

VEHICLE CHARGING SYSTEM

BACKGROUND

TECHNICAL FIELD

[0001]

The present invention relates to a vehicle charging system that can simultaneously charge a plurality of vehicles while performing demand control in detail.

BACKGROUND ART

[0002]

For example, JP-A No. 2020-188669 discloses a vehicle charging system that simultaneously charges a plurality of vehicles including storage batteries, such as EVs and PHVs.

[0003]

In JP-A No. 2020-188669, a current of a transformer is monitored in addition to received power, charge control of a vehicle is performed to avoid an overload of the transformer constituting a power receiving facility while demand control is performed, and thus effective vehicle charging is performed.

[0004]

The technique of JP-A No. 2020-188669 allows avoiding the overload of the transformer while the demand control is performed. However, a current flowing a distribution board, which supplies power to a charger that charges the vehicle, is not monitored. Accordingly, when an operation of a main breaker of the distribution board is tripped due to an overcurrent, the vehicle charging stops. In other words, although the received power and the transformer can be managed, the vehicle charging may stop.

[0005]

Here, a description will be given of a demand value. A maximum value (a maximum demand value) of the demand value (a maximum value of average consumed power every 30 minutes in one month) for the past one year (the present month and the previous 11 months) is

applied to a basic charge of an electric charge. Therefore, when a demand value larger than the demand values of the past 11 months is measured even at once in one month, the basic charge of the electric charge for the subsequent one year is determined based on the value. Specifically, to reduce the electric charge, control (demand control) that reduces the maximum demand value is effective.

SUMMARY

[0006]

Therefore, an object of the present invention is to provide a vehicle charging system that performs demand control, monitors a transformer current, and in addition, monitors a current flowing a main breaker of a distribution board to ensure effective vehicle charging.

[0007]

In order to achieve the above-described object, a vehicle charging system according to a first aspect of the invention is provided. The vehicle charging system includes a plurality of chargers and a charge control unit. The plurality of chargers charge vehicles. The charge control unit controls a charging current of the charger. The charge control unit includes a first measurement unit, a second measurement unit, and a third measurement unit. The first measurement unit obtains current value information indicative of a current of received power from an electric energy meter that measures received high-voltage power. The second measurement unit obtains current value information indicative of a current of a transformer that transforms the received high-voltage power into low-voltage power and supplies the power to the charger. The third measurement unit obtains current value information indicative of a current flowing a main breaker of a distribution board that supplies power to the charger. The charge control unit performs control such that the received current value obtained by the first measurement unit does not exceed a predetermined first setting value, the current value obtained by the second measurement unit does not exceed a predetermined second setting value, and the current value obtained by the third measurement unit does not exceed a predetermined third setting value. According to the configuration, the current of the received power, the current of the transformer, and the current of the main breaker are monitored to control the charging of the vehicle. Accordingly, demand control is performed while an overload of the

transformer is avoided, and efficient vehicle charging without stopping charging can be performed.

[0008]

In the vehicle charging system according to a second aspect of the invention, which is in the configuration according to the first aspect, the charge control unit is formed of a first control master unit, a second control master unit, a third control master unit, and a control slave unit. The first control master unit, the second control master unit, the third control master unit, and the control slave unit are separated from one another. The first control master unit includes the first measurement unit and outputs difference information of a received current with respect to the first setting value. The second control master unit includes the second measurement unit and outputs difference information of a transformer current with respect to the second setting value. The third control master unit includes the third measurement unit and outputs difference information of a main breaker current with respect to the third setting value. The control slave unit is installed for each of the chargers to control the charging current based on the information output from the first control master unit, the second control master unit, and the third control master unit. The control slave unit performs control such that the received current value does not exceed the first setting value, the current value of the transformer does not exceed the second setting value, and the current value flowing the main breaker does not exceed the third setting value based on the difference information transmitted from the first control master unit, the second control master unit, and the third control master unit.

According to the configuration, since the chargers are controlled individually, even the plurality of chargers are disposed, a control unit that collectively controls the entire chargers need not be provided. Therefore, the charger can be easily expanded.

