

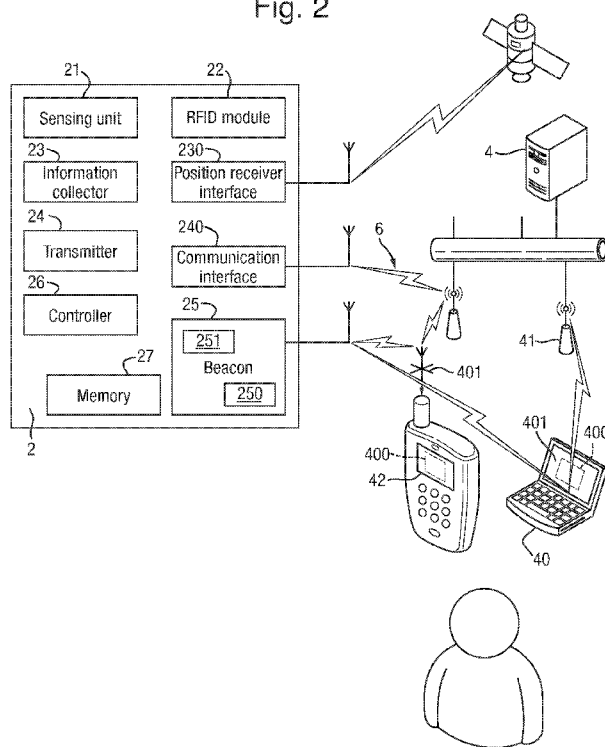


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(54) **Title:** IMPROVED VEHICLE TRACKING AND FAILURE DETECTION

Fig. 2



(57) **Abstract:** In one aspect, a vehicle tracking device is adapted to be mounted on a vehicle, comprising: an information collector configured to collect position information, the position information indicating the position of the device within a first area; a transmitter configured to transmit the position information to a remote apparatus using a communication network, wherein the apparatus is configured to transmit the position information to a user terminal; and a beacon configured to send radio frequency signals to the user terminal (40) within a range covering at least the first area, in order to enable the terminal to locate the device within a second area, wherein the second area is smaller than the first area. In another aspect, a vehicle tracking device (2) is configured to be mounted on a vehicle (20), wherein the device is configured to have a normal operating mode and an energy saving operating mode, wherein the device further comprises a detection module (28) for detecting, in the energy saving mode of the device, at least one of a linear acceleration and an angular acceleration corresponding to a physical displacement of the device (2), and wherein the detection module (28) is configured to provide an operating mode instruction to the device, responsive to the detecting, wherein the instruction is adapted to trigger the device to operate in the normal mode if the detected linear acceleration or the angular acceleration of the device is greater than a threshold of at least one of 0.3m.s^{-2} and 0.3°s^{-2} . In another aspect, a vehicle tracking device (2) is configured to be mounted on a vehicle (20), wherein the device is configured to have a normal operating mode and an energy saving operating mode, wherein the device further comprises a heading measurement module (29) for detecting, in the energy saving mode of the device, a variation of a heading of the vehicle in a predetermined period of time, and wherein the heading measurement module (29) is configured

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to provide an operating mode instruction to the device, responsive to the detecting, wherein the instruction is adapted to trigger the device to operate in the normal mode if the variation of a heading of the vehicle is greater than a threshold corresponding to 30° per minute. In another aspect a lighting interface (21) for a vehicle (1) and trailer (2) combination is provided, wherein the trailer has a plurality of lighting circuits (22, 23, 24) including at least one of a stop signal and direction indicator signals to be powered by the vehicle, wherein the vehicle is arranged to detect the presence of the trailer by detecting a path to ground through a bulb of at least one of the lighting circuits, the interface comprising circuitry (100, 63) for providing a path to ground for the or each circuit within a predetermined resistance range, irrespective of the condition of the lighting circuit.

Improved vehicle tracking and failure detection

The first invention relates to an improved vehicle tracking system. Fig. 1 schematically shows a known vehicle tracking system, which usually combines an electronic device 2 mounted in a vehicle 20 and a central apparatus 4 (usually a server), in order to enable a user (such as the owner of the vehicle or a provider of the vehicle tracking service) to track the vehicle 20.

The device 2 is adapted to collect data, notably GPS location, at regular intervals and to transmit in real-time or at regular intervals the collected data to the apparatus 4 via a communication network 6, usually a cellular or satellite network.

10 The apparatus 4 is adapted to receive the collected data from the device 2, and serve them on demand to the user on a user terminal 40, which may comprise a computer terminal and/or a handheld terminal such as a smartphone. The vehicle location can thus be viewed on the user terminal 40, such as on electronic maps, for example via the Internet or specialized software.

15 The known tracking systems may supply a provider of the tracking service, and subsequently the Police who can thus track and locate the stolen vehicle 20, with the vehicle location with accuracy of less than 500 metres, depending on local terrain. It is appreciated that the vehicle tracking systems are thus desirable for vehicle theft prevention and retrieval.

In some examples however, the accuracy of location is not sufficient to retrieve the vehicle. 20 However the inventors have discovered that, surprisingly, wireless communication capabilities of the device may be used with not specifically dedicated hardware to improve accuracy. The invention thus provides a method enabling the use of hardware, such as a smartphone, which is not dedicated to detection of tracking signals, in order to detect Wi-Fi or Bluetooth (trademark) signals transmitted by the tracking device: the strength of the Wi-Fi or Bluetooth signals is indicative of the distance between the user terminal and the tracking device; 25 and/or the direction detection of the Wi-Fi or Bluetooth signals is indicative of the location direction of the user terminal with respect to the tracking device.

Aspects and preferred examples of the present invention are set out in the appended claims.

In one aspect, it is provided a vehicle tracking device adapted to be mounted on a vehicle, 30 comprising an information collector configured to collect position information, the position information indicating the position of the device; a transmitter configured to transmit the

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position information to a remote apparatus using a communication network, and a beacon configured to broadcast Wi-Fi or Bluetooth signals to facilitate short range location of the device.

The information collector may be configured to collect satellite position information, preferably global positioning system, GPS, position information. The remote apparatus may comprise a server operated by a provider of a vehicle tracking service. The communication network may be a cellular or a satellite network, preferably a global system mobile communications, GSM, network.

The Wi-Fi or Bluetooth signals may be configured to facilitate location of the device with greater accuracy than with the position information alone, preferably within a range of 0.1 to 100 metres, preferably within 1 to 10 metres. The strength of the Wi-Fi or Bluetooth signals when received at a user terminal may be indicative of the distance between the user terminal and the tracking device; and/or the direction detection of the Wi-Fi or Bluetooth signals may be indicative of the location direction of the user terminal with respect to the tracking device.

In another aspect, it is provided a vehicle tracking device adapted to be mounted on a vehicle, comprising: an information collector configured to collect position information, the position information indicating the position of the device; and a beacon configured to broadcast Wi-Fi or Bluetooth signals to facilitate short range location of the device; wherein the beacon comprises a Wi-Fi access point, adapted to communicate with a remote Wi-Fi access point within the transmission range of the beacon.

In another aspect, it is provided a vehicle tracking device adapted to be mounted on a vehicle, comprising: an information collector configured to collect position information, the position information indicating the position of the device; and a beacon configured to broadcast Wi-Fi or Bluetooth signals to facilitate short range location of the device; wherein the beacon comprises a Bluetooth device, adapted to communicate with a remote Bluetooth terminal within the transmission range of the beacon.

The Wi-Fi access point and/or the Bluetooth device may be configured to transmit the position information to any remote Wi-Fi access point or to any paired Bluetooth terminal within the transmission range. The Wi-Fi access point and/or the Bluetooth device of the vehicle tracking device may be further configured to send and receive data, preferably commands and responses. The commands may include commands to activate one or more systems of the vehicle tracking device or of the vehicle itself, such as a camera or a

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microphone located in a suitable position in the vehicle, and/or commands to request the one or more systems to send back data to a user terminal, such as images from the camera or sound recordings from the microphone; and/or wherein the responses may include images from a camera and/or sound recordings from a microphone.

5 In another aspect, it is provided a terminal adapted to operatively cooperate with a device adapted to be mounted on a vehicle, comprising: a receiver configured to receive position information from a remote apparatus using a communication network, the position information indicating the position of the tracking device; and a module configured to receive Wi-Fi or Bluetooth signals from a beacon of the device, and detect the direction and/or the
10 strength of the Wi-Fi or Bluetooth signals, in order to facilitate short range location of the device.

The terminal may further be adapted to: receive position information or other data from a Wi-Fi access point and/or a Bluetooth device of the beacon Bluetooth terminal within the transmission range; and/or send and receive data, preferably commands and responses,
15 wherein the commands include commands to activate one or more systems of the vehicle tracking device or of the vehicle itself, such as a camera or a microphone located in a suitable position in the vehicle, and/or commands to request the one or more systems to send back data to a user terminal, such as images from the camera or sound recordings from the microphone; and/or wherein the responses include images from a camera and/or
20 sound recordings from a microphone.

In another aspect, it is provided a method of tracking a vehicle, comprising: collecting position information, the position information indicating a long range position of a tracking device adapted to be mounted on a vehicle; transmitting the long range position information
25 to a remote apparatus using a communication network to locate the device within the long range; broadcasting Wi-Fi or Bluetooth signals from the tracking device to facilitate location of the device.

In another aspect, it is provided a method of tracking a vehicle, comprising: collecting
30 position information, the position information indicating a long range position of a tracking device adapted to be mounted on a vehicle; locating the device within the long range; broadcasting Wi-Fi or Bluetooth signals from the tracking device to facilitate location of the device; and communicating information and/or data via Wi-Fi with a remote Wi-Fi access point.

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In another aspect, it is provided a method of tracking a vehicle, comprising: collecting position information, the position information indicating a long range position of a tracking device adapted to be mounted on a vehicle; locating the device within the long range;
5 broadcasting Wi-Fi or Bluetooth signals from the tracking device to facilitate location of the device; and communicating information and/or data via Bluetooth with a remote paired Bluetooth terminal.

The information may be the position information and/or the data are commands and responses. The commands may include commands to activate one or more systems of the
10 vehicle tracking device or of the vehicle itself, such as a camera or a microphone located in a suitable position in the vehicle, and/or commands to request the one or more systems to send back data to a user terminal, such as images from the camera or sound recordings from the microphone; and/or wherein the responses may include images from a camera and/or sound recordings from a microphone.

15

In another aspect, it is provided a communications apparatus configured to: provide an interface configured to enable the registration of a user of a terminal to an apparatus defining operation parameters for a vehicle tracking service; and the submission and/or update of identity parameters of the user; and the download of an application from the apparatus
20 comprising program instructions to program a module of the terminal of the user to provide a terminal according to aspects of the invention or to carry out data processing of a method according to aspects of the invention.

In another aspect it is provided an application configured to operate on a terminal according
25 to aspects of the invention and a computer program, a computer program product or a computer readable medium comprising instructions for carrying out a method according to aspects of the invention.

The inventors have therefore invented an improved tracking device, having several
30 advantages above the prior art.

One example of advantages is that the invention provides an improved location accuracy, in order to improve even further the accuracy of the location of the stolen vehicle, to enable the retrieval of the vehicle for example in cases where the stolen vehicle is hidden, such as in a

closed private garage, by enabling the Police to make sure they are opening the appropriate garage to retrieve the stolen vehicle. Another advantage is that non-dedicated hardware may be used in locating the stolen vehicle, such as a smartphone, laptop or tablet, which most vehicle owners and/or the Police have readily available for other uses and which may be able
5 to detect Wi-Fi or Bluetooth signals already or can be configured to detect such signals, for example by simple installation of an appropriate application or program.

In another aspect, the beacon comprises a Wi-Fi access point, adapted to communicate with a remote Wi-Fi access point within the transmission range of the beacon, wherein the Wi-Fi access point is configured to transmit the position information to any remote Wi-Fi access
10 point within the transmission range. This is advantageous because, even if the GSM signal is deliberately jammed so that the tracking device cannot transmit the position information via the GSM network, the position information will instead be transmitted by a Wi-Fi signal to one or more other access points within range and the user and/or Police will still be able to receive the up to date (e.g. GPS) position information for the stolen vehicle. This is
15 particularly advantageous as Wi-Fi access points are becoming ever more widespread (for example the Fon network) and furthermore, by additionally transmitting information identifying the or each remote Wi-Fi access point to the user and/or Police, this gives further, local position information regarding the stolen vehicle (i.e. that the vehicle is within transmission range of the particular remote Wi-Fi access point or points). If the Wi-Fi access
20 point of the beacon is within range of several Wi-Fi access points, then local position information may be given by triangulation of the Wi-Fi access points.

Preferably the Wi-Fi access point of the vehicle tracking device is further configured to send and receive other data, preferably commands and responses. For example, in a particularly preferred embodiment, the Wi-Fi access point receives a command to activate one or more
25 systems of the vehicle tracking device or of the vehicle itself, such as a camera located in a suitable position in the vehicle (internally or externally). Thus the user can instruct the Wi-Fi access point to activate the camera and to send back images to the user (e.g. to their smartphone or laptop) which will provide further information about the stolen vehicle, such as its location or images of the person driving the vehicle. This not only helps to locate the
30 vehicle but also provides evidence in relation to the theft, such as images of the thief for use in prosecution. The Wi-Fi access point may likewise receive commands and feed back information from other systems within the vehicle, such as a microphone for example. In embodiments the systems (such as cameras or microphones) are arranged to switch on automatically in the vehicle (e.g. when the engine of the vehicle is switched on), and the data

is automatically sent to the user. Transmission of information or data between the Wi-Fi access points is performed as known by the person skilled in the art.

