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United States Patent Application Publication	20250256598
Kind Code	A1
Publication Date	August 14, 2025
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VEHICLE

Abstract

A vehicle includes: a motor; a battery that is connected to the motor through a system main relay; a first unit that is connected to the battery through the system main relay; and a second unit that is disposed adjacent to the first unit on a first side in a vehicle front-rear direction. The first unit includes: an isolation transformer including a primary coil and a secondary coil; a first electric circuit that is connected to the primary coil; and a second electric circuit that is connected to the secondary coil. The first electric circuit is connected to the battery. The first electric circuit is located closer to a second side in the vehicle front-rear direction than the isolation transformer.

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Appl. No.: **19/021454**

Filed: **January 15, 2025**

Foreign Application Priority Data

JP	2024-018871	Feb. 09, 2024

Publication Classification

Int. Cl.: **B60L53/22** (20190101); **B60L3/04** (20060101); **B60L53/16** (20190101)

U.S. Cl.:

CPC **B60L53/22** (20190201); **B60L3/04** (20130101); **B60L53/16** (20190201); B60L2210/30 (20130101); B60L2210/40 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2024-018871 filed on Feb. 9, 2024, incorporated herein by reference in its entirety.

BACKGROUND

1. Technical Field

[0002] The present disclosure relates to a vehicle.

2. Description of Related Art

[0003] Japanese Unexamined Patent Application Publication No. 2022-185687 describes a vehicle including a charging unit. The charging unit is disposed in a front compartment of a vehicle body and incorporates a charger that charges a battery by using an external alternating-current electric power supply.

[0004] A bi-directional charger has been known as a charger that is mounted on a vehicle. The bi-directional charger does not only function as a charger that charges a battery, but also functions as an electric power converter that supplies electric power from the battery to an electric power supply outlet provided to the vehicle. It is usually desired that the electric power supply outlet is usable even while the vehicle is traveling. The bi-directional charger is therefore electrically connected to the battery not only while the battery is being charged, but also while the vehicle is traveling.

[0005] In a case where the vehicle has a collision, another adjacent unit may come into contact with the charging unit that incorporates the bi-directional charger. At this time, a casing of the charging unit can also be damaged. Here, a high voltage from the battery may be applied to the bi-directional charger while the vehicle is traveling. It is thus desirable to reduce the influence on the portion to which the high voltage is applied even if the casing of the charging unit is damaged.

[0006] This is not limited to the charging unit that incorporates the bi-directional charger. The same applies to a unit that is electrically connected to the battery even while the vehicle is traveling.

SUMMARY

[0007] According to an aspect of the present disclosure, a vehicle includes: a vehicle body; wheels that supports the vehicle body; a motor configured to drive at least one of the wheels; a battery that is connected to the motor through a system main relay; a first unit that is connected to the battery through the system main relay; and a second unit that is disposed adjacent to the first unit on a first side in the vehicle front-rear direction. The first unit includes: a casing; an isolation transformer; a first electric circuit; and a second electric circuit. The isolation transformer is disposed in the casing. The isolation transformer includes a primary coil and a secondary coil. The first electric circuit is disposed in the casing. The first electric circuit is electrically connected to the primary coil of the isolation transformer. The first electric circuit is electrically connected to the battery. The second electric circuit is disposed in the casing. The second electric circuit is electrically connected to the secondary coil of the isolation transformer. The first electric circuit is located closer to a second side in the vehicle front-rear direction than the isolation transformer in the casing.

[0008] In the vehicle described above, the system main relay is closed and the motor is electrically connected to the battery when the vehicle travels. When the system main relay is closed, the first unit is also electrically connected to the battery. That is, while the vehicle is traveling, the first unit is also connected to the battery through the system main relay. As a result, a high voltage from the battery is applied to the first electric circuit of the first unit. Meanwhile, the second unit is disposed adjacent to the first unit on the first side in the vehicle front-rear direction. Thus, for example, when the vehicle has a collision, the first unit and the second unit come into contact and the casing of the first unit may be hereby damaged. The first electric circuit is, however, located closer to the second side in the vehicle front-rear direction than the isolation transformer in the casing. That is, the first

electric circuit is disposed at a position apart from the second unit in the casing. Thus, even in a case where the contact between the first unit and the second unit damages the casing of the first unit, the first electric circuit to which the high voltage from the battery is applied is prevented or restrained from being exposed to the outside of the casing.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] 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:

[0010] FIG. **1** is a diagram schematically illustrating a configuration of a vehicle;

[0011] FIG. **2** is a plan view schematically illustrating an internal configuration of a major part of the vehicle;

[0012] FIG. **3** is a block diagram illustrating the configuration of the vehicle;

[0013] FIG. **4** is a sectional view schematically illustrating an internal configuration of a charging unit; and

[0014] FIG. **5** illustrates an electric circuit diagram of the charging unit.

