

VEHICLE CHARGING SYSTEM

FIELD OF THE INVENTION

[0001]

The present invention relates to a vehicle charging system, especially a vehicle charging system compatible with a demand control and capable of simultaneously charging a plurality of vehicles.

BACKGROUND OF THE INVENTION

[0002]

As a vehicle charging system that simultaneously charges a plurality of vehicles, such as EVs and PHVs, there is an example of a charging system disclosed in JP 2020-188668 A.

[0003]

In JP 2020-188668 A, the charging system controls currents supplied to the chargers such that received power does not exceed a demand value using a control master unit and control slave units. The control master unit manages the received power while the control slave units control received current of respective chargers.

[0004]

In the vehicle charging system in JP 2020-188668 A, a control unit disposed to each of the chargers individually controls the charging current of the charger without collectively controlling a plurality of chargers in the system. Thus, the vehicle charging system can be easily adapted to increase and decrease of the chargers, providing scalability to the system.

However, when a vehicle is newly connected to a charger in a state where the received power is about to exceed a maximum demand value, the charge of the vehicle causes the received power to increase and possibly to exceed the maximum demand value.

[0005]

Therefore, an object of the present disclosure is to provide a vehicle charging system that, when a new vehicle charge is required in a state where the received power is about to

exceed the maximum demand value, does not charge the new vehicle at least until a first demand period elapses.

SUMMARY OF THE INVENTION

[0006]

In order to achieve the above-described object, a vehicle charging system according to a first aspect of the disclosure is provided. The vehicle charging system includes a plurality of chargers for charging vehicles, and a charge control unit that controls a charging current of the charger. The charge control unit includes a control master unit that obtains information of received power from a power meter that measures the received power supplied from commercial power, compares the received power with a predetermined upper-limit value, and outputs the difference as difference information, and a control slave unit that is installed to each of the chargers and individually controls the charging current of the charger. The control slave unit controls the charging current based on the difference information such that the received power does not exceed the upper-limit value. When a vehicle to be charged is newly added in a state where the control slave unit recognizes that the received power has exceeded or is almost equal to the upper-limit value from the difference information, the control slave unit does not start charging the newly added vehicle at least until a first demand period elapses.

[0007]

According to the present disclosure, since the control slave unit controls the received power so as not to exceed the upper-limit value, setting the upper-limit value to, for example, a maximum demand value or a power value which is smaller than the maximum demand value allows the demand control to be performed even without a center control unit for the entire control. When a new vehicle charge is required in a state where the received power has exceeded or is about to exceed the upper-limit value, the vehicle charge is not started until the first demand period elapses, thus ensuring the control without exceeding the upper-limit value.

Further, since the control master unit only need to output the difference information with respect to the upper-limit value of the received power, a setting of the control master unit does not need to be changed when the number of set chargers are changed. Thus, the number of the chargers can be easily increased and decreased.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a schematic configuration diagram illustrating an exemplary vehicle charging system according to the present disclosure.

FIG. 2 is a block diagram of a control master unit.

FIG. 3 is a block diagram of a control slave unit.

FIG. 4 is a flowchart depicting a procedure of a charge control.

FIG. 5 is a flowchart depicting the procedure of the charge control.

DETAILED DESCRIPTION OF THE INVENTION

[0009]

The following describes an embodiment where the present disclosure is embodied in detail with reference to the drawings. FIG. 1 is a configuration diagram illustrating an exemplary vehicle charging system according to the present disclosure. The vehicle charging system includes a control master unit 1 that obtains information of received power supplied from commercial power P from a smart meter (power meter) 10, and control slave units 3 that communicate with the control master unit 1 and control charging currents of chargers 2. FIG. 1 depicts a state where charge cables L1 extending from vehicles 4 are connected to the chargers 2. The control slave unit 3 is installed to each of the chargers 2.

[0010]

Reference numeral 5 (5a, 5b) denotes step-down transformers that convert powers received at high pressure into low pressure powers, reference numeral 6 denotes a load, such as an air conditioner, to which a three-phase power is supplied, and reference numeral 7

denotes a load, such as an illuminator, to which a single-phase 100/200 V is supplied. FIG. 1 illustrates a configuration in which reference numeral 5a denotes a three-phase transformer, reference numeral 5b denotes a single-phase transformer, and each of the chargers 2 is supplied with a single-phase 200 V power output by the single-phase transformer 5b.

[0011]

FIG. 2 illustrates a block diagram of the control master unit 1. As illustrated in FIG. 2, the control master unit 1 includes a master unit measurement member 11 that obtains received power information from the smart meter 10, a master unit storage member 12 that stores an upper-limit value and the like, a master unit CPU 13 that controls the control master unit 1, a master unit communication member 14 that wirelessly communicates with the control slave units 3. The control master unit 1 is connected to the smart meter 10 via a communication line L2.