Similarly, in another aspect, the beacon comprises a Bluetooth device, adapted to communicate with a remote user terminal using Bluetooth within the transmission range of the beacon, wherein the Bluetooth device is configured to transmit the position information and/or send and receive other data, preferably commands and responses, such as data from systems, to any remote paired user terminal within the transmission range. The pairing of the remote Bluetooth user terminal and the Bluetooth device is performed as known by the person skilled in the art.

10 Embodiments of the first invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1, already discussed, schematically shows a known tracking system;

Figure 2 schematically shows an example tracking system according to the invention;

Figures 3A and 3B show a flow diagram of a method performed on a system of Figure 2; and

15 Figure 4 schematically shows a first area and a second area in a method of Figures 3A and 3B.

With reference to the drawings in general, it will be appreciated that similar features or elements bear identical reference signs. It will also be appreciated that the Figures are not to scale and that for example relative dimensions may have been altered in the interest of clarity in the drawings. Also any functional block diagrams are intended simply to show the functionality that exists within the device and should not be taken to imply that each block shown in the functional block diagram is necessarily a discrete or separate entity. The functionality provided by a block may be discrete or may be dispersed throughout the device or throughout a part of the device. In addition, the functionality may incorporate, where appropriate, hardware elements, software elements or firmware elements or any combination of these.

With reference to the Figures, it will be appreciated that according to an example embodiment of the present invention, a device 2, which is hidden within a vehicle 20, such as a car, a bus or a truck, includes a sensing unit 21, a radio frequency identification (RFID) module 22, an information collector 23, a transmitter 24, a beacon 25, a controller 26 and a memory 27.

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The sensing unit 21 is configured to detect an external or internal status of the vehicle 20, for example by means of information input from at least one sensor hidden within the vehicle 20 (such as an impact sensor and/or a door open sensor and/or movement sensor such as an accelerometer and/or a gyrometer).

5 The RFID module 22 may be configured to act as a receiver or a transmitter of radio-frequency electromagnetic fields, in order to act as an RFID tag or an RFID reader for the vehicle 20. The information collector 23 is configured to collect position information, for example periodically receive position information obtained by a position receiver interface 230 of the device 2. The beacon 25 is configured to send radio frequency signals, using for
10 example Wi-Fi or Bluetooth protocols. The controller 26 is typically implemented with a microprocessor or some form of programmable controller. In S1 the controller 26 collects data from the unit 21 and/or the module 22 and/or the collector 23.

The controller 26 determines in S2 information on whether or not the detected status of the vehicle 20 deviates from a predetermined normal status, for example an abnormal status
15 and/or illegal movement. The determination may be derived from: the unit 21 may detect the generation of an impact or a movement in excess of a reference value and/or a door being opened without using a key or a remote control; and/or the module 22 may detect a case where an ID of the RFID is not matched with a RFID tag and/or reader of the owner of the vehicle; and/or the collector 23 may detect that the vehicle exits and/or enters a
20 predetermined GPS geofence, i.e., as known by those skilled in the art, a virtual perimeter of a physical geographic area which may be dynamically generated, e.g. as a radius around a point location or a custom-digitized drawn zone around an area.

If the status is determined as not abnormal in S2, S1 is performed again.

When the status of the vehicle 20, as detected by the sensing unit 21 and/or the module 22
25 and/or the collector 23, is determined in S2 as deviating from a predetermined normal status by the controller 26, i.e. for example the controller 26 determines an abnormal status and/or illegal movement, in S3 the information collector 23 periodically receives position information obtained by the position receiver interface 230 of the device 2.

In S4 the transmitter 24 transmits the position information, periodically received from the
30 information collector 23, to a central apparatus 4, preferably operated by a provider of a vehicle tracking service. The transmission is preferably performed using a communication network 6, such as preferably a Global System Mobile Communications (GSM) using a

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communication interface 240 of the device 2, but other networks may be used, such as satellite networks.

In embodiments, the transmitter 24 is adapted to: transmit the position information in real time, when the communication network 6 is available or in range of the interface 240, and to
5 store the position information to a memory, usually the memory 27 internal to the device 2, when the network 6 is not available or not in range of the interface 240, and to transmit the stored position information to the apparatus 4 later, when the communication network 6 becomes available again.

In embodiments, in S4 the transmitter 24 further transmits a notification, such as an alarm
10 message, e.g. a SMS message an/or an e-mail, indicating to the apparatus 4 a possible theft of the vehicle 20, without the transmission of the notification appearing on any device of the vehicle 20.

In embodiments the transmitter 24 may further transmit data including at least one of the following: locating technology parameters, such as number of GPS satellites in view, etc.,
15 and/or vehicle parameters, such as speed, heading direction, fuel amount, engine temperature and/or RPM, altitude, tire pressure, battery status, etc., and/or a trigger event, such as key on/off, head/tail lights on/off, door open/closed, etc.

The apparatus 4 preferably comprises one or more servers, in a single location or several locations, and the one or more servers are connected to access points, such as wireless
20 access points 41. The apparatus 4 stores the parameters for the operation of the tracking service, and also stores user profiles (containing the user name), created by the users when registering, as explained in greater detail below.

In S5 the apparatus 4 receives the transmitted information and notification, and securely stores them. As it will be appreciated in greater detail below, the apparatus 4 is configured to
25 serve the information, and sometimes notification, on demand to at least one user (such as the provider and/or the owner of the vehicle and/or the Police) on a user terminal 40, which may comprise a computer terminal and/or a handheld terminal such as a smartphone.

As known by the person skilled in the art, the user terminal 40 typically comprises at least a processor, a memory, a display 42 and telecommunications means comprising a radio
30 frequency signal receiver 401 (including access to cellular and/or communications network

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such as the Internet), such that the vehicle location can thus be viewed on the display 42, such as on electronic maps, for example via the Internet or specialized software.

In S6 the apparatus 4 contacts the owner of the vehicle 20, for example via a phone call and/or a SMS message and/or an email on the terminal 40, and provides vehicle movement
5 details, and determines whether the possible theft is confirmed or not by the user.

If the theft is not confirmed in S6, S1 is performed again.

If the theft is confirmed in S6, in S7 the apparatus 4 continues to receive at least the position information from the transmitter 24, and starts a tracking and recovery procedure, in line with current Police legislation and procedures.

10 In S8 the apparatus 4 obtains a crime reference number from the Police. In S9 the apparatus 4 liaises preferably with the Police (and/or the owner of the vehicle) by sending the data transmitted by the transmitter 24 and stored on the apparatus 4 to the terminal 40, such as a smartphone, used by the Police or the owner, in order to enable to track and to recover the vehicle 20.

15 It is appreciated that the position information, preferably the GPS location information, transmitted by the transmitter 24 enables long range location of the vehicle 20 within a first area R1 only, i.e. with a location accuracy of a few tens of metres depending on local terrain.

In S10 the terminal 40 locates and approaches the stolen vehicle 20 within the first area R1. In embodiments in S11 the terminal 40 is then in range of the beacon 25 (i.e. in a range of up
20 to 100 metres), and the position information corresponding to the radio frequency signals, preferably the Wi-Fi or Bluetooth signals, broadcast by the beacon 25 are received by the receiver 401 of the terminal 40 to enable location of the vehicle 20 within a reduced, short range second area R2, i.e. with a location accuracy of a few metres depending on local terrain (i.e. $R2 < R1$).

25 The user terminal 40 comprises a module 400 configured to locate the stolen vehicle very accurately, using detection by the receiver 401 of the terminal 40 of: the direction D of the source (corresponding to the beacon 25); and/or the strength (corresponding to the distance between the beacon 25 and the terminal 40) of the location information broadcast by the beacon 25. This accuracy enables the retrieval of the vehicle 20 for example in cases where
30 the stolen vehicle 20 is hidden, such as in a closed private garage, in order to enable the

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Police (or the owner) to make sure e.g. they are opening the appropriate garage to retrieve the stolen vehicle 20. In S12 the vehicle is recovered.

The module 400 may incorporate hardware elements in a more specifically dedicated terminal 40, such as a terminal 40 used by the Police, but preferably comprises mainly 5 software elements or firmware elements or any combination of these, for example for a general purpose terminal 40 such as a smartphone used e.g. by the owner of the vehicle 20.

In order to be able to locate and approach the stolen vehicle 20 within the second area R2, a user who does not have a specifically dedicated hardware module 400 (typically the owner of the vehicle 20 only has a general purpose smartphone) needs to register with the apparatus 10 4 operated by the service provider via an application interface (at an address known by the user, such as "<http://www.vehicletracking.com>").

The terminal 40 is then able to download an application from the apparatus 4 as explained in further detail below, to be able to locate and approach the stolen vehicle 20 within the second area, when within range of the beacon 25.

15 The terminal application may be downloaded by the terminal 40 from the apparatus 4 via the Internet for example, and enables the registration of the user to the apparatus 4 to generate the user name, preferably while creating a profile for the user; the submission and/or update of the profile stored on the apparatus 4, by accessing the apparatus 4, e.g. through a web browser or the apparatus application; and the update of the module 400 of the terminal 40, 20 so that the terminal may be configured to locate and approach the stolen vehicle 20 within the second area.

In order to register the user, the apparatus 4 preferably asks the user to create and populate a profile and/or to set up a login (for example an email address) and an authentication parameter (for example a password). The apparatus 4 then provides the registered user with 25 at least one user name associated with the user, preferably unique.

In embodiments, the beacon comprises a Wi-Fi access point 250, adapted to communicate with a remote Wi-Fi access point 60 within the transmission range of the beacon, wherein the Wi-Fi access point is configured to transmit the position information to any remote Wi-Fi access point within the transmission range. This is advantageous because, even if the GSM 30 signal is deliberately jammed so that the tracking device cannot transmit the position information via the GSM network, the position information will instead be transmitted by a Wi-

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Fi signal to one or more other access points within range and the user and/or Police will still be able to receive the up to date (e.g. GPS) position information for the stolen vehicle. This is particularly advantageous as Wi-Fi access points are becoming ever more widespread (for example the Fon network) and furthermore, by additionally transmitting information
5 identifying the or each remote Wi-Fi access point to the user and/or Police, this gives further, local position information regarding the stolen vehicle (i.e. that the vehicle is within transmission range of the particular remote Wi-Fi access point or points). If the Wi-Fi access point of the beacon is within range of several Wi-Fi access points, then local position information may be given by triangulation of the Wi-Fi access points.

10 Preferably the Wi-Fi access point 250 of the vehicle tracking device is further configured to send and receive other data, preferably commands and responses. For example, in a particularly preferred embodiment, the Wi-Fi access point receives a command to activate one or more systems of the vehicle tracking device or of the vehicle itself, such as a camera located in a suitable position in the vehicle (internally or externally). Thus the user can
15 instruct the Wi-Fi access point to activate the camera and to send back images to the user (e.g. to their smartphone or laptop) which will provide further information about the stolen vehicle, such as its location or images of the person driving the vehicle. This not only helps to locate the vehicle but also provides evidence in relation to the theft, such as images of the thief for use in prosecution. The Wi-Fi access point may likewise receive commands and
20 feed back information from other systems within the vehicle, such as a microphone for example. In embodiments the systems (such as cameras or microphones) are arranged to switch on automatically in the vehicle (e.g. when the engine of the vehicle is switched on), and the data is automatically sent to the user.

Similarly, in another aspect, the beacon comprises a Bluetooth device 251, adapted to
25 communicate with a remote user terminal 70 or 40 using Bluetooth within the transmission range of the beacon, wherein the Bluetooth device 251 is configured to transmit the position information and/or send and receive other data, preferably commands and responses such as data from systems, to any remote paired Bluetooth user terminal 70 or 40 within the transmission range. The pairing of the remote Bluetooth user terminal and the Bluetooth
30 device is performed as known by the person skilled in the art.

Modifications and Variations

Detailed embodiments have been described above. As those skilled in the art will appreciate, a number of modifications and alternatives can be made to the above embodiments whilst

still benefiting from the inventions embodied therein, and will not be described in further detail here.

It should also be appreciated that Figure 2 shows functional block diagrams and that in practice the individual blocks shown in Figure 2 may exist as discrete elements or their functionality may be distributed in different combinations or not individually discernable.

In the embodiments described above, the device includes circuitry. Typically this circuitry will be formed by dedicated hardware circuits. However, in some embodiments, part of the circuitry may be implemented as software run by the corresponding controller. It should be appreciated that the functionalities may also be provided, where appropriate, by firmware and/or software and/or hardware or any combination thereof. A software implementation may however be preferred to facilitate the updating of the functionality of an element.

Where software are provided, they may be provided, as appropriate, in compiled or un-compiled form and may be supplied, as the case may be, as a signal over a computer or telecommunications network, or on a computer storage medium such as for instance a disc, an optical disc or a CD ROM.

In embodiments GLONASS, Radio Frequency or cellular technology (such as GSM) may be also used for locating the device 2, instead of or in complement to using GPS, and the data transmitted to the apparatus may also further include GSM and/or GSM area code/cell code.

The device 2 may be self-powered with a battery or wired into the vehicle power system (battery).

In embodiments, the position receiver interface and/or the communication interface and/or the beacon may be at least partially merged.

