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(54) Title: DIAGNOSTIC FUNCTION FOR BRUSHLESS BLOWER MOTOR

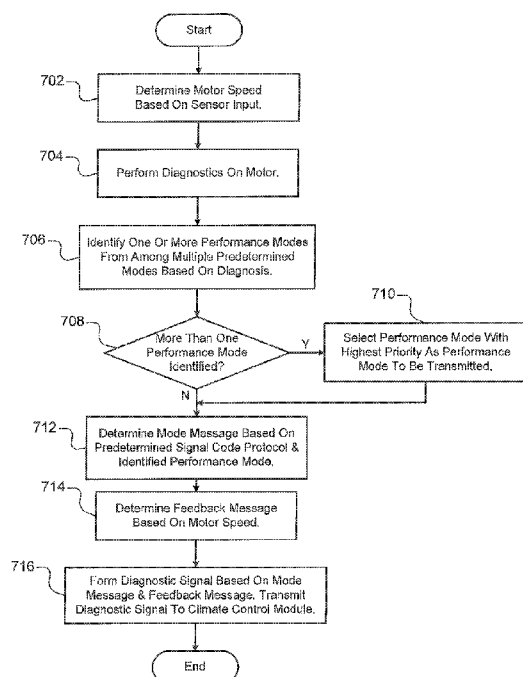


FIG. 14

(57) Abstract: The present disclosure relates to a method for monitoring the performance of a blower motor for a blower unit for a HVAC system positioned in a vehicle. The method includes: diagnosing the motor (704) based on predefined criteria and one or more physical parameters (702) sensed by one or more sensors; identifying a performance mode (706) from among a plurality of modes based on the diagnosis, where the plurality of modes are predefined; determining a mode message (712) based on a signal code protocol, where the mode message is indicative of the performance mode identified and the signal code protocol associates each of the plurality of modes with a different coded signal; and transmitting a diagnostic signal (716) that includes the mode message to a climate control module located in the vehicle separate from the motor.



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DIAGNOSTIC FUNCTION FOR BRUSHLESS BLOWER MOTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/181,446 filed on June 18, 2015, and U.S. Application No. 15/182,266 filed on June 14, 2016. The entire disclosures of these applications is incorporated herein by reference.

FIELD

[0002] The present disclosure relates to performing a diagnostic on a blower motor disposed in a vehicle.

BACKGROUND

[0003] This section provides background information related to the present disclosure which is not necessarily prior art.

[0004] Vehicles are known to incorporate a heating, ventilation, and air conditioning (HVAC) system to improve the comfort of the people within the passenger compartment of the vehicle. The HVAC system heats and cools air blown through the HVAC system using a heating heat exchanger and/or a cooling heat exchanger. The air blown through the HVAC system is drawn in via a blower unit which draws in air from outside the vehicle. The air then flows through the HVAC system where it is conditioned (heated/cooled) and then directed into the passenger compartment of the vehicle through one or more outlet vents.

[0005] The blower unit can include a blower motor and a blower control module that receives control signals from a climate control module to operate the motor at a desired speed. The control signal may be a pulse width modulation (PWM) signal. The blower control module may transmit a feedback signal that indicates the current speed of the blower motor to the climate control module and is used by the climate control module to monitor the speed of the blower motor. To effectively operate the blower motor, the climate control module may also need to know the overall operation status of the blower motor. For example, the climate control module may need information indicating whether the blower motor is operating normally or if a specific failure has been detected.

SUMMARY

[0006] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0007] The present disclosure is generally directed toward a method for
5 monitoring the performance of a blower motor and a blower unit for a HVAC system in a vehicle. As described in detail, the method and the blower unit of the present disclosure, provide a climate control module with information regarding the performance of the blower motor, which can be used to control the operation of the blower motor. Thus, the blower unit can be operated efficiently by the climate control
10 module.

[0008] In an aspect, the present disclosure generally relates to a method for monitoring the performance of a motor for a blower unit positioned in a vehicle. The method may include: sensing one or more physical parameters of the motor by way of a sensor located at the motor; diagnosing the motor based on predefined criteria
15 and the one or more physical parameters sensed by the sensor; identifying a performance mode from among a plurality of modes based on the diagnosis, where the plurality of modes are predefined; determining a mode message based on a signal code protocol, where the mode message is indicative of the performance mode identified and the signal code protocol associates each of the plurality of
20 modes with a different coded signal; and transmitting a diagnostic signal that includes the mode message to a climate control module located in the vehicle separate from the motor.

[0009] In another aspect, the present disclosure is generally directed toward a blower unit for a HVAC system provided in a vehicle. The blower unit may include a
25 blower motor operable to draw air into the HVAC system and a blower motor control module. The blower motor control module may include a driver that operates the blower motor at a desired speed and a diagnostic module. The diagnostic module may diagnose the blower motor with a performance mode identified from among a plurality of modes and transmits a diagnostic signal that includes a mode message
30 indicative of the performance mode to a climate control module of the HVAC system.

[0010] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0011] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

5 [0012] Figure 1 is a block diagram of a heating, ventilation, and air conditioning (HVAC) system of a vehicle;

[0013] Figure 2 is a schematic of a blower motor control (BMC) module disposed at a motor of a blower unit;

[0014] Figure 3 is a block diagram of the BMC module;

10 [0015] Figure 4 is a performance mode table that defines a plurality of modes of the motor;

[0016] Figure 5 is a pulse code table that associates the plurality of modes with a number of pulses as a first signal code protocol for the plurality of modes;

15 [0017] Figures 6A and 6B illustrate diagnostic signals that include a mode message and a feedback message based on the first signal code protocol;

[0018] Figure 7 is a digit code table that associates the plurality of modes with a digit as a second signal code protocol for the plurality of modes;

[0019] Figures 8A and 8B illustrate diagnostic signals that include a mode message and a feedback message based on the second signal code protocol;

20 [0020] Figure 9 is a schematic of a pulse width modulation output circuit;

[0021] Figure 10 is a table that illustrates parameters of the pulse width modulation output circuit of Figure 9;

[0022] Figure 11 illustrates examples of feedback messages to be transmitted as part of the diagnostic signal for selected motor speeds;

25 [0023] Figure 12 illustrates a single mode message for a diagnostic signal;

[0024] Figure 13A and 13B illustrate diagnostic signals that include multiple mode messages transmitted as part of a single transmission of the diagnostic signal; and

[0025] Figure 14 is an example of a diagnostic routine for diagnosing a motor.

30 [0026] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

[0027] The present disclosure will now be described more fully with reference to the accompanying drawings. With reference to Figures 1 and 2, a heating, ventilation, and air conditioning (HVAC) system 100 for a vehicle may include a climate control module 102 and a blower unit 104. The blower unit 104 draws in air into a housing of the HVAC system 100. The air is then conditioned by other components of the HVAC system 100 before being supplied to a passenger compartment of the vehicle.

[0028] The blower unit 104 may include a blower motor control (BMC) module 106, a motor 108, and a scroll (not shown) attached to the motor 108. The motor 108 and the scroll may be referred to as a blower motor. The motor 108 may be a brushless motor and is operable by the BMC module 106 to rotate the scroll at a desired speed. The BMC module 106 may be disposed with the motor 108. For example, Figure 2 illustrates an example configuration in which the BMC module 106 is disposed with the motor 108. Alternatively, the BMC module 106 may be disposed at other suitable locations and is not limited to the position illustrated in Figure 2 and/or to the motor 108. For example, the BMC module 106 may be positioned at a location separate from the motor 108.

[0029] The climate control module 102 controls the overall operation of the HVAC system 100 to have the HVAC system 100 supply conditioned air to the passenger cabin of the vehicle. As an example, a user may input a desired air temperature and air speed via one or more user interfaces (e.g., knob, touchscreen) disposed along an instrument panel of the vehicle. The climate control module 102 may then determine a performance output of one or more components within the HVAC system 100, such as the blower unit 104 to have the HVAC system deliver air at the desired temperature and air speed.

