



- (51) International Patent Classification:
B60H 1/02 (2006.01) *B60H 1/32* (2006.01)
- (21) International Application Number:
PCT/US2014/051819
- (22) International Filing Date:
20 August 2014 (20.08.2014)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/867,864 20 August 2013 (20.08.2013) US
- (71) Applicant: **GENERAL ELECTRIC COMPANY**
[US/US]; 1 River Road, Schenectady, NY 12345 (US).
- (72) Inventors: **YOUNG, Henry, Todd**; 2901 East Lake Rd,
Bld 42-411, Erie, PA 16531 (US). **RANDOLPH, Ord, Allen**;
2901 East Lake Road, B42-415, Erie, PA 16531 (US). **BROWN, Timothy**;
2901 East Lake Road, Bldg 42-415, Erie, PA 16531 (US).
- (74) Agents: **KRAMER, John, A.** et al.; General Electric Company,
Global Patent Operation, 2 Corporated Drive, Suite 648,
Shelton, CT 06484 (US).

- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— with international search report (Art. 21(3))

[Continued on next page]

(54) Title: VEHICLE TEMPERATURE REGULATION SYSTEM AND METHOD

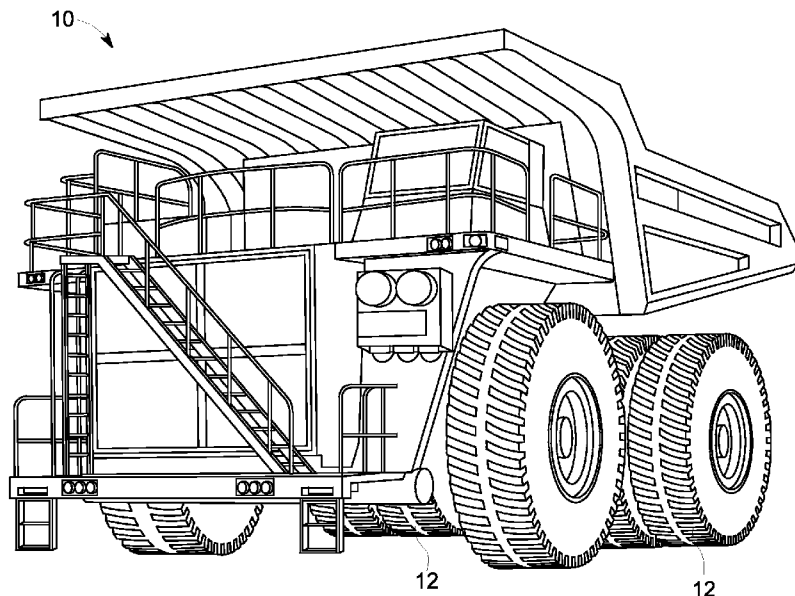


FIG. 1

(57) Abstract: A temperature regulation system for a vehicle includes a drive system configured to be coupled to an engine of the vehicle. The drive system is configured to convert power produced by the engine into electrical power for use by at least one traction motor of the vehicle. The system further includes a control unit for controlling the engine and drive system. The control unit is configured to automatically regulate a temperature of a vehicle component in dependence upon a detected reference temperature.



- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

VEHICLE TEMPERATURE REGULATION SYSTEM AND METHOD

FIELD OF THE INVENTION

[0001] Embodiments of the invention relate generally to temperature regulation systems. Other embodiments relate to temperature regulation systems for a vehicle engine and drive system.

BACKGROUND OF THE INVENTION

[0002] Large off-highway vehicles (“OHVs”), such as mining vehicles used to haul heavy payloads excavated from open pit mines, are well known and typically employ motorized wheels for propelling or retarding the vehicle in an energy efficient manner. This efficiency is typically accomplished by employing a large horsepower diesel engine in conjunction with an alternator, a main traction inverter, and a pair of wheel drive assemblies housed within the rear tires of the vehicle. The diesel engine is directly associated with the alternator such that the diesel engine drives the alternator. The alternator powers the main traction inverter, which supplies electrical power having a controlled voltage and frequency to electric drive motors of the two wheel drive assemblies. Each wheel drive assembly houses a planetary gear transmission that converts the rotation of the associated drive motor energy into a high torque low speed rotational energy output which is supplied to the rear wheels.

[0003] Typical operating loads in an OHV may exceed one hundred tons, while the gross weight of the vehicle and load may be several hundred tons. Besides hauling heavy loads, OHVs frequently operate in remote locations with extreme climatic conditions where temperatures may go as low as -30°C to -60°C. At such extreme cold temperatures, when the OHV is parked or in an idle state, the engine may not generate enough heat on its own to maintain its operating temperature within ranges necessary for sufficient performance. In addition, drive system components may be damaged or exhibit performance degradation in such extreme cold.

[0004] Accordingly, it may be desirable to provide a system and method for regulating the temperature of the engine and/or drive system components of OHVs and other mining equipment in conditions of extreme cold.

BRIEF DESCRIPTION OF THE INVENTION

[0005] An embodiment of the present invention relates to a temperature regulation system for a vehicle. The system includes a drive system configured to be coupled to an engine of the vehicle. The drive system is configured to convert power produced by the engine into electrical power for use by at least one traction motor of the vehicle. The system further includes a control unit for controlling the engine and drive system. The control unit is configured to automatically regulate a temperature of a vehicle component in dependence upon a detected reference temperature.

[0006] In another embodiment of a temperature regulation system for a vehicle, the system comprises a drive system configured to be coupled to an engine of the vehicle. The drive system includes one or more power converters having one or more power semiconductor switches, to convert power produced by the engine into electrical power for use by at least one traction motor of the vehicle. The system further comprises a control unit for controlling the engine and drive system. In an embodiment, the control unit is configured to automatically regulate a temperature of the power semiconductor switches by firing the power semiconductor switches in a manner that does not cause the at least one traction motor to move the vehicle.

[0007] In another embodiment, a method for temperature regulation of a vehicle comprises determining a reference temperature associated with an engine of the vehicle; comparing, by a control unit of the vehicle, the reference temperature with a predetermined minimum operating temperature of the engine; and automatically applying, by the control unit, additional load to the engine, above an idle level of the engine, if the reference temperature is below the minimum operating temperature.

