



(51) International Patent Classification:

**B60N 2/00** (2006.01)      **B62D 1/04** (2006.01)  
**B60N 2/56** (2006.01)      **B60R 16/03** (2006.01)  
**B62D 1/06** (2006.01)      **B60R 22/48** (2006.01)

(21) International Application Number:

PCT/US2018/032821

(22) International Filing Date:

15 May 2018 (15.05.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/506,477      15 May 2017 (15.05.2017)      US

(71) Applicant: **JOYSON SAFETY SYSTEMS ACQUISITION LLC** [US/US]; 2500 Innovation Drive, Auburn Hills, Michigan 48326 (US).

(72) Inventors: **LISSEMAN, Jason**; 2500 Innovation Drive, Auburn Hills, Michigan 48326 (US). **DOLCETTI, Blaine**; 2500 Innovation Drive, Auburn Hills, Michigan 48326 (US). **GARDNER, Valerie**; 2500 Innovation Drive, Auburn Hills, Michigan 48326 (US).

(74) Agent: **JOHNSON, R. Brian** et al.; Meunier Carlin & Curfman LLC, 999 Peachtree Street, NE, Suite 1300, Atlanta, Georgia 30309 (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, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, 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,

(54) Title: SYSTEMS AND METHODS FOR HEATING AND SENSING PROXIMITY TO VEHICLE COMPONENTS

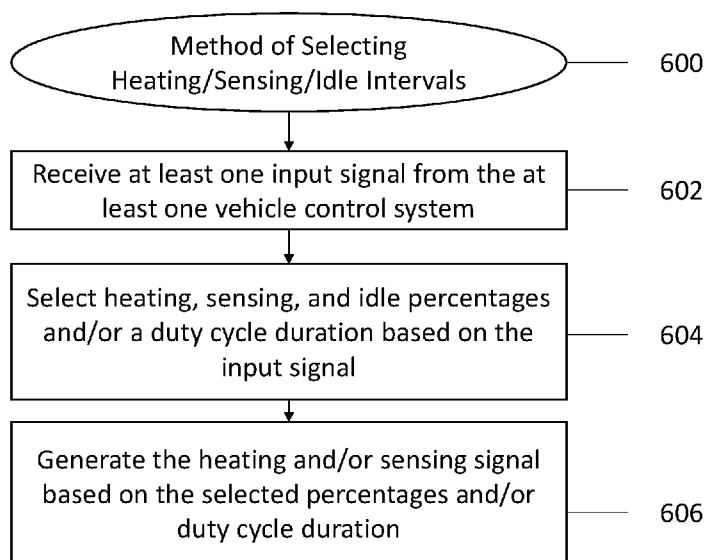


FIG. 6

(57) Abstract: Various implementations include a vehicle component heating system that includes an electrode disposed within a sensing zone, and a processor. The electrode generates heat for a surface of a vehicle component within the sensing zone and senses proximity of an occupant to the sensing zone. The processor selects a heating percentage of a duty cycle for generating a heating signal, a sensing percentage of the duty cycle for generating and measuring a sensing signal and reporting the measured sensing signal, and an idle percentage of the duty cycle during which neither the heating nor the sensing signal is generated, wherein the sum of the heating, sensing, and idle percentages is 100%. The processor generates the heating signal and/or generates and measures the sensing signal and reports the measurement of the sensing signal based on the selected percentages.

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))*
- *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))*

**SYSTEMS AND METHODS FOR HEATING AND SENSING PROXIMITY TO VEHICLE COMPONENTS****CROSS REFERENCE TO PRIOR APPLICATIONS**

This application claims priority to and incorporates entirely by reference co-pending United States  
5 Provisional Patent Application Serial No. 62/506,477 filed on May 15, 2017, and entitled "Systems and  
Methods for Heating and Sensing Proximity to Vehicle Components."

**BACKGROUND**

In colder regions of the world, during colder months, it may be desirable to provide a vehicle  
with heating elements in particular locations (e.g., a vehicle seat, a vehicle steering wheel, etc.) that a  
10 vehicle occupant contacts, so as to provide warmth to the occupant and improve the occupant's driving  
experience. Difficulties may arise when trying to design an occupant sensor system that uses electrodes  
to sense a presence of an occupant that is in relative close proximity to a heating element configured to  
provide warmth to the occupant. For example, without a shield layer positioned between the electrode  
and the heating element, the electrical coupling between the electrode and the heating element may be  
15 greater than the electrical coupling between a vehicle occupant and the electrode. As a result, the  
presence of the occupant may not be reliably determined by the electrode.

Thus, improved systems and methods for sensing proximity to vehicle components, such as  
seats and steering wheels, are needed in the art.

**SUMMARY**

20 Various implementations include a vehicle component heating system that includes a computer,  
at least one electrode, and a processor. The computer controls an electrical power source defining a  
duty cycle for an electrical power signal, and the electrical power signal comprises a heating signal, a  
sensing signal, and an idle period within the duty cycle during which neither a heating signal nor a  
sensing signal is generated. The at least one electrode is connected to the electrical power source and is  
25 disposed within a sensing zone of a vehicle component. The electrode is for generating heat for a  
surface of the vehicle component within the sensing zone in response to receiving the heating signal  
and for sensing proximity of a vehicle occupant to the sensing zone in response to receiving the sensing  
signal. The processor is connected to the computer and is in electrical communication with a memory,  
the electrode, and at least one vehicle control system. The memory stores instructions for controlling  
30 the processor, and the instructions cause the processor to: (1) receive at least one input signal from the  
at least one vehicle control system; (2) based on the at least one input signal from the at least one  
vehicle control system, select a heating percentage of the duty cycle for generating the heating signal, a  
sensing percentage of the duty cycle for generating and measuring the sensing signal and reporting the  
sensing signal measured, and an idle percentage of the duty cycle during which no heating signal or  
35 sensing signal is generated, wherein a sum of the heating, sensing, and idle percentages is 100%; and (3)

generate the heating signal and/or generate and measure the sensing signal and report the sensing signal measured based on the selected percentages.

In some implementations, the instructions further cause the processor to select a duty cycle duration based on the at least one input signal from the at least one vehicle control system, and  
5 generating the heating signal and/or generating and measuring the sensing signal is further based on the selected duty cycle duration.

In some implementations, the selection of the duty cycle duration and/or the percentages of the duty cycle are based on whether the reported sensing signal measurement indicates a change in presence or absence from the sensing zone.

10 In some implementations, the duty cycle duration decreases and/or the sensing percentage increases in response to the reported sensing signal measurement indicating the change in presence or absence from the sensing zone. And, in some implementations, the duty cycle duration increases and/or the heating percentage increases in response to the sensing signal indicating no change in presence or absence from the sensing zone and a temperature of the surface is below a goal  
15 temperature.

In some implementations, the heating percentage decreases as a temperature of the surface of the vehicle component approaches the threshold temperature.

In some implementations, the heating percentage is lower than the sensing percentage in response to the at least one input signal received from the at least one vehicle control system indicating  
20 that an occupant is adjacent the sensing zone and a temperature of the surface of the vehicle component is at or above a threshold temperature and below a goal temperature, wherein the threshold temperature is less than the goal temperature.

In some implementations, the percentages and/or duty cycle duration are selected based on a rate of heating goal for the surface of the vehicle component.

25 In some implementations, the at least one input signal comprises an input indicating a change in a door open/closed condition.

In some implementations, the at least one input signal comprises an input indicating a change in a seat belt buckled/unbuckled condition.

30 In some implementations, the at least one input signal comprises an input indicating a change in a power on/off condition of the vehicle.

In some implementations, the at least one input signal comprises a vehicle speed input that indicates a speed at which the vehicle is traveling.

In some implementations, the at least one input signal comprises an input from a camera-based monitoring system indicating occupant presence/absence within the vehicle.

35 In some implementations, the at least one input signal comprises an input indicating a change in a steering column position.

In some implementations, the at least one input signal comprises an input from an ignition switch, and the input from the ignition switch indicates a change in an ignition switch condition.

In some implementations, the change in the ignition switch condition comprises changing among an on condition, an off condition, an accessory mode condition, or a crank condition.

5 In some implementations, the at least one input signal comprises an input indicating a change in seat position.

In some implementations, the at least one input signal comprises an input indicating depression of a brake pedal.

10 In some implementations, the at least one input signal comprises an input indicating that the vehicle is in autonomous or semi-autonomous driving mode.

In some implementations, the at least one input signal comprises an input indicating that a power on/off condition of the vehicle has been changed remotely.

In some implementations, the at least one input signal comprises an input indicating that a parking assist system has been activated.

15 In some implementations, the at least one input signal comprises an input from a vehicle to vehicle (V2V) communication system.

In some implementations, the at least one input signal comprises an input from a Vehicle-to-Infrastructure (V2I) communication system.

20 In some implementations, the at least one input signal comprises an input indicating that power for the vehicle has been turned on or off remotely.

In some implementations, the electrode is disposed in a steering wheel.

In some implementations, the electrode is disposed in a seat.

25 In some implementations, the sensing zone is a first sensing zone and the electrode is a first electrode, and the system further includes a second electrode that is spaced apart from the first electrode. The second electrode is within a second sensing zone that is spaced apart from the first sensing zone.

In some implementations, the first and second electrodes are disposed on a surface of a substrate.

30 In some implementations, the electrode is a first electrode and the system further includes a second electrode disposed between the first electrode and a frame of the vehicle component. The second electrode is in electrical communication with the processor, and the instructions cause the processor to generate a shielding signal for communicating to the second electrode. The shielding signal reduces parasitic capacitance between the first electrode and the frame of the vehicle component.

35 In some implementations, the instructions further cause the processor to receive a sensing duration value indicating time elapsed between consecutive changes in the reported sensing signal

measurement indicating proximity to the sensing zone, and wherein the selection of the duty cycle and/or percentages of the duty cycle are further based on the sensing duration value.

In various other implementations, a vehicle component heating system may include a computer, at least one electrode, and a processor. The computer controls an electrical power source  
5 defining a duty cycle for an electrical power signal, the electrical power signal including a heating signal, a sensing signal, and an idle period within the duty cycle during which no signal is generated. The at least one electrode is connected to the electrical power source and is disposed within a sensing zone of a vehicle component. The at least one electrode receives the electrical power signal from the electrical power source. The electrode generates heat for a surface of the vehicle component within the sensing  
10 zone in response to receiving the heating signal and senses proximity of a vehicle occupant to the sensing zone in response to receiving the sensing signal. The processor is connected to the computer and is in electrical communication with the electrical power source, a memory, the electrode, and at least one vehicle control system. The memory stores instructions for controlling the processor, and the instructions cause the processor to (1) receive a sensing duration value indicating elapsed time between  
15 consecutive changes in the sensing signal from the electrode and indicating proximity to the sensing zone; (2) based on the sensing duration value received, select a heating percentage of the duty cycle for generating the heating signal, a sensing percentage of the duty cycle for generating and measuring the sensing signal and reporting the measured sensing signal to the memory, and an idle percentage of the duty cycle during which no signal is generated, wherein the sum of the heating, sensing, and idle  
20 percentages is 100%; (3) configure the power source to generate the heating signal and/or the sensing signal according to the selected percentages; and (4) measure the sensing signal and report the sensing signal measured based on the selected percentages.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Features, aspects, and advantages of the present invention will become apparent from the  
25 following description and the accompanying example implementations shown in the drawings, which are briefly described below.