[0009]

In the vehicle charging system according to a third aspect of the invention, which is in the configuration according to the second aspect, the first control master unit, the second control master unit, the third control master unit, and the control slave units wirelessly communicate with one another. The control slave units wirelessly obtain the difference information from the first control master unit, the second control master unit, and the third control master unit.

According to the configuration, since the control slave units wirelessly communicate with the respective control master units, additionally disposing a communication line is unnecessary.

[0010]

In the vehicle charging system according to a fourth aspect of the invention, which is in the configuration according to the third aspect, the first control master unit, the second control master unit, and the third control master unit grasp mutual transmissions of the difference information to the control slave units, and each of the first control master unit, the second control master unit, and the third control master unit performs control so as not to cause a collision of the transmission of the individual difference information to the control slave unit.

According to the configuration, the plurality of control master units never simultaneously transmit control signals to the control slave units, and the control slave units can properly communicate with the respective master units and perform the stable control.

[0011]

According to the present invention, the current of the received power, the current of the transformer, and the current of the main breaker are managed to control the vehicle charging. Therefore, in addition to the demand control and the overload monitoring of the transformer, an overcurrent of the main breaker is monitored, and thus ensuring the efficient charging control without stopping the vehicle charging.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

FIG. 1 is a block diagram illustrating a first configuration of a vehicle charging system.

FIG. 2 is a flowchart depicting a procedure of allocation of priority orders.

FIG. 3 is a flowchart depicting a procedure of charging current control of the vehicle charging system illustrated in FIG. 1.

FIG. 4 is a block diagram illustrating a second configuration of the vehicle charging system.

FIG. 5 is a block diagram of a first control master unit.

FIG. 6 is a block diagram of a second control master unit.

FIG. 7 is a block diagram of a third control master unit.

FIG. 8 is a block diagram of a control slave unit.

FIG. 9 is a flowchart depicting a procedure of transmission control of the first control master unit.

FIG. 10 is a flowchart depicting a procedure of transmission control of the second control master unit.

FIG. 11 is a flowchart depicting a procedure of transmission control of the third control master unit.

FIG. 12 is a flowchart depicting a procedure of charging current control of the control slave unit.

DESCRIPTION OF EMBODIMENTS

[0013]

The following will describe embodiments where the present invention is embodied in detail with reference to the drawings. FIG. 1 is a block diagram illustrating a first configuration of a vehicle charging system according to the present invention. As illustrated in FIG. 1, a vehicle charging system 1 includes a plurality of chargers 2 and a charge control unit 3. Charging cables L1 extending from vehicles 4 are coupled to the plurality of chargers 2. The charge control unit 3 obtains received power information (current information) of high-voltage commercial power Q from a smart meter (an electric energy meter) 10, obtains the current information at a plurality of locations, generates control signals of charging currents, and output the control signals to the respective chargers 2.

[0014]

A step-down transformer 5 (5a and 5b) (hereinafter simply referred to as a "transformer") transforms high-voltage power into low-voltage power. Three-phase power is supplied to a load 6, such as an air conditioner. A single-phase 100/200 V is supplied to a load 7, such as an illumination. A main breaker 11 is disposed on a distribution board (not illustrated) that supplies power to the charger 2. Power at the single-phase 200 V is supplied to the charger 2.

[0015]

The charger 2 include a circuit (not illustrated) that changes a charging current and a circuit that communicates with the coupled vehicle, in response to the control signal from the charge control unit 3.

[0016]

The charge control unit 3 includes, for example, a first measurement unit 31a, a second measurement unit 31b, a third measurement unit 31c, a storage unit 32, a charge control unit CPU 34, and a plurality of communication units 35. The first measurement unit 31a is coupled to the smart meter 10 via a communication line L2 to obtain the current information of the received power. The second measurement unit 31b obtains the current information from a current sensor 8 disposed in a secondary side electric circuit of the transformer 5b that supplies power to the charger 2. The third measurement unit 31c obtains the current information from a current sensor 9 that measures a current flowing the main breaker 11. The storage unit 32 stores, for example, a received current standard value (a first setting value) described later, a rated current value (a second setting value) of the transformer 5b, a rated value (a third setting value) of the main breaker 11), and a charging power threshold described later. The charge control unit CPU 34 determines the charging currents of the respective chargers 2 and controls the respective units in the charge control unit 3. The plurality of communication units 35 communicate with the individual chargers 2.