[0030] In the example embodiment, the climate control module 102 controls the flow of air into the HVAC system 100 by controlling the blower unit 104. Specifically, the climate control module 102 may determine a desired operation speed of the motor 108 and may output a pulse width modulation (PWM) signal 110, which is indicative of the desired operation speed, to the BMC module 106 of the blower unit 104. The BMC module 106 may then drive the motor 108 based on the PWM signal 110. The PWM signal 110 is represented as arrow 110 in the figures.

[0031] In addition to controlling the operation of the motor 108, the BMC module 106 also monitors the motor 108 to determine a diagnosis of the motor 108, as described in detail below. The BMC module 106 may transmit a diagnostic signal (i.e., a diagnostic message) to the climate control module 102, where the diagnostic signal includes information representing, for example, a speed of the motor 108 and a diagnosis of the motor 108. The climate control module 102 evaluates the diagnosis of the motor 108 to assess the desired performance output of the blower unit 104. The diagnostic signal is represented by arrow 112.

[0032] With reference to Figure 3, the BMC module 106 may include a driver 120 and a diagnostic module 122. The driver 120 drives the motor 108 based on the PWM signal 110 from the climate control module 102. The diagnostic module 122 determines the speed of the motor 108 (i.e., a motor speed) based on data from one or more sensors 124. For example, one or more sensors, such as a Hall sensor or temperature sensor, may be positioned near the motor to sense a physical parameter of the motor 108 and/or environment of the motor 108. Input signals from the sensors 124 are represented as arrow 126. The diagnostic module 122 performs a diagnostic on the motor 108 to determine a mode of the motor 108 based on data from sensors disposed at the motor 108 and prestored processes and/or data. The diagnostic module 122 then generates and transmits the diagnostic signal 112 based on the motor speed and the mode of the motor 108. The motor speed can be determined in any other suitable manner as well, such as by way of a feedback circuit, and is not limited to detection with the sensors 124. For example, the motor speed can be determined in the manner described in reference CN 204145346, the entire disclosure of which is incorporated herein by reference.

[0033] With regard to the mode of the motor 108, the diagnostic module 122 may identify one or more modes of the motor 108 from among a plurality of modes. As an example, Figure 4 illustrates a performance mode table 200 that lists possible performance modes of the motor 108. For each of the modes listed, the table 200 defines an operation condition for the mode, an action for addressing the identified condition, and a reset operation. Based on the information received by the sensors and the conditions outlined in the table 200, the diagnostic module 122 determines the mode of the motor 108. For example, if the BMC module 106 determines that the motor 108 is not rotating based on data from a Hall sensor after a preset period of time (e.g., 2.7 seconds), the BMC module 106 may diagnose the motor 108 as a

locked rotor. It should be readily understood that the diagnostic module 122 may be configured in various suitable ways to diagnose the motor 108 and output a predefined mode of the motor 108. For instance, the diagnostic module 122 may store and execute one or more diagnostic routines and output a mode of the motor 108 based on the routines.

[0034] The action defined in the table 200 for a given mode provides the steps taken to correct the detected mode. For example, the climate control module 102 may shut off power to the motor 108 or have the BMC module 106 shut off power to the motor 108 to address the locked rotor mode. The reset defines when or how the detected condition is cleared until the next occurrence of the condition. For example, after the power to the motor 108 is turned off, the BMC module 106 can be instructed to reset the locked rotor condition after 20 seconds for five total attempts, and the attempts will reset after the vehicle is restarted. Alternatively, the climate control module 102 may reset the condition and track the number of occurrences.

[0035] The plurality of predefined modes may include different types of modes, and is not limited to failure modes. As an example, in addition to failure modes, the plurality of modes may include a no failure mode in which the motor is operating properly (i.e., normal mode), and a warning mode in which the motor 108 is under specific characteristics that can or cannot result in a failure. Over heat A is one example of a warning mode. The plurality of modes from which the BMC module 106 may select can vary depending on the performance requirements of the motor 108 and, therefore, should not be limited to the modes defined in the figures and/or described herein. In addition, the BMC module 106 may identify, or in other words diagnose, the motor 108 with more than one mode.

[0036] The BMC module 106 transmits the diagnostic signal in real time to the climate control module 102 and includes two messages. The first message identifies the mode of the motor 108 as diagnosed by the BMC module 106, and may be referred to as a mode message. The second message provides information regarding the speed of the motor, and may be referred to as a feedback message. The motor speed provided in the feedback message can be determined in any suitable manner, such as by way of a feedback circuit, and is not limited to detection with the sensors 124.

[0037] Using a predetermined signal code protocol, a given mode is conveyed as a pulse signal. More particularly, each of the plurality of modes is associated with

a specific coded signal that is transmitted as the mode message. For example, in a first embodiment of a signal code protocol of the present disclosure, each of the modes is associated with a specific number of pulses. Figure 5 illustrates a pulse code table 300 that lists each of the modes and an associated number of pulses.

5 Table 300 lists 11 different modes, and the number of pulses range from 1 to 11. The table 300 also provides the priority level of each mode. Modes with the same priority cannot occur at the same time.

[0038] Figures 6A and 6B, illustrate examples of diagnostic signals 200 and 202, respectively. The diagnostic signals 200 and 202 are a series of pulses in
10 which one cycle of a given diagnostic signal includes: a start/stop pulse (t_0), a mode message start pulse (t_1), the mode message (MM), the start/stop pulse (t_0), a feedback message start pulse (t_2), and the feedback message (FM). The mode message and the feedback message may also be referred to as a mode message signal and the feedback message signal of the diagnostics signal.

[0039] In the example embodiment, the start/stop pulse (t_0) is a 60ms high pulse, and the mode message start pulse (t_1) and the feedback message start pulse (t_2) are both 30ms low pulses. The duration and the polarity (i.e. high and low) of a given pulse can be changed and should not be limited to the examples provided herein. For example, while the start/stop pulse (t_0) is described as a 60ms high
15 pulse, the start/stop pulse (t_0) may have a different duration (e.g., 30ms, 50ms, 80ms, etc.), and/or may be a low pulse (e.g., 0V).

[0040] The start/stop pulse indicates the start and stop of the diagnostic signal, and also separates the mode message and the feedback message. The mode message start pulse and the feedback message start pulse designate the start
20 of the mode message and the start of the feedback message, respectively.

[0041] The mode message transmits the pulses associated with the mode of the motor identified by the BMC module 106. For example, the mode message of diagnostic signal 200 includes one pulse. Based on Figure 5, one pulse represents no failure mode of the motor 108. In the diagnostic signal 202, the mode message
25 includes 11 pulses indicating that the mode of the motor 108 is an input short to ground, as defined in Figure 5. In the event that the BMC module 106 identifies more than one mode, the BMC module 106 transmits the pulse(s) associated with the mode having the highest priority in the mode message. For example, if the motor 108 is diagnosed with a current limitation and Over Heat A, the BMC module
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106 will transmit information indicative of the Over Heat A mode via the mode message, since the Over Heat A mode has higher priority than the current limitation mode. Thus, the mode message will include five pulses.

5 **[0042]** While in the first embodiment of the signal code protocol each of the modes is associated with a specific number of pulses, other codes may be used for identifying the modes. As an example, in a second embodiment of a signal code protocol of the present disclosure, each of the modes is associated with a digit (e.g., 0, 1, 2, 3, 4, etc.). For instance, Figure 7 illustrates a digit code table 400 that associates each of the modes with a digit that can be represented using binary form
10 (e.g., 2 = 0010).