Whilst in some embodiments the terminal 40 may require an application to be downloaded and installed to enable the signal broadcast by the beacon 25 to be recognised, in other embodiments the terminal 40 can use existing application(s) to determine the strength and/or direction of the broadcast signal. For example, an application that indicates signal strength, such as the Wi-Fi signal strength indicator typically displayed on most smartphones, laptops or tablets, can be used to determine the direction of the broadcast signal by shielding the terminal 40 in one direction and monitoring whether the signal strength decreases. No decrease in signal strength indicates that the shield is not positioned between the terminal 40 and the beacon 25 whereas a decrease in signal strength indicates that the shield is

positioned between the terminal 40 and the beacon 25. By moving in the direction indicated, the terminal 40 can be shielded again to confirm the terminal 40 is being moved in the correct direction towards the beacon 25. In alternative embodiments, an application for displaying signal strength with greater sensitivity (e.g. with more bars than typically displayed 5 for a signal strength indicator or the like) may be downloaded to the terminal 40 to facilitate location of the beacon 25.

It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described in relation to any other embodiment.

10 Although the invention was described in relation to stolen vehicle recovery, it is understood that the invention may be implemented in other applications, such as for fleet management, e.g. urban public transit or commercial trucks.

The second invention relates to an improved vehicle tracking system.

Fig. 2 schematically shows a known vehicle tracking system, which usually combines an 15 electronic device 2 mounted in a vehicle 20 and a central apparatus 4 (usually a server), in order to enable a user (such as the owner of the vehicle or a provider of the vehicle tracking service) to track the vehicle 20.

The device 2 is adapted to collect data, notably GPS location, at regular intervals and to transmit in real-time or at regular intervals the collected data to the apparatus 4 via a 20 communication network 6, usually a cellular or satellite network.

The apparatus 4 is adapted to receive the collected data from the device 2, and serve them on demand to the user on a user terminal 40, which may comprise a computer terminal and/or a handheld terminal such as a smartphone. The vehicle location can thus be viewed on the user terminal 40, such as on electronic maps, for example via the Internet or 25 specialized software.

The known tracking systems may supply a provider of the tracking service, and subsequently the Police who can thus track and locate the stolen vehicle 20, with location accuracy of less than 100 metres, depending on local terrain. It is appreciated that the vehicle tracking systems are thus desirable for vehicle theft prevention and retrieval.

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The device 2 may be self-powered with a battery or wired into the vehicle power system (battery), and the device is therefore usually configured to have a normal operating mode and an energy saving operating mode. The device therefore usually comprises a module for detecting physical displacement of the device, and configured to provide an operating mode instruction to the device, responsive to the detecting. The instruction is adapted to trigger the device to operate in the normal mode if the module detects physical displacement. However one of the drawbacks of the known devices is that there are numerous false alarms in a number of applications of the device, such as when the vehicle is subject to vibration.

However the inventors have discovered that, surprisingly, it is possible to efficiently track vehicles, whilst avoiding false alarms and thus saving power (which thus reduces the contribution to global CO₂ production).

Aspects and preferred examples of the present invention are set out in the appended claims.

In one aspect, there is provided a vehicle tracking device configured to be mounted on a vehicle, wherein the device is configured to have a normal operating mode and an energy saving operating mode, wherein the device further comprises a detection module for detecting, in the energy saving mode of the device, at least one of a linear acceleration and an angular acceleration corresponding to a physical displacement of the device, and wherein the detection module is configured to provide an operating mode instruction to the device, responsive to the detecting, wherein the instruction is adapted to trigger the device to operate in the normal mode if the detected linear acceleration or the angular acceleration of the device is greater than a threshold of at least one of 0.3m.s^{-2} and 0.3°s^{-2} .

The device may comprise an information collector configured to collect position information indicating the position of the device; and/or a transmitter configured to transmit the position information to a remote apparatus using a communication network, and wherein the information collector and/or the transmitter may be configured to operate in an energy saving operating mode when the device operates in the energy saving operating mode; and in a normal operating mode when the device operates in the normal operating mode.

The device may comprise a controller of the device configured to control the detection module when the device operates in both the energy saving operating mode and the

normal operating mode, wherein the controller may be configured to operate in a specific energy saving mode when controlling the detection module when the device operates in the energy saving operating mode; and control the information collector and/or the transmitter in the normal operating mode of the device.

5

The information collector may further be configured to validate the trigger responsive to the collection of the position information once operating in the normal operating mode. The information collector may be configured to collect satellite position information, preferably global positioning system, GPS, position information.

10

The detection module may comprise an accelerometer and/or a gyrometer. The device may comprise a rechargeable battery.

In another aspect, there is provided a method of tracking a vehicle, comprising: detecting, in
15 an energy saving mode of a device configured to be mounted on a vehicle and to have a normal operating mode and an energy saving operating mode, at least one of a linear acceleration and an angular acceleration corresponding to a physical displacement of the device; providing an operating mode instruction to the device, responsive to the detecting, wherein the instruction is adapted to trigger, responsive to the detecting, the
20 device to operate in the normal mode if the detected linear acceleration or the angular acceleration of the device is greater than a threshold of at least one of 0.3m.s^{-2} and 0.3°s^{-2} .

The method may comprise collecting position information indicating the position of the
25 device when the device operates in the normal operating mode; and/or transmitting the position information to a remote apparatus using a communication network when the device operates in the normal operating mode. The method may comprise controlling the detection when the device operates in both the energy saving operating mode and the normal operating mode, wherein controlling is performed in a specific energy saving
30 mode when the device operates in the energy saving operating mode; and controlling the collecting of the position information indicating the position of the device and/or the transmitting of the position information to the remote apparatus when the device operates in the normal operating mode. The method may comprise validating the trigger responsive to the collecting of the position information once operating in the normal operating mode.

Collecting the information may comprise collecting satellite position information, preferably global positioning system, GPS, position information.

In another aspect it is provided a computer program, a computer program product or a
5 computer readable medium comprising instructions for carrying out a method according to aspects of the invention.

The inventors have therefore invented an improved tracking device, having several advantages above the prior art. One example of advantages is that the invention provides an
10 improved power saving device, because the device may only trigger the device to operate in the normal mode if the trigger is validated. Another advantage is that the GPS functionality, which is battery consumption intensive, will only be switched on if an important enough physical displacement is detected. In the energy saving operating mode, the controller of the device operates at a specific energy saving operating mode, i.e. sufficient to enable control
15 of the detection module but insufficient to control the GPS functionality, thereby saving energy.

Embodiments of the second invention will now be described, by way of example, with reference to the accompanying drawings, in which:

20 Figure 5, already discussed, schematically shows a known tracking system;

Figure 6 schematically shows an example tracking system according to the invention; and

Figures 7A, 7B and 7C show a flow diagram of a method performed on a system of Figure 6.

With reference to the drawings in general, it will be appreciated that similar features or elements bear identical reference signs. It will also be appreciated that the Figures are not to
25 scale and that for example relative dimensions may have been altered in the interest of clarity in the drawings. Also any functional block diagrams are intended simply to show the functionality that exists within the device and should not be taken to imply that each block shown in the functional block diagram is necessarily a discrete or separate entity. The functionality provided by a block may be discrete or may be dispersed throughout the device
30 or throughout a part of the device. In addition, the functionality may incorporate, where appropriate, hardware elements, software elements or firmware elements or any combination of these.

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With reference to the Figures, it will be appreciated that according to an example embodiment of the present invention, a device 2, which is hidden within a vehicle 20, such as a caravan, a car, a bus, a trailer, or a truck, includes a sensing unit 21.

The device 2 usually also comprises a radio frequency identification (RFID) module 22, an information collector 23, a transmitter 24 configured to transmit position information to a remote apparatus 4 using a communication network 6, a controller 26 and a memory 27.

The sensing unit 21 is configured to detect an external or internal status of the vehicle 20, for example by means of information input from at least one sensor hidden within the vehicle 20 (such as an impact sensor and/or a door open sensor). The device also comprises a detection module 28 for detecting a physical displacement of the device 2. The detection module 28 is configured to detect a physical displacement of the device such as at least one of a linear acceleration and an angular acceleration corresponding to a physical displacement of the device 2, and preferably comprises an accelerometer and/or a gyrometer. However the physical displacement detected by the module 28 excludes vibration of the device, i.e. sustained oscillating change in location and/or orientation, such as vibration caused by the operation of an engine of the vehicle. This enables avoiding false alarms detected by the sensing unit 21 as explained in further detail below.

The RFID module 22 may be configured to act as a receiver or a transmitter of radio-frequency electromagnetic fields, in order to act as an RFID tag or an RFID reader for the vehicle 20.

The information collector 23 is configured, in a normal operating mode, to collect position information, for example periodically receive position information obtained by a position receiver interface 230 of the device 2.

The controller 26 is typically implemented with a microprocessor or some form of programmable controller.

The device is configured to have a normal operating mode and an energy saving operating mode.

In S1 the device 2 operates in an energy saving mode. The detection module 28 is however configured to be operable during the energy saving operating mode of the

device 2. The controller 26 of the device is configured to operate in a specific energy saving mode (e.g. the microprocessor operates with a lower frequency than in a normal operating mode) insufficient for controlling the module 22 or the collector 23 or the transmitter 24, thus saving energy, however sufficient for enabling controlling of the
5 detection module 28 when the device operates in the energy saving operating mode.

When the device operates in the energy saving operating mode, the information collector 23 and the transmitter 24 are configured to operate in an energy saving operating mode, thereby saving energy.

The module 28 determines in S2 information on whether or not the detected physical
10 displacement of the device, excluding vibration of the device, is greater than a threshold. In embodiments, the detection module 28 is configured to detect, in the energy saving mode of the device, if the linear acceleration or the angular acceleration of the device is: greater than a threshold of at least one of 0.3m.s^{-2} and $0.3^{\circ}.\text{s}^{-2}$, or greater than a threshold of at least one of 0.4m.s^{-2} and $0.4^{\circ}.\text{s}^{-2}$, or greater than a threshold of at least
15 one of 0.5m.s^{-2} and $0.5^{\circ}.\text{s}^{-2}$, or greater than a threshold of at least one of 1m.s^{-2} and $1^{\circ}.\text{s}^{-2}$.

If the detected physical displacement of the device corresponds to vibration and/or is inferior to the threshold in S2 (i.e. the linear acceleration or the angular acceleration of the device is lower than a threshold), S1 is performed again.

20 When the detected physical displacement of the device, as detected by the module 28 is determined in S2 as not being vibration and is superior to the threshold (i.e. the linear acceleration or the angular acceleration of the device is greater than a threshold), i.e. for example the module 28 determines a potential illegal movement, in S3 the detection module 28 provides an operating mode instruction to the device, responsive to the detecting. The
25 instruction may be provided via e.g. the sensing unit 21 connected to the module 28, and the controller 26 which collects data from the unit 21. The instruction is adapted to trigger the device to operate in the normal mode.

In embodiments, in the normal operating mode of the device, the module 22, the collector 23 and the transmitter 24 are operating in a normal operating mode, and the controller 26
30 also collects data from the module 22 and/or the collector 23 in S4.

The controller 26 determines in S5 information on whether or not the detected status of the vehicle 20 deviates from a predetermined normal status, for example an abnormal status and/or illegal movement. The determination may be derived from: the unit 21 may detect the generation of an impact or a movement in excess of a reference value (e.g. from the module 5 28) and/or a door being opened without using a key or a remote control; and/or the module 22 may detect a case where an ID of the RFID is not matched with a RFID tag and/or reader of the owner of the vehicle; and/or the collector 23 may detect an unauthorized position of the vehicle and/or that the vehicle exits and/or enters a predetermined GPS geofence, i.e., as known by those skilled in the art, a virtual perimeter of a physical geographic area which 10 may be dynamically generated, e.g. as a radius around a point location or a custom-digitized drawn zone around an area.

The device is thus further configured to validate the trigger of the module 28 responsive to the collection of the position information. If the status is determined as not abnormal in S5, S4 is performed again.

15 When the status of the vehicle 20, as detected by the sensing unit 21 (e.g. via the module 28) and/or the module 22 and/or the collector 23, is determined in S5 as deviating from a predetermined normal status by the controller 26, i.e. for example the controller 26 determines an abnormal status and/or illegal movement, in S6 the information collector 23 periodically receives position information obtained by the position receiver interface 230 of 20 the device 2.

In S7 the transmitter 24 transmits the position information, periodically received from the information collector 23, to a central apparatus 4, preferably operated by a provider of a vehicle tracking service. The transmission is preferably performed using a communication network 6, such as preferably a Global System Mobile Communications (GSM) using a 25 communication interface 240 of the device 2, but other networks may be used, such as satellite networks.

In embodiments, the transmitter 24 is adapted to: transmit the position information in real time, when the communication network 6 is available or in range of the interface 240, and to store the position information to a memory, usually the memory 27 internal to the device 2, 30 when the network 6 is not available or not in range of the interface 240, and to transmit the stored position information to the apparatus 4 later, when the communication network 6 becomes available again.

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In embodiments, in S7 the transmitter 24 further transmits a notification, such as an alarm message, e.g. a SMS message an/or an e-mail, indicating to the apparatus 4 a possible theft of the vehicle 20, without the transmission of the notification appearing on any device of the vehicle 20.