[0017]

The received current standard value is a current value set such that the received power becomes a value smaller than the maximum demand value by, for example, 10% and is a value set by a consumer to reduce the maximum demand value and reduce a contract charge. Additionally, the charging power threshold (hereinafter simply referred to as a "threshold") is electric energy serving as a reference when the priority order of a vehicle subject to charging is set, and is, for example, electric energy required to travel a set distance. The threshold is set for each vehicle 4 under control by the charge control unit CPU 34 based on remaining amount information of a storage battery obtained by the charger 2 from the vehicle 4.

[0018]

The charge control of the vehicle charging system 1 thus configured is performed as follows. First, the priority orders of the vehicles 4 to be charged are allocated. FIG. 2 depicts a procedure of allocation of the priority orders of the vehicles 4 to be charged, and a description will be given with reference to FIG. 2.

When the vehicle 4 is coupled to the charger 2 (a charging plug of the vehicle 4 is coupled) and a charge start operation is performed, the charging starts with a predetermined current value under control by the charge control unit CPU 34. Simultaneously, the priority orders are allocated together with the other vehicles 4 on which the charge control has been already performed.

First, the number of vehicles 4 whose charge amounts are less than the threshold (the number of non-achievements: n) is grasped (S1), and then the number of vehicles 4 that are charged with the threshold or more (the number of achievements: m) is grasped (S2).

The charge control unit CPU 34 grasps the charge amount (the electric energy from when the charge starts) of the individual vehicle 4, compares the value of the charge amount with the threshold and performs determination.

[0019]

Next, the vehicles 4 included in the number of non-achievements n are put in the descending order of the charge amount and prioritized and allocated from the first to the n^{th} (S3), and further the vehicles 4 included in the number of achievements m are put in the descending order of the charge amount and prioritized and allocated from the $(n+1)^{\text{th}}$ to the $(n+m)^{\text{th}}$ (S4).

Thus, the prioritization is made from the first to the $(n+m)^{\text{th}}$, the charge amount of the first vehicle 4 is the largest value and the charge amount of the n^{th} vehicle 4 is the smallest value among the first to the n^{th} vehicles 4. The charge amount of the $(n+1)^{\text{th}}$ vehicle 4 is the largest value and the charge amount of the $(n+m)^{\text{th}}$ vehicle 4 is the smallest value among the $(n+1)^{\text{th}}$ to the $(n+m)^{\text{th}}$ vehicles 4. After the priority orders are thus allocated, the process proceeds to the control of the charging current.

[0020]

FIG. 3 is a flowchart depicting a procedure of charging current control performed by the charge control unit 3, and the charge control will be described with reference to the flowchart.

After the above-described allocation process of the priority orders (S11) ends, deviation information is determined (S12).

Here, the deviation information will be described. There are three pieces of the deviation information, first deviation information, second deviation information, and third deviation information, and the pieces of information are calculated by the following formulae 1 to 3, respectively.

First deviation information (A) = present received current (low pressure conversion value (A)) – received current standard value (low pressure conversion value (A))

••• (formula 1)

Second deviation information (A) = transformer current (A) – transformer rating (A)

••• (formula 2)

Third deviation information (A) = main breaker current (A) – main breaker rating (A)

••• (formula 3)

The low pressure conversion value of the first deviation information is a conversion value in a case of, for example, stepping down a three-phase, high-voltage pressure of 6600 V to a single-phase, low-voltage of 200 V. For example, in the case of 1 A at 6600 V, power P is:

$P = \sqrt{3} \times 6600 \times 1 = 11431.5 \text{ W}$. Through the conversion in the case of 200 V, a current I is:

$$I = 11431.5/200 = 57 \text{ A},$$

and therefore the current I is 57 A.

The transformer rating is a rated capacity (a secondary side current) of the transformer 5b.

The transformer current is a current value on the secondary side of the transformer 5b.