FIG. 1 is a perspective view of a vehicle interior.

FIG. 2 is a schematic front view of a steering wheel including an occupant sensing system which includes a plurality of heater zones, according to an example implementation.

30 FIG. 3 is a schematic diagram of an occupant sensing system having a parallel configuration.

FIG. 4 is a schematic diagram of an occupant sensing system having another parallel configuration.

FIG. 5 is a schematic diagram of an occupant sensing system having a series configuration.

FIG. 6 is a flow chart of selecting a duty cycle duration and/or percentages for generating a  
35 heating signal, generating and measuring a sensing signal and reporting the sensing signal measured, and/or being idle, according to one implementation.

FIG. 7 is a flow chart of selecting a duty cycle duration and/or percentages for generating a heating signal, generating and measuring a sensing signal and reporting the sensing signal measured, and/or being idle, according to another implementation.

FIGS. 8 and 9 illustrate example duty cycles having different percentages and duty cycle durations, according to various implementations.

FIG. 10 is a schematic view of a vehicle component heating system configured to implement computerized instructions of FIG. 6 and FIG. 7.

#### DETAILED DESCRIPTION

It is to be understood that both the foregoing general description and the following detailed description are examples and explanatory only.

Implementations of this disclosure refer to a duty cycle of an electrical power signal generated by an electrical power source, such as, but not limited to a battery subject to computerized control algorithms discussed herein. In one non-limiting example, an electronic control unit or a computer may control the electrical power source (illustrated as a voltage source in Figures 3-5) and be connected to the below-described processors and memory storing relevant software to implement the features of the various implementations. In traditional terms, a duty cycle refers to that percentage of a signal period in which the subject signal has a magnitude other than zero (i.e., when the signal is active). Accordingly, the term “duty cycle” is often, but not always, considered for signals generated at a particular frequency. This disclosure, however, not only includes standard definitions for the term “duty cycle” but also refers to broader considerations. For example, a duty cycle as discussed herein may be composed of percentages of an input electrical power signal that make up one hundred percent (100 %) of a defined cycle of that power signal. The defined cycle may include all desired sequences of any respective magnitudes (including zero magnitude idle periods and any offset voltages) that together define the electrical power signal’s duty cycle duration before the electrical power signal cycle starts over. In one non-limiting example, the duty cycle of the electrical power signal includes respective percentages for a heating signal, an idle time, and a sensing signal, which make up the electrical power signal.

The vehicle component heating system shown in FIG. 10 includes a computer 1000, at least one electrode 18, and a processor 1002. The computer 1000 controls an electrical power source 1010 defining a duty cycle for an electrical power signal. The electrical power signal includes a heating signal, a sensing signal, and an idle period within the duty cycle during which neither a heating nor a sensing signal is generated. In some implementations, no signal may be generated during the idle period. The at least one electrode 18 is connected to the electrical power source 1010 and is disposed within a sensing zone of a vehicle component. The electrode 18 generates heat for a surface of the vehicle component within the sensing zone in response to receiving a heating signal and senses proximity of a vehicle occupant to the sensing zone in response to receiving a sensing signal. The system further

includes a processor 1002 connected to the computer 1000 and in electrical communication with a memory 1004, the electrode 18, and at least one vehicle control system 1020. The memory 1004 stores instructions for controlling the processor 1002, and the instructions cause the processor 1002 to: (1) receive at least one input signal from the at least one vehicle control system 1020 and/or a sensing duration value indicating an elapsed time between consecutive changes in the sensing signal from the electrode 18 and indicating proximity to the sensing zone; (2) select a heating percentage of a duty cycle for generating the heating signal, a sensing percentage of the duty cycle for generating the sensing signal, an idle percentage of the duty cycle during which no heating or sensing signals are generated, and/or a duty cycle duration, wherein the sum of the heating, sensing, and idle percentages is 100%; and (3) generate the heating signal and/or the generate and measure the sensing signal and report the sensing signal measured based on the selected percentages. In some implementations, the instructions also cause the processor 1002 to configure the power source 1010 to generate the heating and/or sensing signals and measure the sensing signal and report the sensing signal measured according to the selected percentages. The computer 1000 may further include clock 1008 and communication hardware 1012. And, the processor 1002 and memory 1004 are components of electronic controller 1006 as shown in FIG. 10, which, in some implementations, is a component of computer 1000.

Similar to the occupant detection systems disclosed in U.S. Published Application Nos. 2007/0192007 and 2014/0151356, the sensing circuit (e.g., the ASIC) could be designed to provide data relating to the change in the complex impedance to detect that an occupant's hand is proximate to a steering wheel or that the occupant's body is proximate to another vehicle component (e.g., a seat). Also, the operation of the heating system could employ the methodology and structural features disclosed in U.S. Pat. No. 7,521,940. These applications and this patent are incorporated by reference herein.

FIG. 1 illustrates an example view of a cockpit of a vehicle cabin. Referring to FIG. 1, a vehicle driver may operate a vehicle from the cockpit (vehicle interior) **10** with a steering wheel **12** and a vehicle seat (e.g., the driver's seat **13**). When sitting on the driver's seat **13**, the driver may rotate the steering wheel **12** to turn the vehicle wheels and steer the vehicle in a desired direction. The steering wheel **12** may also include various controls in the form of switches or buttons provided within easy reach of the driver, such as controls for a vehicle audio system (e.g., volume, tuning, mode, etc.), controls for vehicle lighting (e.g., overhead lighting, headlights, etc.), phone controls, cruise control, or other suitable control. It should be understood by those skilled in the art that the steering wheel **12** may include any combination of the controls disclosed herein, according to various example implementations, and that these configurations are not intended to limit the possible arrangements of controls provided on the steering wheel **12**. For example, elements used in one example implementation may be used in various combinations with elements used in another example implementation.



FIG. 2 illustrates an example steering wheel **12** having a plurality of sensor/heater zones **16**. The steering wheel **12** includes a ring-like outer portion **14**, or rim, and an inner portion **15**, or hub, coupled to a steering column of the vehicle. The outer portion **14** may be formed of a rigid frame or armature, which may be partially or fully covered by an outer layer (e.g., a skin, covering, wrap, etc.). The outer layer may be configured to provide an aesthetically pleasing exterior for the steering wheel **12** and add an ergonomically pleasing layer (i.e., such that the skin improves the ergonomics, feel, grip, etc. of the steering wheel **12**) to an outer surface of the steering wheel **12**. Although a particular steering wheel is described herein, it should be readily understood that a steering wheel system according to the example implementations disclosed herein may have any suitable configuration, and that the particular outer and inner portions are not limiting.

Further, the outer portion **14** of the steering wheel **12** includes one or more sensor/heater zones **16**. The sensor/heater zones **16** are selectively activatable to warm the hands of the driver or sense proximity of the hands to the respective sensor/heater zone **16**. It should be understood that the number, location, and configuration of the sensor/heater zones **16** shown in the figures are examples and are not intended to limit the possible various configurations of sensor/heater zones provided on a steering wheel. For example, the steering wheel **12** may include one or more electrodes **18** to provide one or more corresponding sensor/heater zones **16**. The sensor/heater zones **16** may be provided in any suitable place on the steering wheel **12** (e.g., along the outer portion **14** or on the inner portion **15**). And, as noted above, the sensor/heater zones **16** may be provided in any suitable place on another vehicle component, such as seat **13**.

FIG. 3 illustrates a schematic diagram of a vehicle component heating system **20** according to one implementation. The system **20** includes an electrode **18** (e.g., a heating element), which is disposed within each sensor/heater zone **16**. The system **20** may include any suitable number of such electrodes positioned within any suitable number of sensor/heater zones. The electrode **18** may be used to provide warmth for a vehicle occupant when a heating signal is supplied to the electrode (e.g., the electrode may generate heat that is transferred to the occupant's hands). Further, the electrode **18** may be used to determine the proximity of a hand of an occupant of the vehicle to the sensing zone when a sensing signal is supplied to the electrode **18**. The heating signal may carry a higher current relative to the sensing signal. In this manner, the electrode **18** is cooperatively configured to be used as a sensor and a heater. Thus, the electrode **18** may alleviate the costs and the packaging difficulties associated with adding a separate sensor and shield over a top of a heating element for a heater zone.

The electrode **18** may be coupled to a vehicle power supply (e.g., the vehicle's DC bus which may be supplied power by a battery or alternator, for example). Further, the vehicle power supply may be used to supply the heating signal to the electrode. The system **20** may further include a variety of controls, sensors, and other elements used to control or regulate the heating signal, so as to control the

temperature of the heater zone (so the vehicle component being heated (e.g., a steering wheel **12** or seat **13**) does not overheat).

According to an example implementation, an electronic controller, or processor, of system **20** controls whether the sensing signal, the heating signal, or no signal is supplied to the electrode **18**. In one example implementation, a computer controlled voltage is applied to the electrode **18** as an electric power signal from an electric power source to achieve the purposes of this disclosure, and an application of each signal supplied based on the proximity of the occupant's body to a sensor/heater zone **16**. For example, according to an example implementation in which the electrode **18** is disposed within a sensor/heater zone **16** of steering wheel **12**, the controller may not supply the heating signal to the electrode **18** until or unless a hand is detected in proximity to the sensor/heater zone **16**. In other words, the system **20** may be configured to automatically supply a heating signal to the electrode **18** when a body part is sensed to be proximate to the sensor/heater zone **16**.

According to an example implementation, the controller supplies the heating signal and the sensing signal to the electrode **18** on an alternating basis at a pre-determined time interval. Further, the heating and sensing signals may be time-multiplexed between multiple electrodes, according to how multiple electrodes are arranged in the system **20** (e.g., whether multiple electrodes are arranged in parallel or series).