- 5 In embodiments the transmitter 24 may further transmit data including at least one of the following: locating technology parameters, such as number of GPS satellites in view, etc., and/or vehicle parameters, such as speed, heading direction, fuel amount, engine temperature and/or RPM, altitude, tire pressure, battery status, etc., and/or a trigger event, such as key on/off, head/tail lights on/off, door open/closed, etc.
- 10 The apparatus 4 preferably comprises one or more servers, in a single location or several locations, and the one or more servers are connected to access points, such as wireless access points 41. The apparatus 4 stores the parameters for the operation of the tracking service, and also stores user profiles (containing the user name), created by the users when registering, as explained in greater detail below.
- 15 In S8 the apparatus 4 receives the transmitted information and notification, and securely stores them. As it will be appreciated in greater detail below, the apparatus 4 is configured to serve the information, and sometimes notification, on demand to at least one user (such as the provider and/or the owner of the vehicle and/or the Police) on a user terminal 40, which may comprise a computer terminal and/or a handheld terminal such as a smartphone.
- 20 As known by the person skilled in the art, the user terminal 40 typically comprises at least a processor, a memory, a display 42 and telecommunications means comprising a radio frequency signal receiver 401 (including access to cellular and/or communications network such as the Internet), such that the vehicle location can thus be viewed on the display 42, such as on electronic maps, for example via the Internet or specialized software.
- 25 In S9 the apparatus 4 contacts the owner of the vehicle 20, for example via a phone call and/or a SMS message and/or an email on the terminal 40, and provides vehicle movement details, and determines whether the possible theft is confirmed or not by the user.
- If the theft is not confirmed in S9, S4 is performed again. If the theft is confirmed in S9, in S10 the apparatus 4 continues to receive at least the position information from the
- 30 transmitter 24, and starts a tracking and recovery procedure, in line with current Police legislation and procedures.

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In S11 the apparatus 4 obtains a crime reference number from the Police. In S12 the apparatus 4 liaises preferably with the Police (and/or the owner of the vehicle) by sending the data transmitted by the transmitter 24 and stored on the apparatus 4 to the terminal 40, such as a smartphone, used by the Police or the owner, in order to enable to track and to recover the vehicle 20.

It is appreciated that the position information, preferably the GPS location information, transmitted by the transmitter 24 enables location of the vehicle 20. In S13 the terminal 40 locates and approaches the stolen vehicle 20. In S14 the vehicle is recovered.

The module 400 may incorporate hardware elements in a more specifically dedicated terminal 40, such as a terminal 40 used by the Police, but preferably comprises mainly software elements or firmware elements or any combination of these, for example for a general purpose terminal 40 such as a smartphone used e.g. by the owner of the vehicle 20.

Modifications and Variations

Detailed embodiments have been described above. As those skilled in the art will appreciate, a number of modifications and alternatives can be made to the above embodiments whilst still benefiting from the inventions embodied therein, and will not be described in further detail here. It should also be appreciated that Figure 2 shows functional block diagrams and that in practice the individual blocks shown in Figure 2 may exist as discrete elements or their functionality may be distributed in different combinations or not individually discernable. In the embodiments described above, the device includes circuitry. Typically this circuitry will be formed by dedicated hardware circuits. However, in some embodiments, part of the circuitry may be implemented as software run by the corresponding controller. It should be appreciated that the functionalities may also be provided, where appropriate, by firmware and/or software and/or hardware or any combination thereof. A software implementation may however be preferred to facilitate the updating of the functionality of an element.

Where software are provided, they may be provided, as appropriate, in compiled or un-compiled form and may be supplied, as the case may be, as a signal over a computer or telecommunications network, or on a computer storage medium such as for instance a disc, an optical disc or a CD ROM.

In embodiments GLONASS, Radio Frequency or cellular technology (such as GSM) may be also used for locating the device 2, instead of or in complement to using GPS, and the data transmitted to the apparatus may also further include GSM and/or GSM area code/cell code.

The device 2 may be self-powered with a rechargeable battery or wired into the vehicle power system (battery).

In embodiments, the position receiver interface and/or the communication interface may be at least partially merged.

5 It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described in relation to any other embodiment.

Although the invention was described in relation to stolen vehicle recovery such as a caravan, it is understood that the invention may be implemented in other applications, such
10 as for fleet management, e.g. urban public transit or commercial trucks.

In embodiments, the invention may also be used, separately or in combination with other tracking devices, on a boat.

The third invention relates to an improved vehicle tracking system.

Fig. 8 schematically shows a known vehicle tracking system, which usually combines an
15 electronic device 2 mounted in a vehicle 20 such as a boat and a central apparatus 4 (usually a server), in order to enable a user (such as the owner of the vehicle or a provider of the vehicle tracking service) to track the vehicle 20.

The device 2 is adapted to collect data, notably GPS location, at regular intervals and to transmit in real-time or at regular intervals the collected data to the apparatus 4 via a
20 communication network 6, usually a cellular or satellite network.

The apparatus 4 is adapted to receive the collected data from the device 2, and serve them on demand to the user on a user terminal 40, which may comprise a computer terminal and/or a handheld terminal such as a smartphone. The vehicle location can thus be viewed on the user terminal 40, such as on electronic maps, for example via the Internet or
25 specialized software.

The known tracking systems may supply a provider of the tracking service, and subsequently the Police who can thus track and locate the stolen vehicle 20, with location accuracy of less than 100 metres, depending on local terrain. It is appreciated that the vehicle tracking systems are thus desirable for vehicle theft prevention and retrieval.

The device 2 may be self-powered with a battery or wired into the vehicle power system (battery), and the device is therefore usually configured to have a normal operating mode and an energy saving operating mode. The device therefore usually comprises a module for detecting physical displacement of the device, and configured to provide an operating mode instruction to the device, responsive to the detecting. The instruction is adapted to trigger the device to operate in the normal mode if the module detects physical displacement. However one of the drawbacks of the known devices is that there are numerous false alarms in a number of applications of the device, such as when the vehicle is a boat subject to waves at mooring.

10 However the inventors have discovered that, surprisingly, it is possible to efficiently track vehicles, whilst avoiding false alarms and thus saving power (which thus reduces the contribution to global CO₂ production).

Aspects and preferred examples of the present invention are set out in the appended claims.

In one aspect, it is provided a vehicle tracking device configured to be mounted on a vehicle, wherein the device is configured to have a normal operating mode and an energy saving operating mode, wherein the device further comprises a heading measurement module for detecting, in the energy saving mode of the device, a variation of a heading of the vehicle in a predetermined period of time, and wherein the heading measurement module is configured to provide an operating mode instruction to the device, responsive to the detecting, wherein the instruction is adapted to trigger the device to operate in the normal mode if the variation of a heading of the vehicle is greater than a threshold corresponding to 30° per minute.

The device may further comprise a detection module for detecting, in the energy saving mode of the device, at least one of a linear acceleration and an angular acceleration corresponding to a physical displacement of the device, and wherein the detection module may be configured to provide an operating mode instruction to the device, responsive to the detecting, wherein the instruction may be adapted to trigger the device to operate in the normal mode if the detected linear acceleration or the angular acceleration of the device is greater than a threshold of at least one of 0.3m.s^{-2} and $0.3^{\circ}.\text{s}^{-2}$.

30

The device may comprise an information collector configured to collect position information indicating the position of the device; and/or a transmitter configured to transmit the position information to a remote apparatus using a communication network, and wherein the information collector and/or the transmitter may be configured to operate: in an energy

saving operating mode when the device operates in the energy saving operating mode; and in a normal operating mode when the device operates in the normal operating mode.

The device may comprise a controller of the device configured to: control a heading measurement module when the device operates in both the energy saving operating mode
5 and the normal operating mode, wherein the controller may be configured to operate in a specific energy saving mode when controlling a heading measurement module when the device operates in the energy saving operating mode; and control the information collector and/or the transmitter in the normal operating mode of the device.

The controller may further be configured to control the detection module when the device
10 operates in both the energy saving operating mode and the normal operating mode, wherein the controller may be configured to operate in a specific energy saving mode when controlling the detection module when the device operates in the energy saving operating mode.

The information collector may further be configured to validate the trigger responsive to the
15 collection of the position information once operating in the normal operating mode. The information collector may be configured to collect satellite position information, preferably global positioning system, GPS, position information.

The detection module may comprise an accelerometer and/or a gyrometer. The heading measurement module may comprise a compass and/or a heading indicator. The device may
20 comprise a rechargeable battery.

In another aspect, it is provided a method of tracking a vehicle, comprising: detecting, in an energy saving mode of a device configured to be mounted on a vehicle and to have a normal operating mode and an energy saving operating mode, a variation of a heading of the vehicle; providing an operating mode instruction to the device, responsive to the detecting,
25 wherein the instruction is adapted to trigger, responsive to the detecting, the device to operate in the normal mode if the variation of a heading of the vehicle is greater than a threshold corresponding to 30° per minute.

The method may further comprise: detecting, in an energy saving mode of a device, at least one of a linear acceleration and an angular acceleration corresponding to a physical
30 displacement of the device; providing an operating mode instruction to the device, responsive to the detecting, wherein the instruction may be adapted to trigger, responsive to the detecting, the device to operate in the normal mode if the detected linear acceleration or

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the angular acceleration of the device is greater than a threshold of at least one of 0.3m.s^{-2} and $0.3^{\circ}.\text{s}^{-2}$.

The method may comprise: collecting position information indicating the position of the device when the device operates in the normal operating mode; and/or transmitting the
5 position information to a remote apparatus using a communication network when the device operates in the normal operating mode.

The method may comprise: controlling the detection when the device operates in both the energy saving operating mode and the normal operating mode, wherein controlling is performed in a specific energy saving mode when the device operates in the energy saving
10 operating mode; and controlling the collecting of the position information indicating the position of the device and/or the transmitting of the position information to the remote apparatus when the device operates in the normal operating mode.

The method may comprise: validating the trigger responsive to the collecting of the position information once operating in the normal operating mode.
15

Collecting the information may comprise collecting satellite position information, preferably global positioning system, GPS, position information. The threshold corresponding to 30° per minute, may be at least one of: 0.5° in a predetermined period of one second; 3° in a predetermined period of 6 seconds; 15° in a predetermined period of 30 seconds; 30° in a
20 predetermined period of one minute.

In another aspect it is provided a computer program, a computer program product or a computer readable medium comprising instructions for carrying out a method according to aspects of the invention.

25

The inventors have therefore invented an improved tracking device, having several advantages above the prior art. One example of advantages is that the invention provides an improved power saving device, because the device may only trigger the device to operate in the normal mode if the trigger is validated. Another advantage is that the GPS functionality,
30 which is battery consumption intensive, will only be switched on if an important enough physical displacement is detected. In the energy saving operating mode, the controller of the device operates at a specific energy saving operating mode, i.e. sufficient to enable control of the detection module but insufficient to control the GPS functionality, thereby saving

energy.

Embodiments of the third invention will now be described, by way of example, with reference to the accompanying drawings, in which:

5

Figure 8, already discussed, schematically shows a known tracking system;
Figure 9 schematically shows an example tracking system according to the invention; and
Figures 10A, 10B and 10C show a flow diagram of a method performed on a system of
Figure 9.

10

With reference to the drawings in general, it will be appreciated that similar features or elements bear identical reference signs. It will also be appreciated that the Figures are not to scale and that for example relative dimensions may have been altered in the interest of clarity in the drawings. Also any functional block diagrams are intended simply to show the
15 functionality that exists within the device and should not be taken to imply that each block shown in the functional block diagram is necessarily a discrete or separate entity. The functionality provided by a block may be discrete or may be dispersed throughout the device or throughout a part of the device. In addition, the functionality may incorporate, where appropriate, hardware elements, software elements or firmware elements or any combination
20 of these.

With reference to the Figures, it will be appreciated that according to an example embodiment of the present invention, a device 2, which is hidden within a vehicle 20, such as a boat, includes a sensing unit 21.

The device 2 usually also comprises a radio frequency identification (RFID) module 22, an
25 information collector 23, a transmitter 24 configured to transmit position information to a remote apparatus 4 using a communication network 6, a controller 26 and a memory 27.

The sensing unit 21 is configured to detect an external or internal status of the vehicle 20, for example by means of information input from at least one sensor hidden within the vehicle 20 (such as an impact sensor and/or an ignition of the engine).

30 In some embodiments, the device may also comprise a detection module 28 for detecting a physical displacement of the device 2. The detection module 28 is configured to detect a physical displacement of the device such as at least one of a linear acceleration and an angular acceleration corresponding to a physical displacement of the device 2, and

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preferably comprises an accelerometer and/or a gyrometer. However the physical displacement detected by the module 28 excludes vibration of the device, i.e. sustained oscillating change in location and/or orientation, such as vibration caused by the operation of an engine of the vehicle. This enables avoiding false alarms detected by the sensing unit 21
5 as explained in further detail below.

In some embodiments, the device comprises a heading measurement module 29 for detecting, in the energy saving mode of the device, a variation of a heading of the vehicle. The heading measurement module 29 may comprise a compass and/or a heading indicator.

The RFID module 22 may be configured to act as a receiver or a transmitter of radio-
10 frequency electromagnetic fields, in order to act as an RFID tag or an RFID reader for the vehicle 20.

The information collector 23 is configured, in a normal operating mode, to collect position information, for example periodically receive position information obtained by a position receiver interface 230 of the device 2.

15 The controller 26 is typically implemented with a microprocessor or some form of programmable controller. The device is configured to have a normal operating mode and an energy saving operating mode.

In S1 the device 2 operates in an energy saving mode. The heading measurement module 29 is however configured to be operable during the energy saving operating mode of the
20 device 2. The controller 26 of the device is configured to operate in a specific energy saving mode (e.g. the microprocessor operates with a lower frequency than in a normal operating mode) insufficient for controlling the module 22 or the collector 23 or the transmitter 24, thus saving energy, however sufficient for enabling controlling of the heading measurement module 29 when the device operates in the energy saving operating mode.

25 When the device operates in the energy saving operating mode, the information collector 23 and the transmitter 24 are configured to operate in an energy saving operating mode, thereby saving energy.