[0043] Figures 8A and 8B illustrate examples of diagnostic signals 204 and 206, respectively, which use the digit code table 400 for representing the mode of the motor 108. Similar to the first embodiment, the diagnostic signals 204 and 206 include: the start/stop pulse (t_0), the mode message start pulse (t_1), the mode
15 message (MM), the start/stop pulse (t_0), the feedback message start (t_2), and the feedback message (FM).

[0044] In the second embodiment, the mode message transmits the digit associated with the mode identified by the BMC module 106. Specifically, the digits are represented in binary form in which “0” is represented with a high signal and “1”
20 is represented with a low signal. As an example, in Figure 8A, the mode message of diagnostic signal 204 includes four zeros, which is represented by a high level signal. Based on Figure 7, four zeros represent the no failure mode of the motor 108. In the diagnostic signal 206 of Figure 8B, the mode message includes three “0” and one “1” (i.e., high, high, high, low = 1) indicating that the mode of the motor is an Over
25 Current mode as defined in Figure 7. While the present disclosure describes two specific signal code protocols, which can be prestored by the BMC module 106, it should be readily understood that other suitable protocols may be used and that the present disclosure should not be limited by the examples provided herein.

[0045] With reference to Figures 9-11, the feedback message of the
30 diagnostic signal represents the speed of the motor 108. Figure 9 illustrates a PWM output circuit diagram which shows the feedback message from the motor 108 to the climate control module 102, and Figure 10 provides the blower motor PWM signal specification for two possible states: running and stopping.

[0046] The speed of the motor can be conveyed by a series of pulses. As an example, in Figure 11, a feedback message 500 can be transmitted when the motor 108 is at a maximum motor speed, a feedback message 510 can be transmitted when the motor 108 is at a minimum motor speed, and a feedback message 520 can be transmitted when the motor 108 is in a stop condition.

[0047] The BMC module 106 may include predefined tables that associate one or more motor speeds with a specific feedback message. Based on the speed of the motor 108, the BMC module 106 is able to determine which of the predefined feedback messages is to be transmitted. While specific examples of a feedback message are provided, other feedback messages may be used for identifying a speed of the motor 108, and the present disclosure should not be limited to the examples provided herein.

[0048] In the example embodiments, the diagnostic signal is configured such that the mode message is transmitted prior to the feedback message. Alternatively, the diagnostic signal may be configured such that the feedback message is transmitted first and then the mode message is transmitted. Furthermore, while the mode message and the feedback message are illustrated as having different durations in Figures 6A, 6B, 8A, and 8B (e.g., mode message has a duration T_M and feedback message has a duration T_F), the diagnostic signal may be configured so that the mode message and the feedback message have the same duration.

[0049] In the example embodiments, the mode message and the feedback message are transmitted once in one cycle. Alternatively, the mode message and/or the feedback message may be transmitted multiple times based on various parameters. As an example, Figure 12 illustrates a mode message signal 600 in which the mode message is transmitted once and provides some of the key design parameters to be considered in transmitting the mode message. A message start pulse (t_0) is provided before the mode message signal 600 and indicates the start of the mode message portion of a diagnostic signal.

[0050] The mode message signal 600 transmits a particular mode of the motor using the pulse coding method of the first embodiment. The design parameters for the mode message signal may include: a total duration of the message using pulse coding (t_1); duration of low level portion of one pulse (x_0); duration of high level portion of one pulse (x_1); duration of one pulse (y); and mode message end pulse (t_2). Using the pulse coding of the first embodiment, the data

length, or in other words the total duration of the mode message, is substantially equal to eleven pulses multiplied by the duration of each pulse (i.e., $t_1 = 11 \cdot y$). The time needed to transmit a mode message once is equal to the sum of the durations of the mode message and the end pulse (i.e., $T_1 = t_1 + t_2$).

5 **[0051]** Each of the design parameters can be configured to meet the requirements of the HVAC system, and should not be limited to a particular value. As an example, if the time needed to transmit a mode message once is set to a specific range (e.g., $110\text{ms} \leq T_1 \leq 220\text{ms}$), the duration for transmitting the mode message (i.e., t_1) using a particular signal code protocol and the duration of the mode
10 message end pulse (t_2) can be set so that T_1 is within the specific range.

[0052] Figures 13A and 13B illustrate diagnostic signals 620 and 640, in which the mode message is transmitted five times in a single diagnostic signal. For example, the diagnostic signal 620 includes a mode message portion 620A that has a duration T_2 and a feedback message portion 620B that has a duration T_3 . In the
15 mode message portion 620A, a single transmission of the mode message has a duration of T_1 , and therefore, the total duration for transmitting the mode message five times may be provided as: $T_2 = T_1 \cdot 5$. The total duration of the mode message portion 620A and the feedback portion 620B is provided as signal period T , where $T = T_2 + T_3$. Accordingly, the diagnostic signal can be configured to transmit the mode
20 message multiple times within a single signal transmission.

[0053] Similarly, in Figure 13B, the diagnostic signal 640 includes a mode message portion 640A that has duration T_2 and a feedback message duration 640B that has a duration T_3 . In the message portion 640A, a single mode message having a transmission duration of T_1 is transmitted five times within a single transmission of
25 the diagnostic signal 640.

[0054] With reference to Figure 14, an example implementation of a diagnostic routine is presented. The diagnostic routine may be performed by the BMC module of the blower unit. At 702, the BMC module may determine the speed of the motor based on inputs from one or more sensors, such as a hall sensor, and
30 at 704, the BMC module may perform diagnostics on the motor. Specifically, the BMC module may include pre-stored algorithms and/or processes that are executed by the BMC module to evaluate the performance of the motor and diagnosis the motor.

[0055] Based on the diagnosis, the BMC module may identify one or more performance modes from among a plurality of predetermined modes stored in the BMC module, at 706. For example, the BMC module may store a table that lists possible modes of the motor (e.g., performance mode table 200), and the modes may include a failure mode, warning modes, and/or a normal operation mode. The BMC module may determine if more than one performance mode is identified at 708, and if so, the BMC module may select the performance mode with the highest priority as the mode to be transmitted to climate control module, at 710.

[0056] At 712, the BMC module may determine the mode message based on a predetermined signal code protocol stored by the BMC module and the identified performance mode. The signal code protocol associates each of the modes stored by the BMC module with a different coded signal, which is provided as the mode message. At 714, the BMC module may determine the feedback message based on the speed of motor, and then form and transmit a diagnostic signal based on the mode message and the feedback message to the climate control module at 716.

[0057] The present disclosure relates to a brushless motor with PWM control, so the method used to identify the modes may depend on the characteristics of the processor of the BMC module. The climate control module 102 and the BMC module 106 store a key that associates each of the modes with a specific code. Accordingly, the climate control module 102 may decode the diagnostic signal from the BMC module 106 to identify the mode of the motor and the speed of the motor. In addition, based on the identified mode, the climate control module may adjust the performance output of the motor 108 by adjusting the desired speed and/or may perform a predetermined action to address the mode.

[0058] The blower unit of the present disclosure not only operates a blower motor based on control signals from the climate control module, but also performs a diagnostic on the blower motor to determine the performance mode of the blower motor. The performance mode is transmitted to the climate control module as part of a diagnostic signal. Specifically, using a predetermined signal code protocol, the diagnostic signal includes a mode message that is a predefined pulse signal for representing a given performance mode. In addition to the performance mode, the diagnostic signal also transmits the speed of the blower motor by way of feedback message, which is also a pulse signal.

[0059] Using the diagnostic signal and pre-stored information for decoding the signal, the climate control module may identify the performance mode of the blower motor and, therefore, be able to control the performance output of the motor. Accordingly, the HVAC system of the present disclosure is able to effectively operate the blower motor by monitoring the performance mode of the blower motor.