[0008] In another embodiment, a method for regulating the temperature of a vehicle or other power generating device comprises determining a reference temperature associated with a drive system component of the vehicle or other device; comparing, by a control unit of the vehicle or other device, the reference temperature with a predetermined minimum operating temperature associated with the drive system component; and automatically actuating, by the control unit, the drive system component to increase an operating temperature of the component if the reference temperature is below the minimum operating temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present invention will be better understood from reading the following description of non-limiting embodiments, with reference to the attached drawings, wherein below:

[0010] FIG. 1 is a perspective view of a haul truck according to an embodiment of the invention.

[0011] FIG. 2 is a schematic diagram of a power/traction system of the haul truck of FIG. 1.

[0012] FIG. 3 is a flowchart illustrating a method for regulating the temperature of the engine of a vehicle, according to an embodiment of the invention.

[0013] FIG. 4 is a flowchart illustrating a method for regulating the temperature of the drive system of a vehicle, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Reference will be made below in detail to exemplary embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numerals used throughout the drawings refer to the same or like parts. Although exemplary embodiments of the present invention are described with respect to haul trucks having a diesel engine that are utilized in the surface mining industry, embodiments of the invention are also applicable for use with internal combustion engines and vehicles employing such engines, generally. For example, the vehicles may be off-highway vehicles (“OHVs”) designed to perform an operation associated with a particular industry, such as mining, construction, farming, etc., and may include haul trucks, cranes, earth moving machines, mining machines, farming equipment, tractors, material handling equipment, earth moving equipment, etc. Alternatively or additionally, the vehicles may be on-road vehicles, such as tractor-trailer rigs, on-road dump trucks, etc. As used herein, “electrical communication” or “electrically coupled” means that certain components are configured to communicate with one another through direct or indirect signaling by way of direct or indirect electrical connections. As used herein, “reference temperature” means the temperature seen by the engine or drive system components of the vehicle. “Reference temperature” may be ambient temperature, the temperature within the engine, or the temperature of one of the drive system components.

[0015] FIG. 1 illustrates a haul truck 10, in which the temperature regulation system of the present invention may be incorporated. The haul truck 10 is a dump truck specifically engineered for use in high production mining and heavy-duty construction environments, and

includes drive wheels 12 coupled to a diesel-electric power/drive system 100 which provides motive power to the haul truck 10. (The haul truck 10 is illustrative of vehicles generally, although in embodiments, a system and/or method of the invention is implemented on a haul truck specifically.)

[0016] With reference to FIG. 2, the power/drive system 100 is shown. As indicated above, the haul truck has at least two drive wheels 12. Each wheel 12 is driven by a three-phase alternating-current (AC), induction type wheel motor. The wheel motors are referenced as a first wheel motor 102 and a second wheel motor 104. Electrical power is supplied by a diesel engine 106 driving a three-phase AC generator 108. In other embodiments, other types of mechanical/fuel engines may be utilized. The diesel engine 106 and generator 108 are housed within the haul truck 10. The AC output of the generator 108 is fed into one or more rectifiers 110 (e.g., a three-phase diode array), which delivers voltage V_{dc}. The direct current (DC) output of the rectifiers 110 is fed into a set of power converters 112, 114. The power converters include switch modules 116, 118, 120, 122, comprising one or more power semiconductor switches, which together commutate V_{dc} to deliver three-phase AC electrical power to traction motors 102, 104. (Traction motors are electric motors configured for use in moving a vehicle.)

[0017] It will be appreciated that the invention is not limited by the particular arrangement of the switch modules 111, 112, etc. to form a power converter 110. Rather, the present invention is equally applicable in other embodiments (not shown), including, for example, a single switch module or an array of switch modules used for electrical power conversion.

[0018] Although FIG. 2 specifically illustrates an exemplary embodiment wherein the power semiconductor switch is an insulated gate bipolar transistor (IGBT), the present invention may also be applicable to other voltage-controlled or other semiconductor devices, including, by way of non-limiting examples, bi-mode isolated gate transistors, reverse-conducting IGBTs, MOSFETs and JFETs.

[0019] With further reference to FIG. 2, a control unit 124 is electrically coupled to the power converters 112, 114 (and to the switch modules 116, 118, 120, 122 thereof). As is known in the art, the control unit 124 determines and sends a desired torque request signal to the inverters 112, 114. The torque request signal is processed by the controller for the inverters 112, 114 to drive the motors 102, 104 to the desired torque output magnitude, and in the desired rotational direction corresponding to the intended direction of vehicle movement. The control unit 124 includes one or more microprocessors operating according to a set of

stored instructions to provide for vehicle control and automatic temperature regulation of vehicle components, as discussed in detail hereinafter.

[0020] As discussed above, during periods of extreme cold, when the vehicle 10 is parked or in an idle situation, the engine 106 may not be able to generate enough heat on its own, even at an elevated idle, to maintain its operating temperature within preferred ranges. As a result, engine damage, slow response, and reduction in fuel burning efficiency is possible. In addition, during periods of extreme cold, the components of the drive system 100, such as the IGBT switch modules 116, 118, 120, 122 may be damaged by temperatures below approximately -40°C.

[0021] In connection with the above, therefore, the control unit 124 is configured to monitor a reference temperature, e.g., one or more of engine temperature utilizing sensor 126 positioned within or adjacent to the engine 106, ambient temperature utilizing an ambient temperature sensor (not shown), and power converter temperature utilizing a sensor 128 configured for coupling adjacent to or within the power converters 112, 114. In an embodiment, the temperature sensors are electrically coupled to the control unit 124 and are configured to automatically relay signals representative of the detected temperature(s) to the control unit at predetermined time intervals. In other embodiments, the temperature sensors are configured to relay signals representative of the detected temperatures(s) continuously. In yet other embodiments, the control unit 124 may communicate with the temperature sensors wirelessly.

[0022] In an embodiment, in order to maintain the operating temperature of the engine 106 within a predetermined, optimal range, the control unit 124 is configured to automatically utilize the drive system 100 to apply additional load to the engine 106 when one or more of the detected temperatures reaches a predetermined low value. In an embodiment, the additional load is a load upon the engine above an idle level of the engine. As will be readily appreciated, by applying additional load to the engine 106, the operating temperature thereof may be increased and automatically maintained above a predetermined value. In connection with this, the control unit 124 utilizes the drive system 100 to monitor engine parameters while loading the engine 106, thus taking the operator out of the loop and optimizing fuel burn.