In embodiments, the detection module 28 is also configured to be operable during the energy saving operating mode of the device 2. The controller 26 of the device may be configured to
30 control the detection module 28 when the device operates in the energy saving operating mode in the specific energy saving mode.

The heading measurement module 29 determines in S2 information on whether or not the variation of a heading of the vehicle, excluding normal variation of a heading due to the waves when the vehicle is e.g. at mooring, is greater than a threshold. In embodiments, the module 29 is configured to detect, in the energy saving mode of the device, if the variation of
5 a heading of the vehicle is greater than a threshold corresponding to 30° per minute, such as 0.5° in a predetermined period of one second, or 3° in a predetermined period of 6 seconds, or 15° in a predetermined period of 30 seconds, or 30° in a predetermined period of one minute. Other predetermined periods are possible.

If the detected variation of the heading of the vehicle corresponds to normal variation due to
10 waves and/or is inferior to the threshold in S2 (i.e. the heading may vary, sometimes rapidly, and may oscillate respective to an initial heading, but overall the variation of the heading varies less, in a same direction respective to an initial heading, than a threshold corresponding to 30° per minute), S1 is performed again.

When the detected variation of the heading, as detected by the module 29, is determined in
15 S2 as not being due to waves and is superior to the threshold (i.e. the heading varies more, overall in a same direction respective to an initial heading at a beginning of the predetermined period of time, than a threshold corresponding to 30° per minute, such as 0.5° in a predetermined period of one second, or 3° in a predetermined period of 6 seconds, or 15° in a predetermined period of 30 seconds, or 30° in a predetermined period of one
20 minute), i.e. for example the module 29 determines a potential illegal movement (such as towing or lifting of the vehicle), in S3 the measurement module 29 provides an operating mode instruction to the device, responsive to the detecting. The instruction may be provided via e.g. the sensing unit 21 connected to the module 29, and the controller 26 which collects data from the unit 21. The instruction is adapted to trigger the device to operate in the normal
25 mode.

In embodiments, the module 28 may also determine in S2 information on whether or not the detected physical displacement of the device, excluding vibration of the device, is greater than a threshold. In embodiments, the detection module 28 is configured to detect, in the energy saving mode of the device, if the linear acceleration or the angular acceleration of the
30 device is greater than a threshold of at least one of 0.3m.s^{-2} and $0.3^\circ.\text{s}^{-2}$, or greater than a threshold of at least one of 0.4m.s^{-2} and $0.4^\circ.\text{s}^{-2}$, or greater than a threshold of at least one of 0.5m.s^{-2} and $0.5^\circ.\text{s}^{-2}$, or greater than a threshold of at least one of 1m.s^{-2} and $1^\circ.\text{s}^{-2}$.

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If the detected physical displacement of the device corresponds to vibration and/or is inferior to the threshold in S2 (i.e. the linear acceleration or the angular acceleration of the device is lower than a threshold), S1 is performed again.

Optionally when the detected physical displacement of the device, as detected by the module 5 28 is determined in S2 as not being vibration and is superior to the threshold (i.e. the linear acceleration or the angular acceleration of the device is greater than a threshold), i.e. for example the module 28 determines a potential illegal movement, in S3 the detection module 28 provides an operating mode instruction to the device, responsive to the detecting. The instruction may be provided via e.g. the sensing unit 21 connected to the module 28, and the 10 controller 26 which collects data from the unit 21. The instruction is adapted to trigger the device to operate in the normal mode.

In embodiments, in the normal operating mode of the device, the module 22, the collector 23 and the transmitter 24 are operating in a normal operating mode, and the controller 26 also collects data from the module 22 and/or the collector 23 in S4.

15 The controller 26 determines in S5 information on whether or not the detected status of the vehicle 20 deviates from a predetermined normal status, for example an abnormal status and/or illegal movement. The determination may be derived from: the unit 21 may detect the generation of an impact or a movement in excess of a reference value (e.g. from the modules 29 and/or 28) and/or ignition of the engine of the vehicle and/or a door being 20 opened without using a key or a remote control; and/or the module 22 may detect a case where an ID of the RFID is not matched with a RFID tag and/or reader of the owner of the vehicle; and/or the collector 23 may detect an unauthorized position of the vehicle and/or that the vehicle exits and/or enters a predetermined GPS geofence, i.e., as known by those skilled in the art, a virtual perimeter of a physical geographic area which may be dynamically 25 generated, e.g. as a radius around a point location or a custom-digitized drawn zone around an area.

The device is thus further configured to validate the trigger of the modules 29 or 28 responsive to the collection of the position information. If the status is determined as not abnormal in S5, S4 is performed again.

30 When the status of the vehicle 20, as detected by the sensing unit 21 (e.g. via the modules 29 and/or 28) and/or the module 22 and/or the collector 23, is determined in S5 as deviating from a predetermined normal status by the controller 26, i.e. for example the controller 26

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determines an abnormal status and/or illegal movement, in S6 the information collector 23 periodically receives position information obtained by the position receiver interface 230 of the device 2.

In S7 the transmitter 24 transmits the position information, periodically received from the information collector 23, to a central apparatus 4, preferably operated by a provider of a vehicle tracking service. The transmission is preferably performed using a communication network 6, such as preferably a Global System Mobile Communications (GSM) using a communication interface 240 of the device 2, but other networks may be used, such as satellite networks.

10 In embodiments, the transmitter 24 is adapted to: transmit the position information in real time, when the communication network 6 is available or in range of the interface 240, and to store the position information to a memory, usually the memory 27 internal to the device 2, when the network 6 is not available or not in range of the interface 240, and to transmit the stored position information to the apparatus 4 later, when the communication network 6
15 becomes available again.

In embodiments, in S7 the transmitter 24 further transmits a notification, such as an alarm message, e.g. a SMS message an/or an e-mail, indicating to the apparatus 4 a possible theft of the vehicle 20, without the transmission of the notification appearing on any device of the vehicle 20.

20 In embodiments the transmitter 24 may further transmit data including at least one of the following: locating technology parameters, such as number of GPS satellites in view, etc., and/or vehicle parameters, such as speed, heading direction, fuel amount, engine temperature and/or RPM, altitude, tire pressure, battery status, etc., and/or a trigger event, such as key on/off, head/tail lights on/off, door open/closed, etc.

25 The apparatus 4 preferably comprises one or more servers, in a single location or several locations, and the one or more servers are connected to access points, such as wireless access points 41. The apparatus 4 stores the parameters for the operation of the tracking service, and also stores user profiles (containing the user name), created by the users when registering, as explained in greater detail below.

30 In S8 the apparatus 4 receives the transmitted information and notification, and securely stores them. As it will be appreciated in greater detail below, the apparatus 4 is configured to

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serve the information, and sometimes notification, on demand to at least one user (such as the provider and/or the owner of the vehicle and/or the Police) on a user terminal 40, which may comprise a computer terminal and/or a handheld terminal such as a smartphone.

As known by the person skilled in the art, the user terminal 40 typically comprises at least a
5 processor, a memory, a display 42 and telecommunications means comprising a radio frequency signal receiver 401 (including access to cellular and/or communications network such as the Internet), such that the vehicle location can thus be viewed on the display 42, such as on electronic maps, for example via the Internet or specialized software.

In S9 the apparatus 4 contacts the owner of the vehicle 20, for example via a phone call
10 and/or a SMS message and/or an email on the terminal 40, and provides vehicle movement details, and determines whether the possible theft is confirmed or not by the user. If the theft is not confirmed in S9, S4 is performed again.

If the theft is confirmed in S9, in S10 the apparatus 4 continues to receive at least the position information from the transmitter 24, and starts a tracking and recovery procedure, in
15 line with current Police legislation and procedures.

In S11 the apparatus 4 obtains a crime reference number from the Police. In S12 the apparatus 4 liaises preferably with the Police (and/or the owner of the vehicle) by sending the data transmitted by the transmitter 24 and stored on the apparatus 4 to the terminal 40, such as a smartphone, used by the Police or the owner, in order to enable to track and to recover
20 the vehicle 20.

It is appreciated that the position information, preferably the GPS location information, transmitted by the transmitter 24 enables location of the vehicle 20. In S13 the terminal 40 locates and approaches the stolen vehicle 20. In S14 the vehicle is recovered.

The module 400 may incorporate hardware elements in a more specifically dedicated
25 terminal 40, such as a terminal 40 used by the Police, but preferably comprises mainly software elements or firmware elements or any combination of these, for example for a general purpose terminal 40 such as a smartphone used e.g. by the owner of the vehicle 20.

Modifications and Variations

Detailed embodiments have been described above. As those skilled in the art will appreciate,
30 a number of modifications and alternatives can be made to the above embodiments whilst still benefiting from the inventions embodied therein, and will not be described in further

detail here.

It should also be appreciated that Figure 2 shows functional block diagrams and that in practice the individual blocks shown in Figure 2 may exist as discrete elements or their
5 functionality may be distributed in different combinations or not individually discernable.

In the embodiments described above, the device includes circuitry. Typically this circuitry will be formed by dedicated hardware circuits. However, in some embodiments, part of the circuitry may be implemented as software run by the corresponding controller. It should be appreciated that the functionalities may also be provided, where appropriate, by firmware
10 and/or software and/or hardware or any combination thereof. A software implementation may however be preferred to facilitate the updating of the functionality of an element.

Where software are provided, they may be provided, as appropriate, in compiled or un-compiled form and may be supplied, as the case may be, as a signal over a computer or telecommunications network, or on a computer storage medium such as for instance a disc,
15 an optical disc or a CD ROM.

In embodiments GLONASS, Radio Frequency or cellular technology (such as GSM) may be also used for locating the device 2, instead of or in complement to using GPS, and the data transmitted to the apparatus may also further include GSM and/or GSM area code/cell code.

The device 2 may be self-powered with a rechargeable battery or wired into the vehicle
20 power system (battery). In embodiments, the position receiver interface and/or the communication interface may be at least partially merged.

It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described in relation to any other embodiment.

25 Although the invention was described in relation to stolen vehicle recovery such as a a boat, it is understood that the invention may be implemented in other applications, such as for such as a caravan, a car, a bus, a trailer, or a truck, notably for fleet management, e.g. urban public transit or commercial trucks.

Figures 11A and 11B show that a trailer 2 (i.e. a vehicle used for transport of e.g. goods
30 and materials), which may removeably be towed by a tractor 1, includes at least: a brake circuit 23, a left hand directional indicator, L/H DI, circuit 22, and a right hand directional

indicator, R/H DI, circuit 24.

Usually the circuits 22, 23 and 24 comprise bulbs (i.e. filament lamps), and, in order to control the circuits 22, 23 and 24 of the trailer 2, the tractor 1 often includes a by-pass relay which draws current from rear bulbs 12 of a lighting harness of the tractor 1 (including also usually a brake bulb, a L/H DI bulb and a R/H DI bulb), in order to power the corresponding bulbs 22, 23 and 24 of the trailer 2. Other systems not using the tractor lighting harness in order to control the bulbs 22, 23 and 24 of the trailer 2 may also be possible.

10

The tractor 1 also includes trailer detection and bulb-check systems 11, in order to detect the presence of the trailer 2 and to check the status of the bulbs on the trailer 2, in order to be able to trigger specific safety features, such as trailer stability programs (including anti snaking trailer and specific braking programs) or bulb failure reporting.

15

The systems 11 are often proprietary and thus different from a tractor brand to another tractor brand (for example, some systems use current pulses to detect the trailer, whilst others use charges and discharges in electronic LCR circuits or others uses a low intensity constant current). The trailer detection and monitoring units are thus designed for a specific tractor.

The inventors have however managed to design a unit which may be fitted in a trailer and which may cooperate with all sorts of tractors.

25 Another issue is that, in some cases (e.g. when the trailer is detected by a current flowing in a bulb of the trailer) failure of the bulbs 22, 23 and 24 may impact the detection of the trailer. However it is understood that the presence of the trailer 2 must be detected in order to trigger the appropriate specific safety features.

30 The fourth invention provides trailer detection regardless of the status of the bulbs of the trailer, thereby improving safety.

Yet another issue is that the bulbs 22, 23 and 24 are currently more and more replaced

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by Light Emitting Diode, LED, lamps (or clusters) in trailers. However electrical features of LED lamps (including their low resistor) make it more difficult for the existing systems 11 on the existing tractors 1 to detect the presence of the trailer 2 and to check the status of the LED lamps on the trailer 2. However it is understood that the presence of the 5 trailer 2 must be detected in order to trigger the appropriate specific safety features, and the status of the LED lamps must be correctly assessed so that appropriate measures (such as reporting the lamp failure) may be taken.

The fourth invention provides trailer detection regardless of the type of the lamp of the 10 trailer, either filament lamp or LED lamp, thereby improving safety.

Embodiments of the fourth invention thus aim to ameliorate at least one of the above mentioned issues. Aspects and preferred examples of the present invention are set out in the appended claims.

15

In one aspect, there is provided a lighting interface for a vehicle and trailer combination, wherein the trailer has a plurality of lighting circuits including at least one of a stop signal and direction indicator signals to be powered by the vehicle, wherein the vehicle is arranged to detect the presence of the trailer by detecting a path to ground through a 20 bulb of at least one of the lighting circuits, the interface comprising circuitry for providing a path to ground for at least one circuit within a predetermined resistance range, irrespective of the condition of the lighting circuit.

The circuitry may be arranged for providing a path to ground for each of the stop and two 25 direction indicator circuits. The circuitry may be arranged to provide a current load when a short duration pulse is applied to the interface in order to detect the presence of the trailer, or to provide a current load when a low voltage, insufficient to power the lighting circuits significantly, is applied to the interface in order to detect the presence of the trailer.