DETAILED DESCRIPTION OF EMBODIMENTS

[0015] A vehicle includes: a vehicle body; a plurality of wheels that supports the vehicle body; a motor configured to drive at least one of the wheels; a battery that is connected to the motor through a system main relay; a first unit that is connected to the battery through the system main relay; and a second unit that is disposed adjacent to the first unit on a first side (e.g., rear side) in the vehicle front-rear direction. The first unit includes: a casing; an isolation transformer; a first electric circuit; and a second electric circuit. The isolation transformer is disposed in the casing. The isolation transformer includes a primary coil and a secondary coil. The first electric circuit is disposed in the casing. The first electric circuit is electrically connected to the primary coil of the isolation transformer. The first electric circuit is electrically connected to the battery. The second electric circuit is disposed in the casing. The second electric circuit is electrically connected to the secondary coil of the isolation transformer. The first electric circuit is located closer to a second side (e.g., front side) in the vehicle front-rear direction than the isolation transformer in the casing.

[0016] The vehicle may further include an electric power supply outlet configured to cause an electric device to be attached and detached to and from the electric power supply outlet. The electric power supply outlet is electrically connected to the second electric circuit of the first unit. In the case, the isolation transformer, the first electric circuit, and the second electric circuit in the first unit may be included in an electric power converter configured to convert direct-current electric power supplied from the battery to alternating-current electric power that is supplied to the electric power supply outlet. According to such a configuration, the first unit is electrically connected to the battery and it is possible for the first unit to supply electric power from the battery to the electric power supply outlet while the vehicle is traveling.

[0017] The first electric circuit may include a first electric power conversion circuit configured to convert the direct-current electric power supplied from the battery to high-frequency alternating-current electric power that is input to the isolation transformer. In the case, the second electric circuit may include: a second electric power conversion circuit configured to convert the high-frequency alternating-current electric power output from the isolation transformer to direct-current electric power; and a third electric power conversion circuit configured to convert the direct-current electric power output from the second electric power conversion circuit to the alternating-current electric power that is supplied to the electric power supply outlet.

[0018] The vehicle may further include a charging inlet configured to cause an external alternating-

current electric power supply to be attached and detached to and from the charging inlet. The charging inlet is electrically connected to the second electric circuit of the first unit. The isolation transformer, the first electric circuit, and the second electric circuit in the first unit may be included in a bi-directional charger configured to convert alternating-current electric power supplied from the external alternating-current electric power supply to direct-current electric power with which the battery is charged.

[0019] The third electric power conversion circuit of the second electric circuit may be configured to convert the alternating-current electric power supplied from the external alternating-current electric power supply to direct-current electric power. The second electric power conversion circuit of the second electric circuit may be configured to convert the direct-current electric power output from the third electric power conversion circuit to high-frequency alternating-current electric power that is input to the isolation transformer. The first electric power conversion circuit of the first electric circuit may be configured to convert the high-frequency alternating-current electric power output from the isolation transformer to the direct-current electric power with which the battery is charged.

[0020] The second unit may include a housing made of metal. The housing made of metal has relatively high rigidity. The presence of the housing having high rigidity in the second unit increases the possibility that the casing of the first unit is damaged when the first unit and the second unit come into contact. Adopting the present technology, however, prevents or restrains the first electric circuit to which a high voltage from the battery is applied from being exposed to the outside of the casing. It is to be noted that the metal included in the second unit may be an aluminum-based metal or a steel-based metal that is, however, merely an example.

[0021] The second unit may include a hydraulic device including a brake master cylinder. In the case, the housing may be a part of the hydraulic device. The housing of the hydraulic device of a brake system is required to have high rigidity. Thus, when the first unit and the second unit come into contact, the possibility further increases that the casing of the first unit is damaged. Adopting the present technology, however, prevents or restrains the first electric circuit to which a high voltage from the battery is applied from being exposed to the outside of the casing.

[0022] The second unit may be disposed to be offset to a first side (e.g., left side) in the vehicle left-right direction with respect to the first unit. In the case, the side surface of the housing on a second side (e.g., right side) in the vehicle left-right direction may be provided with a recess in the area close to the first unit. According to such a configuration, it is possible to increase the interval between the first unit and the second unit. The first unit and the second unit are thus prevented or restrained from coming into contact and damage to the casing of the first unit due to the contact is prevented or restrained.

[0023] The vehicle body may include a cabin and a front compartment that is located in the front direction of the cabin. In the case, the first unit and the second unit may be disposed in the front compartment.