[0060] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

[0061] In this application, including the definitions below, the term 'module' or the term 'controller' may be replaced with the term 'circuit.' The term 'module' may refer to, be part of, or include: an Application Specific Integrated Circuit (ASIC); a digital, analog, or mixed analog/digital discrete circuit; a digital, analog, or mixed analog/digital integrated circuit; a combinational logic circuit; a field programmable gate array (FPGA); a processor circuit (shared, dedicated, or group) that executes code; a memory circuit (shared, dedicated, or group) that stores code executed by the processor circuit; other suitable hardware components that provide the described functionality; or a combination of some or all of the above, such as in a system-on-chip.

[0062] The module may include one or more interface circuits. In some examples, the interface circuits may include wired or wireless interfaces that are connected to a local area network (LAN), the Internet, a wide area network (WAN), or combinations thereof. The functionality of any given module of the present disclosure may be distributed among multiple modules that are connected via interface circuits. For example, multiple modules may allow load balancing. In a further example, a server (also known as remote, or cloud) module may accomplish some functionality on behalf of a client module.

CLAIMS

What is claimed is:

1. A method for monitoring the performance of a motor for a blower unit positioned in a vehicle, the method comprising:

5 sensing one or more physical parameters of the motor by way of one or more sensors located at the motor;

diagnosing, by a blower motor control module, the motor based on predefined criteria and the one or more physical parameters sensed by the sensors;

10 identifying, by the blower motor control module, a performance mode from among a plurality of modes based on the diagnosis, wherein the plurality of modes are predefined and stored in the blower motor control module;

determining, by the blower motor control module, a mode message based on a signal code protocol, wherein the mode message is indicative of the performance mode identified and the signal code protocol associates each of the plurality of
15 modes with a different coded signal; and

outputting, by the blower motor control module, a diagnostic signal that includes the mode message to a climate control module located in the vehicle separate from the motor.

20 2. The method of claim 1 further comprising:

determining, by the blower motor control module, a speed of the motor, wherein the diagnostic signal includes a feedback message that is indicative of the speed of the motor.

25 3. The method of claim 1 wherein the signal code protocol associates each of the plurality of modes with a predefined number of pulses, as the coded signal, where each of the modes is associated with a different number of pulses.

30 4. The method of claim 1 wherein the signal code protocol associates each of the plurality of modes with a digit represented as a binary value, as the coded signal for a given mode, and each of the modes is associated with a different digit.

5. The method of claim 1 wherein the plurality of modes includes a normal mode and at least one failure mode.

6. The method of claim 1 wherein the diagnostic signal includes a start pulse provided before the mode message and a stop pulse provided after the mode message.

7. The method of claim 1 further comprising:
determining, by the climate control module, a desired operation speed of the motor based on information provided in the diagnostic signal;
transmitting, by the climate control module, a pulse width modulation signal indicative of the desired operation speed to the blower control module; and
operating, by the blower control module, the motor at the desired operation speed transmitted by the climate control module.

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8. The method of claim 1 wherein the blower control module is positioned separately from the climate control module.

9. The method of claim 1 wherein identifying the performance mode further comprises:
selecting, from among multiple performance modes identified, a high priority mode as the performance mode to be transmitted when more than one performance mode is identified.

10. A blower unit for a HVAC system provided in a vehicle, the HVAC system is controlled by a climate control module, the blower unit comprising:
a blower motor operable to draw air into the HVAC system; and
a blower motor control module including a driver and a diagnostic module, wherein the driver outputs a drive signal to the blower motor to operate the blower motor at a desired speed, and the diagnostic module diagnoses the blower motor with a performance mode identified from among a plurality of modes and transmits a diagnostic signal that includes a mode message indicative of the performance mode to the climate control module.

11. The blower unit of claim 10 wherein the blower motor control module stores a signal code protocol that associates each of the plurality of modes with a different coded signal to be transmitted as the mode message.

5 12. The blower unit of claim 11 wherein the signal code protocol associates each of the plurality of modes with a predefined number of pulses such that each of the modes is associated with a different number of pulses.

10 13. The blower unit of claim 11 wherein the signal code protocol associates each of the plurality of modes with a digit represented as a binary value such that each of the modes is associated with a different digit.

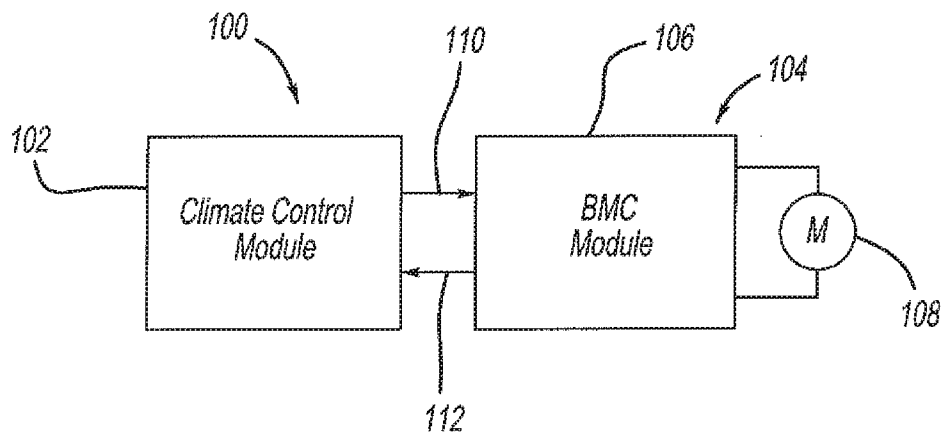
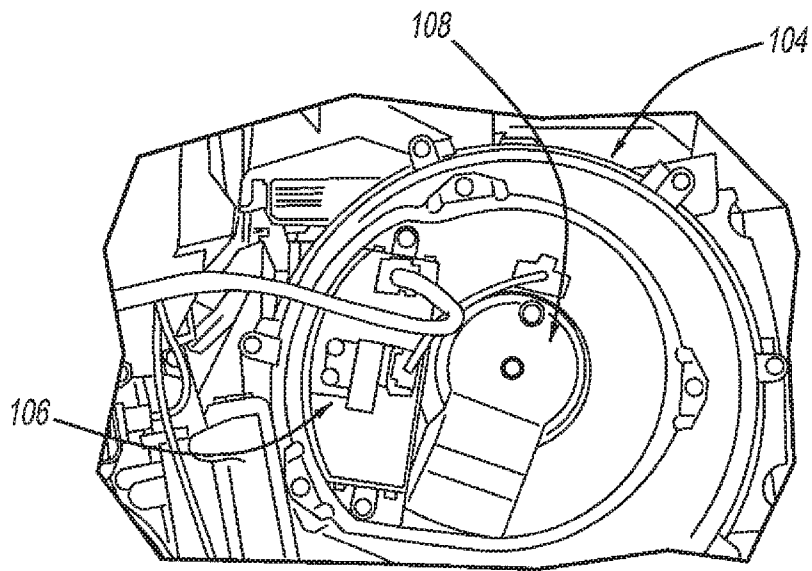
15 14. The blower unit of claim 10 further comprising:
a sensor disposed at the motor and sensing a rotational speed of the blower motor, wherein the diagnostic signal transmitted by the blower motor control module includes a feedback message that is indicative of the speed of the blower motor.

20 15. The blower unit of claim 10 wherein the blower control module receives a pulse width modulation signal that is indicative of the desired speed of the blower motor from the climate control module.