[0023] The control unit 124 is also configured to maintain the operating temperature of the drive system components and, in particular, the IGBTs or other power semiconductor switches 116, 118, 120, 122, within a preferred range. In particular, when one or more of the detected temperatures reaches a predetermined lower threshold, the control unit 124 is

configured to keep the IGBTs 116, 118, 120, 122 warm by firing them in a DC sequence which does not rotate the AC traction motors 102, 104. By automating the firing of the IGBTs in a DC sequence in dependence upon drive system parameters, e.g., the sensed temperature of the power converters 112, 114, the drive system components may be maintained within preferred operating ranges without requiring operator input or action.

[0024] Turning now to FIGS. 3, a method 200 of regulating the temperature of a vehicle is provided. The method 200 includes, at step 202, determining the temperature seen by the engine 106 of the vehicle 10. The temperature may be the temperature of ambient air or the temperature within the engine 106. As step 204, the control unit 124 checks to see if the detected/sensed temperature falls below a predetermined minimum temperature. If the temperature does not, at step 206, no action regarding the regulation of engine temperature is undertaken. If the detected temperature does fall below the minimum permissible temperature value stored in memory, then additional load is applied to the engine, at step 208, to warm the engine to within a preferred operating range.

[0025] With reference to FIG. 4, similarly, a method 300 of regulating the temperature of a vehicle (e.g., the drive system 100 thereof) or power generating device, is provided. The method 300 includes, at step 302, determining a temperature seen by one of the drive system components of the vehicle or other device. The temperature may be the temperature of ambient air, the temperature adjacent to one of the power converters 112, 114, and/or the temperature of the engine 106, as hereinbefore disclosed. At step 304, the control unit 124 checks to see if the detected/sensed temperature falls below a predetermined minimum temperature. If the temperature does not, at step 306, no action regarding the regulation of the drive system 100 temperature is undertaken. If the detected temperature does fall below the minimum permissible temperature value stored in memory, then the control unit 124 controls the power semiconductor switches (e.g., IGBTs 116, 118, 120, 122 to fire in a DC sequence), at step 208, to warm the drive system (e.g., including the IGBTs) to within a preferred operating range.

[0026] As will be readily appreciated, therefore, the vehicle temperature regulation system of the present invention automatically maintains the engine at its optimum operating temperature during periods of inactivity, while at the same time optimizing fuel burn. In addition, the temperature regulation system avoids damage to the engine and drive system components in extreme cold temperatures. In contrast to existing systems, the temperature regulation system of the present invention is configured to automatically maintain engine and drive system temperature above a predetermined lower threshold, thereby obviating the need

for operator input. As a result, the temperature regulation system may be operated in both static and dynamic conditions.

[0027] An embodiment relates to a system, e.g., a temperature regulation system for a vehicle. The system comprises a drive system configured to be coupled to an engine of the vehicle. The drive system is configured to convert power produced by the engine into electrical power for use by at least one traction motor of the vehicle. The system further comprises a control unit for controlling the engine and drive system. The control unit is configured to automatically regulate a temperature of a vehicle component in dependence upon a detected reference temperature.

[0028] Another embodiment relates to a system, e.g., a temperature regulation system for a vehicle. The system comprises a drive system configured to be coupled to an engine of the vehicle. The drive system is configured to convert power produced by the engine into electrical power for use by at least one traction motor of the vehicle. The system further comprises a control unit for controlling the engine and drive system. The control unit is configured to automatically regulate a temperature of the engine in dependence upon a detected reference temperature. For doing so, the control unit is configured to automatically control the drive system to apply additional load to the engine when the detected reference temperature is below a predetermined value. The additional load is a load upon the engine above an idle level of the engine. The system may further comprise a temperature sensor associated with the engine and electrically coupled to the control unit. The temperature sensor is configured to sense the detected reference temperature.

[0029] Another embodiment relates to a system, e.g., a temperature regulation system for a vehicle. The system comprises a drive system configured to be coupled to an engine of the vehicle. The drive system is configured to convert power produced by the engine into electrical power for use by at least one traction motor of the vehicle. The system further comprises a control unit for controlling the engine and drive system. The control unit is configured to automatically regulate a temperature of the engine in dependence upon a detected reference temperature. For doing so, the control unit is configured to automatically control the drive system to apply additional load to the engine when the detected reference temperature is below a predetermined value. The additional load is a load upon the engine above an idle level of the engine. The control unit is further configured to monitor engine parameters while applying the additional load to the engine, so as to avoid burning more fuel than is needed while applying the additional load for the temperature of the engine to be above a designated level.

[0030] Another embodiment relates to a system, e.g., a temperature regulation system for a vehicle. The system comprises a drive system configured to be coupled to an engine of the vehicle. The drive system includes one or more power converters having one or more power semiconductor switches (e.g., diodes, FET's, IGBT's, BJT's, other transistors), to convert power produced by the engine into electrical power for use by at least one traction motor of the vehicle. The system further comprises a control unit for controlling the engine and drive system. In an embodiment, the control unit is configured to automatically regulate a temperature of the power semiconductor switches by firing the power semiconductor switches in a manner that does not cause the at least one traction motor to move the vehicle. (For example, if a particular AC waveform or sequence is required to power the traction motor to move the vehicle, then the power semiconductor switches may be fired to produce a DC waveform (i.e., fired in a DC sequence), or to produce an AC waveform that differs from the particular AC waveform, e.g., an AC waveform at too low a magnitude of voltage and/or current to cause the motor to overcome vehicle inertia.) In another embodiment, the control unit is configured to automatically regulate the temperature of the power semiconductor switches (by firing the power semiconductor switches in a manner that does not cause the at least one traction motor to move the vehicle), responsive to a detected reference temperature (e.g., an ambient temperature, or a temperature within the vehicle) being below a predetermined value.