[0024] The vehicle may further include a power controller that controls supply electric power between the battery and the motor. In the case, the first unit and the second unit may be disposed above the power controller.

[0025] The vehicle may further include an engine that is disposed in a front compartment. The vehicle may be a plug-in hybrid electric vehicle (PHEV). When the engine is present further in the front compartment, the front compartment has limited redundant space. The first unit and the second unit may be disposed closer to each other. Thus, the first unit and the second unit come into contact and the possibility further increases that the casing of the first unit is damaged. Adopting the present technology, however, prevents or restrains the first electric circuit to which a high voltage from the battery is applied from being exposed to the outside of the casing.

[0026] The casing of the first unit may include a first connector port, a second connector port, and a third connector port. In the case, the first connector port may be configured to cause a first

connector of a first cable to be attached and detached to and from the first connector port. The first cable is electrically connected to the battery. The second connector port may be configured to cause a second connector of a second cable to be attached and detached to and from the second connector port. The second cable is electrically connected to an electric power supply outlet. The third connector port may be configured to cause a third connector of a third cable to be attached and detached to and from the third connector port. The third cable is electrically connected to a charging inlet. The first connector port may be then located closer to the second side in the vehicle front-rear direction than the second connector port and the third connector port. According to such a configuration, it is possible to prevent or restrain the first connector electrically connected to the battery from being damaged by the second unit when the vehicle has a collision.

[0027] The first electric circuit may be located closer to the second side (e.g., front side) in the vehicle front-rear direction than the central position of the first unit in the vehicle front-rear direction. According to such a configuration, the first electric circuit is disposed at a position farther from the second unit in the casing.

[0028] The first side in the vehicle front-rear direction may be the rear side in the vehicle front-rear direction. The second side in the vehicle front-rear direction may be the front side in the vehicle front-rear direction.

[0029] Typical and non-limiting specific examples of the present disclosure will be described in detail below with reference to the drawings. The detailed description of the typical and non-limiting specific examples of the present disclosure simply intends to show details for carrying out the examples of the present disclosure to those skilled in the art and does not intend to limit the scope of the present disclosure. In addition, it is possible to use the additional features disclosed below and the disclosure separately from or along with other features and the disclosure to provide a further improved vehicle.

[0030] In addition, a combination of features and steps disclosed in the following detailed description is not required to carry out the present disclosure in the widest terms. The combination is demonstrated only to describe a typical specific example of the present disclosure in particular. Furthermore, the various features of the typical specific examples described above and below and the various features of what are described in the independent and dependent claims do not have to be combined in accordance with the specific examples described herein or in the order of a list to provide an additional and useful embodiment of the present disclosure.

[0031] All the features described in the present specification and/or the claims intend to be disclosed individually and independently as limiting the disclosure as originally filed and the claimed specifying matters separately from the configurations of the features described in the embodiment and/or the claims. Furthermore, all the descriptions regarding the numerical ranges and the groups or the sets intend to disclose, as limiting the disclosure as originally filed and the claimed specifying matters, the intermediate configurations.

[0032] A vehicle **10** according to an embodiment will be described with reference to the drawings. The vehicle **10** according to the present embodiment is a plug-in hybrid electric vehicle (PHEV). The vehicle **10** is not, however, limited to a plug-in hybrid electric vehicle. The vehicle **10** may be another type of electrified vehicle such as a battery electric vehicle (BEV) or a hybrid electric vehicle (HEV).

[0033] Here, a direction FR in the drawings refers to the front direction of the vehicle front-rear direction and a direction RR refers to the rear direction of the vehicle front-rear direction. In addition, a direction LH refers to the left direction of the vehicle left-right direction (or the width direction) and a direction RH refers to the right direction of the vehicle left-right direction. A direction UP then refers to the up direction of the vehicle-height direction and a direction DW refers to the down direction of the vehicle-height direction. In the present specification, the front side in the vehicle front-rear direction, the rear side in the vehicle front-rear direction, the left side in the vehicle left-right direction, the right side in the vehicle left-right direction, the up side in the

vehicle-height direction, and the down side in the vehicle-height direction are sometimes referred to simply as the front side, the rear side, the left side, the right side, the up side, and the down side, respectively.

[0034] As illustrated in FIG. **1** to FIG. **3**, the vehicle **10** includes a vehicle body **12** and a plurality of wheels **14***f*, **14***r*. The vehicle body **12** includes, for example, metal such as a steel-based material or an aluminum-based material. The wheels **14***f*, **14***r* support the vehicle body **12**. The wheels **14***f*, **14***r* include the pair of front wheels **14***f* located at the front of the vehicle body **12** and the pair of rear wheels **14***r* located at the rear of the vehicle body **12**. The pair of respective front wheels **14***f* is located at the left and right of the vehicle body **12**. The pair of respective rear wheels **14***r* is located at the left and right of the vehicle body **12**.