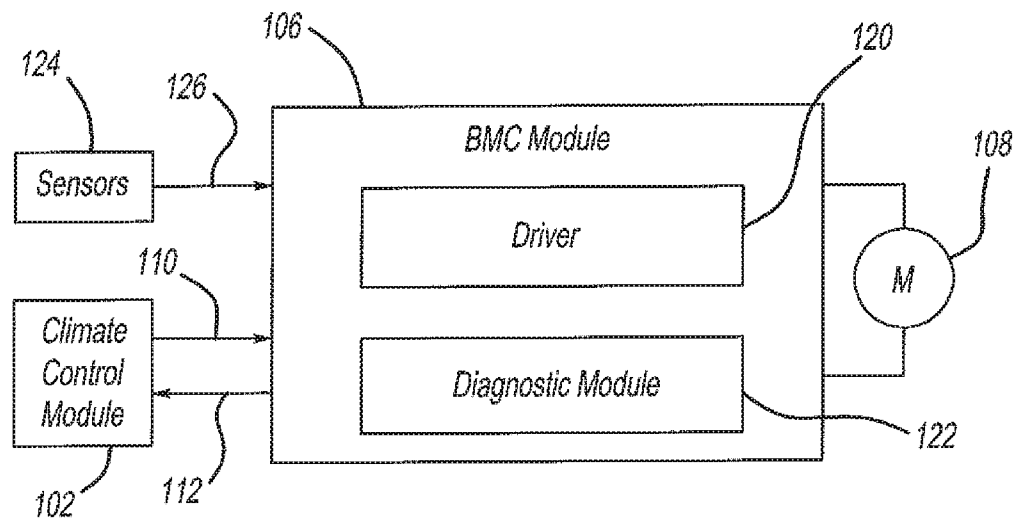
25 16. The blower unit of claim 10 wherein the diagnostic signal includes a start pulse provided before the mode message and a stop pulse provided after the mode message.

30 17. The blower unit of claim 10, wherein a rotational speed of the blower motor is determined with a feedback circuit, and the diagnostic signal transmitted by the blower motor control module includes a feedback message that is indicative of the speed of the blower motor.

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FIG - 1FIG - 2

2/10



300

Mode	Number of Pulses	Priority
No Failure	1	1
Over Current	2	2
Current Limitation	3	3
Locked Rotor	4	2
Over Heat A	5	4
Over Heat B	6	5
Over Heat C	7	2
Over Voltage	8	6
Under Voltage	9	2
Input Open or Short PWR	10	7
Input Short to GND	11	8

FIG - 5

200

FIG - 4

Mode	Condition	Action	Reset
Over Current	Current draw measured by the shunt resistor is > 55 A during 0.6 s.	Circuit shuts off all power to FETs.	Blower Controller will turn on FETs after 20 S, for 5 total attempts. Attempts will reset after vehicle IGN is reset.
Current Limitation	Input power limited from 13-16 V and 351W to protect the FETs. (Load point requirement still accomplish)	Decrease PWM- output until input power is lower than 351W	Condition will be reset when input power is lower than 351W
Locked Rotor	Microcomputer detects no rotation from the hall sensor after 2.7 s.	Turn off all power to the motor.	Condition will be reset after 20 s for 5 total attempts. Attempts will reset after vehicle IGN is reset.
Over Heat A	Before Limp Mode	Speed motor will be affected.	Condition will be reset when the temperature falls 2° C from Over Heat A threshold
Over Heat B	The thermistor positioned near the FET reaches a temperature correlated to the atmosphere temperature of -65°C (program dependent)	Motor reduce speed (Limp Mode)	Condition will be reset when the temperature falls 20° C from Over Heat B threshold
Over Heat C	The thermistor positioned near the FET reaches a temperature correlated to the atmosphere temperature of -85°C.	Motor shuts down.	Condition will be reset when the temperature falls until Over Heat B threshold
Over Voltage	If the applied voltage is > 18 V and the motor's PWM % is < 30 %	Increase PWM % to 30 % during 2 s.	Conditions will be reset when applied voltage is < 16 V
Under Voltage	Supply voltage < 7.5 V	The motor will stop until supply voltage > 8.5 V.	Conditions will be reset when applied voltage is > 8.5 V
Input Open or Short to PWR	PWM input = 0%	Motor shuts down.	Conditions will be reset when PWM input between 5 % to 95 % (± 5)
Input short to GND	PWM input = 100%	Motor shuts down.	Conditions will be reset when PWM input between 5 % to 95 % (± 5)

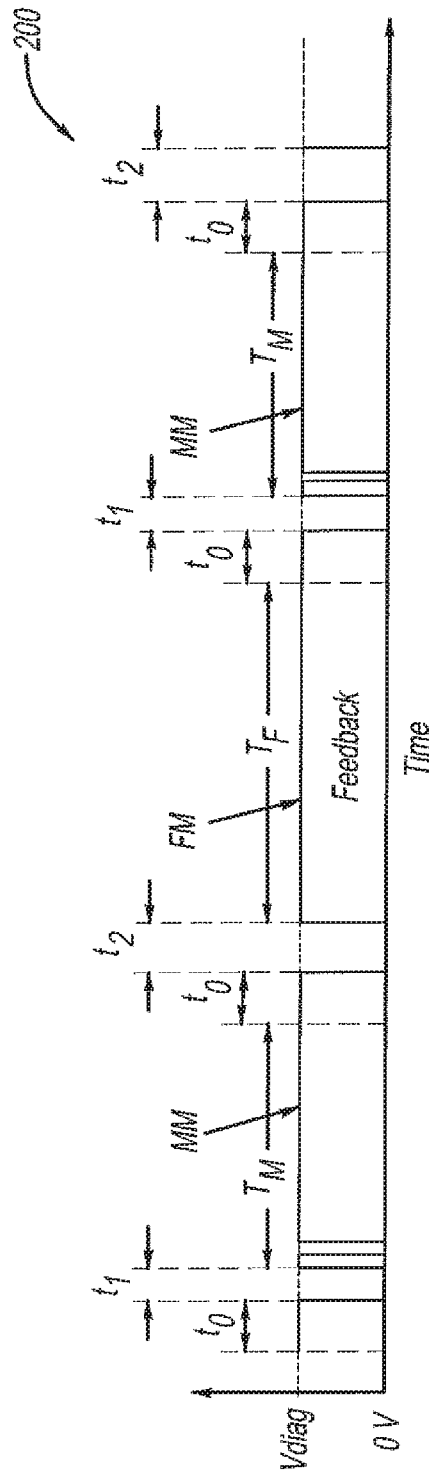


FIG - 6A

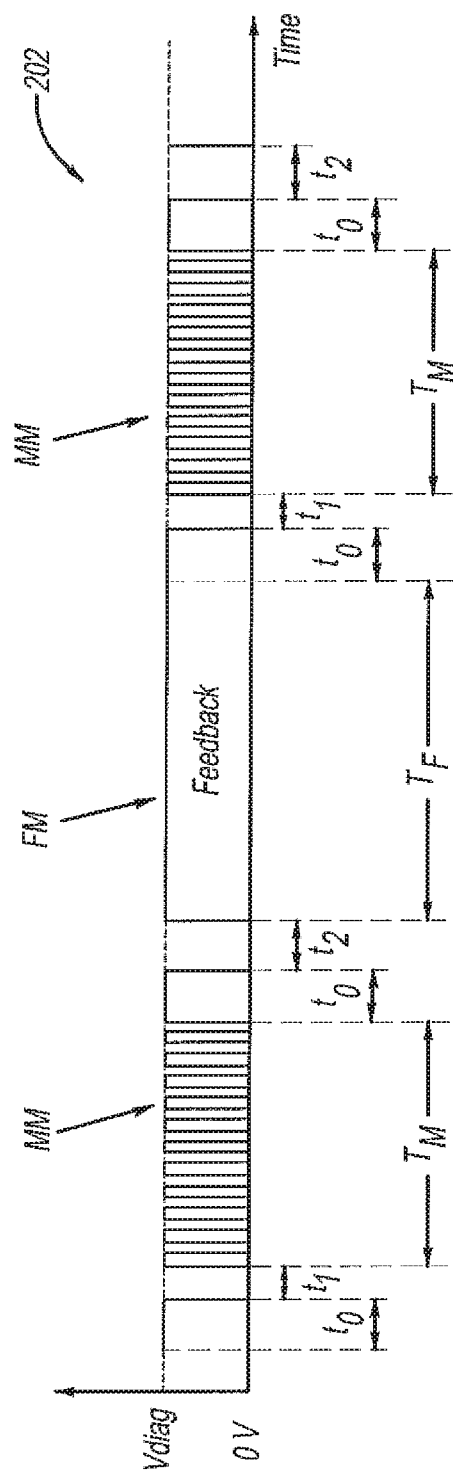


FIG - 6B

400

Mode	Digits	Priority
No Failure	0000=0	1
Over Current	0001=1	2
Current Limitation	0010=2	3
Locked Rotor	0011=3	2
Over Heat A	0100=4	4
Over Heat B	0101=5	5
Over Heat C	0110=6	2
Over Voltage	0111=7	6
Under Voltage	1000=8	2
Input Open or Short PWR	1001=9	7
Input Short to GND	1010=10	8