[0021]

For determination of the deviation information, the first deviation information to the third deviation information are comprehensively determined. The deviation information is determined as any of positive, zero, and negative. The determination is performed as follows.

<Determination as Positive> The received current exceeds the first setting value that is the received current standard value. The current of the transformer 5b exceeds the

transformer rated value. The current of the main breaker 11 exceeds the rated value of the main breaker 11. In a case where at least any of them is determined as true, determination is made as positive.

As described above, the first setting value is a current value set such that the electric energy of the received power becomes a value smaller than the set maximum demand value by, for example, 10%. The case where the received current exceeds the first setting value is a case where average power in 30 minutes is calculated from the present received power to be expected, and it is determined that there is a possibility of the expected value exceeding 90% of the demand value and approaching the maximum demand value.

<Determination as Zero> The received current is approximately equal to the first setting value (includes a case of a difference by several percent). The current of the transformer 5b is approximately equal to the transformer rated value. The current of the main breaker 11 is approximately equal to the rated value. In a case where any of them is true and all of them do not exceed the setting value or the rated value, determination is made as zero.

<Determination as Negative> The received current does not reach the first setting value. The current of the transformer 5b does not reach the transformer rated value. The current of the main breaker 11 does not reach the rated value. In a case where all of them are met, determination is made as negative.

[0022]

The control differs depending on whether the deviation information thus determined is positive, zero, or negative, when the deviation information has the positive value, the process proceeds to S13, when the deviation information is zero, the control ends, and when the deviation information is negative, the process proceeds to S18.

[0023]

When the deviation information is positive, control to reduce the current is performed. Specifically, the maximum value of the deviation information on the current value in excess is used as a deviation value (S13), and reduction control of the charging current (S14) is performed in the ascending order from the $(n+m)^{\text{th}}$ vehicle 4 that reaches the threshold and has the smallest charge

amount.

It is assumed that the maximum value of the amount of reduction per vehicle 4 is the smaller value of a value obtained by subtracting a predetermined minimum current value from the present current value or the calculated deviation value (S15). For example, when the deviation value is 10 amperes and the value obtained by subtracting the predetermined minimum current value from the present charging current value is 5 amperes, 5 amperes is selected. Then, the control is performed such that the charging current of the $(n+m)^{\text{th}}$ vehicle 4 having the lowest priority order (the large charge amount) in the set priority orders is reduced by 5 amperes. Thus, the vehicle 4 having the smallest charge amount among the vehicles 4 that have reached the threshold becomes a target having the highest priority for the charging current reduction.

[0024]

Then, a current value obtained by subtracting the reduced current value from the deviation value is set as a new deviation value (S16), steps S14 to S17 are repeated until the deviation value becomes zero or the processes are performed on all of the vehicles 4, and the control is performed in the orders set to the vehicles. Thus, the newly set charging current value is notified from the communication unit 35 to the individual charger 2 (S23), and the controls from S11 to S23 are repeated at a predetermined time interval, thus controlling the charging current.

As a result, among the vehicles 4 whose charge amounts have reached the threshold, the charging current is reduced from the vehicle 4 having the smallest charge amount. Accordingly, the charge amount of the vehicle 4 that starts charging later does not exceed the charge amount of the vehicle 4 that has started charging previously, and control can be performed such that a user of a vehicle 4 where a charging period is long is not dissatisfied.

[0025]

When the deviation information is zero, all of the vehicles 4 do not change the charging current, the process returns to S11 as the first step, and the priority orders are allocated again.

[0026]

On the other hand, when the deviation information is negative, control to increase the charging current is performed. Specifically, a minimum value of an absolute value of the deviation

information on the current value that can be increased is used as a margin value (S18), a current value (margin information) that can be increased until reaching the threshold is calculated based on the following formulae 4 to 6.

First margin information = absolute value of first deviation information ... (formula 4)

Second margin information = absolute value of second deviation information ...
(formula 5)

Third margin information = absolute value of third deviation information ... (formula 6)

The margin value becomes the minimum value among the first margin information to the third margin information, and among the vehicles 4 not meeting the threshold, the charging current is increased in the order from the vehicle 4 having the largest charge amount to the vehicle 4 having the small charging amount (S19).