[0035] A cabin **12***c* and a front compartment **12***f* located in the front direction of the cabin **12***c* are defined inside the vehicle body **12**. The cabin **12***c* is configured to allow a user to get in the cabin **12***c*. The vehicle body **12** includes a floor panel **12***b* and a dash panel **12***d*. The floor panel **12***b* defines the floor of the cabin **12***c*. The dash panel **12***d* is interposed between the cabin **12***c* and the front compartment **12***f*.

[0036] The vehicle **10** includes a battery **16**, an engine **18**, a motor unit **20**, a power control unit (PCU) **22**, a charging unit **24**, a brake unit **42**, a charging inlet **40**, an electric power supply outlet **38**, and a system main relay **48**.

[0037] The battery **16** is disposed below the floor panel **12***b*. The battery **16** includes one or more secondary battery cells and is configured to be chargeable and dischargeable. The secondary battery cells are not limited in particular. Each of the secondary battery cells may be, for example, a lithium ion battery cell or a fully solid-state battery cell.

[0038] The engine **18** is disposed in the front compartment **12***f*. The engine **18** is a heat engine that burns fuel to generate motive power and is not limited in particular. The engine **18** includes a gasoline engine, a diesel engine, a hydrogen engine, and the like. The engine **18** is connected to the pair of front wheels **14***f* through a reducer **19** and an unillustrated power split device. The engine **18** drives the pair of front wheels **14***f*.

[0039] The motor unit **20** is disposed in the front compartment **12***f*. The motor unit **20** is connected to the battery **16** through the PCU **22**. The motor unit **20** is connected to the pair of front wheels **14***f* through the reducer **19**. The motor unit **20** includes a traction motor that uses electric power supplied from the battery **16** to drive the pair of front wheels **14***f*. The pair of front wheels **14***f* is not, however, limitative. It is sufficient if the motor unit **20** drives at least one of the wheels **14***f*, **14***r*.

[0040] The PCU **22** is disposed in the front compartment **12***f*. The PCU **22** is connected to the battery **16** through the system main relay **48**. The PCU **22** is electrically connected to both the battery **16** and the motor unit **20**. The PCU **22** includes an inverter, a converter, and the like. The PCU **22** controls supply electric power between the battery **16** and the motor unit **20**. For example, in a case where the vehicle **10** accelerates, the PCU **22** controls driving electric power that is supplied from the battery **16** to the motor unit **20**. Alternatively, in a case where the vehicle **10** decelerates, the PCU **22** controls regenerated electric power that is supplied from the motor unit **20** to the battery **16**. It is to be noted that the PCU **22** is disposed between the motor unit **20** and the charging unit **24**. The PCU **22** is disposed on the motor unit **20** and integrated into the motor unit **20**.

[0041] The charging inlet **40** is configured to allow an external alternating-current electric power supply **2** to be attached and detached to and from the charging inlet **40**. The external alternating-current electric power supply **2** is, for example, a commercial electric power supply for home use. The charging inlet **40** receives, from the external alternating-current electric power supply **2**, charging electric power with which the battery **16** is charged. The charging inlet **40** according to the present embodiment is connected to the external alternating-current electric power supply **2** through a cable. As another embodiment, the charging inlet **40** may be, however, wirelessly

connected to the external alternating-current electric power supply **2**.

[0042] The electric power supply outlet **38** is disposed in the cabin **12***c*. The electric power supply outlet **38** is configured to allow an electric device to be attached and detached to and from the electric power supply outlet **38**. The electric power supply outlet **38** outputs alternating-current electric power to the electric device. The electric device here includes, for example, a home appliance, a personal computer, a smartphone, a tablet terminal, and the like.

[0043] The charging unit **24** is disposed in the front compartment **12***f*. If described in detail, the charging unit **24** is disposed on the PCU **22** located in the up direction of the motor unit **20**. For example, the charging unit **24** may be placed in contact with the upper surface of the PCU **22**. The charging unit **24** is electrically connected to the battery **16** through a first cable **17** and the system main relay **48**. The first cable **17** includes a first connector **17***a*. The first connector **17***a* is configured to be attachable and detachable to and from the charging unit **24**. The charging unit **24** is electrically connected to the electric power supply outlet **38** through a second cable **39**. The second cable **39** includes a second connector **39***a*. The second connector **39***a* is configured to be attachable and detachable to and from the charging unit **24**. The charging unit **24** is connected to the charging inlet **40** through a third cable **41**. The third cable **41** includes a third connector **41***a*. The third connector **41***a* is configured to be attachable and detachable to and from the charging unit **24**.