FIG - 7

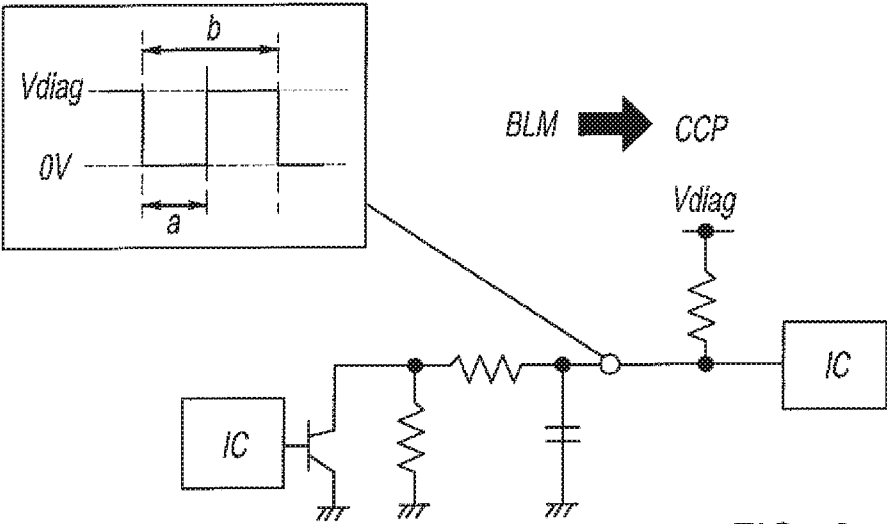


FIG - 9

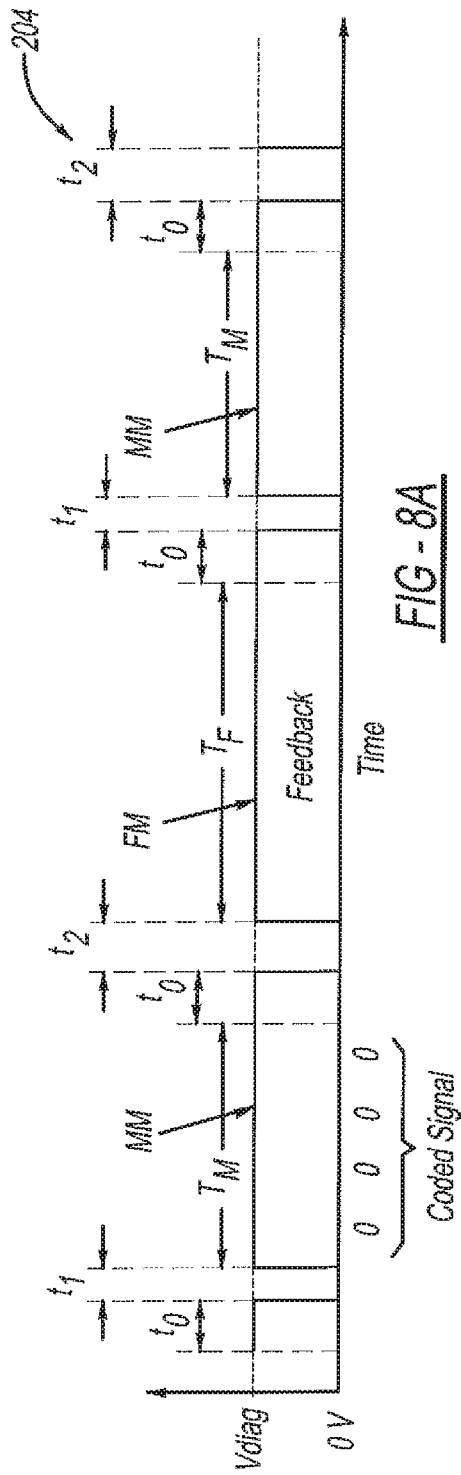


FIG - 8A

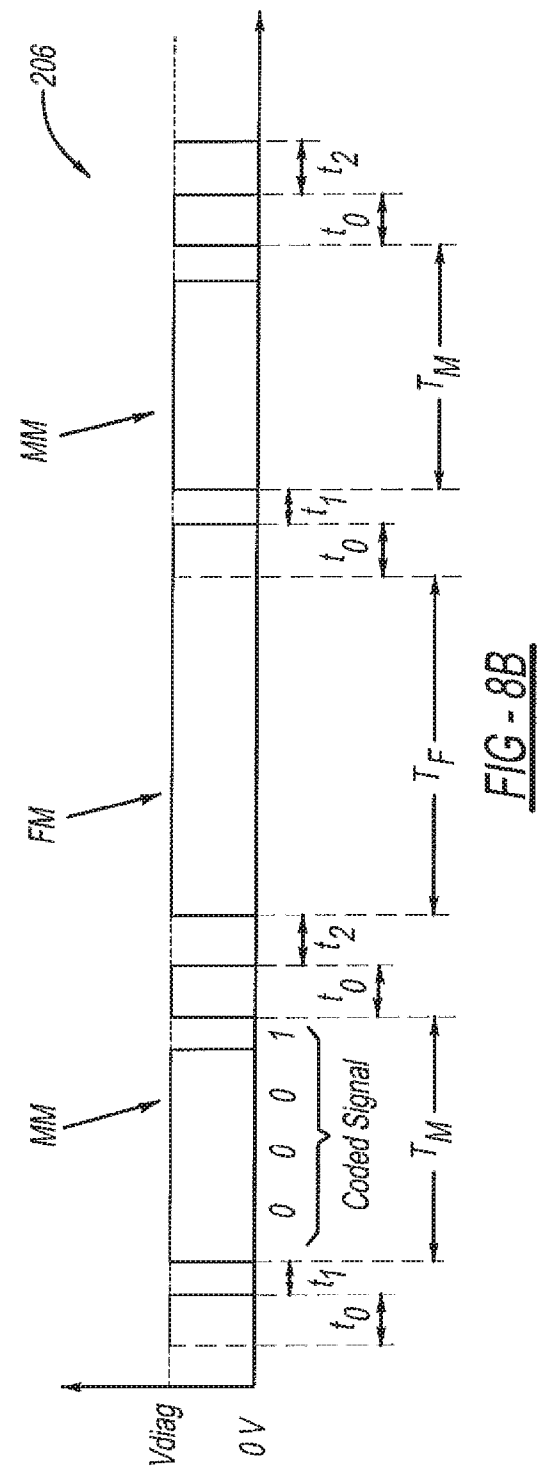


FIG - 8B

Motor	Specification	
	Duty Cycle (%)	Frequency (Hz)
Motor Running	50 ± 5	6 pulses / rev Motor Speed = 60 * f / 6 (rpm)
Motor Stopping	50 ± 5	12.5 ± 4.5