[0031] An embodiment relates to a system, e.g., a temperature regulation system for a vehicle. The system comprises a drive system configured to be coupled to an engine of the vehicle. The drive system is configured to convert power produced by the engine into electrical power for use by at least one traction motor of the vehicle. The system further comprises a control unit for controlling the engine and drive system. The control unit is configured to automatically regulate a temperature of a vehicle component in dependence upon a detected reference temperature. The vehicle component comprises a plurality of power semiconductor switches of at least one power converter of the drive system of the vehicle. The at least one power converter is configured to provide the electrical power for use by the at least one traction motor of the vehicle. The electrical power comprises AC power produced by firing of the power semiconductor switches in an AC sequence. The control unit is configured, for regulating the temperature of the power semiconductor switches when the power converter is not being used to provide the electrical power to the at least one traction motor, to automatically fire the plurality power semiconductor switches in a

DC sequence. As one example, the power semiconductor switches may be insulated gate bipolar transistors.

[0032] An embodiment relates to a system, e.g., a temperature regulation system for a vehicle. The system comprises a drive system configured to be coupled to an engine of the vehicle. The drive system is configured to convert power produced by the engine into electrical power for use by at least one traction motor of the vehicle. The system further comprises a control unit for controlling the engine and drive system. The control unit is configured to automatically regulate a temperature of a vehicle component in dependence upon a detected reference temperature. The control unit is configured to automatically control the drive system to apply additional load to the engine when the detected reference temperature is below a predetermined value. The additional load being a load upon the engine above an idle level of the engine. The vehicle component comprises a plurality of power semiconductor switches of at least one power converter of the drive system of the vehicle. The power converter is configured to provide the electrical power for use by the at least one traction motor of the vehicle. The electrical power comprises AC power produced by firing of the power semiconductor switches in an AC sequence. The control unit is configured, for regulating the temperature of the power semiconductor switches when the power converter is not being used to provide the electrical power to the at least one traction motor, to automatically fire the plurality power semiconductor switches in a DC sequence.

[0033] An embodiment relates to a mine haul truck. The mine haul truck comprises an engine, a drive system coupled to the engine, a control unit, and at least one traction motor. The drive system is configured to convert power produced by the engine into electrical power for use by the at least one traction motor of the vehicle. The control unit is configured to control the engine and the drive system, and to automatically regulate a temperature of a vehicle component in dependence upon a detected reference temperature. (The mine haul truck may be further configured as otherwise set forth herein.)

[0034] In another embodiment, a method for temperature regulation of a vehicle comprises determining a reference temperature associated with an engine of the vehicle, comparing, by a control unit of the vehicle, the reference temperature with a predetermined minimum operating temperature of the engine, and automatically applying, by the control unit, additional load to the engine, above an idle level of the engine, if (i.e., responsive to) the reference temperature is below the minimum operating temperature. The reference temperature may be ambient temperature, or a temperature within the engine.

[0035] In another embodiment of the method, the method further comprises monitoring engine parameters while applying the additional load to the engine, so as to avoid burning more fuel than is needed while applying the additional load for the temperature of the engine to be above a designated level.

[0036] In another embodiment of the method, the method further comprises regulating the temperature of insulated gate bipolar transistors of a power converter of the vehicle, when the power converter is not being used to provide electrical power to any traction motors of the vehicle, by firing the insulated gate bipolar transistors in a DC sequence.

[0037] In another embodiment of the method, the step of regulating the temperature of the insulated gate bipolar transistors is carried out when a sensed temperature is below a predetermined value, the sensed temperature being different than the reference temperature.

[0038] Another embodiment relates to a temperature regulation system for a power generating device. (Power generating device refers to a device that uses fuel to generate electricity for powering a load. Examples include locomotives, mine haul trucks, and other diesel-electric vehicles (and other fuel-electric and/or hybrid vehicles), stationary generators, and the like.) The system comprises a drive system configured to be coupled to an engine of the device. The drive system is configured to convert power produced by the engine into electrical power for use by a load. The system further comprises a control unit for controlling the engine and drive system. The control unit is configured to determine a reference temperature associated with a component of the drive system; compare the reference temperature with a predetermined minimum operating temperature associated with the drive system component; and automatically actuate the drive system component to increase an operating temperature of the component if the reference temperature is below the minimum operating temperature. The reference temperature may be ambient temperature, or a temperature within the device. The predetermined minimum operating temperature may be a predetermined minimum operating temperature of the component itself, or a predetermined minimum operating temperature of the environment in which the component operates.

[0039] In an embodiment, the drive system component of the power generating device comprises a plurality of power semiconductor switches of one or more power converters of the device. The one or more power converters are electrically connected to drive a load. The step of actuating the drive system component includes firing the power semiconductor switches in a manner that heats the power semiconductor switches without driving the load. For example, the control unit may be configured to fire the power

semiconductor switches to an extent sufficient to maintain the power semiconductor switches above a lower temperature threshold. The lower temperature threshold may be the predetermined minimum operating temperature or another temperature. For example, if the predetermined minimum operating temperature is of the environment of the power semiconductor switches, then the power semiconductor switches may be fired to maintain the power semiconductor switches above the lower temperature threshold which is different than (e.g., higher than) the predetermined minimum operating temperature.

[0040] In another embodiment, a method for regulating the temperature of a power generating device comprises determining a reference temperature associated with a drive system component of the device; comparing, by a control unit of the device, the reference temperature with a predetermined minimum operating temperature associated with the drive system component; and automatically actuating, by the control unit, the drive system component to increase an operating temperature of the component if the reference temperature is below the minimum operating temperature. The reference temperature may be ambient temperature, or a temperature within the device. The predetermined minimum operating temperature may be a predetermined minimum operating temperature of the component itself, or a predetermined minimum operating temperature of the environment in which the component operates.

[0041] In an embodiment, the drive system component of the power generating device comprises a plurality of power semiconductor switches of one or more power converters of the device. The one or more power converters are electrically connected to drive a load. The step of actuating the drive system component includes firing the power semiconductor switches in a manner that heats the power semiconductor switches without driving the load. For example, the power semiconductor switches may be fired to an extent sufficient to maintain the power semiconductor switches above a lower temperature threshold. The lower temperature threshold may be the predetermined minimum operating temperature or another temperature. For example, if the predetermined minimum operating temperature is of the environment of the power semiconductor switches, then the power semiconductor switches may be fired to maintain the power semiconductor switches above the lower temperature threshold which is different than (e.g., higher than) the predetermined minimum operating temperature.