[0044] The charging unit **24** includes a casing **26** and a bi-directional charger **28** that is accommodated in the casing **26**. The casing **26** includes metal. The metal included in the casing **26** may be, for example, an aluminum-based metal or a steel-based metal. The bi-directional charger **28** is a type of electric power converter. The bi-directional charger **28** is capable of converting alternating-current electric power supplied from the external alternating-current electric power supply **2** to direct-current electric power with which the battery **16** is charged. In addition, the bi-directional charger **28** is capable of converting direct-current electric power supplied from the battery **16** to alternating-current electric power that is supplied to the electric power supply outlet **38**. Although described in detail later, the charging unit **24** is electrically connected to the battery **16** not only while the vehicle **10** is being charged, but also while the vehicle **10** is traveling. This allows the bi-directional charger **28** to supply electric power from the battery **16** to the electric power supply outlet **38** even while the vehicle **10** is traveling.

[0045] The casing **26** includes a first connector port **26***a*, a second connector port **26***b*, and a third connector port **26***c*. The first connector port **26***a* is configured to allow the first connector **17***a* of the first cable **17** to be attached and detached to and from the first connector port **26***a*. The first connector port **26***a* is electrically connected to the battery **16** through the first cable **17**. The second connector port **26***b* is configured to allow the second connector **39***a* of the second cable **39** to be attached and detached to and from the second connector port **26***b*. The second connector port **26***b* is electrically connected to the electric power supply outlet **38** through the second cable **39**. The third connector port **26***c* is configured to allow the third connector **41***a* of the third cable **41** to be attached and detached to and from the third connector port **26***c*. The third connector port **26***c* is electrically connected to the charging inlet **40** through the third cable **41**. The first connector port **26***a*, the second connector port **26***b*, and the third connector port **26***c* are disposed on the upper surface of the casing **26**. The first connector port **26***a* is located closer to the front side than the second connector port **26***b* and the third connector port **26***c*.

[0046] An internal structure of the charging unit **24** will be described with reference to FIG. **4** and FIG. **5**. As described above, the charging unit **24** accommodates the bi-directional charger **28** inside the casing **26**. The bi-directional charger **28** includes an isolation transformer **30**, a first electric circuit **32**, and a second electric circuit **34**. The isolation transformer **30** is provided between the first electric circuit **32** and the second electric circuit **34** and electrically isolates the first electric circuit **32** and the second electric circuit **34**. The isolation transformer **30** includes a primary coil **30***a*, a secondary coil **30***b*, and a core **30***c*. The core **30***c* includes a magnetic material. The primary

coil **30***a* and the secondary coil **30***b* are wound around the core **30***c*. The primary coil **30***a* and the secondary coil **30***b* are electrically isolated from each other and magnetically connected to each other through the core **30***c*.

[0047] The first electric circuit **32** is electrically connected to the primary coil **30***a*. In addition, the first electric circuit **32** is electrically connected to the first connector port **26***a*. That is, the first electric circuit **32** is interposed between the first connector port **26***a* and the primary coil **30***a* of the isolation transformer **30** and electrically connected to the battery **16** through the first cable **17**. The first electric circuit **32** includes a first electric power conversion circuit **32***a*. The first electric power conversion circuit **32***a* includes a plurality of switching elements **32***a***1**. Freewheeling diodes are connected in parallel to the respective switching elements **32***a***1**.

[0048] The second electric circuit **34** is electrically connected to the secondary coil **30***b*. In addition, the second electric circuit **34** is electrically connected to the second connector port **26***b* and the third connector port **26***c*. That is, the second electric circuit **34** is interposed between the second connector port **26***b* and the secondary coil **30***b* of the isolation transformer **30** and electrically connected to the electric power supply outlet **38** through the second cable **39**. In addition, the second electric circuit **34** is interposed between the third connector port **26***c* and the secondary coil **30***b* of the isolation transformer **30** and electrically connected to the charging inlet **40** through the third cable **41**.

[0049] The second electric circuit **34** includes a second electric power conversion

[0050] circuit **34***a*, a third electric power conversion circuit **34***b*, and a filter circuit **34***f*. The second electric power conversion circuit **34***a* is electrically connected to the secondary coil **30***b*. The third electric power conversion circuit **34***b* is electrically connected to the second electric power conversion circuit **34***a*. The third electric power conversion circuit **34***b* is electrically connected to the second connector port **26***b* and the third connector port **26***c* (i.e., the electric power supply outlet **38** and the charging inlet **40**) through the filter circuit **34***f*. As with the first electric power conversion circuit **32***a*, the second electric power conversion circuit **34***a* includes a plurality of switching elements **34***a***1** and the third electric power conversion circuit **34***b* includes a plurality of switching elements **34***b***1**.