The system **20** may include a variety of solid state components positioned in-line with the electrode **18**. The solid state components switch between a high impedance in a sensing mode and a low impedance in a heating mode. The solid-state components may include, but are not limited to, transistors, such as MOSFETS, that can be configured as high side drivers and low side drivers. The solid state components may have any suitable impedance at the sensing frequency in the sensing mode and at the heating frequency in the heating mode. A switch load may be used in the sensing mode to calibrate the electrode. According to an example implementation, a driven shield signal may be imposed to shield a sensing signal from the inductors. Further, a multi-measurement approach may be utilized which may involve applying multiple driven shield signal levels to the shielded nodes and switching in impedance between the sensor and shield nodes. In this way, an error caused by (e.g., resulting from, attributed to, etc.) the configuration of inductors (e.g., the measurement architecture) may be reduced, cancelled, lessened, etc.

FIGS. 3-5 illustrate various architectural examples of system **20**. The examples include the high-side and low-side MOSFETs and other solid state switching components, which are shown as switches **26a**, **26b**, respectively. Further, the system **20** includes high current switches **24** as an additional impedance source or inductor between the switches **26** for the electrodes **18** and the sensing nodes **28**. However, as described above, in alternative example implementations, an impedance source is not limited to any particular solid state switching components and may include other FETs or any other suitable element having an appropriate impedance.

With reference to FIG. 3, the system **20** is shown as having a parallel heating setup in which the sensing and heating is time multiplexed. As shown in FIG. 3, the system **20** may include a high-side switch **26a** and a low-side switch **26b** for multiple heater zones **16a**, **16b**. Such a parallel heating setup may reduce the complexity and cost of the system **20**. Further, each sensor/heater zone **16a**, **16b** may include an isolation impedance source (i.e., an inductor), shown as switch **24**, on either side of the electrode **18**. As shown in FIG. 3, the system **20** may be configured to sense the presence of a vehicle occupant when heating is off for all sensor/heater zones **16a**, **16b**. It should be understood by those skilled in the art that, although two sensor/heater zones **16a**, **16b** are shown in FIG. 3, the system **20** could be configured to include any number of sensor/heater zones.

Referring now to FIG. 4, the system **20'** may include a parallel heating setup in which an occupant sensing function and a heating function are time-multiplexed for individual sensing/heating zones. For example, the system **20'** shown in FIG. 4 is configured to simultaneously sense the presence of an occupant in a first sensor/heater zone **16a'** and/or provide warmth/heat in a second sensor/heater zone **16b'**. After a specified period of time, the first and second sensor/heater zones **16a'**, **16b'** may alternate (i.e., switch) functions, such that the system **20'** is configured to simultaneously sense the presence of an occupant in the second sensor/heater zone **16b'** and provide warmth/heat in the first sensor/heater zone **16a'**. A high-side switch **26a'** and a low-side switch **26b'** is provided for each of the sensor/heater zones **16a'**, **16b'**. It should be understood by those skilled in the art that, although two sensor/heater zones **16'** are shown in FIG. 4, the system **20'** could be configured to include any number of sensor/heater zones.

Referring now to FIG. 5, the system **20''** may include a series heating setup in which an occupant sensing function and a heating function are time-multiplexed. The system **20''**, as shown in FIG. 5, may include appropriate solid state switches, including but not limited to, a high-side switch **26a''** and a low-side switch **26b''**. Further, the sensor system **20''** shown in FIG. 5 may include less isolation impedance sources (e.g., switches **24''**) when compared to a parallel design (e.g., as described above and shown in FIGS. 3-4). Thus, the cost of a system (e.g., system **20''**) having a series design may be less than a system (e.g., system **20**, **20'**) having a parallel design. Further, as shown in FIG. 5, the sensor system **20''** having a series design may sense the presence of an occupant in a single sensor/heater zone **16''** if a heating function for each heater zone **16''** is off. It should be understood by those skilled in the art that, while three sensor/heater zones **16''** are shown in FIG. 5, the sensor system **20''** could be configured to include any number of sensor/heater zones.

With any of the above described systems **20**, **20'**, **20''**, the processor **22**, **22'**, **22''** is in electrical communication with a memory, the electrode **18**, **18'**, **18''**, and at least one vehicle control system **23**, **23'**, **23''**. The memory stores instructions for controlling the processor **22**, **22'**, **22''** such as, for example, instructions configured to implement the flow charts of FIG. 6 and FIG. 7. FIG. 6 illustrates a method of selecting heating, sensing, and idle intervals, which may be executed by the processor **22**, **22'**, **22''**.

The method **600** begins at step **602** with receiving at least one input signal from the at least one vehicle control system **23, 23', 23''**. Then, at step **604**, a heating percentage of a duty cycle for generating the heating signal, a sensing percentage of the duty cycle for generating and measuring the sensing signal and reporting the sensing signal measured, an idle percentage of the duty cycle during which the heating and sensing signal are not generated (e.g., no signal is generated), and/or a duty cycle duration are selected based on the at least one input signal from the at least one vehicle control system **23, 23', 23''**. The sum of the heating, sensing, and idle percentages is 100% of a defined duty cycle for an overall electrical power signal used to accommodate heating and sensing pursuant to the circuits and computerized control algorithms described herein. The duty cycle of the electric power signal is variable over time for different conditions, as determined, at least in part, by the input signal from the at least one vehicle control system **23, 23', 23''**. The duration of the duty cycle may be pre-set, selected based on the at least one input signal, or based on a change in and/or duration of the sensing measurement. Then, in step **606**, the time that the heating signal is generated and/or the time that the sensing signal is generated and measured and the measurement is reported is based on the selected percentages and/or the duty cycle duration.

The duty cycle is may be considered a time period in which an entire series of various signal magnitudes (including zero magnitude) is completed. The time period (referred to as a "duty cycle duration") is divided into portions during which the processor **22, 22', 22''** generates a heating signal (referred to as "heating percentage"), generates and measures a sensing signal and reports the sensing signal (referred to collectively as "sensing percentage"), and/or is idle (referred to as "idle percentage"). The sum of the percentages of the time period for heating, sensing, and being idle is 100%, and each of the heating, sensing, and idle percentages can be between 0% and 100% of the duty cycle duration. The heating signal and the sensing signal may have either the same or different magnitudes appropriate for the conditions at hand, and the idle portion of the duty cycle may be periods of zero magnitude or another constant magnitude that denotes an off. For example, the duty cycle may have a duty cycle duration of between 100 ms and 4 seconds, according to some implementations. Nothing in this disclosure limits the portions of a duty cycle to any particular number, type, or use for a given electric power signal, and the duty cycle may include percentages for additional portions therein having respective magnitudes necessary for a particular purpose.

According to some implementations, the selection of the duty cycle duration and/or the percentages of the duty cycle is based on the measurement of the sensing signal and whether the measurement of the sensing signal received from the electrode **18** indicates a change in presence or absence from the respective sensor/heater zone **16**. For example, in certain implementations, the duty cycle duration is decreased and/or the sensing percentage increases in response to the measurement of the sensing signal indicating a change in presence or absence from the sensor/heater zone **16**. And, the duty cycle duration increases and/or the heating percentage increases in response to the measurement

of the sensing signal indicating no change in presence or absence from the heater/sensor zone and a temperature of the surface is below a goal temperature.

For example, the sensing signal measured and reported in a subsequent duty cycle from the electrode **18** changes from the sensing signal measured and reported in a previous duty cycle when the occupant's body changes from being present or away from the vehicle component. For example, if an occupant touches and then does not touch the steering wheel (or vice versa) during consecutive duty cycles, the sensing signal measured and reported indicates a change in presence or absence. However, if the occupant continues to touch or continue to not touch the vehicle component during consecutive duty cycles, the sensing signal measured and reported does not indicate a change (or a change greater than a certain threshold to indicate a change in presence or absence) in the sensing signal measured from consecutive duty cycles. In response to detecting a change in the sensing signal measured and reported, the processor selects a shorter duty cycle duration and/or increases the sensing percentage to generate and measure the sensing signal and report the measurement more frequently. When the processor no longer detects a change in the sensing signal measurement, the processor increases the duty cycle duration and/or decreases the sensing percentage.

In addition, in some implementations, the system selects the heating, sensing, and idle percentages of the duty cycle and/or the duty cycle duration based on the sensing duration value indicating the time elapsed between consecutive changes in the sensing signal measurement that indicates a change in presence or absence. For example, FIG. 7 illustrates a method of selecting heating, sensing, and idle percentages, which may be executed by the processor **22**, **22'**, **22''**. The method **700** begins at step **702** with receiving a sensing duration value indicating elapsed time between consecutive changes in the sensing signal and indicating proximity to the sensing zone. Then, at step **704**, a heating percentage, a sensing percentage, an idle percentage and/or a duty cycle duration are selected based on the sensing duration value. Then, in step **706**, the power source is configured for generating the heating signal and/or the sensing signal according to the selected percentages. In step **708**, the sensing signal is measured and the measured sensing signal is reported. For example, in some implementations, the heating percentage and/or duty cycle duration increases as the sensing duration value increases. The increase in the sensing duration value indicates more consistent presence or absence, which provides an opportunity to generate the heating signal for a greater time period than when the presence or absence status is changing more frequently. If the sensing duration value reaches a predetermined threshold, the heating percentage may be increased and the sensing percentage and/or idle percentage decreased. The duty cycle duration may be increased also. For example, the heating and sensing percentages may be set at 40% and the idle percentage set to 20% for a 100 ms duty cycle duration during more consistent sensor signal measurements, which indicates a more consistent presence/absence status. These settings result in the generation of the heating signal for 40 ms, generation and measurement of the sensing signal and reporting of the measurement for 40 ms,

and no signal generated for 20 ms. Nothing in this or other examples, limits the order of any heating signal, sensing signal, or idle time for any implementation of this disclosure. Also, if the sensing duration value between the change in sensor signal measurements reaches or crosses the predetermined threshold, the heating percentage may be increased to 80%, the sensing percentage  
5 decreased to 5%, and the idle percentage is decreased to 15%, and the duty cycle duration is increased to 1 second, which is shown in FIG. 8.

In addition, the predetermined threshold, relative percentages, and/or duty cycle durations can be set at installation or thereafter. In this implementation, the predetermined threshold is a time-based threshold (such as milliseconds, seconds, minutes, etc.). However, in other implementations, the  
10 predetermined threshold may be a level of the sensing signal (e.g., occupant detection coupling to ground) or an amount of change (delta) in the level of the sensing signal.

