumed that the first electromagnetic switch **51** is turned on, the second electromagnetic switch **52** is turned off, and the third electromagnetic switch **53** is turned off.

[0073] In S**200**, the controller **10** determines whether or not the power supply device **3** and the charging device **6** are connected to the vehicle **4**. In a case where the power supply device **3** and the charging device **6** are connected to the vehicle **4** (YES in S**200**), the controller **10** proceeds with the processing to S**201**. In a case where the power supply device **3** and the charging device **6** are not connected to the vehicle **4** (NO in S**200**), the controller **10** ends the processing. The processing of S**200** may be omitted.

[0074] In S**201**, the controller **10** acquires information related to the generated power of the photovoltaic power generation device **8** and acquires information related to power consumption (load power) of each load in the house **101**A. The controller **10** determines whether a generated power amount (power generation amount) within a specified time is larger than a load power amount (load amount) within the same specified time. In a case where the power generation amount is larger than the load amount (YES in S**201**), the controller **10** proceeds with the processing to S**202**.

[0075] In S**202**, the controller **10** determines whether or not the power generation amount of the photovoltaic power generation device **8** is larger than a predetermined amount. The predetermined amount is determined to be a power amount sufficient to charge the vehicle **4**. In a case where the power generation amount of the photovoltaic power generation device **8** is larger than the predetermined amount (YES in S**202**), the controller **10** proceeds with the processing to S**203**.

[0076] In S**203**, the controller **10** determines whether the SOC of the vehicle **4** is higher than a needed value. As described above, the needed value may be determined as a value corresponding to the power amount needed for the vehicle **4** to travel the next day. In a case where the SOC is higher than the needed value (YES in S**203**), that is, in a case where the power generation amount of the photovoltaic power generation device **8** is sufficient to charge the vehicle **4**, but the power amount needed for traveling is already stored in the vehicle **4**, the controller **10** turns on the first electromagnetic switch **51**, turns off the second electromagnetic switch **52**, and turns off the third electromagnetic switch **53** (S**204**). In this case, both the power supply from the vehicle **4** and the charging of the vehicle **4** are not performed. The alternating current power of the system power supply **900** or the generated power of the photovoltaic power generation device **8** (power after AC conversion) is supplied to the load **123**.

[0077] In a case where the SOC is equal to or less than the needed value (NO in S**203**), that is, in a case where the power generation amount of the photovoltaic power generation device **8** is sufficient to charge the vehicle **4** and the power amount stored in the vehicle **4** is insufficient, the controller **10** turns on the first electromagnetic switch **51**, turns off the second electromagnetic switch **52**, and turns on the third electromagnetic switch **53** (S**205**). In this case, the vehicle **4** is charged with the generated power of the photovoltaic power generation device **8**. The alternating current power of the system power supply **900** or the generated power of the photovoltaic power generation device **8** is supplied to the load **123**.

[0078] Returning to S**202**, in a case where the power generation amount of the photovoltaic power generation device **8** is equal to or less than the predetermined amount (NO in S**202**), that is, in a case where the power generation amount is larger than the load amount, but is not sufficient to charge the vehicle **4**, the controller **10** turns on the first electromagnetic switch **51**, turns off the second electromagnetic switch **52**, and turns off the third electromagnetic switch **53** (S**206**). In this case, both the power supply from the vehicle **4** and the charging of the vehicle **4** are not performed. The alternating current power of the system power supply **900** or the generated power of the photovoltaic power generation device **8** is supplied to the load **123**.

[0079] Returning to S**201**, in a case where the power generation amount of the photovoltaic power generation device **8** is equal to or less than the load amount (NO in S**201**), that is, in a case where the photovoltaic power generation device **8** alone cannot satisfy the power demand of the house **101**A, the controller **10** proceeds with the processing to S**207**. In S**207**, the controller **10** determines whether the SOC of the vehicle **4** is higher than a needed value. The needed value may be the same value as the needed value in S**203** or may be a different value.

[0080] In a case where the SOC is higher than the needed value (YES in S**207**), that is, when there is a margin in the power amount stored in the vehicle **4**, the controller **10** proceeds with the processing to S**208**. In a case where the SOC is equal to or less than the needed value (NO in S**207**), the controller **10** progresses the processing to S**211**.

[0081] In S**208**, the controller **10** acquires information on the electricity charge when the vehicle **4** is previously charged from, for example, the energy management server (not shown). Then, in S**209**, the controller **10** calculates a difference between the current electricity charge and the electricity charge at the time of the previous charging acquired in S**208**, and determines whether or not the difference is larger than the threshold value a. In a case where the difference is larger than the threshold value a (YES in S**209**), the controller **10** proceeds with the processing to S**210**. In a case where the difference is equal to or less than the threshold value a (NO in S**209**), the controller **10** proceeds with the processing to S**213**. In S**209**, the same processing as S**106** in FIG. **3** is performed, so that a detailed description thereof will be omitted.