[0051] As described above, the bi-directional charger **28** is capable of converting direct-current electric power supplied from the battery **16** to alternating-current electric power that is supplied to the electric power supply outlet **38** (see a leftward arrow in FIG. **5**). In the case, the first electric power conversion circuit **32***a* converts the direct-current electric power supplied from the battery **16** to high-frequency alternating-current electric power that is input to the primary coil **30***a* of the isolation transformer **30**. When the high-frequency electric power is input to the primary coil **30***a*, the isolation transformer **30** outputs high-frequency electric power from the secondary coil **30***b*. The second electric power conversion circuit **34***a* then converts the high-frequency alternating-current electric power output from the isolation transformer **30** to direct-current electric power. The third electric power conversion circuit **34***b* then converts the direct-current electric power output from the second electric power conversion circuit **34***a* to alternating-current electric power that is supplied to the electric power supply outlet **38**.

[0052] In addition, the bi-directional charger **28** is capable of converting alternating-current electric power supplied from the external alternating-current electric power supply **2** to direct-current electric power with which the battery **16** is charged (see a rightward arrow in FIG. **5**). In the case, the third electric power conversion circuit **34***b* converts the alternating-current electric power supplied from the external alternating-current electric power supply **2** to direct-current electric power. The second electric power conversion circuit **34***a* then converts the direct-current electric power output from the third electric power conversion circuit **34***b* to high-frequency alternating-current electric power that is input to the secondary coil **30***b* of the isolation transformer **30**. When the high-frequency electric power is input to the secondary coil **30***b*, the isolation transformer **30** outputs high-frequency electric power from the primary coil **30***a*. The first electric power

conversion circuit **32***a* then converts the high-frequency alternating-current electric power output from the isolation transformer **30** to direct-current electric power with which the battery **16** is charged.

[0053] The brake unit **42** is disposed in the front compartment **12***f*. The brake unit **42** is disposed adjacent to the charging unit **24** on the rear side. The brake unit **42** is disposed to be offset to the left side with respect to the charging unit **24**. The brake unit **42** includes a hydraulic device **44** including a brake master cylinder and the like. The hydraulic device **44** is mechanically connected to a brake pedal (not illustrated). The hydraulic device **44** generates high pressure in hydraulic oil in the hydraulic device **44** in response to an operation performed on the brake pedal. The hydraulic device **44** includes a housing **46**. The housing **46** holds the hydraulic oil in a liquid-tight manner. The high pressure of the hydraulic oil acts on the housing **46** and the housing **46** thus has relatively high rigidity. Although not limited in particular, the housing **46** according to the present embodiment includes metal. The metal included in the housing **46** is, for example, an aluminum-based metal. In a modification example, the metal included in the housing **46** may be a steel-based metal. The side surface of the housing **46** on the right side is provided with a recess **46***r* in the area close to the charging unit **24**. As with the housing **46**, the side surface of the casing **26** on the left side is provided with a recess **26***r* in the area close to the brake unit **42**.

[0054] In the vehicle **10** according to the present embodiment, the system main relay **48** is closed and the motor unit **20** is electrically connected to the battery **16** when the vehicle **10** travels. When the system main relay **48** is closed, the charging unit **24** is also electrically connected to the battery **16**. That is, while the vehicle **10** is traveling, the charging unit **24** is also connected to the battery **16** through the system main relay **48**. As a result, a high voltage from the battery **16** is applied to the first electric circuit **32** of the charging unit **24**. Meanwhile, the brake unit **42** is disposed adjacent to the charging unit **24** on the rear side. Thus, for example, when the vehicle **10** has a collision, the charging unit **24** and the brake unit **42** come into contact and the casing **26** of the charging unit **24** may be hereby damaged.

[0055] In this regard, as illustrated in FIG. **4**, in the charging unit **24** according to the present embodiment, the first electric circuit **32** is located closer to the front side than the isolation transformer **30** in the casing **26**. That is, the first electric circuit **32** is disposed at a position apart from the brake unit **42** in the casing **26**. Thus, even in a case where the contact between the charging unit **24** and the brake unit **42** damages the casing **26** of the charging unit **24**, the first electric circuit **32** to which the high voltage from the battery **16** is applied is prevented or restrained from being exposed to the outside of the casing **26**.

