United States Patent Application Publication	20250256667
Kind Code	A1
Publication Date	August 14, 2025
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CONTROL DEVICE

Abstract

A control device for controlling a power supply system including a DC-to-DC converter that supplies power of a power supply source to a load, an alternator that is connected in parallel with DC-to-DC converter so as to be capable of supplying power generated by rotation of the engine to the load, and a battery that is connected to the load so as to be capable of supplying power, the control device comprising: an acquisition unit that acquires information regarding a current of the battery; and a control unit that controls an operation of the engine and the alternator based on the information, wherein the control unit prohibits stopping of the engine in operation when the battery is in a discharging state for outputting a current to the load.

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Appl. No.: **18/959644**

Filed: **November 26, 2024**

Foreign Application Priority Data

JP	2024-018794	Feb. 09, 2024

Publication Classification

Int. Cl.: **B60R16/033** (20060101); **H02J7/00** (20060101)

U.S. Cl.:

CPC **B60R16/033** (20130101); **H02J7/0063** (20130101); H02J2207/20 (20200101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION
[0001] This application claims priority to Japanese Patent Application No. 2024-018794 filed on Feb. 9, 2024, incorporated herein by reference in its entirety.
BACKGROUND
1. Technical Field
[0002] The present disclosure relates to control devices for vehicles that control output power of a power supply system.
2. Description of Related Art
[0003] Japanese Unexamined Patent Application Publication No. 2005-020854 (JP 2005-020854 A) discloses a control device that stops an engine (for idle reduction) when a predetermined automatic stop condition based on the engine coolant temperature and the vehicle speed is satisfied in a hybrid electric vehicle.
SUMMARY
[0004] The control device described in JP 2005-020854 A determines whether the engine can be stopped based on the engine coolant temperature and the vehicle speed. Therefore, for example, even in a situation where the demand for electric power by a load mounted on the vehicle increases and electric power needs to be supplied not only from a battery but also from an alternator that generates electric power by rotation of the engine, the engine may be stopped if the automatic stop condition is satisfied. In this situation, it is possible to perform control such as restarting the stopped engine in order to supply electric power. However, it is desirable to avoid such an engine operation (restarting the engine immediately after stopping it) because it is wasteful.
[0005] The present disclosure was made in view of the above issue, and an object of the present disclosure is to provide a control device that can avoid an engine being stopped when an alternator needs to generate electric power to supply electric power to an in-vehicle load.
[0006] In order to solve the above issue, an aspect of the technique of the present disclosure is a control device that controls a power supply system.
[0007] The power supply system includes a direct current-to-direct current (DC-to-DC) converter that supplies electric power of a power supply source to a load, an alternator connected in parallel with the DC-to-DC converter in such a manner that the alternator is able to supply electric power generated by rotation of an engine to the load, and a battery connected to the load in such a manner that the battery is able to supply electric power to the load. The control device includes: [0008] an acquisition unit that acquires information on a current of the battery; and [0009] a control unit that controls an operation of the engine and an operation of the alternator based on the information.
[0010] When the battery is in a discharging state in which the battery outputs a current to the load, the control unit prohibits the engine that is running from being stopped.
[0011] According to the control device of the present disclosure, when the alternator also needs to supply electric power, such as when power supply from the DC-to-DC converter is not enough and the battery needs to be discharged to supply electric power to the load, the engine is prohibited from being stopped. This can avoid the engine being stopped when the alternator needs to generate electric power, and can eliminate wasteful stopping and restarting of the engine.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0012] Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which