[0042] Another embodiment relates to a method for regulating the temperature of a vehicle. The method comprises determining a reference temperature associated with a drive system component of the vehicle, comparing, by a control unit of the vehicle, the reference

temperature with a predetermined minimum operating temperature of the drive system component, and automatically actuating, by the control unit, the drive system component to increase an operating temperature of the component if (i.e., responsive to) the reference temperature is below the minimum operating temperature. The reference temperature may be, for example, ambient temperature.

[0043] In another embodiment of the method, the drive system component comprises a plurality of power semiconductor switches of one or more power converters of the vehicle. The one or more power converters are electrically connected to drive one or more traction motors of the vehicle. The step of actuating the drive system component includes firing the power semiconductor switches in a manner that does not cause the one or more traction motors to move the vehicle.

[0044] In another embodiment of the method, the drive system component is a plurality of insulated gate bipolar transistors. The step of actuating the drive system component includes firing the insulated gate bipolar transistors in a DC sequence if the reference temperature is below the minimum operating temperature. The insulated gate bipolar transistors may be fired to an extent sufficient to maintain the insulated gate bipolar transistors above a lower temperature threshold.

[0045] It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments (and/or aspects thereof) may be used in combination with each other. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its scope. While the dimensions and types of materials described herein are intended to define the parameters of the invention, they are by no means limiting and are exemplary embodiments. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. As used herein, the terms “including” and “in which” are used as the plain-English equivalents of the respective terms “comprising” and “wherein.” Moreover, the terms “first,” “second,” “third,” “upper,” “lower,” “bottom,” “top,” etc. are used merely as labels, and are not intended to impose numerical or positional requirements on their objects.

[0046] This written description uses examples to disclose several embodiments of the invention, including the best mode, and also to enable one of ordinary skill in the art to practice the embodiments of invention, including making and using any devices or systems and performing any incorporated methods. As used herein, an element or step recited in the singular and proceeded with the word “a” or “an” should be understood as not excluding

plural of said elements or steps, unless such exclusion is explicitly stated. Furthermore, references to “one embodiment” of the present invention are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Moreover, unless explicitly stated to the contrary, embodiments “comprising,” “including,” or “having” an element or a plurality of elements having a particular property may include additional such elements not having that property.

[0047] Since certain changes may be made in the vehicle temperature regulation system, without departing from the spirit and scope of the invention herein involved, it is intended that all of the subject matter of the above description or shown in the accompanying drawings shall be interpreted merely as examples illustrating the inventive concept herein and shall not be construed as limiting the invention.

CLAIMS:

1. A temperature regulation system for a vehicle, comprising:
 - a drive system configured to be coupled to an engine of the vehicle, the drive system being configured to convert power produced by the engine into electrical power for use by at least one traction motor of the vehicle; and
 - a control unit for controlling the engine and drive system, the control unit being configured to automatically regulate a temperature of a vehicle component in dependence upon a detected reference temperature.
2. The system of claim 1, wherein the vehicle component is the engine, and the control unit is configured to automatically control the drive system to apply additional load to the engine, the additional load being a load upon the engine above an idle level of the engine, when the detected reference temperature is below a predetermined value.
3. The system of claim 2, further comprising:
 - a temperature sensor associated with the engine and electrically coupled to the control unit, the temperature sensor being configured to sense the detected reference temperature.
4. The system of claim 2, wherein:
 - the control unit is configured to monitor engine parameters while applying the additional load to the engine, so as to avoid burning more fuel than is needed while applying the additional load for the temperature of the engine to be above a designated level.
5. The system of claim 1, wherein:
 - the vehicle component comprises a plurality of power semiconductor switches of one or more power converters of the drive system of the vehicle, the one or more power converters electrically connected to provide the electrical power for use by the at least one traction motor of the vehicle; and
 - the control unit is configured to automatically regulate the temperature of the power semiconductor switches by firing the power semiconductor switches in a manner that does not cause the at least one traction motor to move the vehicle.
6. The system of claim 1, wherein:

the vehicle component comprises a plurality of power semiconductor switches of one or more power converters of the drive system of the vehicle, the one or more power converters electrically connected to provide the electrical power for use by the at least one traction motor of the vehicle; and

the control unit is configured to automatically regulate the temperature of the power semiconductor switches, responsive to the detected reference temperature being below a predetermined value, by firing the power semiconductor switches in a manner that does not cause the at least one traction motor to move the vehicle.

7. The system of claim 1, wherein:

the vehicle component comprises a plurality of power semiconductor switches of at least one power converter of the drive system of the vehicle, the at least one power converter being configured to provide the electrical power for use by the at least one traction motor of the vehicle, said electrical power comprising AC power produced by firing of the power semiconductor switches in an AC sequence; and

the control unit is configured, for regulating the temperature of the power semiconductor switches when the power converter is not being used to provide the electrical power to the at least one traction motor, to automatically fire the plurality power semiconductor switches in a DC sequence.

8. The system of claim 7, wherein the power semiconductor switches are insulated gate bipolar transistors.

9. The system of claim 1, wherein:

the control unit is configured to automatically control the drive system to apply additional load to the engine, the additional load being a load upon the engine above an idle level of the engine, when the detected reference temperature is below a predetermined value;

the vehicle component comprises a plurality of power semiconductor switches of at least one power converter of the drive system of the vehicle, the power converter being configured to provide the electrical power for use by the at least one traction motor of the vehicle, said electrical power comprising AC power produced by firing of the power semiconductor switches in an AC sequence; and

the control unit is configured, for regulating the temperature of the power semiconductor switches when the power converter is not being used to provide the electrical

power to the at least one traction motor, to automatically fire the plurality power semiconductor switches in a DC sequence.