As another example, in some implementations, the heating percentage decreases as a temperature of the surface of the vehicle component increases. For example, in some implementations, the heating percentage is higher than the sensing and/or idle percentages when the  
15 at least one input received from the at least one vehicle control system indicates that an occupant is adjacent the sensor/heater zone 16 and a temperature of the surface of the vehicle component is below a threshold temperature. For example, the heating percentage may be 90%, the sensing percentage 10%, and the idle percentage 0% under these conditions. Under this scenario, for a duty cycle duration of 1 second, the processor generates a heating signal for 900 ms and generates and measures a sensing  
20 signal and reports the measurement for 100 ms of the duty cycle. For a duty cycle duration of 4 seconds, the processor generates a heating signal for 3600 ms and generates and measures a sensing signal and reports the measurement for 400 ms of the duty cycle. And, as another example, as shown in FIG. 9, the duty cycle duration is decreased to 10 ms, the sensing percentage is set to 60%, the idle percentage is set to 30%, and the heating percentage is set to 10%. In the duty cycle shown in FIG. 9,  
25 the sensing signal is generated first, then no signal is generated, then the heating signal is generated. However, in other implementations, the order in which the heating and sensing signals are generated and the idle time within the duty cycle duration may be different. As the temperature of the surface of the vehicle component increases to be above the threshold temperature (but below a goal temperature), the heating percentage decreases. The threshold temperature is less than the goal  
30 temperature, and the goal temperature is the temperature that the vehicle component is intended to reach. Once the goal temperature is reached, the heating percentage and idle percentage may be set to 0% and the sensing percentage may be set to 100%. As another example, the heating percentage may be set to 0%, and the sensing and idle percentages may be set to between 0% and 100% (e.g., 80% sensing and 20% idle, or 100% sensing and 0% idle).

35 In additional or further implementations, the heating, sensing, and/or idle percentages and/or duration of the duty cycle are selected based on a rate of heating goal for the surface of the vehicle

component. A rate of heating goal indicates the change in temperature over time expected for the vehicle component and/or the maximum time expected for the vehicle component to reach the goal temperature. In some implementations, the heating percentage decreases as the temperature of the surface of the vehicle component approaches the threshold and/or goal temperatures. For example, in some implementations, the percentages selected allow the system to generate the heating signal sufficiently to heat the vehicle component to the goal temperature within the maximum time expected.

The relative percentages of the duty cycle and/or the duty cycle duration may be selected based on secondary input received by the processor from various vehicle control systems. For example, inputs that may result in an increase in the sensing percentage or the duty cycle duration may include an input indicating that an occupant has entered or is within the vehicle cabin. For example, the input may include an input indicating a change in a door open/closed condition (e.g., from a door sensor system), an input indicating a change in a seat belt buckled/unbuckled condition (e.g., from a seat belt sensor system), a vehicle speed input that indicates a speed at which the vehicle is traveling (e.g., from a vehicle speed sensor system), an input from an camera-based system indicating occupant presence/absence within the vehicle, an input indicating a change in a steering column position (e.g., from a steering sensor system), an input from an ignition switch indicating a change in an ignition switch condition (e.g., changing among an on condition, an off condition, an accessory mode condition, or a crank condition), an input indicating a change in seat position (e.g., from a seat position sensing system), an input indicating depression of a brake pedal (e.g., from a brake pedal sensor system), an input indicating that the vehicle is in autonomous or semi-autonomous driving mode (e.g., from an operation mode system), an input that a parking assist system has been activated, input from vehicle to vehicle (V2V) communication system, or an input from a Vehicle-to-Infrastructure (V2I) communication system. For situations when at least one input signal comprises an input indicating that the vehicle is in autonomous or semi-autonomous driving mode, it is noted that semi-autonomous or autonomous driving mode indicates a driving state wherein the vehicle operates, at least partially, without requiring certain occupant inputs. For example, semi-autonomous or autonomous driving mode includes operating modes in which the vehicle operates without requiring an occupant to contact the steering wheel, accelerator, brake, and/or components and accessories used to change lanes while driving. For example, semi-autonomous or autonomous driving modes may include SAE levels 1-5 of SAE International Standard J3016.

Implementations of this disclosure further include apparatuses as illustrated in FIG. 10 such as a computer **1000** controlling an electrical power source **1010** and defining a duty cycle for an electrical power signal, the electrical power signal comprising a heating signal, a sensing signal, and an idle period within the duty cycle during which neither a heating signal nor a sensing signal is generated. The computer **1000** is configured to be in a data connection with at least one electrode via communication hardware **1012** connected to the electrical power source and disposed within a sensing zone of a vehicle

component and receiving the electrical power signal from the electrical power source, the electrode for generating heat for a surface of the vehicle component within the sensing zone in response to receiving a heating signal and for sensing proximity of a vehicle occupant to the sensing zone in response to receiving a sensing signal. The computer may include or be configured for connecting to a processor in electrical communication with the electrical power source **1010**, a memory **1004**, the electrode **18**, and at least one vehicle control system **1020**. The memory stores instructions for controlling the processor, and the instructions causing the processor to: (1) receive a sensing duration value indicating elapsed time between consecutive changes in the sensing signal from the electrode and indicating proximity to the sensing zone; (2) based on the sensing duration value received, select a heating percentage of the duty cycle for generating the heating signal, a sensing percentage of the duty cycle for generating and measuring the sensing signal and reporting the measured sensing signal to the memory, and an idle percentage of the duty cycle during which no heating signal or sensing signal is generated, wherein the sum of the heating, sensing, and idle percentages is 100%; and (3) configure the power source to generate the heating signal and/or the sensing signal according to the selected percentages; and (4) measure the sensing signal and report the sensing signal measured based on the selected percentages.

Other types of inputs that may be used to determine the percentages and/or the duty cycle duration include input indicating a change in a power on/off condition (e.g., battery or engine on/off condition) or input indicating that the power to the vehicle has been turned on or off remotely (e.g., from a remote power on/off system). The inputs may be tailored for any type of vehicle, regardless of the type of propulsion system, such as internal combustion engine (ICE) cars, electric cars, and combinations thereof.

As another example, the heating percentage and/or the duty cycle duration may be increased in response to receiving input that indicates sensing is not a critical task and heating can take priority, such as when the vehicle is stationary, when the speed of the vehicle is less than a threshold speed, when the temperature of a heated vehicle component or when the interior temperature of the vehicle is below a threshold temperature, or when the operator is not detected to be within the vehicle. For example, if the input from the vehicle control system indicates that the power has been started remotely and no input has been received indicating that the occupant has entered the vehicle, the heating percentage of the duty cycle for generating the heating signal provided to each electrode **18** in the steering wheel **12** may be selected to be 100% since no sensing function is needed. When an occupant enters the vehicle, as indicated by input from another vehicle control system, the processor decreases the heating percentage to allow the system to sense if/when the occupant touches the steering wheel **12**.

In addition, the electrodes **18** may be disposed on a substrate, such as a mat. The electrodes may be disposed on the same or different sides of the substrate, according to some implementations. Furthermore, in some implementations, the system **20** may further include a shielding electrode disposed between the electrode **18** for the sensor/heater zone and a frame of the vehicle component.



The shielding electrode is in electrical communication with the processor, and the instructions cause the processor to generate a shielding signal for communicating to the shielding electrode. The shielding signal prevents parasitic capacitance between the electrode **18** and the frame of the vehicle component.

5           For purposes of this disclosure, the term “coupled” means the joining of two components (electrical, mechanical, or magnetic) directly or indirectly to one another. Such joining may be stationary in nature or movable in nature. Such joining may be achieved with the two components (electrical or mechanical) and any additional intermediate members being integrally defined as a single unitary body with one another or with the two components or the two components and any additional member  
10   being attached to one another. Such joining may be permanent in nature or alternatively may be removable or releasable in nature.

          The present disclosure has been described with reference to example implementations, however persons skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the disclosed subject matter. For example, although different  
15   example implementations may have been described as including one or more features providing one or more benefits, it is contemplated that the described features may be interchanged with one another or alternatively be combined with one another in the described example implementations or in other alternative implementations. Because the technology of the present disclosure is complex, not all changes in the technology are foreseeable. The present disclosure described with reference to the  
20   example implementations is manifestly intended to be as broad as possible. For example, unless specifically otherwise noted, the example implementations reciting a single particular element also encompass a plurality of such particular elements.

          Example implementations may include program products comprising computer or machine-readable media for carrying or having machine-executable instructions or data structures stored  
25   thereon. For example, the sensors and heating elements may be computer driven. Example implementations illustrated in the methods of the figures may be controlled by program products comprising computer or machine-readable media for carrying or having machine-executable instructions or data structures stored thereon. Such computer or machine-readable media can be any available media which can be accessed by a general purpose or special purpose computer or other  
30   machine with a processor. By way of example, such computer or machine-readable media can comprise RAM, ROM, EPROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to carry or store desired program code in the form of machine-executable instructions or data structures and which can be accessed by a general purpose or special purpose computer or other machine with a processor. Combinations of the  
35   above are also included within the scope of computer or machine-readable media. Computer or machine-executable instructions comprise, for example, instructions and data which cause a general

purpose computer, special purpose computer, or special purpose processing machines to perform a certain function or group of functions. Software implementations of the present disclosure could be accomplished with standard programming techniques with rule based logic and other logic to accomplish the various connection steps, processing steps, comparison steps and decision steps.

5           It is also important to note that the construction and arrangement of the elements of the system as shown in the preferred and other example implementations is illustrative only. Although only a certain number of implementations have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of  
10 parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited. For example, elements shown as integrally formed may be constructed of multiple parts or elements shown as multiple parts may be integrally formed, the operation of the assemblies may be reversed or otherwise varied, the length or width of the structures and/or members or connectors or other elements of the  
15 system may be varied, the nature or number of adjustment or attachment positions provided between the elements may be varied. It should be noted that the elements and/or assemblies of the system may be constructed from any of a wide variety of materials that provide sufficient strength or durability. Accordingly, all such modifications are intended to be included within the scope of the present disclosure. The order or sequence of any process or method steps may be varied or re-sequenced  
20 according to alternative implementations. Other substitutions, modifications, changes and omissions may be made in the design, operating conditions and arrangement of the preferred and other example implementations without departing from the spirit of the present subject matter.

## CLAIMS

## 1. A vehicle component heating system comprising:

a computer controlling an electrical power source defining a duty cycle for an electrical power signal, the electrical power signal comprising a heating signal, a sensing signal, and an idle period within the duty cycle during which neither a heating signal nor a sensing signal is generated;

at least one electrode connected to the electrical power source and disposed within a sensing zone of a vehicle component, the electrode for generating heat for a surface of the vehicle component within the sensing zone in response to receiving the heating signal and for sensing proximity of a vehicle occupant to the sensing zone in response to receiving the sensing signal; and

a processor connected to the computer and in electrical communication with a memory, the electrode, and at least one vehicle control system, the memory storing instructions for controlling the processor, the instructions causing the processor to:

receive at least one input signal from the at least one vehicle control system;

based on the at least one input signal from the at least one vehicle control system, select a heating percentage of the duty cycle for generating the heating signal, a sensing percentage of the duty cycle for generating and measuring the sensing signal and reporting the sensing signal measured, and an idle percentage of the duty cycle during which no heating signal or sensing signal is generated, wherein a sum of the heating, sensing, and idle percentages is 100%; and

generate the heating signal and/or generate and measure the sensing signal and report the sensing signal measured based on the selected percentages.