30

The circuitry may comprise a depletion mode transistor in series with a resistor, whereby the transistor may be configured to remain in a conducting state if insufficient power is applied to power logic controlling said transistor. The interface may further be arranged

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to provide a load to simulate a filament bulb when the trailer light circuit comprises a light emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb.

5 In another aspect, there is provided a lighting interface for a vehicle and trailer combination, wherein the trailer has a plurality of lighting circuits including at least one of a stop signal and direction indicator signals to be powered by the vehicle, and wherein the interface may further comprise circuitry arranged to provide a load to simulate a filament bulb when the trailer light circuit comprises a light emitting element with a lower
10 current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb.

The circuitry may be arranged to signal a fault to the vehicle by providing a high resistance path to ground or open circuit on detection of a fault in the trailer lighting
15 circuit.

In another aspect, there is provided a lighting interface for a vehicle and trailer combination, wherein the trailer has a plurality of lighting circuits including at least one of a stop signal and direction indicator signals to be powered by the vehicle, wherein the
20 vehicle is arranged to detect a path to ground through at least one of the lighting circuits, wherein the interface further comprises circuitry arranged to signal a fault to the vehicle by providing a high resistance path to ground or open circuit on detection of a fault in the trailer lighting circuit.

25 The interface may comprise circuitry arranged to disconnect a path to ground for a trailer detection signal from the vehicle, optionally wherein the circuitry may comprise a depletion mode transistor in series with a current load, whereby the transistor may be configured to open if a filament bulb is detected. The interface may be arranged not to connect said further load if a filament bulb is detected in the trailer lighting circuit.

30

In another aspect, there is provided a lighting interface for a vehicle and trailer combination, wherein the trailer has a plurality of lighting circuits including indicator to be flashed by spaced apart power pulses provided by the vehicle, wherein the vehicle is

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arranged to detect a path to ground through at least one of the lighting circuits, wherein the interface comprises: energy storage circuitry for storing energy provided by the power pulses, for a time period at least equal to the expected spacing between adjacent power pulses, and latching circuitry arranged, on detection of a fault during a first pulse
5 of power from the vehicle, to signal the detected fault to the vehicle by providing a high resistance path to ground or open circuit at the next pulse of power.

The energy storage circuitry may be arranged for storing energy for a time period sufficient to power the latching circuitry in order to signal the detected fault at the next
10 pulse of power, such as for at least two seconds.

In another aspect, there is provided a lighting interface for a vehicle and trailer combination, wherein the trailer has a plurality of lighting circuits including at least a stop signal circuit and a tail signal circuit which are interconnected, to detect a path to
15 ground through at least one of the lighting circuits, wherein the interface comprises circuitry arranged to detect a fault condition in the stop circuit, irrespective of whether the tail circuit is powered.

The interface may comprise circuitry providing a voltage drop between the stop signal
20 circuit and the tail signal circuit, in order to facilitate discrimination of the power voltage of the stop signal circuit and the tail signal circuit for the fault detection.

The fault may comprise an open circuit or failure of an LED light, based on an LED light current threshold, or an open circuit or failure of a filament light, or an overload or short
25 circuit based on an overload current threshold.

The interface may be arranged to disconnect the trailer lighting circuit in an overload condition, and optionally may comprise an enhancement mode transistor arranged to be in series with the lighting circuits, whereby the transistor may be configured not to
30 conduct if an overload condition is detected.

In another aspect, there is provided a lighting interface for a vehicle and trailer combination, wherein the trailer has a plurality of lighting circuits including at least one of

a stop signal and direction indicator signals to be powered by the vehicle, wherein the vehicle is arranged to detect the presence of the trailer by detecting a path to ground through a bulb of at least one of the lighting circuits, the interface comprising circuitry comprising a depletion mode transistor in series with a current load comprising a resistor, 5 whereby the transistor is configured to remain in a conducting state if insufficient power is applied to power logic controlling said transistor; wherein the circuitry is arranged for providing, for at least one circuit: a path to ground through the resistor, when a short duration pulse or a low voltage insufficient to power the lighting circuits significantly is applied to the interface, irrespective of the condition of the lighting circuit, to enable trailer 10 detection by the vehicle; and a current load through the resistor in order to simulate a filament bulb when the trailer light circuit is powered by the vehicle and comprises a light emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb. The transistor may be configured to open if a filament bulb is detected and/or if a fault in the trailer lighting circuit is detected.

15

In another aspect, there is provided a lighting interface for a vehicle and trailer combination, wherein the trailer has a plurality of lighting circuits including at least one of a stop signal and direction indicator signals to be powered by the vehicle, wherein the vehicle is arranged to provide power supply to the interface and to detect the presence of 20 a path to ground through at least one of the lighting circuits; the interface comprising circuitry comprising a depletion mode transistor in series with a resistor, whereby the transistor is configured to remain in a conducting state if insufficient power is applied to power logic controlling said transistor; wherein the circuitry is arranged for providing a current load through the resistor in order to simulate a filament bulb when the trailer light 25 circuit comprises a light emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb; and wherein the interface is arranged, on detection of a power supply voltage drop below a predetermined threshold, to keep the transistor in series with the resistor for at least a predetermined time period, such as at least two seconds, in order to avoid detection of a fault in the trailer lighting 30 circuit due to short term transient voltage drops. The power supply may be comprised in a predetermined nominal voltage supply range of [+18V; +32V], and the predetermined threshold is +18V.

In another aspect, there is provided a lighting interface for a vehicle and trailer combination, wherein the trailer has a plurality of lighting circuits including at least one of a stop signal and direction indicator signals to be powered by the vehicle, wherein the vehicle is arranged to detect a path to ground in at least one of the lighting circuits; 5 wherein the interface further comprises circuitry arranged to provide a load to simulate a filament bulb when the trailer light circuit comprises a light emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb; wherein the interface further comprises circuitry arranged to, on detection of a current draw of the light emitting element below a predetermined LED light current 10 threshold, signal a fault in the light emitting element of the trailer lighting circuit to the vehicle by providing a high resistance path to ground or open circuit, irrespective of the current draw in other elements of the interface. The interface may be connected to each of the stop and two direction indicator circuits.

15 In another aspect, there is provided a lighting interface for a vehicle and trailer combination, wherein the trailer has a plurality of lighting circuits including at least a stop signal and direction indicator signals to be powered by the vehicle, wherein the vehicle is arranged to detect the presence of the trailer by detecting a path to ground through a bulb of at least one of the lighting circuits; the interface comprising circuitry for providing 20 a path to ground for the or each circuit within a predetermined resistance range, irrespective of the condition of the lighting circuit, and a load to simulate a filament bulb when the trailer light circuit comprises a light emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb, whilst not providing a further load if a filament bulb is detected in the lighting circuit; wherein the 25 circuitry optionally comprises a depletion mode transistor in series with a resistor, whereby the transistor is configured to remain in a conducting state if insufficient voltage is applied to power logic controlling said transistor and arranged to disconnect a path to ground for a trailer detection signal from the vehicle, and to open if a filament bulb is detected; the interface further comprising circuitry arranged to signal fault to the vehicle 30 by providing a high resistance path to ground or open circuit on detection of a fault in the trailer lighting circuit; wherein the trailer has a plurality of lighting circuits including indicator to be flashed by spaced apart power pulses provided by the vehicle; wherein the interface comprises: energy storage circuitry for storing energy provided by the

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power pulses, for a time period at least equal to the expected spacing between adjacent power pulses, and latching circuitry arranged, on detection of a fault during a first pulse of power from the vehicle, to signal the detected fault to the vehicle by providing a high resistance path to ground or open circuit at the next pulse of power.

5

The trailer may have a plurality of lighting circuits including at least a stop signal circuit and a tail signal circuit which are interconnected, wherein the vehicle may be arranged to detect the presence of a bulb in at least one of the lighting circuits, wherein the interface may comprise circuitry arranged to detect a fault condition in the stop circuit, irrespective
10 of whether the tail circuit is powered.

The current load may be equivalent to a cold bulb resistance. The depletion mode transistor may be a MOSFET. The load may be equivalent to a 21W filament lamp powered by nominal 24V, and may preferably comprise a resistor having a resistance of
15 about $30\Omega \pm 50\%$. The LED light current threshold may be comprised between 2mA and 500mA. The overload current threshold may be comprised between 2.5A and 7.5A, preferably 4.2A.

A filament bulb may be detected in the trailer lighting circuit on detection of a current
20 draw superior or equal to a current representative of a filament bulb through the lighting circuits, the current draw being comprised between 0.5A and 2A, preferably 0.8A. The interface may comprise a logic arranged on a Printed Circuit Board placed in a housing. The interface may comprise a heat sink, the heat sink, preferably may comprise radiating fins and preferably may be fitted on a housing of the unit using an elastomer O-ring.

25

The interface may comprise a housing comprising: an input from the at least one lamp circuit of the trailer; and an output to the controller adapted to be fitted on the vehicle, wherein the housing is filled with potting compound to seal the input and the output. The interface may comprise a housing adapted to be fitted on the trailer.

30

The load may have a variable resistance, whereby the load may be arranged to be configurable with a plurality of sets of lighting circuits, the load being configured to a specific set of lighting circuits by setting the resistance of the load. The load may be

arranged to be manually configured. The interface may comprise logic adapted to measure a level of a working current of the plurality of lighting circuits of the trailer when powered by the vehicle and to automatically configure the load. The interface may be built-in with the lighting circuits (22, 23, 24) of the trailer.

5

As already mentioned, advantages of the invention include that the unit may be fitted in a trailer and may cooperate with all sorts of legacy tractors, regardless of the way the tractors are arranged to detect the trailer or to monitor the status of the lighting circuits. They also include that the invention enables the presence of the trailer to be detected in
10 all the cases, regardless of the status of the lighting circuits, in order to trigger the appropriate specific safety features of the tractor, thereby improving safety. Furthermore any fault in a circuit is always signalled to the tractor by an open circuit. Bulb simulation is not performed when the lighting circuits comprise at least a bulb, in order to avoid overload.

15

The invention also enables trailer detection and bulb simulation with a same resistor, which simplifies the layout of the circuit. The invention is also preferably adapted to work even in the event of cranking voltage drops, and for flashing direction indicator lights. The invention also enables fault detection in a stop circuit even in the case where the tail
20 and stop circuit are combined, and fault detection in a low current draw LED lamp irrespective of the draw current of other elements in the unit. The invention is usually designed for specific lighting circuits, but embodiments may be configurable to all sorts of circuits, manually or automatically.

25 Embodiments of the fourth invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figures 11A and 11B, already discussed, schematically show a trailer and tractor;

Figures 12A and 12B schematically show elevation views of a unit according to the invention;

30 Figure 13 schematically shows example steps of a method performed by a unit according to the invention;

Figure 14A and 14B schematically show an example electrical diagram in a unit according to the invention;

Figures 15A, 15B and 15C respectively schematically show example electrical diagrams of bulb simulators referred to as 5A, 5B and 5C in Figure 14A;

Figures 16A, 16B and 16C respectively schematically show example electrical diagrams of simulation controls referred to as 6A, 6B and 6C in Figures 15A, 15B and 15C 5 respectively; and

Figures 17A, 17B and 17C respectively schematically show example electrical diagrams of low power controls referred to as 7A, 7B and 7C in Figures 15A, 15B and 15C respectively.

10 With reference to the drawings in general, it will be appreciated that the Figures are not necessarily to scale, and that for example relative dimensions may have been altered in the interest of clarity in the drawings. All the dimensions are shown as examples, and it will be appreciated that other dimensions are possible. Also any functional block diagrams are intended simply to show the functionality that exists within the unit and 15 should not be taken to imply that each block shown in the functional block diagram is necessarily a discrete or separate entity. The functionality provided by a block may be discrete or may be dispersed throughout the unit or throughout a part of the unit. In addition, the functionality may incorporate, where appropriate, hard-wired elements, software elements or firmware elements or any combination of these.

20

Overview

Figures 11A and 11B show that a trailer 2 may removeably be towed by a tractor 1 (such as a vehicle such as a truck) including a trailer detection and bulb-check system 11, and includes at least: a brake lamp circuit 23, a left hand directional indicator, L/H DI, lamp 25 circuit 22, and a right hand directional indicator, R/H DI, lamp circuit 24. Optionally, the trailer 2 may further include: a fog lamp circuit 25; a left hand tail lamp circuit 26; and a right hand tail lamp circuit 27.

The tractor 2 also comprises a unit or lighting interface 21 which is fitted on the trailer 2. 30 Two elevation views of an example unit 21 according to the invention are shown in Figures 12A and 12B. As explained in more detail below, the unit 21 takes power from its connection with the tractor 1 (e.g. using a connection when the trailer 2 is connected to the tractor 1), which has the advantage that no permanent power supply is required in

the unit 21. In embodiments the unit is built-in with the lighting circuits 22, 23 and/or 24 of the trailer 2. As described in more detail below, the unit 21 preferably comprises three modules 5A, 5B or 5C, i.e. one for each the lamp circuits 22, 23 and 24, acting as a bulb monitor and a bulb simulator. Each of the modules operate independently.

5

As can be seen from the Figures, the unit 21 provides an interface between the lamp circuits 22, 23 and 24, and optionally 25, 26 and 27, and the system 11 of the tractor 1.