[0012]

FIG. 3 illustrates a block diagram of the control slave unit 3. As illustrated in FIG. 3, the control slave unit 3 includes a slave unit communication member 31 that wirelessly communicates with the control master unit 1, a slave unit storage member 32 that stores a threshold value of a charge amount, a duration described later, and a standby period and the like, a slave unit CPU 33 that controls the control slave unit 3, a charger control unit 34 that transmits a control signal to the charger 2, and the like. The control slave unit 3 is connected to the charger 2 via a transmission line L3.

The threshold value is a required charge amount of the vehicle 4 to travel a predetermined distance, such as 50 km. The threshold value may be set to a predetermined value for all the vehicles 4, or be set individually for each of the vehicles 4 by the charger 2 obtaining electric mileage information and the like from the vehicle 4. The control slave unit 3 and the charger 2 may be configured integrally.

[0013]

Here, a description is given of an upper-limit value stored in the master unit storage member 12. The upper-limit value is a power value set to be smaller by, for example, 10%

than a maximum demand value, and is set based on a background, such as the following.

A demand value is a maximum value of an average consumed power every 30 minutes as a demand period in one month, and a maximum value of the demand value, namely a maximum demand value, for the past one year which includes the present month and the previous 11 months is applied to a basic charge of an electric charge. Therefore, when the demand value larger than the demand values of the past 11 months is measured even once in a span of one month, the value becomes a basis to determine the basic charge of the electric charge for the subsequent one year. That is, to suppress or reduce the electric charge, performing the control, so called demand control, to suppress the maximum demand value is effective. Therefore, an upper-limit value that is set to be a value that does not exceed the maximum demand value is used. The upper-limit value is set by a consumer.

[0014]

The charge control of the vehicle charging system thus configured is performed as the following.

First, the control master unit 1 obtains received power information from the smart meter 10, and notifies each of the control slave units 3 of deviation information as difference information in a constant interval, such as a one-second interval.

The deviation information is information indicating the difference between a value of the present received power and the upper-limit value or the difference between an expected value of a power amount in 30 minutes calculated based on the received power and the upper-limit value. The control significantly varies depending on whether the value of the present received power is equal to or above, or below the upper-limit value. When the current received power is almost equal to the upper-limit value, the master unit CPU 13 outputs information indicating "0" as the deviation information from the master unit communication member 14 and transmits the information to each of the control slave units 3. Information indicating "positive" is output when the current received power exceeds the upper-limit value. Information indicating "negative" is output when the current received power has not reached the upper-limit value.

The received power being almost equal to the upper-limit value means that the received power is close to the upper-limit value and has a difference, for example, within 2% with respect to the upper-limit value.

[0015]

The individual control slave units 3 that have received deviation information from the control master unit 1 perform a control as the following. FIG. 4 and FIG. 5 depict flowcharts of a procedure of a current control performed by the slave unit CPU 33 of the control slave unit 3, and the procedure will be described with reference to the flowcharts. The control is performed every time the deviation information is received.

When the deviation information is received (S1), it is determined if the charger 2 is charging or is going to start charging. If the charge has already started, the procedure proceeds to S6, and if a vehicle is newly connected to start to be charged (YES at S2), remaining time until the demand period elapses is determined (S3).

At S3, it is determined whether or not there is less than a predetermined period, such as 3 minutes, before the demand time limit, that is, before the demand period elapses. If there is less than the predetermined period, the procedure proceeds to S6, and if there is equal to or more than the predetermined period, proceeds to S4.

At S4, a determination is made based on the deviation information. If the deviation information is equal to or above 0, that is if the received power is equal to or above the upper-limit value (YES at S4), a charging current of 0 ampere is maintained until the demand time limit (S5). If the deviation information is negative, the procedure proceeds to S6.

[0016]

Thus, when a charge of the vehicle 4 is newly required in a state where the received power has exceeded or is about to exceed the upper-limit value, since the charge of the vehicle does not start until the first demand period elapses, the received power can be controlled surely not to exceed the upper-limit value.

[0017]

If the received power continues to remain near the upper-limit value even after the

first demand period elapses, the charging current may continuously be kept in a 0 ampere. The demand period is managed by the control master unit 1 in communication with the smart meter 10, and information of the demand period is notified to the control slave unit 3.

[0018]

At S6, the charge amount is determined, and different controls are performed depending on whether or not the charge amount has reached the threshold value. If the charge amount has not reached the threshold value, the procedure proceeds to S7, and if the charge has reached the threshold value, the procedure proceeds to S11.

When the charge amount has not reached the threshold value (NO at S6) and the deviation information is negative, that is, when the received power has not reached the upper-limit value (NO at S7) and the charging current is allowed to be increased, an increasable current is calculated by the following formula (Formula 1), and the charging current is increased (S10). Since a maximum value of the charging current is set, the charging current does not get increased any further once it reaches the maximum value.