2. The vehicle component heating system of Claim 1, wherein the instructions further cause the processor to select a duty cycle duration based on the at least one input signal from the at least one vehicle control system, and generating the heating signal and/or generating and measuring the sensing signal and reporting the sensing signal measured is further based on the selected duty cycle duration.

3. The vehicle component heating system of Claim 2, wherein the selection of the duty cycle duration and/or the heating, sensing, and idle percentages of the duty cycle are based on whether the reported sensing signal measurement indicates a change in presence or absence from the sensing zone.

4. The vehicle component heating system of Claim 3, wherein the duty cycle duration decreases and/or the sensing percentage increases in response to the reported sensing signal measurement indicating the change in presence or absence from the sensing zone.
5. The vehicle component heating system of Claim 3, wherein the duty cycle duration increases and/or the heating percentage increases in response to the reported sensing signal measurement indicating no change in presence or absence from the sensing zone and a temperature of the surface is below a goal temperature.
6. The vehicle component heating system of Claim 1, wherein the heating percentage decreases as a temperature of the surface of the vehicle component increases.
7. The vehicle component heating system of Claim 1, wherein the heating percentage is higher than the sensing percentage in response to the at least one input signal received from the at least one vehicle control system indicating that an occupant is adjacent the sensing zone and a temperature of the surface of the vehicle component is below a threshold temperature.
8. The vehicle component heating system of Claim 7, wherein the heating percentage decreases as the temperature of the surface of the vehicle component approaches the threshold temperature.
9. The vehicle component heating system of Claim 1, wherein the heating percentage is lower than the sensing percentage in response to the at least one input signal received from the at least one vehicle control system indicating that an occupant is adjacent the sensing zone and a temperature of the surface of the vehicle component is at or above a threshold temperature and below a goal temperature, the threshold temperature being less than the goal temperature.
10. The vehicle component heating system of Claim 1, wherein the percentages and/or duty cycle are selected based on a rate of heating goal for the surface of the vehicle component.
11. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input indicating a change in a door open/closed condition.
12. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input indicating a change in a seat belt buckled/unbuckled condition.

13. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input indicating a change in a vehicle power on/off condition.

14. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises a vehicle speed input that indicates a speed at which the vehicle is traveling.

15. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input from a camera-based monitoring system indicating occupant presence/absence within the vehicle.

16. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input indicating a change in a steering column position.

17. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input from an ignition switch, the input from the ignition switch indicating a change in an ignition switch condition.

18. The vehicle component heating system of Claim 17, wherein the change in the ignition switch condition comprises changing among an on condition, an off condition, an accessory mode condition, or a crank condition.

19. The vehicle component heating system of Claim 1 wherein the at least one input signal comprises an input indicating a change in seat position.

20. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input indicating depression of a brake pedal.

21. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input indicating that the vehicle is in autonomous or semi-autonomous driving mode.

22. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input indicating that a parking assist system has been activated.

23. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input from a vehicle to vehicle (V2V) communication system.

24. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input from a Vehicle-to-Infrastructure (V2I) communication system.

25. The vehicle component heating system of Claim 1, wherein the at least one input signal comprises an input indicating that power for the vehicle has been turned on or off remotely.

26. The vehicle component heating system of Claim 1, wherein the electrode is disposed in a steering wheel.

27. The vehicle component heating system of Claim 1, wherein the electrode is disposed in a seat.

28. The vehicle component heating system of Claim 1, wherein the sensing zone is a first sensing zone and the electrode is a first electrode, and the system further comprising a second electrode that is spaced apart from the first electrode, the second electrode being within a second sensing zone that is spaced apart from the first sensing zone.

29. The vehicle component heating system of Claim 28, wherein the first and second electrodes are disposed on a surface of a substrate.

30. The vehicle component heating system of Claim 1, wherein the electrode is a first electrode and the system further comprises a second electrode disposed between the first electrode and a frame of the vehicle component, the second electrode being in electrical communication with the processor, and the instructions causing the processor to generate a shielding signal for communicating to the second electrode, the shielding signal preventing parasitic capacitance between the first electrode and the frame of the vehicle component.

31. The vehicle component of Claim 1, wherein the instructions further cause the processor to receive a sensing duration value indicating time elapsed between consecutive changes in the reported sensing signal measurement indicating proximity to the sensing zone, and wherein the selection of the duty cycle and/or percentages of the duty cycle are further based on the sensing duration value.

32. A vehicle component heating system comprising:

a computer controlling an electrical power source defining a duty cycle for an electrical power signal, the electrical power signal comprising a heating signal, a sensing signal, and an idle period within the duty cycle during which no signal is generated;

at least one electrode connected to the electrical power source and disposed within a sensing zone of a vehicle component and receiving the electrical power signal from the electrical power source, the electrode for generating heat for a surface of the vehicle component within the sensing zone in response to receiving a heating signal and for sensing proximity of a vehicle occupant to the sensing zone in response to receiving a sensing signal; and

a processor in electrical communication with the electrical power source, a memory, the electrode, and at least one vehicle control system, the memory storing instructions for controlling the processor, the instructions causing the processor to:

receive a sensing duration value indicating elapsed time between consecutive changes in the sensing signal from the electrode and indicating proximity to the sensing zone;

based on the sensing duration value received, select a heating percentage of the duty cycle for generating the heating signal, a sensing percentage of the duty cycle for generating and measuring the sensing signal and reporting the measured sensing signal to the memory, and an idle percentage of the duty cycle during which no signal is generated, wherein the sum of the heating, sensing, and idle percentages is 100%; and

configure the power source to generate the heating signal and/or the sensing signal according to the selected percentages; and

measure the sensing signal and report the sensing signal measured.

33. The vehicle component heating system of Claim 32, wherein the instructions further cause the processor to select a duty cycle duration based on the sensing duration value indicating time elapsed between consecutive changes in the reported sensing signal measuring proximity to the sensing zone, and the heating, sensing, and idle percentages are further based on the selected duty cycle duration.

34. The vehicle component heating system of claim 33, wherein the selection of the duration and/or the percentages of the duty cycle are based on whether the reported sensing signal measurement indicates a change in presence or absence from the sensing zone.

35. The vehicle component heating system of Claim 33, wherein the duty cycle duration decreases and/or the sensing percentage increases in response to the reported sensing signal measurement indicating the change in presence or absence from the sensing zone.

36. The vehicle component heating system of Claim 33, wherein the duty cycle duration increases and/or the heating percentage increases in response to the reported sensing signal measurement indicating no change in presence or absence from the sensing zone and a temperature of the surface is below a goal temperature.

37. The vehicle component heating system of claim 32, wherein the heating percentage decreases as a temperature of the surface of the vehicle component increases.

38. The vehicle component heating system of claim 32, wherein the heating percentage is higher than the sensing percentage in response to the reported sensing signal measurement indicating that an occupant is adjacent the sensing zone and a temperature of the surface of the vehicle component is below a threshold temperature.

39. The vehicle component heating system of Claim 38, wherein the heating percentage decreases as the temperature of the surface of the vehicle component approaches the threshold temperature.

40. The vehicle component heating system of claim 32, wherein the heating percentage is lower than the sensing percentage in response to the reported sensing signal measurement indicating that an occupant is adjacent the sensing zone and a temperature of the surface of the vehicle component is at or above a threshold temperature and below a goal temperature, the threshold temperature being less than the goal temperature.

41. The vehicle component heating system of claim 33, wherein the heating and sensing percentages and/or duty cycle duration are selected based on a rate of heating goal for the surface of the vehicle component.

42. The vehicle component heating system of claim 32, wherein the electrode is disposed in a steering wheel.

43. The vehicle component heating system of claim 32, wherein the electrode is disposed in a seat.

44. The vehicle component heating system of claim 32, wherein the sensing zone is a first sensing zone and the electrode is a first electrode, and the system further comprising a second electrode that is spaced apart from the first electrode, the second electrode being within a second sensing zone that is spaced apart from the first sensing zone.

45. The vehicle component heating system of Claim 44, wherein the first and second electrodes are disposed on a surface of a substrate.

46. The vehicle component heating system of Claim 32, wherein the electrode is a first electrode and the system further comprises a second electrode disposed between the first electrode and a frame of



the vehicle component, the second electrode being in electrical communication with the processor, and the instructions causing the processor to generate a shielding signal for communicating to the second electrode, the shielding signal preventing parasitic capacitance between the first electrode and the frame of the vehicle component.

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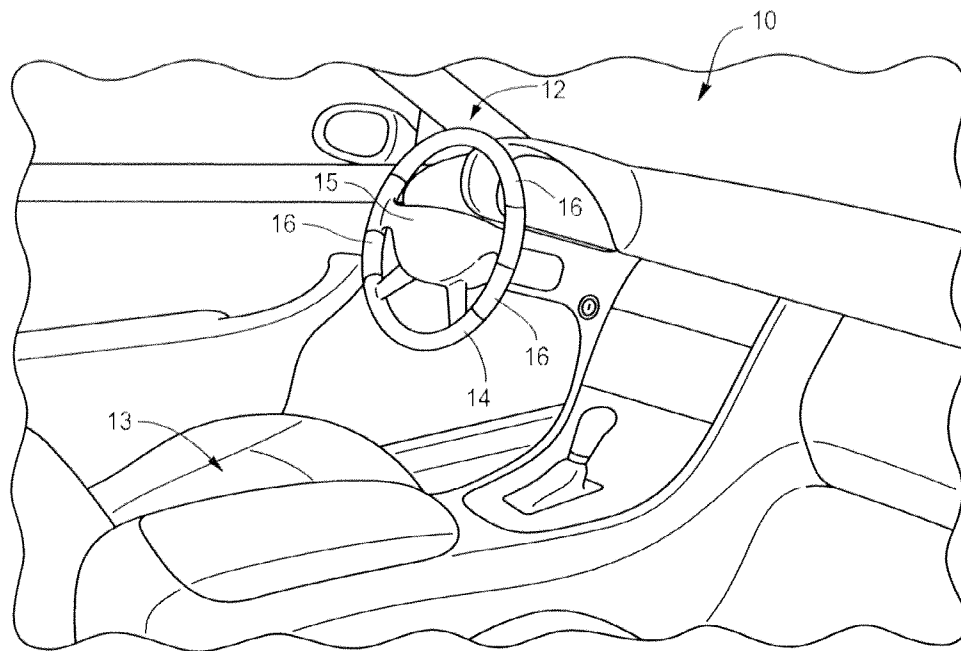