Electrical Specifications

10 Table 1 shows examples of the main electrical features of the unit 21.

Supply Voltage*	+18V to +32V
Ambient Operating Temperature**	-40°C to +85°C
Operating current, no bulb simulation***	< 20mA, e.g. Max 15mA
LED bulb failure detection	Factory set
Bulb simulation current	Standard 21W filament bulb
LED bulb failure trip speed	<5ms

Table 1

*Preferred supply voltage: 24V $\pm$ 0.5 V; **Preferred Operating Temperature Range: 25°C $\pm$ 5°C; Operating Voltage: 12 to 45 Vdc; ***Current Consumption for a single channel with bulb monitoring, i.e. DI or Stop: <20mA, e.g. Max 15mA; Quiescent current during
 15 fault condition for a single channel with bulb monitoring, i.e. DI or Stop: < 3mA; and Overload trip current: 4.2A. Usually tail and fog channels do not include bulb monitoring, and in that case draw approximately 80mA each.

Mechanical Specifications

20 In one embodiment, the unit 21 has a housing 216 with a length of 200mm, a width of 120mm, and height of 70mm. Other dimensions are possible. As is shown in Figures 12A and 12B, the housing 216 may be fitted on the trailer 2 using holes 2161 cooperating with screws, although it is understood that other means to fit the unit 21 on the trailer 2 are also possible. As is shown in Figures 12A and 12B, the housing 216 includes a built-
 25 in heat sink 213 which allows the unit 21 to meet power dissipation requirements, and the unit 21 has thus the advantage of solving the issue of power dissipation of bulb simulation resistors 100, shown in Figure 14B. In embodiments, the heat sink 213

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includes radiating fins 2131 to improve heat dissipation. The heat sink 213 is preferably fitted on a housing 216 of the unit using an elastomer O-ring 217. The housing 216 also comprises a cable entry 214 (forming an input from the at least one lamp circuit 22, 23, 24 of the trailer 2) and a cable exit 215 (forming an output 215 to the system 11 fitted on 5 the tractor 1 via a connector, as explained in greater detail below) provided in the housing 216.

The unit 21 is fitted in series with at least each one of the circuits 22, 23, 24, and is preferably also fitted in series with the circuits 25, 26 and 27. Preferably any other circuit 10 cabling (such as reverse lamp or registration plate cablings) passes through the cable entry 214 and the cable exit 215 through the housing 216 without being necessarily wired to a Printed Circuit Board (PCB) of the module 21. The connection of the circuits 22, 23, 24 and optionally 25, 26 and 27 to the unit 21 is preferably performed via cable mounted, inline connectors, and cable harness connection to the Printed Circuit Board is preferably 15 performed via spade terminal connectors.

The fact that the unit 21 is fitted in series with the circuits 22, 23, 24 and optionally 25, 26 and 27 means that the unit 21 is only active when the circuits 22, 23, 24, and optionally 25, 26 and 27, are active. The housing 216 is preferably filled with potting compound, in 20 order to seal the cable entry 214 and exit 215.

Detailed Electrical Specifications

As shown in Figures 14A and 14B, the unit 21 comprises connections (such as solder pads), referred to as SK in the Figures, adapted to be connected to corresponding plugs 25 of the system 11 of the tractor 1, and thus provides an interface between the system 11 and the lamp circuits 22, 23 and 24, and optionally 25, 26 and 27.

The unit 21 preferably mainly comprises three modules 5A, 5B and 5C: the module 5A being a bulb simulation module corresponding to the R/H DI circuit 24; the module 5B 30 being a bulb simulation module corresponding to the L/H DI circuit 22; and the module 5C being a bulb simulation module corresponding to the brake (also sometimes referred to stop) circuit 23. The three modules work independently of each other and require no additional power.

Each one of the modules 5A, 5B and 5C has a Field Effect Transistor (FET) current input and an IN current input. The Field Effect Transistor (FET) current input (RH_DI, LH_DI and STOP respectively) comes from a corresponding simulation resistor 100 provided in 5 a Jumper connector J1 shown in Figure 14B and flows to an electrical ground 66 through a simulation switch 63 as shown in Figures 16A, 16B and 16C. As explained in more detail below, the unit thus comprises circuitry referred to as 100 and 63, comprising the simulation resistor or current load 100, for providing a path to ground for at least one 10 of the lighting circuit. In that case the current load 100 is equivalent to a cold bulb resistance. This enables trailer detection. In embodiments the circuitry 100, 63 is also arranged to provide a current load 100 to simulate a filament bulb when the trailer light circuit comprises a light emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb.

15

As explained in more detail below, in the embodiments of the Figures the circuitry comprises the switch 63 comprising a depletion mode transistor in series with the resistor 100, whereby the transistor is configured to remain in a conducting state if insufficient power is applied to power logic controlling said transistor.

20

In order to enable trailer detection, the circuitry is arranged to provide the current load 100 when a short duration pulse is applied to the interface in order to detect the presence of the trailer, or when a low voltage, insufficient to power the lighting circuits 22, 23, or 24 significantly, is applied to the interface in order to detect the presence of the 25 trailer. Trailer detection is thus enabled for all types of legacy tractors.

The IN current input is derived from a corresponding control current from the respective circuits 24, 22, 23 (RH_DI, LH_DI and STOP respectively), as controlled by the tractor 1 (e.g. when voltage is applied, e.g. the preferred 24V, e.g. from connection 9, 11 or 13 30 respectively).

As shown in Figure 14B, the bulb simulation resistors 100 are connected in series with the IN current and they are configured to deliver a power corresponding to a standard

21W filament bulb power, dissipated by the heat sink 213. The load is equivalent to a 21W filament lamp powered by nominal 24V, preferably comprising the resistor 100 having a resistance of about $30\Omega \pm 50\%$.

5 Each of the modules 5A, 5B and 5C has an OUT current output (RH_DI, LH_DI and STOP respectively), back to the system 11, via e.g. the connection 10, 12 or 14 respectively. As described in greater detail below, when the circuits 22, 23 or 24 are powered up, the status of the OUT current output enables the system 11 to: detect a bulb current if the corresponding lamp is in normal operation, regardless of the LED or
10 filament type of the lamp; or detect an overloaded or an insufficient current, i.e. in that case there is no OUT current, thus providing a high resistance path to ground or open circuit to the system 11.

As already explained, when the circuits are not powered up significantly, the invention
15 also provides trailer detection both when the trailer circuit 22, 23 or 24 comprises bulbs or LEDs, and regardless of the status of the lamps, i.e. whether they are faulty or not.

The modules 5A, 5B and 5C are shown in greater detail in Figures 15A, 15B and 15C respectively. As shown in Figures 15A, 15B and 15C, each module 5A, 5B and 5C
20 comprises a circuit 50 which monitors a current flowing in a resistor R53, R39 or R60 respectively. The current flowing in the resistor R53, R39 or R60 respectively, corresponds to the IN currents RH_DI_IN, LH_DI_IN and STOP_IN respectively of Figure 14A. The circuit 50 is also adapted to output a measure current I_OVERLOAD representative of the current in the resistor R53, R39 or R60, and to that effect mainly
25 comprises a comparator 501 whose inputs are connected upstream and downstream of the resistor R53, R39 or R60 respectively. The comparator also outputs a current ISIM.

Each module 5A, 5B and 5C also comprises a circuit 51 which monitors a current flowing in a resistor R50, R17 or R57 respectively. The current flowing in the resistor R50, R17
30 or R57 respectively corresponds to the IN currents RH_DI_IN, LH_DI_IN and STOP_IN respectively. The circuit 51 is also adapted to output a measure current IBULB representative of the current in the resistor R50, R17 or R57, and thus mainly comprises a comparator 511 whose inputs are connected upstream and downstream of the resistor

R50, R17 or R57 respectively. The comparator also outputs a current ITRIP.

A switch 52, mainly comprising e.g. an enhancement metal–oxide–semiconductor field-effect transistor (MOSFET) Q14, Q3 or Q19 respectively, is located in the VIN-OUT 5 branch of the module 5A, 5B or 5C of Figure 4A respectively, between the circuits 50 and 51.

When the circuits 22, 23 or 24 are not powered up significantly (typically when the trailer 2 is connected to the tractor 1 but no lamp control current is sent from the system 11), the switch 52 is open (because the enhancement mode MOSFET Q14, Q3 or Q19 is OFF by default). Any trailer detection current from system 11 thus flows through the bulb simulation resistor 100, and through the closed switch 63, as explained below. When the circuits 22, 23 or 24 are powered up and operating in the normal operation mode, the switch 52 is closed.

15

The switch 52 is also controlled by a current FAULT_LATCHED corresponding to the presence in the circuit 22, 23 or 24 of an overload or an insufficient current. The current FAULT_LATCHED is provided by an output from a low power control module 7A, 7B or 7C respectively, as described in greater detail below. In other words, when the current 20 FAULT_LATCHED is asserted, the switch 52 is opened by the current FAULT_LATCHED, thereby opening the branch VIN-OUT and preventing a current from flowing in the VIN-OUT branch of the module 5A, 5B or 5C of Figure 14A respectively, thereby “switching off” the corresponding module.

25 In the absence of output from the modules 5A, 5B or 5C, the system 11 concludes that a fault is present in the circuit 22, 23 or 24 respectively, and thus warns the driver of the tractor 1. The driver can thus take steps according to the appropriate legislation. It is understood that opening the switch 52 also provides output overload protection for the system 11. It is also appreciated that the system 11 is provided with a high resistance to 30 ground or open circuit, irrespective of the nature of the fault, i.e. overload (in embodiment an overload current threshold is comprised between 2.5A and 7.5A, and is preferably equal to 4.2A) or insufficient current (in embodiments the insufficient current is based on a LED light current threshold which is comprised between 2mA and 500mA (for LED

strings or clusters), depending on the circuits 22, 23 and 24).

As explained above, the modules 5A, 5B, 5C are powered up and active only when the circuits 22, 23 and 24 are controlled to be active. It is understood that there is a settling
5 or reaction time for the unit to detect a fault, for example in a still working but faulty LED lamp (such as low current). There is also a time to decide to open the circuit. This could be a problem with the direction indicators, because the reaction time might represent a significant proportion of the power up of the DI circuits. The detection might therefore not be reliable. In order to solve this problem, the unit 21 comprises energy storage circuitry
10 53 for storing energy provided by the power pulses, for a time period at least equal to the expected spacing between adjacent power pulses. During and just after the first pulse, the detection of the fault can take place thanks to the energy storage circuitry 53. The unit also comprises latching circuitry 70 arranged, on detection of a fault during a first pulse of power from the vehicle, to signal the detected fault to the vehicle by providing a
15 high resistance path to ground or open circuit at the next pulse of power. The decision can thus more rapidly take place during and just after the second pulse.

Thus preferably each module 5A, 5B and 5C thus also comprises a power storage circuit 53, comprising a capacitor C2, C1 or C70 respectively (100 μ F) which stores power from
20 a power supply from the system 11 derived from the branch VIN. The power storage by the circuit 53 enables the modules 5A, 5B and 5C to operate for long enough (typically a few seconds) after the power supply is switched off. This solves the problem of the circuits 22, 23 or 24 not being powered on for long enough to allow appropriate operation of the modules 5A, 5B or 5C (e.g. a flash of a DI lamp). A fault status of the circuit is thus
25 latched for a predetermined time at least corresponding to an interval between direction indicator flashes as explained above. Also in embodiments the power storage by the circuit 53 enables the modules 5A, 5B and 5C to operate for long enough when a power supply voltage drop occurs below a predetermined threshold (typically when a power supply is comprised in a predetermined nominal voltage supply range of [+18V; +32V],
30 the predetermined threshold is +18V), in order to keep a transistor in series with the resistor 100 for at least a predetermined time period, such as at least two seconds, in order to avoid detection of a fault in the trailer lighting circuit due to short term transient voltage drops. The resistor 100 is thus arranged to simulate a filament bulb when the

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trailer light circuit comprises a light emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb even during short term cranking power supply voltage drops.

5 Each module 5A, 5B and 5C comprises moreover: a simulation control module 6A, 6B or 6C respectively, as shown in greater detail in Figures 16A, 16B or 16C; and a low power control block 7A, 7B or 7C respectively, as shown in greater detail in Figures 17A, 17B or 17C. As shown in Figures 16A, 16B and 16C, each simulation control module 6A, 6B or 6C comprises, as inputs, currents corresponding to: TAIL_IN; VIN; IBULB; ITRIP;
10 I_OVERLOAD; FAULT_LATCHED; SIM_FET_CONTROL; +5V0_SW; +5V0; and -5V0.

Each simulation control module 6A, 6B or 6C comprises, as outputs, currents corresponding to: OVERLOAD_N; and ISOLATE_N. Each simulation control module 6A, 6B or 6C comprises a trailer detection circuit 63 comprising mainly a switch 63
15 connected in series between the bulb simulation resistor 100, located in the connector J1 of Figure 14B, and the electrical ground 66. The switch 63 comprises e.g. a depletion mode MOSFET Q11, Q12 or Q26 respectively. It will be appreciated that when the circuits 22, 23 or 24 are not powered up, the switch 63 is closed (because the depletion mode MOSFET Q11, Q12 or Q26 is ON by default), thus providing a path to the ground
20 66 for a trailer detection current (typically e.g. 5mA) from the system 11. This has the advantage that the trailer 2 may be detected regardless of the status or type of the circuits 22, 23 or 24. The bulb simulation resistor 100 and the MOSFET Q11, Q12 or Q26 respectively thus provide a resistor equivalent to a cold bulb resistor to the system 11 (low resistance), which thus detects the presence of the trailer 2.