[0056] It is to be noted that the second electric circuit **34** may be possibly exposed to the outside when the casing **26** of the charging unit **24** is damaged. The second electric circuit **34** is, however, isolated from the first electric circuit **32** by the isolation transformer **30**. That is, the second electric circuit **34** is isolated from the battery **16** by the isolation transformer **30**. The electric circuit electrically connected to the battery **16** is thus prevented from being exposed to the outside of the casing **26** even if the second electric circuit **34** is exposed to the outside of the casing **26**.

[0057] The brake unit **42** according to the present embodiment includes the housing **46** including metal and has relative high rigidity. The presence of the housing **46** having high rigidity in the brake unit **42** increases the possibility that the casing **26** of the charging unit **24** is damaged when the charging unit **24** and the brake unit **42** come into contact. Adopting the present technology, however, prevents or restrains the first electric circuit **32** to which a high voltage from the battery **16** is applied from being exposed to the outside of the casing **26**.

[0058] The brake unit **42** according to the present embodiment includes the hydraulic device **44** of the brake system. The housing **46** of the hydraulic device **44** is required to have high rigidity. Thus, if the brake unit **42** includes the housing **46** or another member having high rigidity, the possibility further increases that the casing **26** of the charging unit **24** is damaged when the brake unit **42** and the charging unit **24** come into contact. Adopting the present technology, however, prevents or

restrains the first electric circuit **32** to which a high voltage from the battery **16** is applied from being exposed to the outside of the casing **26**.

[0059] The brake unit **42** according to the present embodiment is disposed to be offset to the left side with respect to the charging unit **24**. Accordingly, the side surface of the housing **46** of the brake unit **42** on the right side is provided with the recess **46***r* in the area close to the charging unit **24**. According to such a configuration, it is possible to increase the interval between the charging unit **24** and the brake unit **42**. The charging unit **24** and the brake unit **42** are thus prevented or restrained from coming into contact and damage to the casing **26** of the charging unit **24** due to the contact is prevented or restrained. It is to be noted that, although not limited in particular, the charging unit **24** according to the present embodiment is provided with the recess **26***r* on the side surface of the casing **26** of the charging unit **24** on the left side in the area close to the brake unit **42**. According to such a configuration, it is possible to further increase the interval between the charging unit **24** and the brake unit **42**.

[0060] The vehicle **10** according to the present embodiment is a plug-in hybrid electric vehicle and includes the engine **18** that is disposed in the front compartment **12***f*. The engine **18** is further present in the front compartment **12***f* to limit the redundant space of the front compartment **12***f*. The charging unit **24** and the brake unit **42** may be thus disposed closer to each other. In the case, the charging unit **24** and the brake unit **42** come into contact and the possibility further increases that the casing **26** of the charging unit **24** is damaged. Adopting the present technology, however, restrains the first electric circuit **32** to which a high voltage from the battery **16** is applied from being exposed to the outside of the casing **26**. It is to be noted that the present embodiment uses a collision degree that causes the first electric circuit **32** to be exposed to the outside from the casing **26** as an example, but the collision degree is not limited to the example. According to the present technology, it is possible to reduce the influence of a collision on the first electric circuit **32** regardless of the collision degree of the vehicle **10**.

[0061] In the casing **26** of the charging unit **24** according to the present embodiment, the first connector port **26***a* is located closer to the front side than the second connector port **26***b* and the third connector port **26***c*. According to such a configuration, the first connector **17***a* is disposed at a position relatively apart from the brake unit **42** in the casing **26**. This makes it possible to restrain the first connector **17***a* electrically connected to the battery **16** from being damaged by the brake unit **42** when the vehicle **10** has a collision.

Correspondence

[0062] The charging unit **24** is an example of the “first unit” according to the present technology. It is sufficient if the “first unit” is a unit that incorporates an isolation transformer and is electrically connected to the battery **16** even while the vehicle **10** is traveling. The brake unit **42** is an example of the “second unit” according to the present technology. The rear side in the vehicle front-rear direction is an example of the “first side in the vehicle front-rear direction” according to the present technology and the front side in the vehicle front-rear direction is an example of the “second side in the vehicle front-rear direction” according to the present technology. The left side in the vehicle left-right direction is an example of the “first side in the vehicle left-right direction” according to the present technology and the right side in the vehicle left-right direction is an example of the “second side in the vehicle left-right direction” according to the present technology.

Claims

1. A vehicle comprising: a vehicle body; wheels that supports the vehicle body; a motor configured to drive at least one of the wheels; a battery that is connected to the motor through a system main relay; a first unit that is connected to the battery through the system main relay; and a second unit that is disposed adjacent to the first unit on a first side in a vehicle front-rear direction, wherein: the first unit includes: a casing; an isolation transformer that is disposed in the casing, the isolation

transformer including a primary coil and a secondary coil; a first electric circuit that is disposed in the casing, the first electric circuit being electrically connected to the primary coil of the isolation transformer, the first electric circuit being electrically connected to the battery; and a second electric circuit that is disposed in the casing, the second electric circuit being electrically connected to the secondary coil of the isolation transformer; and the first electric circuit is located closer to a second side in the vehicle front-rear direction than the isolation transformer in the casing.