FIG. 1

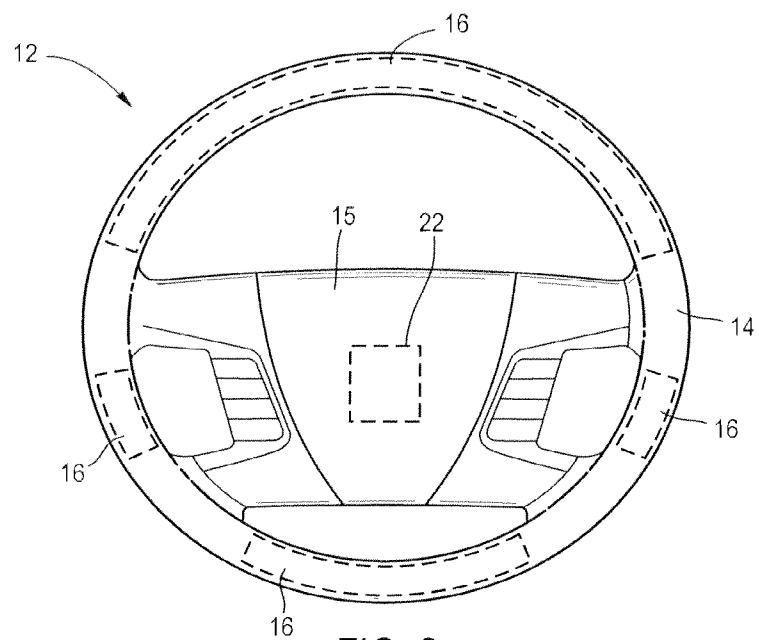


FIG. 2

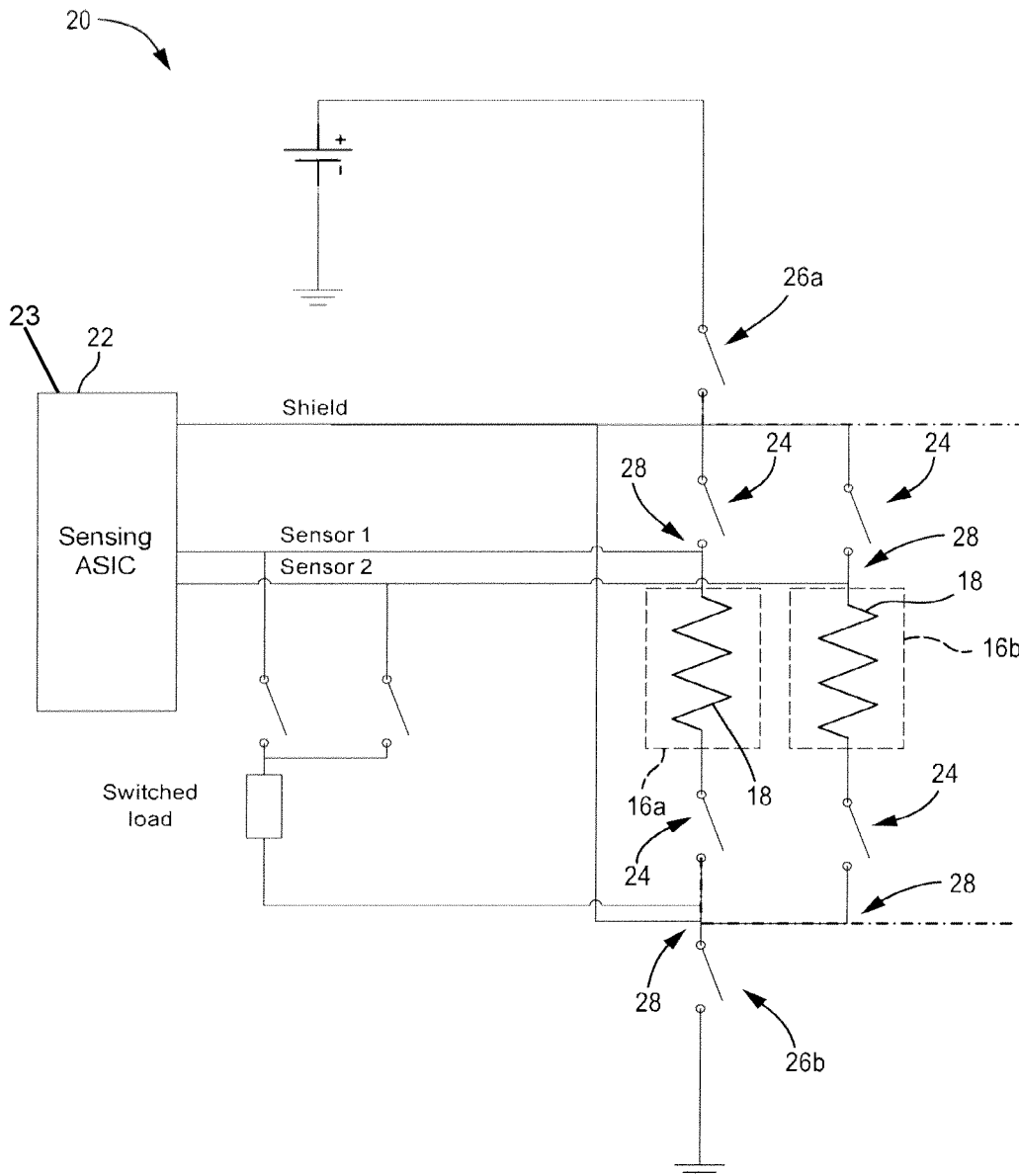


FIG. 3

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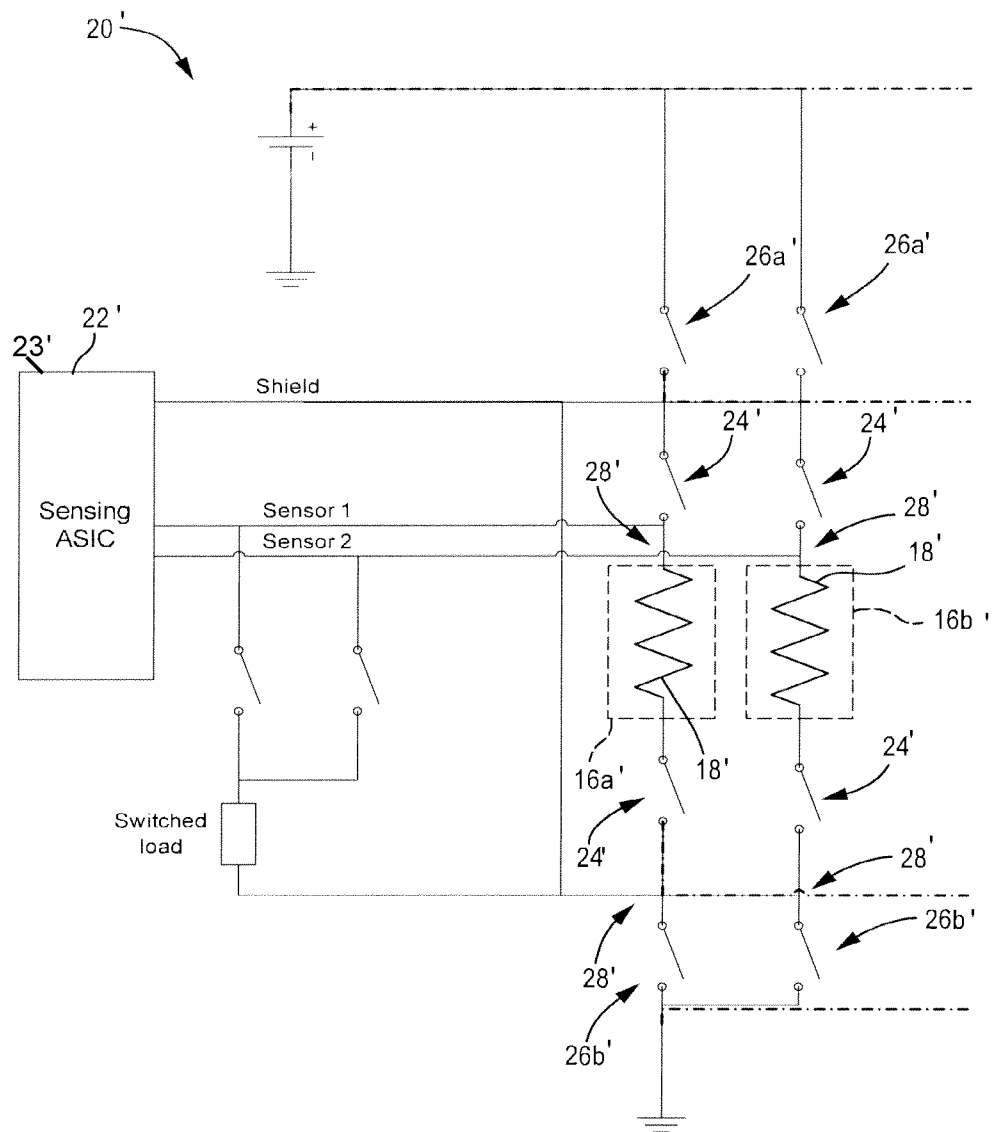