[0082] The controller **10** turns off the first electromagnetic switch **51**, turns on the second electromagnetic switch **52**, and turns off the third electromagnetic switch **53** (S**210**). That is, the power supply from the vehicle **4** to the load **123** is performed instead of the power supply from the system power supply **900**.

[0083] In a case where the SOC is equal to or less than the needed value (NO in S**207**), that is, in a case where there is no margin in the power amount stored in the vehicle **4** to supply power to the outside, the controller **10** determines whether or not there is a charging command of the vehicle **4** (S**211**).

[0084] In a case where there is the charging command (YES in S**211**), the controller **10** turns on the first electromagnetic switch **51**, turns off the second electromagnetic switch **52**, and turns on the third electromagnetic switch **53** (S**212**). In this case, the vehicle **4** is charged with the generated power of the photovoltaic power generation device **8**. The alternating current power from the system power supply **900** or the generated power of the photovoltaic power generation device **8** is supplied to the load **123**.

[0085] When there is no charging command (NO in S**211**), the controller **10** turns on the first electromagnetic switch **51**, turns off the second electromagnetic switch **52**, and turns off the third electromagnetic switch **53** (S**213**). In this case, both the power supply from the vehicle **4** and the charging of the vehicle **4** are not performed.

[0086] FIG. **9** is a flowchart showing a third example of the processing procedure related to the control of the electromagnetic switch. Here again, the power supply system **201** shown in FIG. **4** will be described as an example. At start of serial processing, it is assumed that the first electromagnetic switch **51** is turned on, the second electromagnetic switch **52** is turned off, and the third electromagnetic switch **53** is turned off.

[0087] In S**300**, the controller **10** determines whether or not the power supply device **3** and the charging device **6** are connected to the vehicle **4**. In a case where the power supply device **3** and the charging device **6** are connected to the vehicle **4** (YES in S**300**), the controller **10** proceeds with the processing to S**301**. In a case where the power supply device **3** and the charging device **6** are not connected to the vehicle **4** (NO in S**300**), the controller **10** ends the processing. The processing of S**300** may be omitted.

[0088] In S**301**, the controller **10** determines whether or not there is a power supply command. When there is the power supply command (YES in S**301**), the controller **10** proceeds with the processing to S**302**. When there is no power supply command (NO in S**301**), the controller **10** proceeds with the processing to S**306**.

[0089] In S**302**, the controller **10** acquires information on the electricity charge when the vehicle **4** is previously charged from, for example, the energy management server (not shown). Then, in S**303**, the controller **10** calculates a difference between the current electricity charge and the electricity charge at the time of the previous charging acquired in S**302**, and determines whether or not the difference is larger than the threshold value α. When the difference is larger than the threshold value α (YES in S**303**), the controller **10** proceeds with the processing to S**304**. When the difference is equal to or less than the threshold value α (NO in S**303**), the controller **10** proceeds with the processing to S**306**. In S**303**, the same processing as S**106** in FIG. **3** is performed, so that a detailed description thereof will be omitted.

[0090] In S**304**, the controller **10** turns off the first electromagnetic switch **51**, turns on the second electromagnetic switch **52**, and turns off the third electromagnetic switch **53**. Then, the controller **10** controls the power supply device **3** such that the power supply from the vehicle **4** is started (S**305**).

[0091] In S**306**, the controller **10** determines whether or not there is the charging command. In a case where there is the charging command (YES in S**306**), the controller **10** proceeds with the processing to S**307**, turns on the first electromagnetic switch **51**, turns off the second electromagnetic switch **52**, and turns on the third electromagnetic switch **53**. Then, the controller **10** controls the charging device **6** such that the charging of the vehicle **4** is started (S**308**). The alternating current power from the system power supply **900** or the generated power of the photovoltaic power generation device **8** is supplied to the load **123**.

[0092] In a case where there is neither power supply command nor charging command (NO in S**306**), the controller **10** proceeds with the processing to S**309**, turns on the first electromagnetic switch **51**, turns off the second electromagnetic switch **52**, and turns off the third electromagnetic switch **53**. In this case, both the power supply from the vehicle **4** and the charging of the vehicle **4** are not performed. The alternating current power from the system power supply **900** or the generated power of the photovoltaic power generation device **8** is supplied to the load **123**.