FIG - 10

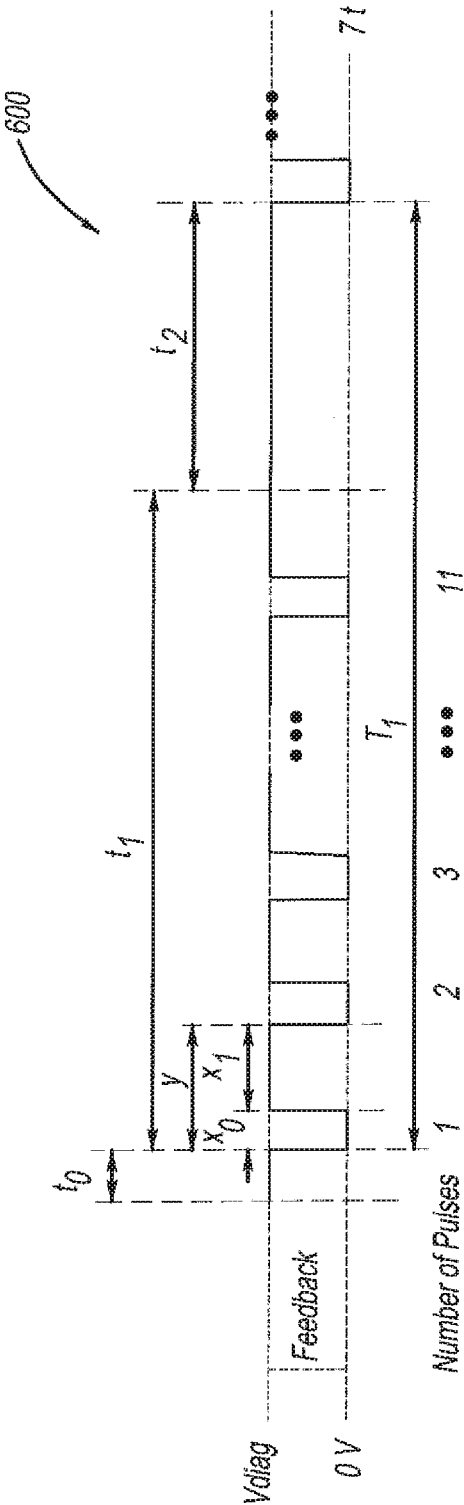
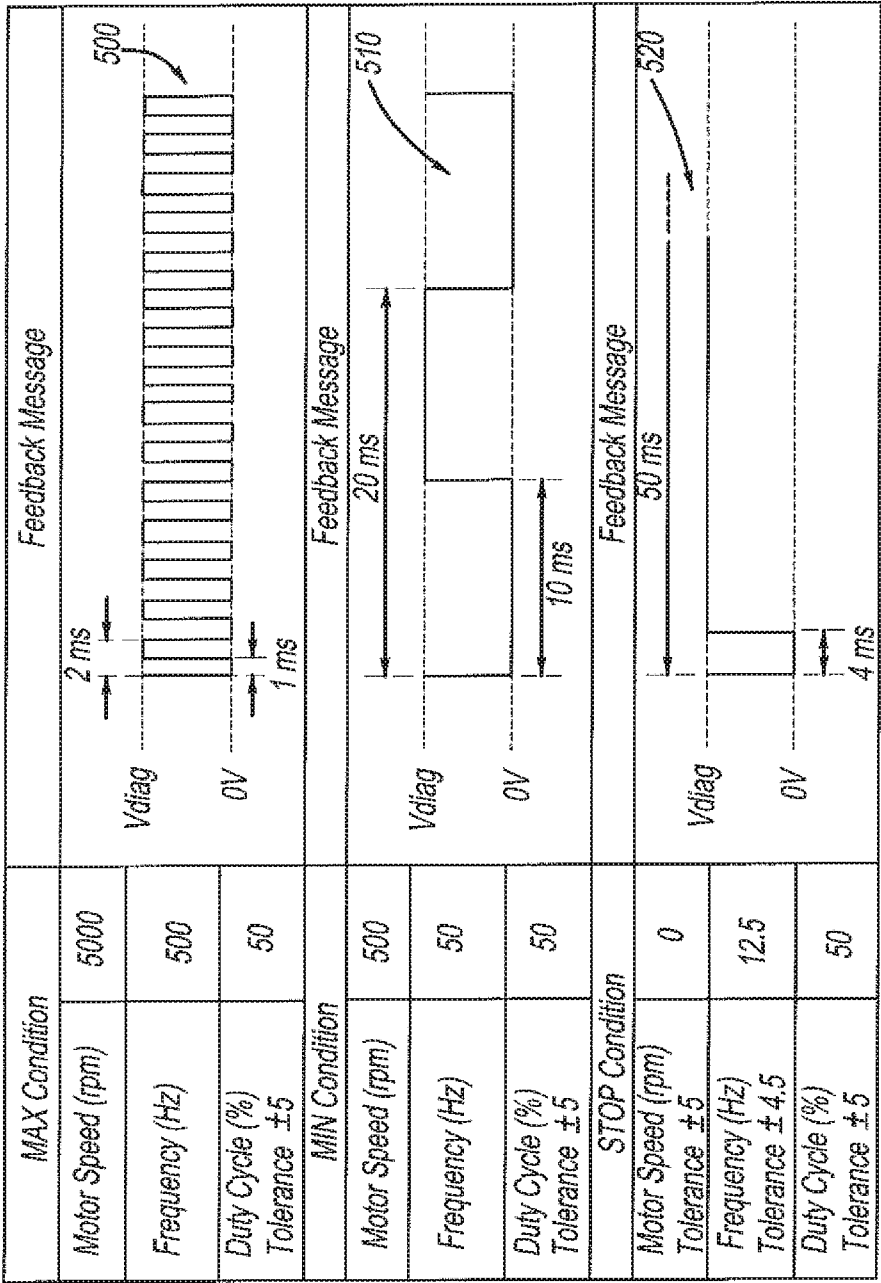
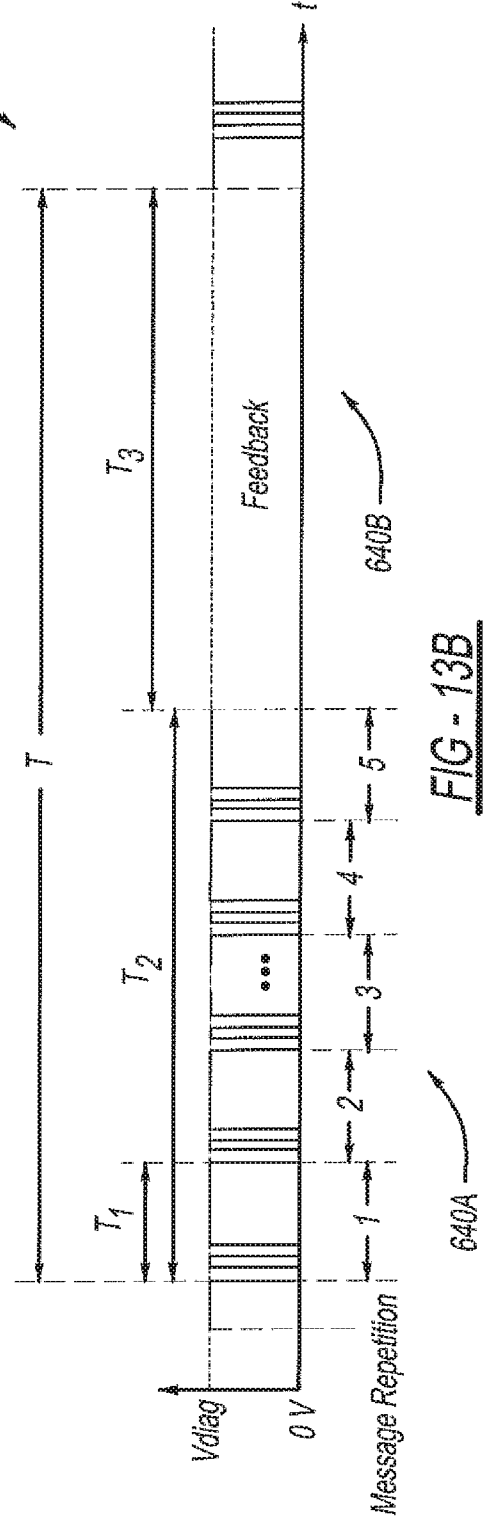
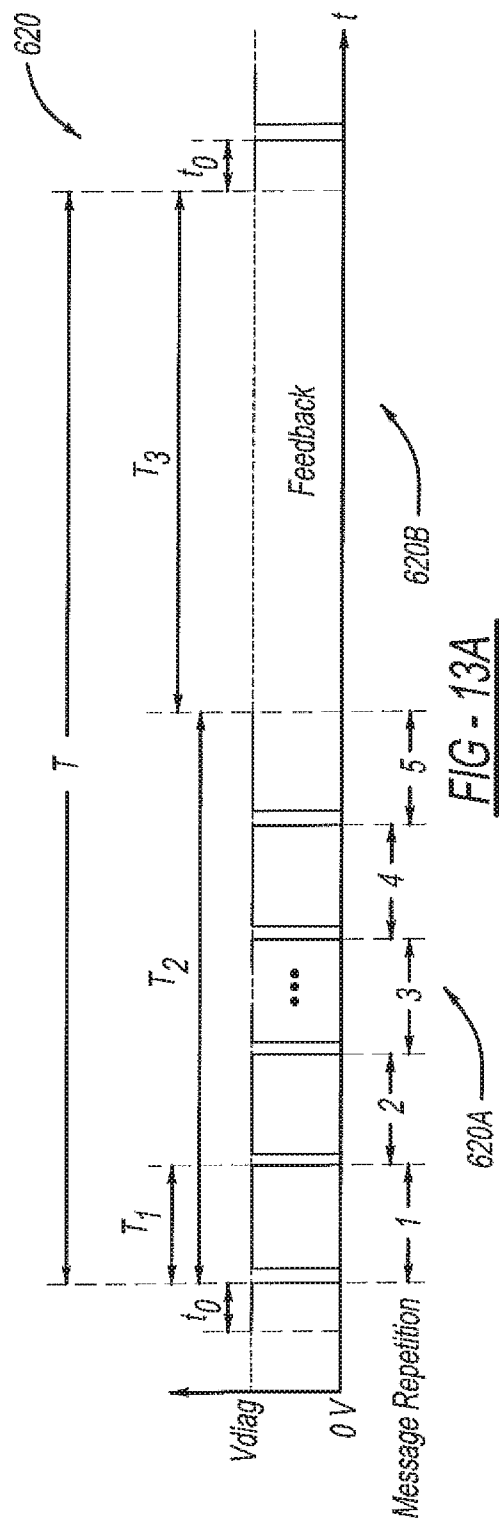