like signs denote like elements, and wherein:
[0013] FIG. **1** is a block diagram of a control device and a peripheral portion thereof according to an embodiment of the present disclosure;
[0014] FIG. **2**A is a process flowchart of power control executed by a control device; and
[0015] FIG. **2**B is a process flowchart of power control executed by a control device.
DETAILED DESCRIPTION OF EMBODIMENTS
[0016] The control device of the present disclosure determines whether or not the engine can be stopped according to whether or not alternator power generation is required based on whether or not there is a discharge current from the auxiliary battery to the auxiliary load. As a result, it is possible to prevent the engine from being stopped when power generation of the alternator is required.
[0017] Hereinafter, an embodiment of the present disclosure will be described in detail with reference to the drawings.
Embodiment
Configuration
[0018] FIG. **1** is a functional block diagram illustrating a schematic configuration of a control device **50** and a peripheral portion thereof according to an embodiment of the present disclosure. The functional block illustrated in FIG. **1** includes a power supply system **10**, a power supply source **20**, an engine **30**, a load **40**, and a control device **50**. In FIG. **1**, a power line through which power is transmitted and received is indicated by a solid line, and a signal line through which a control instruction, a detection value, and the like are transmitted and received is indicated by a broken line.
[0019] The control device **50** according to the present embodiment is mounted on vehicles such as, for example, hybrid electric vehicle (HEV) and plug-in hybrid electric vehicle (PHEV) using the engine **30** as an internal combustion engine as a power source.
[0020] The power supply system **10** is a configuration for supplying power to the load **40**. The power supply system **10** includes a battery **11**, a DC-to-DC converter **12**, an alternator **13**, and a sensor **14**.
[0021] The battery **11** is a secondary battery configured to be chargeable and dischargeable, such as a lithium-ion battery. The battery **11** is connected to DC-to-DC converters **12** so as to be able to be charged by the electric power outputted from the power supply source **20**. Further, the battery **11** can supply the electric power stored therein to the load **40**. As the battery **11**, an auxiliary battery mounted on a vehicle can be exemplified.
[0022] DC-to-DC converters **12** are power converters capable of converting the inputted power into a predetermined-voltage power and outputting the converted power. DC-to-DC converters **12** have one end (primary side) connected to the power supply source **20**, and the other end (secondary side) connected to the battery **11**. DC-to-DC converters **12** can supply the electric power outputted by the power supply source **20** connected to the primary side to the batteries **11** and the loads **40** connected to the secondary side. The operation of DC-to-DC converters **12** is controlled by the control device **50**.
[0023] The alternator **13** is a generator capable of generating electric power in response to rotation (driving) of the engine **30**. The alternator **13** is connected in parallel with DC-to-DC converter **12** so that it can provide its own generated power together with the power of DC-to-DC converter **12** to the battery **11** and loads **40**. Whether or not power generation by the alternator **13** is possible (whether or not power generation is output) is controlled by the control device **50**.
[0024] The sensor **14** is configured to detect at least the current flowing out of the battery **11** and the current flowing into the battery **11** as the physical quantity of the battery **11**. A detection device such as a current sensor is used for the sensor **14**. Information regarding the current of the battery **11** detected by the sensor **14** is output to the control device **50**.
[0025] The power supply source **20** is a configuration for exclusively supplying electric power to a

main engine load (the engine **30** or the like) such as electronic equipment and equipment related to the traveling of the vehicle. The power supply source **20** also supplies power to the load **40**, which is an auxiliary load other than the main engine load, via DC-to-DC converters **12**. As the power supply source **20**, for example, a secondary battery (main battery) such as a lithium-ion battery or a power generation device such as a motor generator that generates regenerative electric power is used.

[0026] The engine **30** is an internal combustion engine serving as a power source of the vehicle. The power of the power supply source **20** is used to start the engine **30**. Starting/stopping of the engine **30**, permission/non-permission thereof, and the like are controlled by the control device **50**.

[0027] The load **40** is an auxiliary load such as an electronic device or equipment that does not relate to the traveling of the vehicle. The loads **40** are configured to operate mainly by the power of the power supply source **20** supplied via DC-to-DC converters **12** and the power generated by the alternator **13**, and in certain cases, by the power of the battery **11**.

[0028] The control device **50** is a configuration for controlling power to be output (supplied) from the power supply system **10** to the load **40**. The control device **50** includes an acquisition unit **51** and a control unit **52**.

[0029] The acquisition unit **51** acquires information on the current of the battery **11** from the sensor **14** of the power supply system **10**. The information on the current of the battery **11** acquired by the acquisition unit **51** is an incoming current (charging current) input by the battery **11** at the time of acquisition (at present) or an outgoing current (discharging current) output by the battery **11**.

[0030] The control unit **52** controls the operation of the alternator **13** and the engine **30** of the power supply system **10** based on the information on the current of the battery **11** acquired by the acquisition unit **51**. Although the details of the control will be described later, in a case where the battery **11** is in a discharging state in which a current is output to the load **40**, the control unit **52** performs control for prohibiting the engine **30** in operation from being stopped so that the alternator **13** can generate electric power.

[0031] Note that a part or all of the above-described control device **50** may typically be constituted by an electronic control unit (HV_ECU, EFI_ECU, or the like) including a processor such as a microcomputer, a memory, an input/output interface, and the like. The electronic control unit can realize some or all of the functions performed by the acquisition unit **51** and the control unit **52** by the processor reading and executing the program stored in the memory. **20**

Control

[0032] Next, the control performed by the control device **50** according to the present embodiment will be described with reference to FIGS. **2**A and **2**B. FIGS. **2**A and **2**B are flow charts for describing the steps of the power control executed by the respective components of the control device **50**. The process of FIG. **2**A and the process of FIG. **2**B are connected by the couplers X and Y, respectively.

[0033] The power control illustrated in FIGS. **2**A and **2**B is started, for example, when the power of the vehicles is turned IG-ON, READY-ON. It is assumed that the operation of the alternator **13** is stopped (power is not generated) at the start of the power control, but the operating state of the engine **30** is not particularly limited.