10. A method for temperature regulation of a vehicle, comprising:
 - determining a reference temperature associated with an engine of the vehicle;
 - comparing, by a control unit of the vehicle, the reference temperature with a predetermined minimum operating temperature of the engine; and
 - automatically applying, by the control unit, additional load to the engine, above an idle level of the engine, if the reference temperature is below the minimum operating temperature.
11. The method of claim 10, wherein:
 - the reference temperature is ambient temperature.
12. The method of claim 10, wherein:
 - the reference temperature is a temperature within the engine.
13. The method of claim 10, further comprising the step of:
 - monitoring engine parameters while applying the additional load to the engine, so as to avoid burning more fuel than is needed while applying the additional load for the temperature of the engine to be above a designated level.
14. The method of claim 10, further comprising the step of:
 - regulating the temperature of insulated gate bipolar transistors of a power converter of the vehicle, when the power converter is not being used to provide electrical power to any traction motors of the vehicle, by firing the insulated gate bipolar transistors in a DC sequence.
15. The method of claim 14, wherein:
 - the step of regulating the temperature of the insulated gate bipolar transistors is carried out when a sensed temperature is below a predetermined value, the sensed temperature being different than the reference temperature.
16. A method for regulating the temperature of a power generating device, comprising:

determining a reference temperature associated with a drive system component of the device;

comparing, by a control unit of the device, the reference temperature with a predetermined minimum operating temperature associated with the drive system component; and

automatically actuating, by the control unit, the drive system component to increase an operating temperature of the component if the reference temperature is below the minimum operating temperature.

17. The method of claim 16, wherein:

the reference temperature is ambient temperature.

18. The method of claim 16, wherein:

the drive system component comprises a plurality of power semiconductor switches of one or more power converters of the device, the one or more power converters electrically connected to drive a load; and

the step of actuating the drive system component includes firing the power semiconductor switches in a manner that heats the power semiconductor switches without driving the load.

19. The method of claim 18, wherein the power semiconductor switches are fired to an extent sufficient to maintain the power semiconductor switches above a lower temperature threshold.

20. The method of claim 18, wherein:

the device is a vehicle, and the load comprises one or more traction motors of the vehicle; and

the step of actuating the drive system component includes firing the power semiconductor switches in a manner that does not cause the one or more traction motors to move the vehicle.

21. The method of claim 16, wherein:

the drive system component is a plurality of insulated gate bipolar transistors; and

the step of actuating the drive system component includes firing the insulated gate bipolar transistors in a DC sequence if the reference temperature is below the minimum operating temperature.

22. The method of claim 21, wherein:

the insulated gate bipolar transistors are fired to an extent sufficient to maintain the insulated gate bipolar transistors above a lower temperature threshold.