Increasable current = maximum current value (A) × charge amount (Wh)/threshold value (Wh)...(Formula 1)

[0019]

When the deviation information is 0, that is, when the received power is almost equal to the upper-limit value (YES at S8), a signal of not changing the charging current is transmitted to the charger 2 (S18), and the procedure is terminated.

When the deviation information is positive, that is, when the received power exceeds the upper-limit value (NO at S8), and the charging current shall be controlled to be reduced, a reducible current is calculated by the following formula (Formula 2), and the charging current is reduced (S9). Since a minimum value of the charging current is set, the charging current does not get reduced any further once it reaches the minimum value.

Reducible current = maximum current value (A) × (threshold value (Wh) – charge amount (Wh))/threshold value (Wh)...(Formula 2)

A new current value thus set is notified to the charger 2 (S18), and the charger 2

changes the current value according to the received notification.

[0020]

On the other hand, in a case that the charge has been proceeding up to or beyond the threshold value at the time of receiving the deviation information (YES at S6), the charge is controlled as the following.

When the deviation information is negative, that is, when the received power has not reached the upper-limit value (NO at S11), a duration stored in the slave unit storage member 32 is read. The duration is time until a set standby period elapses after the charging current is set to 0. When the duration has not reached the set standby period, such as 60 seconds, (NO at S12), the duration is added by one unit which is time interval of receiving the deviation information (S14) and stored. A signal of not changing the current is transmitted to the charger 2 (S18), and the procedure is terminated.

If the duration has reached the standby period (YES at S12), a signal of adding a minimum increased current to the present current (S13) is transmitted to the charger 2 (S18), and the procedure is terminated.

[0021]

With the control, charging current of the vehicle 4 whose charge amount has reached the threshold value is stopped from being increased until the set standby period elapses. Therefore, if there is the vehicle 4 whose charge amount has not reached the threshold value, the standby period can be used for the vehicle 4 to increase the charging current and proceed the charge, and thus a balanced current control is possible even without a control unit to collectively manage the chargers 2.

[0022]

When the deviation information is 0 or positive, that is, when the received power is equal to or above the upper-limit value (YES at S11), the following control is performed. When the deviation information is 0, that is when the received power is almost the upper-limit value (YES at S15), the stored duration is reset (S17) to 0, a signal of not changing the current is transmitted to the charger 2 (S18), and the procedure is terminated.

In a case where the deviation information is positive, that is when the received power exceeds the upper-limit value (NO at S15), a signal of the charging current being 0 is transmitted to the charger 2 and the charging current is set to 0, while the stored duration is reset to 0 (S17), and the procedure is terminated.

[0023]

With the control, when the received power exceeds the upper-limit value, a charge of the vehicle 4 that has proceeded up to or above the threshold value is stopped regardless of whether or not the duration has reached the standby period, allowing the demand control to be performed. Further, since the duration is reset, a sufficient standby period can be set, and during that period, a charge of the vehicle 4 whose charge amount has not reached the threshold value can be continued. Therefore, the charging current can be distributed in a balanced manner.

[0024]

Since the control slave units 3 control the received power so as not to exceed the upper-limit value, the demand control can be performed even without a central control unit for the entire control. In addition, since the control master unit 1 only needs to output the deviation information, that is the difference information, with respect to the upper-limit value of the received power, the setting of the control master unit 1 does not need to be changed when changing the installed number of the chargers 2, and thus the number of the charger 2 can be increased and decreased easily.

Further, even by individually controlling the charging currents of the respective chargers 2, a balanced charge can be performed on the vehicles 4 connected to the individual chargers 2.

Furthermore, since the control master unit 1 and the control slave units 3 communicate wirelessly, a signal line between them does not need to be installed, thus providing a fine constructability of the system.

[0025]

While a communication between the control master unit 1 and the control slave units

3 is performed wirelessly in the above embodiment, they may also be connected by a wire.

It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

REFERENCE SIGNS LIST

[0026]

- 1... Control master unit (charge control unit)
- 2... Charger
- 3... Control slave unit (charge control unit)
- 4... Vehicle
- 10... Smart meter (power meter)
- 11... Master unit measurement member
- 14... Master unit communication member (wireless communication unit)
- 12... Master unit storage member
- 31... Slave unit communication member (wireless communication unit)
- 32... Slave unit storage member

CLAIMS

1. A vehicle charging system comprising:
 - a plurality of chargers for charging vehicles; and
 - a charge control unit that controls a charging current of the charger, wherein the charge control unit includes:
 - a control master unit that obtains information of received power from a power meter that measures the received power supplied from commercial power, compares the received power with a predetermined upper-limit value, and outputs the difference as difference information; and
 - a control slave unit that is installed to each of the chargers and individually controls the charging current of the charger, wherein
 - the control slave unit controls the charging current based on the difference information such that the received power does not exceed the upper-limit value, and when a vehicle to be charged is newly added in a state where the control slave unit recognizes that the received power has exceeded or is almost equal to the upper-limit value from the difference information, the control slave unit does not start charging the newly added vehicle at least until a first demand period elapses.