S**201**

[0034] The acquisition unit **51** of the control device **50** acquires information related to the current of the battery **11** from the sensor **14**. When the acquisition unit **51** acquires information about the current of the battery **11**, the process proceeds to S**202**.

[0035] It should be noted that the acquisition unit **51** appropriately acquires information on the current of the battery **11** based on a predetermined timing (a predetermined cycle or the like) even during processing of each step described later.

S**202**

[0036] The control unit **52** of the control device **50** determines whether or not the battery **11** is in

the discharging state. This determination can be made based on the current incoming and outgoing current and/or the cumulative value of the incoming and outgoing current of the battery **11** obtained from the information acquired by the acquisition unit **51** in the above-described S**201**.

[0037] For example, based on the current incoming and outgoing current of the battery **11**, the following can be performed. When the power demand (consumed current) by the load **40** does not exceed the power supply capacity (output limit) of DC-to-DC converter **12**, the excess power (current) is inputted to the battery **11** and charged, or DC-to-DC converter **12** is controlled so that the excess power is eliminated. Therefore, in this case, since the current flows into the battery **11** or the current becomes zero, the control unit **52** can determine that the battery **11** is in the charging state. On the other hand, when the power demand by the load **40** exceeds the power-supply capability of DC-to-DC converters **12**, the battery **11** discharges the amount of power (current) that is insufficient to the load **40**. Therefore, in this case, since the current flows out of the battery **11**, the control unit **52** can determine that the battery **11** is in the discharging state. Note that the discharging state of the battery **11** may be determined not only based on whether or not there is a current flowing out of the battery **11**, but also based on whether or not there is an outgoing current equal to or more than a predetermined threshold value.

[0038] Further, based on the cumulative value up to the current incoming and outgoing current of the battery **11**, it can be performed as follows. For example, the control unit **52** integrates the current incoming and outgoing current sequentially acquired by the acquisition unit **51** with the negative sign of the outgoing current from the battery **11** using the positive sign of the incoming current to the battery **11**. The control unit **52** can determine that the battery **11** is in the charging state if the cumulative value of the incoming and outgoing current in an arbitrary period is a positive value, and can determine that the battery **11** is in the discharging state if the cumulative value of the incoming and outgoing current in an arbitrary period is a negative value. An arbitrary period can exemplify a period from a time point when the battery **11** reaches the specified electric storage capacity (SOC=80%, or the like) to a current time point when the determination is made.

[0039] Furthermore, based on both the incoming and outgoing current of the battery **11** and the cumulative value up to the current incoming and outgoing current, for example, if the cumulative value of the incoming and outgoing current is a negative value even if the current flows into the battery **11**, it is also possible to determine that the battery **11** is in a discharging state (needs to be charged). In addition, when the cumulative value of the incoming and outgoing current is a positive value, it is also possible to determine that the battery **11** is in a charging state until the current is reduced to the specified storage amount even if the current flows out of the battery **11**.

[0040] When the control unit **52** determines that the battery **11** is in the discharging state (S**202**, Yes), the process proceeds to S**203**. On the other hand, when the control unit **52** determines that the battery **11** is not in the discharging state (S**202**, No), the process proceeds to S**201**.

S**203**

[0041] The control unit **52** of the control device **50** brings the engine **30** into an operating state. Specifically, the control unit **52** starts the engine **30** to operate when the engine **30** is in the stopped state, and continues the operating state when the engine **30** is already in the operating state. In addition, the control unit **52** prohibits the engine **30** from being stopped at the same time as the engine **30** is put into an operating state. The stopping prohibition of the engine **30** can be controlled by setting a predetermined prohibition flag to ON or the like. When the control unit **52** activates the engine **30**, the process proceeds to S**204**.

S**204**

[0042] The control unit **52** of the control device **50** starts counting the time during which the engine **30** is operating (hereinafter referred to as “engine operating time”). This time counting is started from the time when the process of S**203** is completed by using a predetermined-time timer. When the control unit **52** starts counting the operating hours, the process proceeds to S**205**.

S**205**

[0043] The control unit **52** of the control device **50** starts power generation by the alternator **13**. Thus, the electric power generated by the alternator **13** is supplied to the loads **40** and the batteries **11** together with the electric power outputted from DC-to-DC converters **12**. When the control unit **52** starts power generation of the alternator **13**, the process proceeds to S**206**.

S**206**

[0044] The control unit **52** of the control device **50** determines whether the engine operating time has reached the first time period. This determination is made in order to provide a timing for checking the state of the battery **11**. Therefore, this first time period is set to a predetermined period of time for which it is desired to check again whether or not the battery **11** remains in the discharging state.