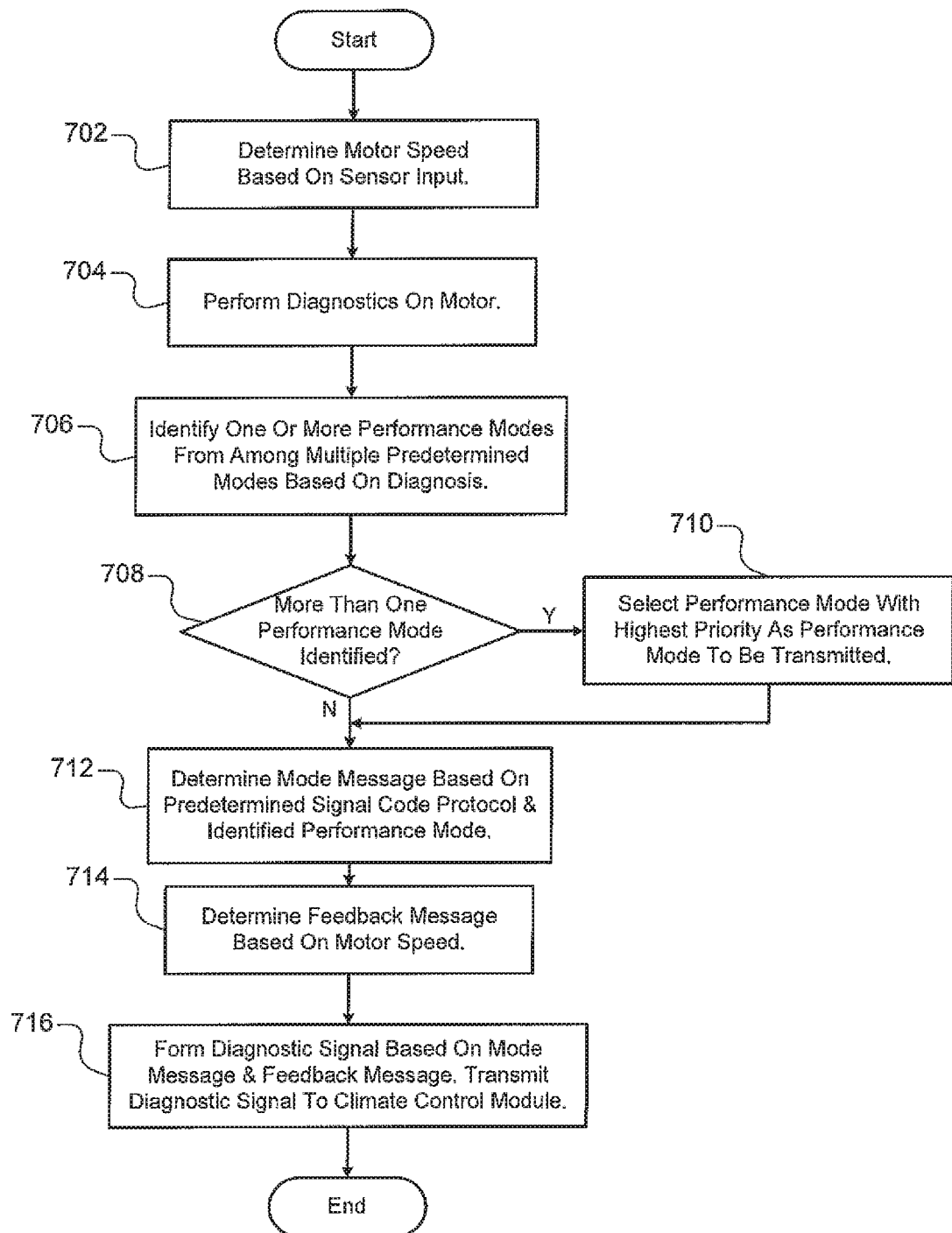
FIG - 12

FIG - 11





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FIG. 14

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/037876

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60H1/00 F04D27/00 H02P29/02
ADD.

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 F04D H02P

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/096398 A1 (KYRTSOS CHRISTOS [US] ET AL) 16 April 2009 (2009-04-16) the whole document	1-17
X	----- CN 204 283 951 U (VALEO AUTOMOTIVE AIR CONDITIONING HUBEI CO LTD) 22 April 2015 (2015-04-22) abstract; figure 1	1,10
A	----- US 4 827 730 A (DOI SHIGETOSHI [JP] ET AL) 9 May 1989 (1989-05-09) column 10, lines 20-26; figures 3,6b	1-17
A	----- US 2010/106810 A1 (GROHMAN WOJCIECH [US]) 29 April 2010 (2010-04-29) paragraphs [0031], [0038], [0104]; tables II, VII	1-17



Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

12 September 2016

Date of mailing of the international search report

23/09/2016

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Gumbel, Andreas

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/037876

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 2009096398	A1	16-04-2009	NONE	

CN 204283951	U	22-04-2015	NONE	

US 4827730	A	09-05-1989	NONE	

US 2010106810	A1	29-04-2010	NONE	