Increase control of the charging current (S20) is performed in the ascending order from the first vehicle 4 that does not reach the threshold and has the largest charge amount to the $(n+m)^{\text{th}}$ vehicle 4.

[0027]

However, it is assumed that the maximum increased amount per vehicle 4 is the smaller value of a value obtained by subtracting the present current value from a predetermined maximum charging current value or the calculated margin value (S20). For example, when the value obtained by subtracting the present current value from the maximum charging current value is 5 amperes and the margin value is 10 amperes, 5 amperes is selected. Then, the control is performed such that the charging current of the first vehicle 4 having the smallest charge amount is increased by 5 amperes.

Thus, the vehicle 4 having the largest charge amount among the vehicles 4 that have not reached the threshold becomes a target having the highest priority for the charging current increase and the current is increased.

[0028]

Then, a current value obtained by subtracting the increased current value from the margin value is set as a new margin value (S21), steps S19 to S22 are repeated until the margin value becomes zero or the processes are performed on all of the vehicles 4, and the control is performed in

the orders set to the vehicles. Thus, the newly set charging current value is notified to the individual charger 2 (S23), thus controlling the charging.

As a result, among the vehicles 4 whose charge amounts fall below the threshold, the charging current is increased from the vehicle 4 having the largest charge amount. Accordingly, the charge amount of the vehicle 4 that starts charging later does not exceed the charge amount of the vehicle 4 that has started charging previously, and control can be performed such that a user of a vehicle 4 where a charging period is long is not dissatisfied.

[0029]

Thus, the current of the received power, the current of the transformer 5b, and the current of the main breaker 11 are monitored to control the charging of the vehicle 4. Accordingly, the demand control is performed while an overload of the transformer 5b is avoided, and efficient vehicle charging without stopping charging can be performed.

[0030]

Next, a second configuration of the vehicle charging system 1 will be described.

FIG. 4 is a block diagram illustrating the second configuration of the vehicle charging system 1, and a description will be given with reference to FIG. 4. Identical reference numerals are given to components common to those in the first configuration and the description thereof will be omitted.

The vehicle charging system 1 includes the plurality of chargers 2, a first control master unit 110, a second control master unit 115, a third control master unit 120, and a control slave unit 130. The first control master unit 110 obtains the current information of the received power from the smart meter 10 that measures the power received from the high-voltage commercial power Q and outputs the first deviation information (difference information). The second control master unit 115 obtains the current information from the current sensor 8 disposed on the secondary side of the transformer 5b and outputs the second deviation information (difference information). The third control master unit 120 obtains the current information of the current flowing the main breaker 11 by the current sensor 9 and outputs the third deviation information (difference information). The control slave unit 130 is installed for each of the chargers 2 and controls the charging current of the

charger 2.

The first deviation information to the third deviation information (the difference information) are information described in the above-described formulae 1 to 3.

[0031]

FIG. 5 illustrates a block diagram of the first control master unit 110. As illustrated in FIG. 5, the first control master unit 110 includes, for example, a first master unit measurement unit 111, a first master unit storage unit 112, a first master unit CPU 113, and a first master unit communication unit 114. The first master unit measurement unit 111 obtains the received current information from the smart meter 10. The first master unit storage unit 112 stores the received current standard value (the first setting value) and the like. The first master unit CPU 113 controls the first control master unit 110. The first master unit communication unit 114 performs wireless communications with the control slave unit 130 and also performs wireless communications with the second control master unit 115 and the third control master unit 120. The first control master unit 110 is coupled to the smart meter 10 via the communication line L2.

[0032]

FIG. 6 illustrates a block diagram of the second control master unit 115. As illustrated in FIG. 6, the second control master unit 115 includes, for example, a second master unit measurement unit 116, a second master unit storage unit 117, a second master unit CPU 118, and a second master unit communication unit 119. The second master unit measurement unit 116 obtains the current information of the transformer 5b from the current sensor 8. The second master unit storage unit 117 stores, for example, a transformer rated current (the second setting value). The second master unit CPU 118 controls the second control master unit 115. The second master unit communication unit 119 performs wireless communications with the control slave unit 130 and also performs wireless communications with the first control master unit 110 and the third control master unit 120.