[0093] In FIGS. **8** and **9**, the third electromagnetic switch **53** is described as being turned on or off. As shown in FIG. **7**, even in a system configuration in which the third electromagnetic switch **53** is not provided, those skilled in the art will understand that the same function can be realized by switching between the charging and the power supply through the bidirectional power conversion device **9**.
[0094] As described above, in Embodiment 2, the power supply systems **201** to **204** include the first electromagnetic switch **51** and the second electromagnetic switch **52**, as in Embodiment 1. As a result, the power from the vehicle **4** can be supplied to the load with a simple system configuration in which the two electromagnetic switches are merely added. In addition, in Embodiment 2, the power supply systems **201** to **203** include the third electromagnetic switch **53**. As a result, with a simple system configuration in which the third electromagnetic switch is merely added, it is possible to charge the vehicle **4** with the generated power of the photovoltaic power generation device **8** in addition to the supplied power from the vehicle **4**.
[0095] In the embodiment, an example in which the leakage breaker is provided in the power supply system has been described, but the present disclosure is not limited thereto. Instead of the leakage breaker, an overcurrent breaker that electrically disconnects the system power supply **900** and the circuits PL**1**, PL**2** from each other during overcurrent (at the time of detection of overcurrent detection), or a leakage interrupter with an overcurrent breaker that electrically disconnects the system power supply **900** and the circuits PL**1**, PL**2** from each other during overcurrent and during leakage (at the time of detection of leakage) may be provided.
[0096] In the embodiment, an example in which the power supply device **3** and the bidirectional power conversion device **9** supply the power to the load **123** connected to the circuit PL**1** for AC 100 V has been described, but the present disclosure is not limited thereto. A power supply device or a bidirectional power conversion device that supplies the power from the vehicle **4** to a load connected to the circuit PL**2** for AC 200 V may be provided. The power supply device and the bidirectional power conversion device correspond to the “power conversion device” according to the present disclosure.
[0097] In the embodiment, an example shown in which the first electromagnetic switch **51** is electrically connected to the leakage breaker **1** and the overcurrent breaker **113** has been described, but the present disclosure is not limited thereto. As shown in FIG. **10**, the first end of the first electromagnetic switch **51** may be electrically connected to the overcurrent breaker **113**, and the second end of the first electromagnetic switch **51** may be electrically connected to the load **123**. In this case, the first end of the second electromagnetic switch **52** is electrically connected to the overcurrent breaker **113** and the load **123**. Although FIG. **10** shows a modification example of the power supply system **101** in FIG. **1**, the power supply systems **102**, **201**, **202**, **203**, **204** may be similarly modified.
[0098] The embodiment disclosed herein is to be considered merely illustrative and not restrictive in all respects. The scope of the present disclosure is indicated by the scope of claims rather than by the description of the embodiment, and is intended to include all modifications within the scope and meaning equivalent to the scope of the claims.

Claims

1. A power supply system, the power supply system being a power supply system that supplies alternating current power from a system power supply to a power load of a house, the power supply system comprising: a current breaker configured to receive the alternating current power from the system power supply to the house and disconnect the alternating current power during at least one of leakage or overcurrent; a load breaker configured to electrically disconnect the current breaker and the power load from each other; a power conversion device configured to supply, in a case where a vehicle is connected, alternating current power from the vehicle to the power load; a first switch configured to switch electrical connection and disconnection between the current breaker and the load breaker; and a second switch configured to switch electrical connection and disconnection between the first switch and the power conversion device and switch electrical connection and disconnection between the load breaker and the power conversion device.

2. The power supply system according to claim 1, wherein: the house includes a power conditioning system configured to receive generated power of a photovoltaic power generation device; the power conversion device is configured to charge, in a case where the vehicle is connected, the vehicle with alternating current power from the power conditioning system; and the power supply system further comprises a third switch configured to switch electrical connection and disconnection between the power conditioning system and the power conversion device.

3. The power supply system according to claim 1, wherein: the power conversion device is further configured to charge, in a case where the vehicle is connected, the vehicle with alternating current power from the current breaker; and the power supply system further comprises a third switch configured to switch electrical connection and disconnection between the current breaker and the power conversion device.

4. The power supply system according to claim 1, wherein, in a case where the vehicle is connected to the power conversion device and a current electricity charge is higher than an electricity charge at a time when power currently charged in the vehicle is charged, the first switch is opened and the second switch is closed.

5. The power supply system according to claim 4, wherein, in a case where the vehicle is connected to the power conversion device and the current electricity charge is higher than an electricity charge at a time when the vehicle is previously charged, the first switch is opened and the second switch is closed.

6. The power supply system according to claim 1, further comprising a control device configured to control the first switch and the second switch, wherein: the control device is configured to, in a case where power is supplied from the system power supply to the power load, close the first switch and open the second switch; and the control device is configured to, in a case where power is supplied from the vehicle to the power load, open the first switch and close the second switch.

7. The power supply system according to claim 2, further comprising a control device configured to control the first switch, the second switch, and the third switch, wherein: the control device is configured to, in a case where power is supplied form the vehicle, open the first switch, close the second switch, and open the third switch; the control device is configured to, in a case where power is charged to the vehicle, close the first switch, open the second switch, and close the third switch; and the control device is configured to, in a case where power is not supplied from the vehicle and power is not charged to the vehicle, close the first switch, open the second switch, and open the third switch.