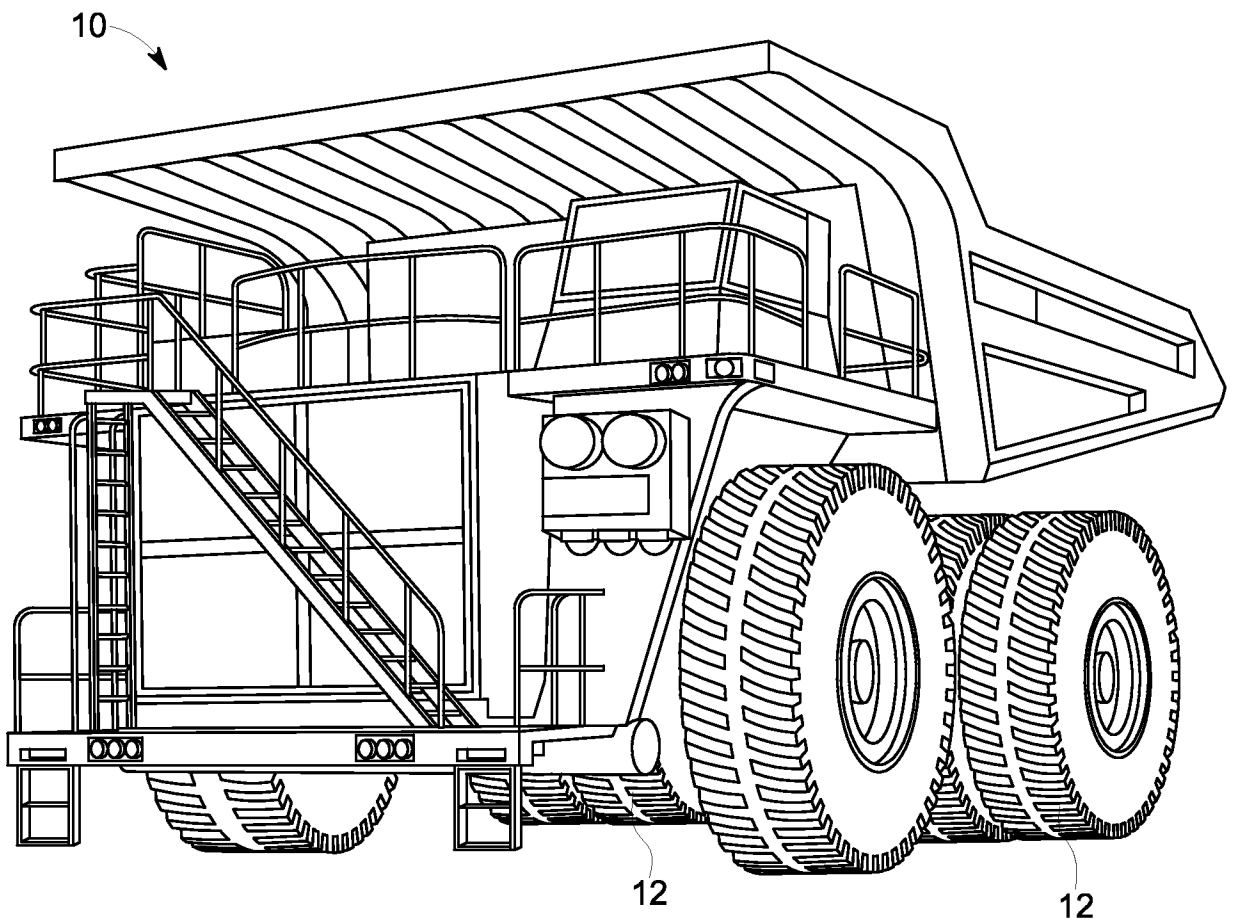


FIG. 1

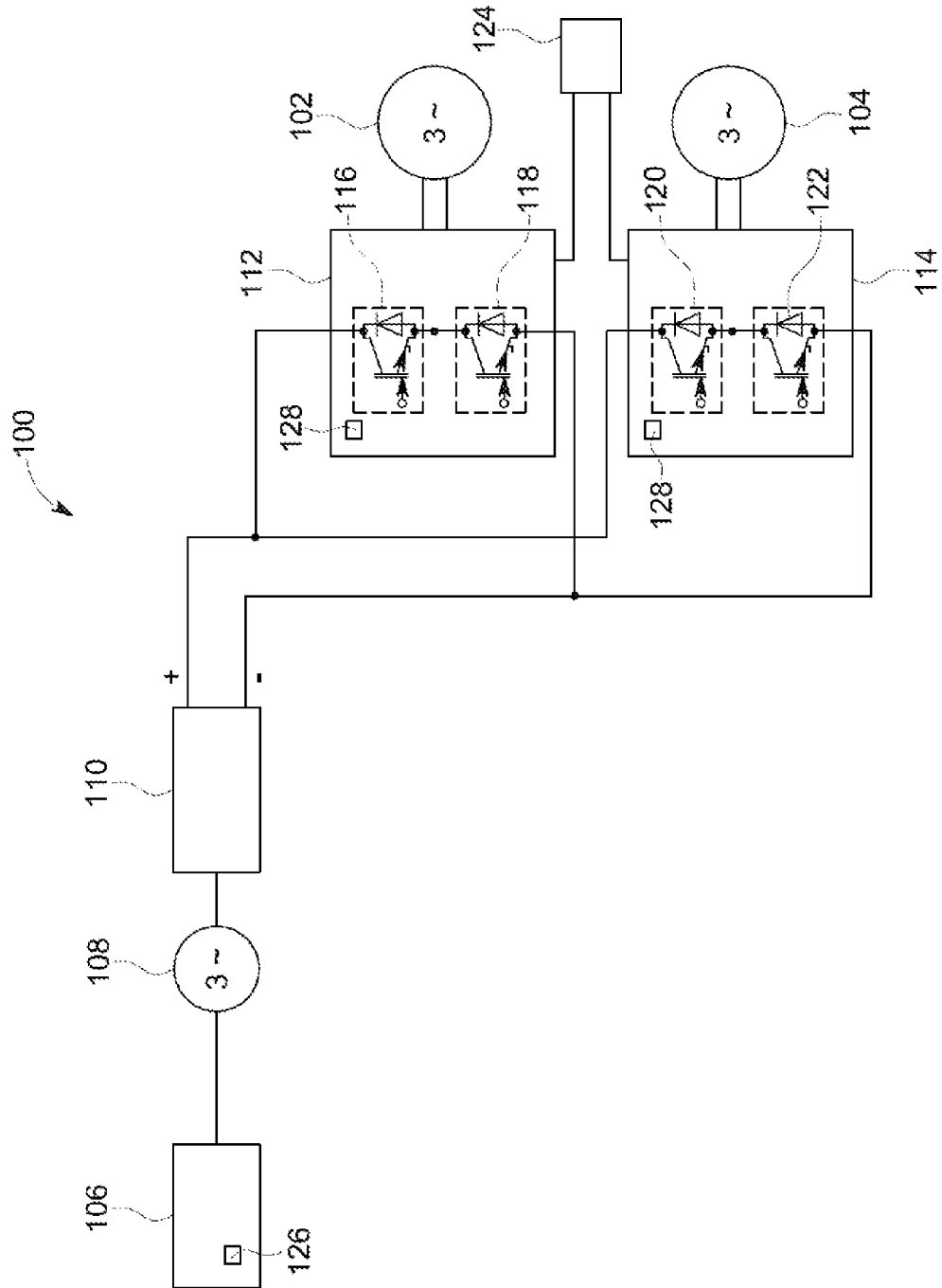


FIG. 2

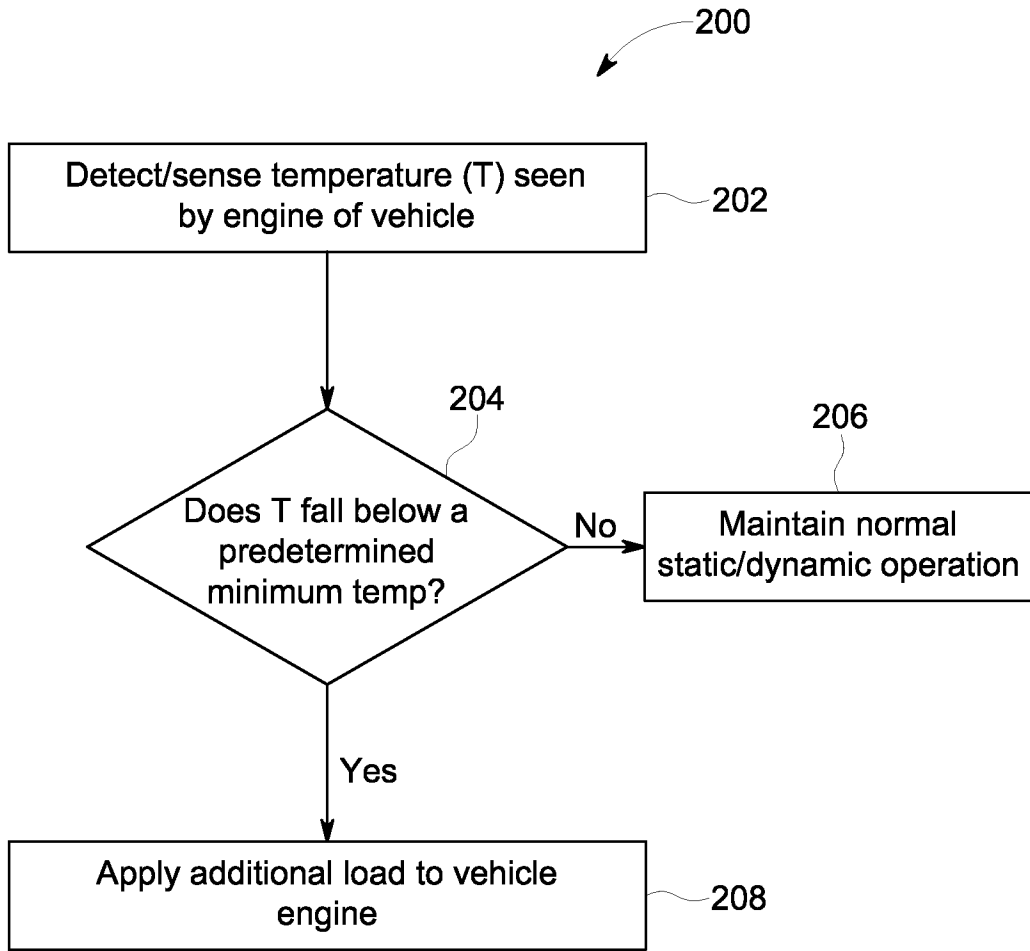


FIG. 3

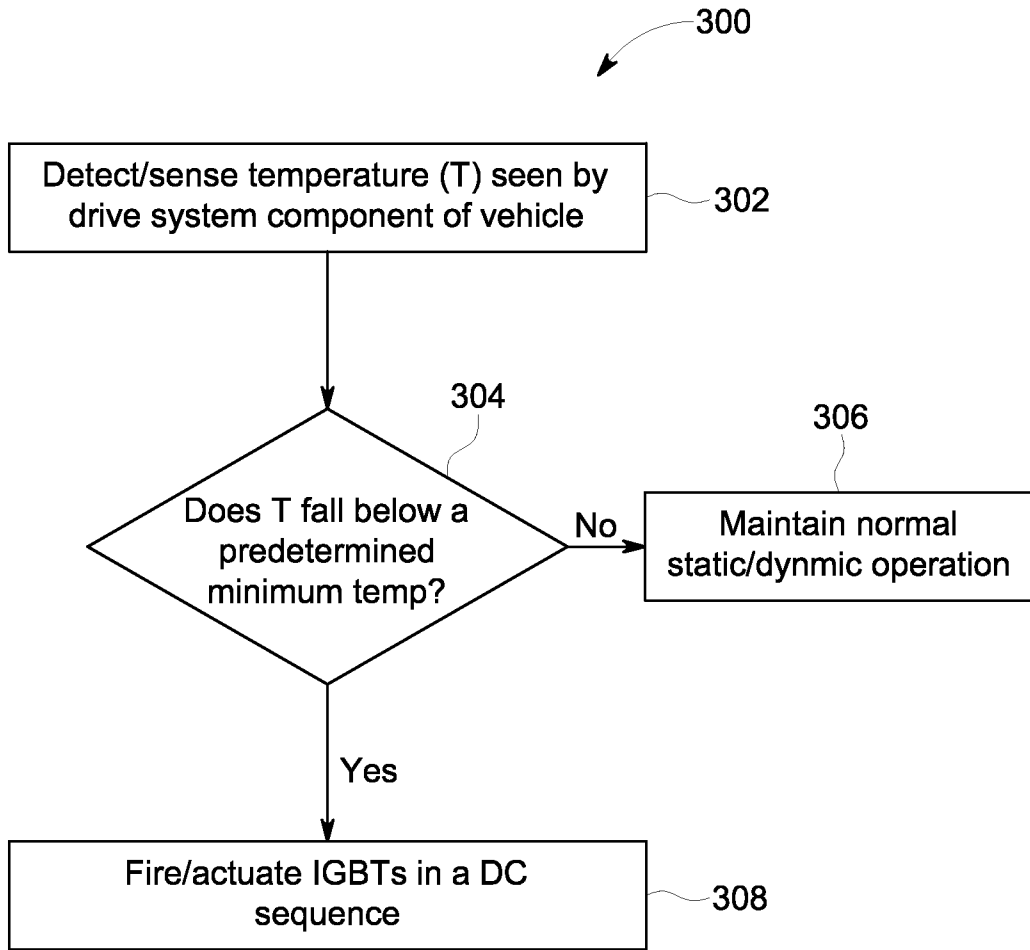


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/051819**A. CLASSIFICATION OF SUBJECT MATTER****B60H 1/02(2006.01)i, B60H 1/32(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60H 1/02; H02P 7/00; H02H 7/06; F02B 47/08; F02D 29/02; H02P 11/00; F02D 41/08; F01N 3/02; F04B 49/02; B60H 1/32

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: temperature sensor, control unit, diesel engine, power converter, and semiconductor switch**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5923135 A (TAKEDA, YASUSHI) 13 July 1999 See abstract, column 4, line 10 - column 8, line 17, claims 1, 5, 8, 15, 16 and figures 1A-7B.	1-22
A	US 2005-0258807 A1 (YANAGI, MITSUNORI) 24 November 2005 See abstract, paragraphs [0016]-[0037], claims 1, 7 and figures 1-4.	1-22
A	US 2011-0253113 A1 (ROTH et al.) 20 October 2011 See abstract, paragraphs [0048]-[0091] and figures 3-5, 7, 8.	1-22
A	US 2013-0108476 A1 (GUZELGUNLER, YILCAN) 02 May 2013 See abstract, paragraphs [0010]-[0019] and figures 1-3.	1-22
A	KR 10-2013-0087072 A (DOOSAN INFRACORE CO., LTD.) 06 August 2013 See abstract, paragraphs [0025]-[0037] and figure 3.	1-22

 Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

12 December 2014 (12.12.2014)

Date of mailing of the international search report

12 December 2014 (12.12.2014)

Name and mailing address of the ISA/KR

International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701,
Republic of Korea

Facsimile No. +82-42-472-7140

Authorized officer

LEE, Hun Gil

Telephone No. +82-42-481-8525



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/051819

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5923135 A	13/07/1999	JP 03695023 B2 JP 10-164703 A	14/09/2005 19/06/1998
US 2005-0258807 A1	24/11/2005	DE 102005022569 A1 JP 03992017 B2 JP 2005-333686 A US 7199559 B2	15/12/2005 17/10/2007 02/12/2005 03/04/2007
US 2011-0253113 A1	20/10/2011	US 8831858 B2	09/09/2014
US 2013-0108476 A1	02/05/2013	None	
KR 10-2013-0087072 A	06/08/2013	None	