[0033]

FIG. 7 illustrates a block diagram of the third control master unit 120. As illustrated in FIG. 7, the third control master unit 120 includes, for example, a third master unit measurement unit 121, a third master unit storage unit 122, a third master unit CPU 123, and a third master unit

communication unit 124. The third master unit measurement unit 121 obtains information of a current flowing from the current sensor 9 to the main breaker 11. The third master unit storage unit 122 stores, for example, a rated value (the third setting value) of the main breaker 11. The third master unit CPU 123 controls the third control master unit 120. The third master unit communication unit 124 performs wireless communication with the control slave unit 130 and also performs wireless communications with the first control master unit 110 and the second control master unit 115.

[0034]

FIG. 8 illustrates a block diagram of the control slave unit 130. As illustrated in FIG. 8, the control slave unit 130 is disposed for each of the chargers 2 and includes, for example, the first control master unit 110, the second control master unit 115, a slave unit communication unit 131, a slave unit storage unit 132, a slave unit CPU 133, and a charger control unit 134. The slave unit communication unit 131 performs wireless communications with the third control master unit 120. The slave unit storage unit 132 stores, for example, the threshold of the charge amount and a duration and a standby period described later. The slave unit CPU 133 controls the control slave unit 130. The charger control unit 134 outputs a control signal to the charger 2. The control slave unit 130 is coupled to the charger 2 via a transmission line L3.

The control slave unit 130 and the charger 2 may be integrally formed.

[0035]

The first setting value stored in the first master unit storage unit 112 and the transformer rating stored in the second master unit storage unit 117 are same as the setting values described in the first embodiment. The first setting value is a value set so as to be a value smaller than the maximum demand value by, for example, 10%, and the transformer rating is a value set based on the rated value of the transformer 5b.

[0036]

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

First, the first control master unit 110 obtains the information of the received current from the smart meter 10 and notifies each of the control slave units 130 of the deviation information at a

constant interval, such as a one-second interval. Simultaneously, current information and voltage information of the transformer 5b are obtained from, for example, the current sensor 8 and the deviation information is notified at a constant interval, such as a one-second interval, to each of the control slave units 130.

The deviation information notified to each of the control slave units 130 is similar to the deviation information of the first configuration, and is information (the difference information) formed of the three values, positive, zero, and negative, determined based on the first deviation information to the third deviation information calculated with Formula 1 to Formula 3.

[0037]

The first to third control master units 110, 115, and 120 transmit the information to the control slave units 130 as follows.

FIG. 9 depicts a procedure of transmission control of the first control master unit, FIG. 10 depicts a procedure of transmission control of the second control master unit, and FIG. 11 depicts a procedure of transmission control of the third control master unit. The description will be given with reference to the drawings.

The first control master unit 110 first transmits the calculated first deviation information to the control slave unit 130 (S31). Afterwards, the first control master unit 110 waits for the transmission of the third deviation information from the third control master unit 120. Then, the first control master unit 110 receives the third deviation information from the third control master unit 120 (S32, S33) and recognizes it, and stands by for a certain period of time (S34). Afterwards, next first deviation information is transmitted to the control slave unit 130.

[0038]

The second control master unit 115 waits for the transmission of the first deviation information from the first control master unit 110 to the control slave unit 130, after the transmission, receives (S35, S36) and recognizes it, and further stands by for a certain period of time (S37). Afterwards, the second deviation information is transmitted to the control slave unit 130 (S38).

[0039]

The third control master unit 120 waits for the transmission of the second deviation

information from the second control master unit 115 to the control slave unit 130, after the transmission, receives (S39, S40) and recognizes it, and further stands by for a certain period of time (S41). Afterwards, the third deviation information is transmitted to the control slave unit 130 (S42). [0040]

Thus, since the control slave units 130 wirelessly communicate with the respective control master units 110, 115, and 120, additionally disposing a communication line is unnecessary, and the charger 2 can be increased and decreased easily. In addition, the certain rule is provided for the transmission timing of the information from each of the control master units 110, 115, and 120 to the control slave unit 130 and simultaneous transmission does not occur. Therefore, a malfunction due to a collision of signals to transmit the information to the control slave units 130 does not occur.