FIG. 4

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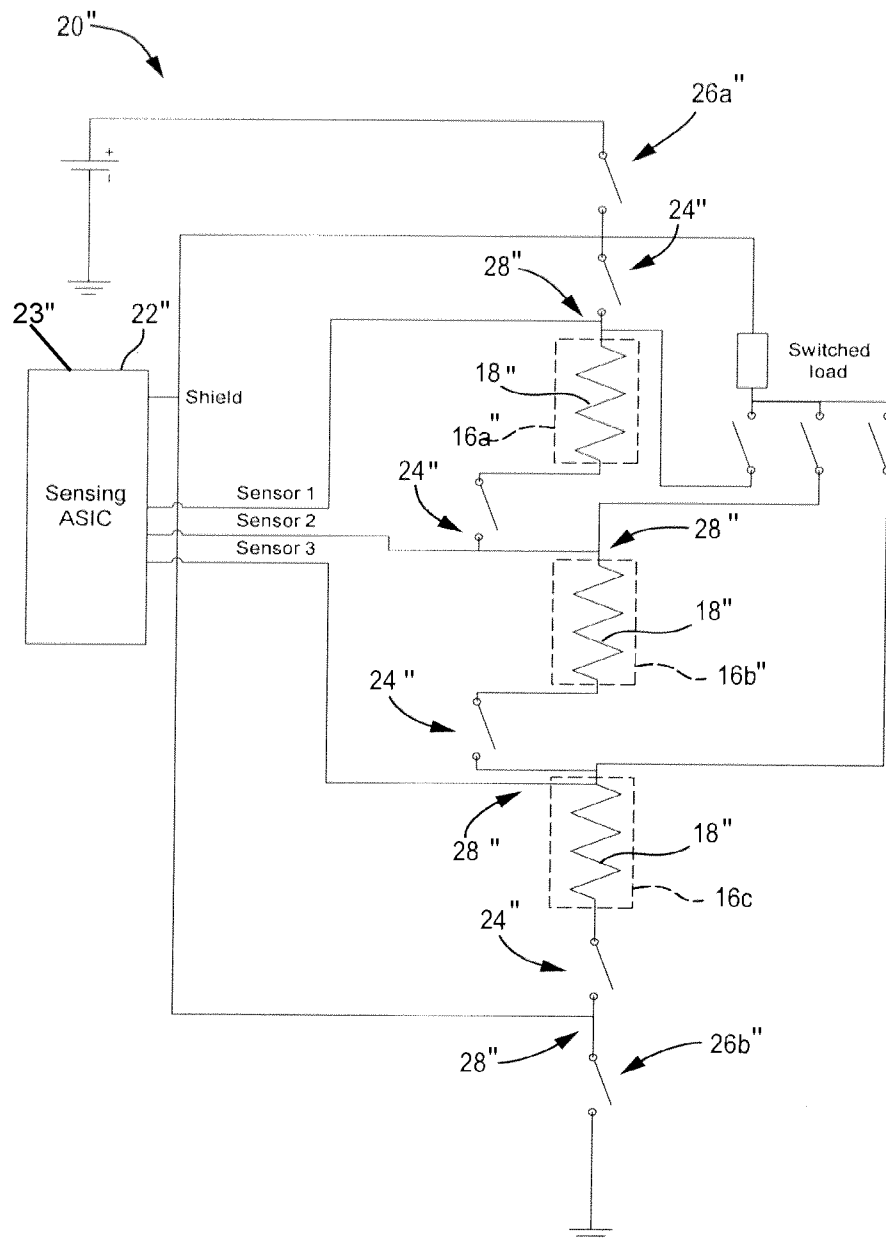


FIG. 5

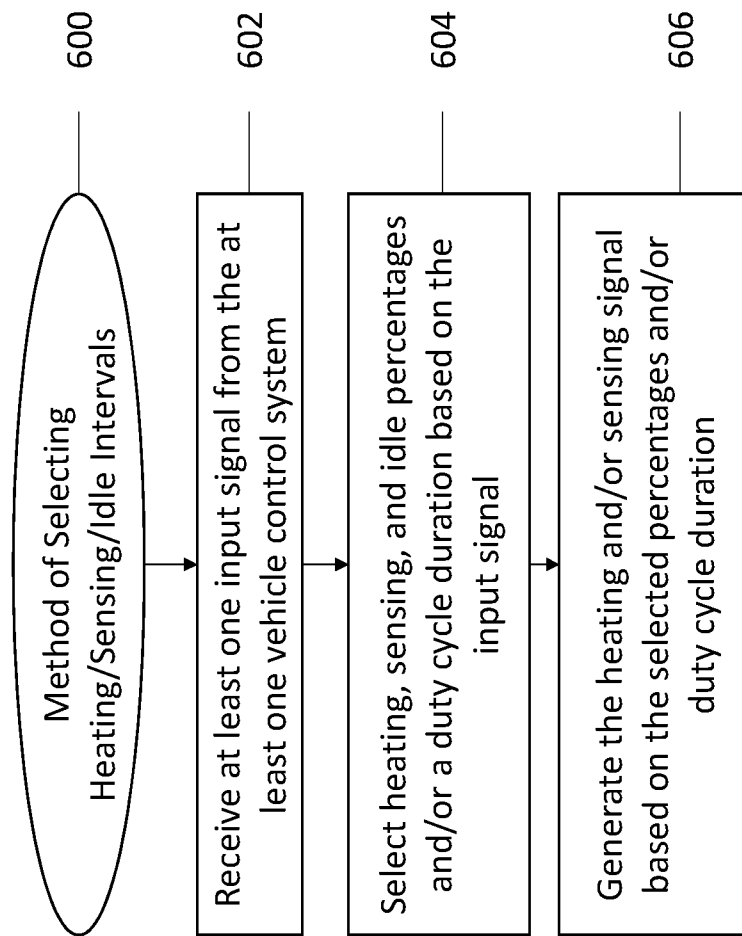


FIG. 6

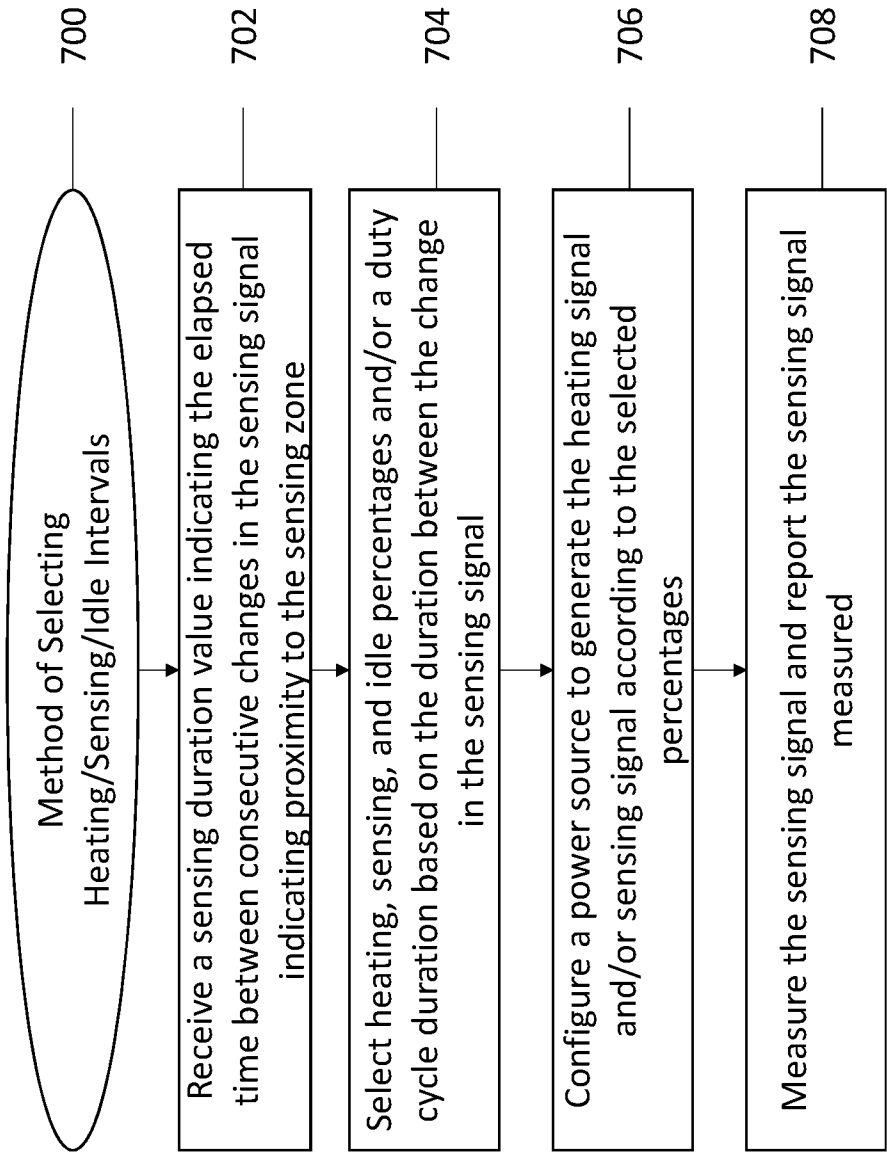
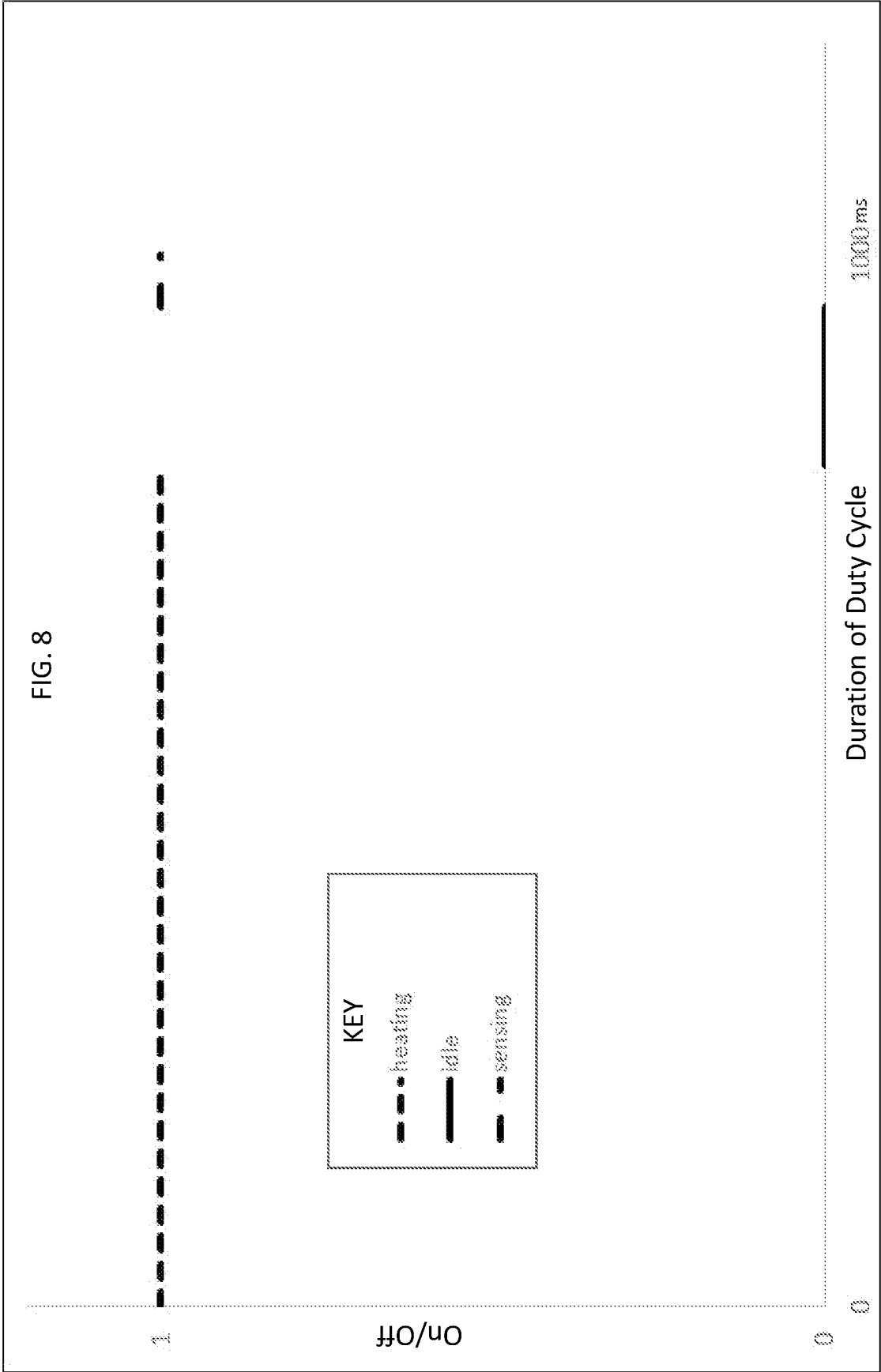
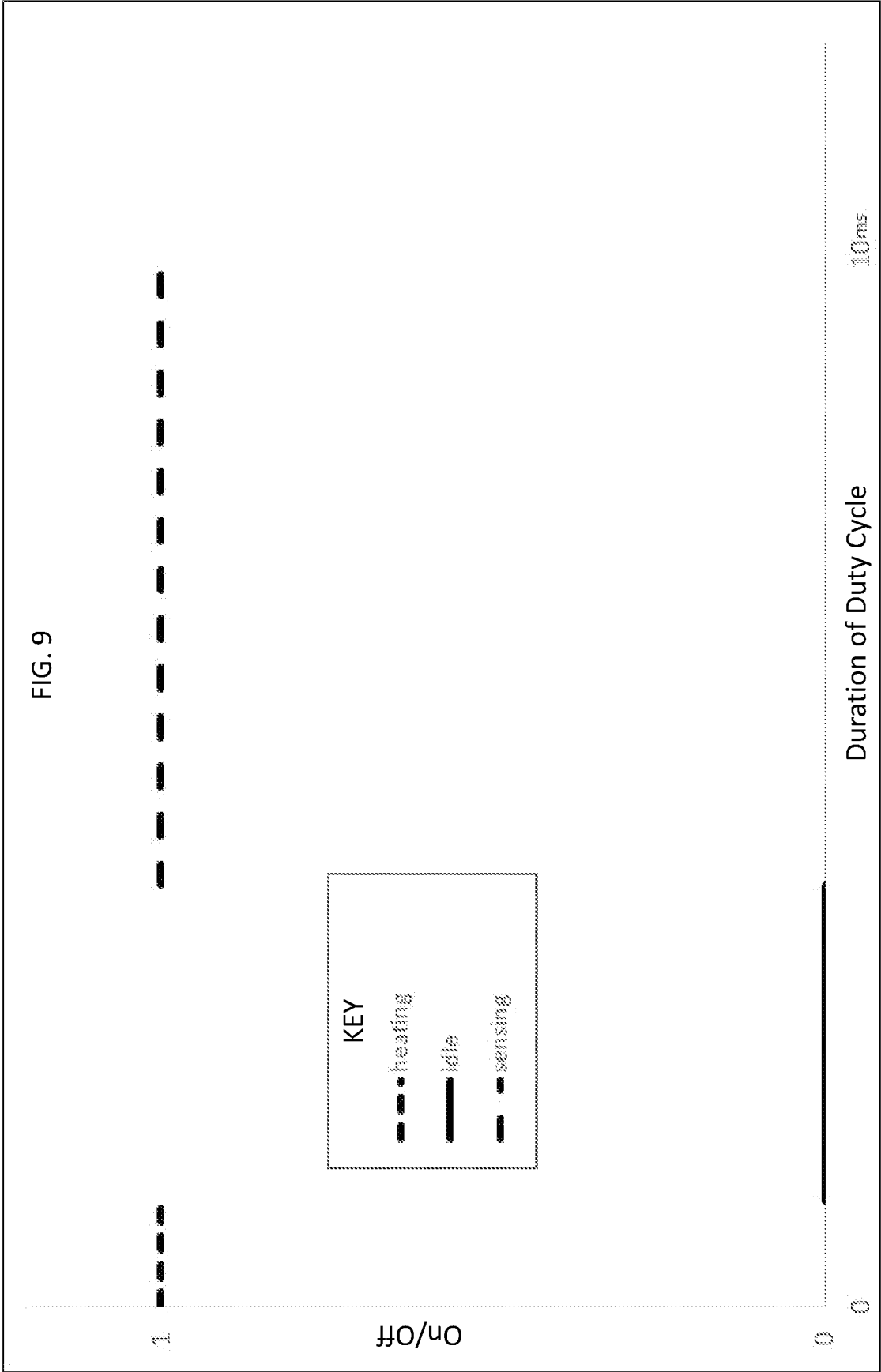