[0045] If the control unit **52** determines that the engine-running time has reached the first time period (S**206**, Yes), the process proceeds to S**207**. On the other hand, when the control unit **52** determines that the engine operating time has not yet reached the first time period (S**206**, No), the power generation of the alternator **13** is continued until the first time period is reached.

S**207**

[0046] The control unit **52** of the control device **50** stops power generation by the alternator **13**. As a result, only the electric power outputted from DC-to-DC converters **12** is supplied to the loads **40** and the batteries **11**. When the power generation of the alternator **13** is stopped by the control unit **52**, the process proceeds to S**208**.

S**208**

[0047] The control unit **52** of the control device **50** determines whether the cumulative value of the incoming and outgoing current of the battery **11** during the first time period is equal to or greater than the second threshold. Specifically, the control unit **52** calculates a cumulative value (with a positive or negative sign) by sequentially cumulating the incoming and outgoing current currents of the battery **11** acquired by the acquisition unit **51** until the engine operating time reaches the first time period, and compares the calculated cumulative value of the incoming and outgoing current with the second threshold. This determination is made to determine whether the battery **11** remains in the discharging state. Therefore, the second threshold is set to a predetermined amount of current that can determine that the battery **11** is no longer in the discharging state.

[0048] When the control unit **52** determines that the cumulative value of the incoming and outgoing current of the battery **11** during the first time period is equal to or larger than the second threshold (S**208**, Yes), it is determined that power generation by the alternator **13** is not necessary, and the process proceeds to S**209**. On the other hand, when the control unit **52** determines that the cumulative value of the incoming and outgoing current of the battery **11** during the first time period is less than the second threshold (S**208**, No), it is determined that power generation by the alternator **13** is still required, and the process proceeds to S**210**.

S**209**

[0049] The control unit **52** of the control device **50** permits the engine **30** to be stopped. The stopping permission of the engine **30** can be controlled by setting a predetermined prohibition flag to OFF or the like. When the stop of the engine **30** is permitted by the control unit **52**, this power control is ended.

S**210**

[0050] The control unit **52** of the control device **50** resets the engine operating time. As a result, the timing of the engine operating time is started again from zero. When the control unit **52** resets the operating period, the process proceeds to S**204**.

Operations and Effects

[0051] As described above, according to the control device **50** according to the embodiment of the present disclosure, when the battery **11** is in a discharging state in which current is output to the load **40**, stopping of the engine **30** in operation is prohibited so that the alternator **13** can be operated by the engine **30** to generate electric power.

[0052] By this control, when the power demand (consumed current) by the load **40** exceeds the supply capacity (output limit) of DC-to-DC converter **12**, the battery **11** can switch the power supplied to the load **40** to the power of the alternator **13** by causing the alternator **13** to generate electric power. Therefore, it is possible to maintain the specified amount of electricity storage (control target amount) defined in the battery **11** without being affected by the fluctuation of the power demand in the load **40**.
[0053] Further, according to the control device **50** of the present embodiment, it is possible to determine whether or not the battery **11** is in the discharging state by using the detection value of the battery sensor originally mounted on the vehicle. Therefore, the above-described power control can be realized at low cost without adding a new hardware configuration.
[0054] Although an embodiment of the present disclosure has been described above, the present disclosure can be regarded as not only a control device but also a method executed by a control device including a processor, a memory, and the like, a program for executing the method, a computer-readable non-transitory storage medium storing a program, a vehicle equipped with a control device, and the like.
[0055] The control device of the present disclosure is applicable to a vehicle equipped with a power supply system including a DC-to-DC converter and an alternator, and in particular, to a vehicle for intermittently stopping an engine for improving fuel efficiency and reducing emissions.

Claims

1. A control device that controls a power supply system, the power supply system including a DC-to-DC converter that supplies electric power of a power supply source to a load, an alternator connected in parallel with the DC-to-DC converter in such a manner that the alternator is able to supply electric power generated by rotation of an engine to the load, and a battery connected to the load in such a manner that the battery is able to supply electric power to the load, the control device comprising: an acquisition unit that acquires information on a current of the battery; and a control unit that controls an operation of the engine and an operation of the alternator based on the information, wherein when the battery is in a discharging state in which the battery outputs a current to the load, the control unit prohibits the engine that is running from being stopped.
2. The control device according to claim 1, wherein the control unit determines the discharging state of the battery based on a current incoming and outgoing current of the battery and a cumulative value up to the current incoming and outgoing current that are obtained from the information.
3. The control device according to claim 1, wherein when the battery is in the discharging state, the control unit allows the engine to be stopped on a condition that the battery is no longer in the discharging state after the alternator generates electric power for a first time period.
4. The control device according to claim 3, wherein when a cumulative value of the incoming and outgoing current of the battery during the first time period is equal to or larger than a second threshold, the control unit determines that the battery is not in the discharging state.