[0041]

While the rules are provided for the transmission timings of the control master unit 110, 115, and 120 to avoid the collision of the signals in the embodiment, the control slave units 130 may sequentially obtain the information from the respective control master units 110, 115, and 120 in order.

[0042]

The individual control slave unit 130 that has received the deviation information from each of the control master units 110, 115, and 120 performs the following control.

FIG. 12 is a flowchart depicting a procedure of current control by the slave unit CPU 133 in the control slave unit 130, and the description will be given with reference to the flowchart. The control is performed each time that the deviation information (the first deviation information to the third deviation information) is received.

When the deviation information is received (S50), the deviation information is determined (S51). Similarly to the above-described embodiment, the first deviation information to the third deviation are comprehensively determined and are determined as any of positive, zero, and negative.

After that, the state of the charge amount is determined (S52) and control different depending on the charge amount after the charging starts is performed. When the charge amount does not reach a preset threshold, the process proceeds to S53, and when the charge amount reaches

the preset threshold, the process proceeds to S56.

[0043]

When the charging current does not reach the threshold (proceeds to S53 from S52) and the deviation information is negative (proceeds to S55 from S53), that is, the charging current has a margin, a current amount to be increased is calculated in the following formula (Formula 7), and the calculated current is added to increase the charging current (S55). The maximum value is set to the charging current, and when the charging current has reached the maximum value, the charging current is not increased any further.

Current to be increased = maximum current value (A) × charge amount (Wh)/threshold (Wh) ... (Formula 7)

[0044]

On the other hand, when the deviation information is zero (proceeds to S62 from S53), a signal of not changing the charging current is output to the charger 2 (S62), and the process ends.

When the deviation information is positive (proceeds to S54 from S53), that is, when the current need to be reduced, a current amount to be reduced is calculated by the following formula (Formula 8), and the amount of current to be reduced is reduced from the current value (S54). The minimum value is set to the charging current, and when the charging current has reached the minimum value, the charging current is not reduced any further.

Current to be reduced = maximum current value (A) × (threshold (Wh) – charge amount (Wh))/threshold (Wh)

... (Formula 8)

The new current value thus set is notified to the charger 2 (S62).

[0045]

On the other hand, when the charging proceeds equal to or more than the threshold at the phase of receiving the deviation information (proceeds to S56 from S52), control is performed as follows.

When the deviation information is negative (proceeds to S57 from S56), that is, the charging current has a margin, the duration stored in the slave unit storage unit 132 is read. When

the duration does not reach the set standby period, such as 60 seconds, (NO at S57), the duration is added by one unit (a time interval of receiving the deviation information) (S58) and stored, the signal of not changing the current is output to the charger 2 (S62), and the process ends.

When the duration reaches the standby period (YES at S57), a signal of adding (S59) the minimum current amount to be increased to the present current is output to the charger 2 (S62), and the process ends.

[0046]

By the control, the vehicle 4 whose charging current has reached the threshold sets the standby period and stops the change of the charging current until the period passes. Accordingly, when the vehicle 4 whose charge amount does not reach the threshold is present, the use of the standby period allows promoting the charging by increasing the charging current, and therefore even without a control unit that collectively manages the chargers 2, the current control can be performed in a balanced manner.

[0047]

When the deviation information is approximately zero in S56 (proceeds to S61 from S56), the stored duration is reset (S61) to be zero, the signal of not changing the current is output to the charger 2 (S62), and the process ends.

In a case where the deviation information is positive (proceeds to S60 from S56), that is, the current needs to be reduced, the charging current is zeroed (S60) and also the stored duration is reset to zero (S61). Consequently, the signal of setting the charging current to zero is output to the charger 2, and the process ends.

[0048]

By the control, when the current of the received power exceeds the first setting value or the current of the transformer 5b exceeds the transformer rating, regardless of the standby period, the charging of the vehicle 4 in which the charging proceeds equal to or more than the threshold is stopped, and therefore while simultaneously performing the demand control, the satisfactory state of the transformer 5b can be maintained.