2. The vehicle according to claim 1, further comprising an electric power supply outlet configured to cause an electric device to be attached and detached to and from the electric power supply outlet, the electric power supply outlet being electrically connected to the second electric circuit of the first unit, wherein the isolation transformer, the first electric circuit, and the second electric circuit in the first unit are included in an electric power converter configured to convert direct-current electric power supplied from the battery to alternating-current electric power that is supplied to the electric power supply outlet.

3. The vehicle according to claim 2, wherein: the first electric circuit includes a first electric power conversion circuit configured to convert the direct-current electric power supplied from the battery to high-frequency alternating-current electric power that is input to the isolation transformer; and the second electric circuit includes: a second electric power conversion circuit configured to convert the high-frequency alternating-current electric power output from the isolation transformer to direct-current electric power; and a third electric power conversion circuit configured to convert the direct-current electric power output from the second electric power conversion circuit to the alternating-current electric power that is supplied to the electric power supply outlet.

4. The vehicle according to claim 3, further comprising a charging inlet configured to cause an external alternating-current electric power supply to be attached and detached to and from the charging inlet, the charging inlet being electrically connected to the second electric circuit of the first unit, wherein the isolation transformer, the first electric circuit, and the second electric circuit in the first unit are included in a bi-directional charger configured to convert alternating-current electric power supplied from the external alternating-current electric power supply to direct-current electric power with which the battery is charged.

5. The vehicle according to claim 4, wherein: the third electric power conversion circuit of the second electric circuit is configured to convert the alternating-current electric power supplied from the external alternating-current electric power supply to direct-current electric power; the second electric power conversion circuit of the second electric circuit is configured to convert the direct-current electric power output from the third electric power conversion circuit to high-frequency alternating-current electric power that is input to the isolation transformer; and the first electric power conversion circuit of the first electric circuit is configured to convert the high-frequency alternating-current electric power output from the isolation transformer to the direct-current electric power with which the battery is charged.

6. The vehicle according to claim 5, wherein the second unit includes a housing made of metal.

7. The vehicle according to claim 6, wherein: the second unit includes a hydraulic device including a brake master cylinder; and the housing is a part of the hydraulic device.

8. The vehicle according to claim 7, wherein: the second unit is disposed to be offset to a first side in a vehicle left-right direction with respect to the first unit; and a side surface of the housing on a second side in the vehicle left-right direction is provided with a recess in an area close to the first unit.

9. The vehicle according to claim 1, wherein: the vehicle body includes a cabin and a front compartment that is located in a front direction of the cabin; and the first unit and the second unit are disposed in the front compartment.

10. The vehicle according to claim 9, further comprising a power controller that controls supply electric power between the battery and the motor, wherein the first unit and the second unit are disposed above the power controller.

11. The vehicle according to claim 9, further comprising an engine that is disposed in the front compartment, wherein the vehicle is a plug-in hybrid electric vehicle.

12. The vehicle according to claim 1, wherein: the casing of the first unit includes a first connector port, a second connector port, and a third connector port; the first connector port is configured to cause a first connector of a first cable to be attached and detached to and from the first connector port, the first cable being electrically connected to the battery; the second connector port is configured to cause a second connector of a second cable to be attached and detached to and from the second connector port, the second cable being electrically connected to an electric power supply outlet; the third connector port is configured to cause a third connector of a third cable to be attached and detached to and from the third connector port, the third cable being electrically connected to a charging inlet; and the first connector port is located closer to the second side in the vehicle front-rear direction than the second connector port and the third connector port.

13. The vehicle according to claim 1, wherein the first electric circuit is located closer to the second side in the vehicle front-rear direction than a central position of the first unit in the vehicle front-rear direction.

14. The vehicle according to claim 1, wherein: the first side in the vehicle front-rear direction is a rear side in the vehicle front-rear direction; and the second side in the vehicle front-rear direction is a front side in the vehicle front-rear direction.

15. The vehicle according to claim 1, wherein the second unit includes a housing made of metal.

16. The vehicle according to claim 15, wherein: the second unit includes a hydraulic device including a brake master cylinder; and the housing is a part of the hydraulic device.

17. The vehicle according to claim 16, wherein: the second unit is disposed to be offset to a first side in a vehicle left-right direction with respect to the first unit; and a side surface of the housing on a second side in the vehicle left-right direction is provided with a recess in an area close to the first unit.