FIG. 7







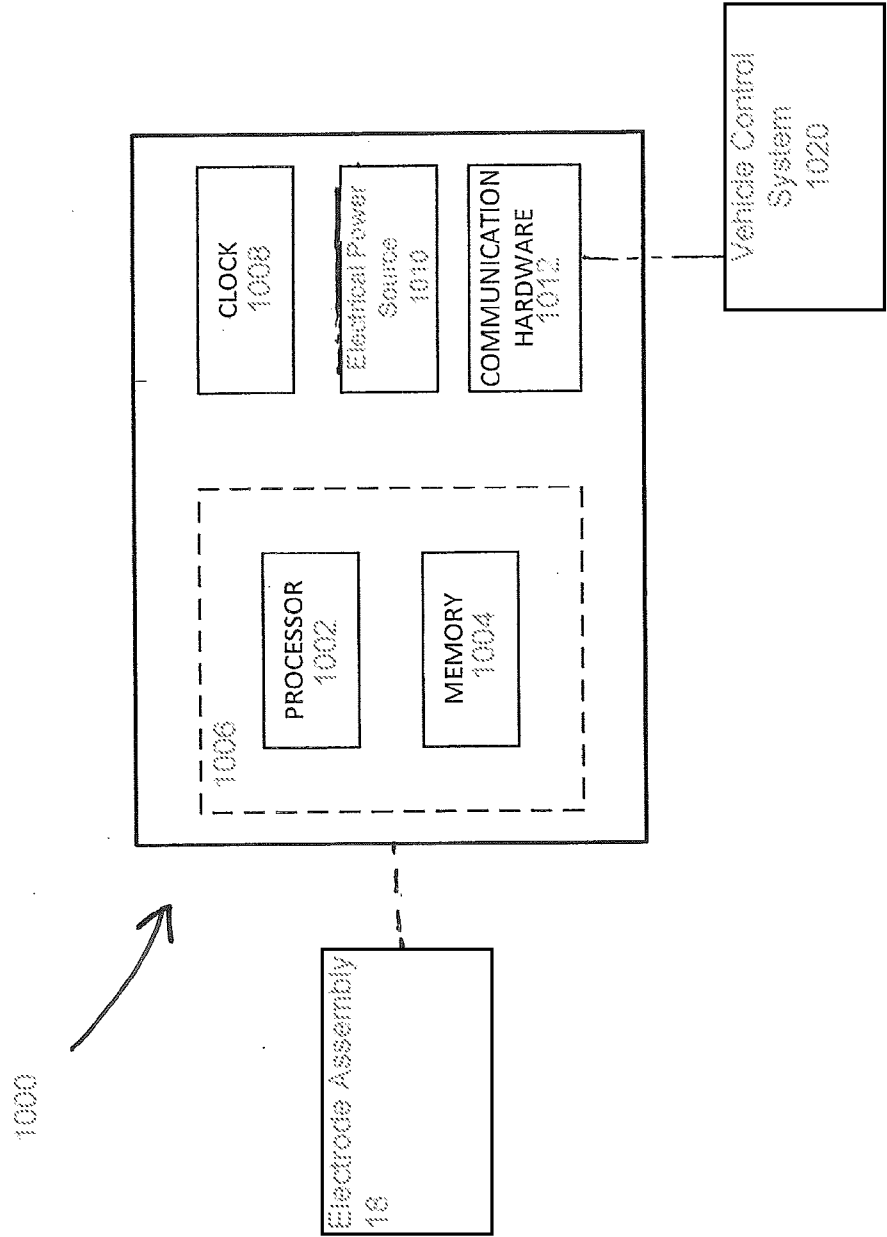


FIG. 10

## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/US2018/032821****A. CLASSIFICATION OF SUBJECT MATTER****B60N 2/00(2006.01)i, B60N 2/56(2006.01)i, B62D 1/06(2006.01)i, B62D 1/04(2006.01)i, B60R 16/03(2006.01)i, B60R 22/48(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)

B60N 2/00; B62D 1/06; G06F 15/00; G01L 21/00; B62D 1/04; B60N 2/56; B60R 21/00; G08B 23/00; B60R 16/03; B60R 22/48

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 models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) &amp; Keywords: vehicle, heating system, duty cycle, electrode, component, sensing zone, heating, sensing, idle, signal, percentage

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014-0151356 A1 (TK HOLDINGS INC.) 05 June 2014 See paragraphs [0015]-[0032]; claim 1; and figures 2-5.	1-46
A	US 2015-0102024 A1 (GENTHERM CANADA LTD.) 16 April 2015 See paragraphs [0006]-[0007], [0052]-[0055]; and figures 1, 2A-2B, 3.	1-46
A	US 2015-0298590 A1 (IEE INTERNATIONAL ELECTRONICS & ENGINEERING S.A.) 22 October 2015 See claims 1-8; and figures 1-3.	1-46
A	US 2013-0334196 A1 (LAMESCH et al.) 19 December 2013 See paragraph [0024]; and figure 1.	1-46
A	US 2005-0242965 A1 (RIETH et al.) 03 November 2005 See paragraphs [0036]-[0058]; and figures 1-6.	1-46
A	US 2007-0208529 A1 (KOCH et al.) 06 September 2007 See claims 1-13; and figures 1-3.	1-46



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

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Date of the actual completion of the international search

13 September 2018 (13.09.2018)

Date of mailing of the international search report

**13 September 2018 (13.09.2018)**

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea



Facsimile No. +82-42-481-8578

Authorized officer

HWANG, Chan Yoon

Telephone No. +82-42-481-3347



**INTERNATIONAL SEARCH REPORT**

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**PCT/US2018/032821**

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