Since the count of the standby period is reset, the sufficient standby period (the duration)

can be set, and the charging of the vehicle 4 whose charge amount does not reach the threshold can be continued during the period, thus ensuring balanced distribution of the charging currents.

[0049]

Thus, since the chargers 2 are controlled individually, even the plurality of chargers 2 are disposed, a function that collectively controls the entire chargers 2 need not be provided. Therefore, it is only necessary to increase and decrease the control slave units 130 according to the increase and decrease of the chargers 2, the change or the like of the first control master unit 110, the second control master unit 115, and further the third control master unit 120 does not occur, the charger 2 can be easily expanded, and the system has scalability.

[0050]

While the second setting value is set based on (the transformer rating) the rated power of the transformer 5b in the embodiment, a value slightly smaller than the rated value, for example, a value smaller by 10% may be set. The way of providing the setting value is similarly performed on the third setting value.

REFERENCE SIGNS LIST

[0051]

- 1... Vehicle charging system
- 2... Charger
- 3... Charge control unit
- 4... Vehicle
- 5b... Transformer(step-down transformer)
- 9... Current sensor
- 10... Smart meter (electric energy meter)
- 11... Main breaker
- 31... Measurement unit
- 31a... First measurement unit
- 31b... Second measurement unit

31c... Third measurement unit
32... Storage unit
34... Charge control unit CPU
35... Communication unit
110... First control master unit (charge control unit)
111... First master unit measurement unit (first measurement unit)
114... First master unit communication unit (wireless communication unit)
115... Second control master unit (charge control unit)
116... Second master unit measurement unit (second measurement unit)
118... Second master unit CPU
120... Third control master unit (charge control unit)
121... Third master unit measurement unit (third measurement unit)
123... Third master unit CPU
130... Control slave unit (charge control unit)
131... Slave unit communication unit (wireless communication unit)

CLAIMS

1. A vehicle charging system comprising:
 - a plurality of chargers that charge vehicles; and
 - a charge control unit that controls a charging current of the charger, wherein the charge control unit includes:
 - a first measurement unit that obtains current value information indicative of a current of received power from an electric energy meter that measures received high-voltage power;
 - a second measurement unit that obtains current value information indicative of a current of a transformer that transforms the received high-voltage power into low-voltage power and supplies the power to the charger; and
 - a third measurement unit that obtains current value information indicative of a current flowing a main breaker of a distribution board that supplies power to the charger, wherein the charge control unit performs control such that the received current value obtained by the first measurement unit does not exceed a predetermined first setting value, the current value obtained by the second measurement unit does not exceed a predetermined second setting value, and the current value obtained by the third measurement unit does not exceed a predetermined third setting value.
2. The vehicle charging system according to claim 1, wherein the charge control unit is formed of:
 - a first control master unit that includes the first measurement unit and outputs difference information of a received current with respect to the first setting value;
 - a second control master unit that includes the second measurement unit and outputs difference information of a transformer current with respect to the second setting value;
 - a third control master unit that includes the third measurement unit and outputs difference information of a main breaker current with respect to the third setting value; and
 - a control slave unit installed for each of the chargers to control the charging

current based on the information output from the first control master unit, the second control master unit, and the third control master unit, and

the first control master unit, the second control master unit, the third control master unit, and control slave unit are separated from one another, wherein

the control slave unit performs control such that the received current value does not exceed the first setting value, the current value of the transformer does not exceed the second setting value, and the current value flowing the main breaker does not exceed the third setting value based on the difference information transmitted from the first control master unit, the second control master unit, and the third control master unit.

3. The vehicle charging system according to claim 2, wherein

the first control master unit, the second control master unit, the third control master unit, and the control slave units wirelessly communicate with one another, and

the control slave units wirelessly obtain the difference information from the first control master unit, the second control master unit, and the third control master unit.

4. The vehicle charging system according to claim 3, wherein

the first control master unit, the second control master unit, and the third control master unit grasp mutual transmissions of the difference information to the control slave units such that each of the first control master unit, the second control master unit, and the third control master unit performs control so as not to cause a collision of the transmission of the individual difference information to the control slave unit.