25

It will be appreciated that the trailer detection is thus not provided by a trailer detection current from the tractor flowing through a LED or a filament lamp of any of the circuits 22, 23 or 24, but rather is provided by a single bulb simulation resistor 100 and a single switch 63, the bulb simulation resistor not being connected to the actual lamps of the
30 circuits 22, 23 or 24. The trailer detection is thus provided regardless of the status or type of the circuits 22, 23 or 24.

Each simulation control module 6A, 6B or 6C comprises a determination circuit 60 which

determines a measure current representative of the current IBULB, by comparing it to a threshold T1 (e.g. 1.6V, approximately 0.8A). To that effect, the circuit 60 mainly comprises a comparator 601 whose inputs are connected to IBULB (- input) and a reference (+ input) respectively. The value of T1=0.8A is an example only, and the 5 threshold may be any value representative of a filament lamp, such as comprised between e.g. 0.5A and 2A.

If the current IBULB is higher than the threshold T1 (e.g. 1.6V, corresponding to approximately 0.8A), then the circuit 22, 23 or 24 respectively comprises at least a 10 filament lamp. In that case preferably the simulation resistor 100 is isolated from the ground 66, in order to avoid overload of the circuit and power consumption. To that effect, the output of the comparator 601 controls and opens the switch 63, e.g. comprising the depletion mode MOSFET 63.

15 It is appreciated however that in that case the switch 52 is closed when the circuit 22, 23 or 24 comprising the filament lamp is powered up (e.g. by a 24V voltage from the tractor 1), such that there is current flowing through the resistors R53 and R50, or R39 and R17, or R60 and R57 respectively, and also the filament lamp of the circuit 22, 23 or 24, such that the output current of the module 5A, 5B or 5C to the system 11 is representative of a 20 filament lamp, although the simulation resistor is isolated from the ground 66.

If the current IBULB is lower than the threshold T1, then the circuit 22, 23 or 24 respectively comprises LED lamps only. In that case, the resistance of the LED lamps of the circuit 22, 23 or 24 is too low and cannot be representative of a filament lamp. The 25 simulation resistor 100 thus needs to be connected to the ground 66, in order to simulate properly a filament lamp to the system 11. To that effect, the output of the comparator 601 does not control the depletion mode MOSFET 63 which thus remains in the ON status.

30 Once again, in that case the switch 52 is closed when the circuit 22, 23 or 24 comprising the LED lamps is powered up, such that there is current flowing through the LED lamps of the circuit 22, 23 or 24 respectively, the resistors R53 and R50, or R39 and R17, or R60 and R57 respectively, and also the simulation resistor 100 of the connector J1, such

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that the output current of the module 5A, 5B or 5C to the system 11 is also representative of a filament lamp, with the simulation resistor being connected to the ground 66.

5 As explained above, the unit 21 is adapted to detect the presence of a LED lamp and simulate a bulb to the tractor. In the case where the circuit comprises filament lamps, the bulb simulator does not operate, to avoid unnecessary overload of the unit 21. In both cases, in normal operation the system of the tractor 1 thus monitors a bulb, and the unit 21 enables the bulb failure monitoring system 11 on the tractor 1 to operate correctly,
10 enabling the required functions to conform to the legislation for bulb failure monitoring. The system 11 of the tractor 1 thus experiences no difference when connected to a trailer 2 provided with LED lamps or filament lamps.

Furthermore, in normal operation mode, IBULB also ensures that the circuits 7A, 7B and
15 7C do not latch as explained in greater detail below without a current FAULT_LATCHED being asserted.

The current FAULT_LATCHED, when asserted, controls the circuitry 64 of Figures 16A, 16B and 16C and opens the switch 63 of the modules 5A, 5B or 5C, by controlling the
20 depletion mode MOSFET 63. The simulation resistor 100 is then isolated from the ground 66. As explained below, the current FAULT_LATCHED, when asserted, also controls the switch 52 and opens the branch VIN-OUT of Figure 15A, 15B or 15C.

Each module 6A, 6B and 6C also comprises an overload detection circuit 61, comprising
25 a comparator U18, U5 or U22 respectively, which determines if the current I_OVERLOAD (output of circuit 50) is higher than a threshold T2 (e.g. 4.2A corresponding to 4.2V applied at the input + of U18, U5 or U22 respectively). As indicated by the Figures 16A, 16B or 16C, if the current I_OVERLOAD is higher than the threshold, then there is an output current OVERLOAD_N coming out of the circuit 61.
30 The value of T2=4.2A is an example only, and the threshold may be any value representative of an overload current, such as comprised between e.g. 2.5A and 7.5A.

Each module 6A, 6B and 6C also comprises a trip detection circuit 62, comprising a

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comparator U2:A, U1:A or U6:A respectively, which determines if the current I_TRIP (output of circuit 51) is lower than a threshold T3 (e.g. 40mA corresponding to 0.8V applied at the input - of U2:A, U1:A or U6:A respectively). As indicated by the Figures 16A, 16B or 16C, if the current I_TRIP is lower than the threshold, then there is an output 5 current ISOLATE_N coming out of the circuit 62. The value of T3=40mA is an example only, and the threshold may be any value representative of an insufficient current, such as comprised between e.g. 2mA and 500mA, depending on the circuits 22, 23 or 24.

T3 is indeed specific to the circuits 22, 23 or 24 so that the circuitry, such as trip 10 detection circuit 62 and switch 52, is arranged to, on detection of a current draw of the LED (such as I_TRIP) below a predetermined LED light current threshold, signal a fault to the vehicle by providing a high resistance path to ground or open circuit, irrespective of the current draw in other elements of the interface.

15 In embodiments having e.g. only one LED, and thus where the LED light current threshold may be as low as 3mA, the switch 52 thus may open up when a draw current in the LED is insufficient, even if the drive circuit of the unit still drives a current up to e.g. 10mA even if the circuit is faulty. This has the advantage that the unit does not consider that this remnant 10mA drive current as a normal LED draw current.

20

The inputs OVERLOAD_N (from the circuit 61) and ISOLATE_N (from the circuit 62) are wired as a logic OR in the low power control blocks 7A, 7B and 7C described in greater detail below, and as soon as a OVERLOAD_N or ISOLATE_N is asserted by the blocks 7A, 7B and 7C, the corresponding module 5A, 5B or 5C is "switched off", via the opening 25 of the switch 52 as explained above.

As shown in Figures 17A, 17B and 17C, each block 7A, 7B or 7C comprises, as inputs, currents corresponding to: OVERLOAD_N; ISOLATE_N; +5V0_SW; and +5V0. Each block 7A, 7B or 7C comprises, as an output, a current corresponding to 30 FAULT_LATCHED.

As shown in Figures 17A, 17B and 17C, each block 7A, 7B and 7C also comprises a circuit comprising a latch 70 (comprising e.g. an enhancement mode MOSFET Q31, Q10

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or Q39, respectively) which latches the current FAULT_LATCHED once a current OVERLOAD_N or ISOLATE_N is asserted and as long as energy is supplied by power storage circuit 53. In other words the fault is remembered by the unit 21, even when the unit 21 is switched off (e.g. between flashes of a DI lamp or when the power supply to the unit is momentarily insufficient), providing thus the current FAULT_LATCHED, as long as a current OVERLOAD_N or ISOLATE_N is asserted and as long as energy is supplied by power storage circuit 53.

As explained above, trailer detection circuits comprising the switch 63, corresponding to the unit 21, are built into the circuits 22, 23 and 24 respectively, by providing a path to the ground 66 for a current from the tractor 1 (e.g. using SK7 and SK8), thus ensuring that the system 11 is able to detect the trailer 2 when the trailer is connected to the tractor 1 and when the circuits are not powered up, i.e. when a short duration pulse is applied to the interface in order to detect the presence of the trailer or when a low voltage, insufficient to power the lighting circuits 22, 23, or 24 significantly, is applied to the interface in order to detect the presence of the trailer. The circuits enable the existing systems 11 of the different brands of tractors 1 to detect the trailer 2, regardless of the operation mode of the tractor. The invention thus provides both a bulb simulator and a trailer detector, which are combined in an innovative way, and which minimise costs and maximise compatibility with existing tractor systems 11.

As shown in Figure 14A, in embodiments, additional trailer detect circuits 45 (comprising e.g. resistors R5, R6, R7), 46 (comprising e.g. resistors R1, R8, R9) and 47 (comprising e.g. resistors R10, R11, R12) respectively, are added to the fog circuit 25, the L/H tail circuit 26 and the R/H tail circuit 27 respectively, to further compatibility with existing tractor systems 11.

In some embodiments of trailers, the tail lamp is used also by the brake circuit, and the intensity of the tail lamp is higher when the brake is in operation. Extra circuitry is thus preferably included to address the needs of single LED lighting units that combine stop and tail functions. In that case, in embodiments, the unit 21 comprises circuits 46 and 47 creating a voltage drop in the tail circuits 26 and 27 (e.g. for circuit 47 using at least diodes D4, D5, D26 and D27, and e.g. for circuit 46 using at least diodes D6, D7, D12

and D21), to ensure that it is possible to distinguish between the voltage in the stop circuit 23 and in the tail circuits 26 and 27 (this facilitates discrimination of the power voltage of the stop signal circuit 23 and the tail signal circuit 26 or 27 for the fault detection), and that a current may flow in the stop circuit 23 despite the tail circuits 26 and 27, when it is desired. The unit thus comprises circuitry arranged to detect a fault condition in the stop circuit, irrespective of whether the tail circuit is powered.

In that case, each module 6A, 6B and 6C also comprises a differentiating circuit 65, comprising a comparator U2:B, U1:B or U6:B respectively whose inputs are connected to the tail circuits 26 and 27 (current representative of TAIL_IN in the + input, see also Figure 4A) and the stop circuit 23 (current representative of VIN in the - input). The comparator U2:B, U1:B or U6:B determines if the current representative of TAIL_IN is higher than the current representative of VIN. As indicated by the Figures 6A, 6B or 6C, if the current TAIL_IN is higher than VIN, then the output of the comparator U2:B, U1:B or U6:B respectively controls and closes a switch 67 (comprising e.g. an enhancement mode MOSFET Q33, Q6 or Q34 respectively). The value of T3 is thus lowered, which means that the condition: $ITRIP \geq T3$ is more easily verified and the switch 52 is therefore less easily opened.

20 Operation

As can be seen from Figure 13, the unit 21 detects the trailer in S21, using the path to the ground 66 through the respective simulation resistors 100.

In S22, the unit 21 determines if the lamp circuit 22, 23 or 24 includes at least a bulb (i.e. a filament lamp), using the measure of the current IBULB compared to T1.

If the circuit 22, 23 or 24 comprises at least a filament lamp, then the corresponding simulation resistor is isolated from the ground 66 by opening the switch 63. This avoids unnecessary overload of the unit 21. In S23 the unit 21 determines if there is a failure in the relevant bulb (an overload or an insufficient current), using circuits 61 and 62 and the corresponding currents OVERLOAD_N or ISOLATE_N. If no failure is determined, then in S24 the normal operation of the bulb is reported to the system 11, since the system 11 measures current coming from the relevant bulb through branch VIN-OUT.

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If a failure is determined, then in S25 the switches 63 and 52 are opened and the system 11 detects an open circuit and thus a failure status of the bulb, and appropriate steps according to legislation are taken. This also provides overload protection for STOP, L/H 5 and R/H circuits.

If in S22 it is determined that the circuit 22, 23 or 24 only comprises Light Emitting Diode, LED, lamps, then the corresponding simulation resistor is kept connected to the ground 66 via the closed switch 63. This simulates a bulb to the system 11 with the same 10 resistors 100 as for trailer detection. In S26 the unit 21 determines if there is a failure in the relevant LED (an overload or an insufficient current), using circuits 61 and 62 and the corresponding currents OVERLOAD_N or ISOLATE_N. If no failure is determined, then in S27 normal operation of a bulb is reported to the system 11, since the system 11 measures current coming from the LED lamp through branch VIN-OUT, but mainly 15 current in the corresponding simulation resistor 100 to the ground 66 via the switch 63.

If a failure is determined, then in S28 the switches 63 and 52 are opened and the system 11 detects an open circuit and thus a failure status of the lamp, and appropriate steps according to legislation are taken. This again provides overload protection for STOP, L/H 20 and R/H circuits.

The invention thus provides a unit 21 which enables bulb failure monitoring of different types of lamps fitted to the trailer 2. The unit 21 is configured to distinguish between filament lamps and LED lamps.

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The invention thus overcomes the issues of the different bulb failure monitoring and trailer detection for different types of tractors.

Modifications and Variations

30 Various features described above may have advantages with or without other features described above.

The above embodiments are to be understood as illustrative examples of the invention.

Further embodiments of the invention are envisaged. It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other 5 of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

For example, a unit dedicated to specific circuits has been described. In other 10 embodiments, the load has a variable resistance and is arranged to be configurable with a plurality of sets of lighting circuits. The load may be configured to a specific set of lighting circuits by setting the resistance of the load once in place. In that case, the load may be arranged to be manually configured, e.g. using a knob connected to a rheostat or potentiometer. Alternatively or additionally, the unit may comprise logic adapted to 15 measure a level of a working current of the plurality of lighting circuits of the trailer when powered by the vehicle, thus automatically detecting whether or not the circuits comprise LEDs or bulbs, and adapted to automatically configure the load to the circuits.

The invention may be applied to any type of trailer, such as recreational vehicles or travel 20 trailers.

CLAIMS

1. A vehicle tracking device (2) adapted to be mounted on a vehicle (20), comprising:

an information collector (23) configured to collect position information, the position information indicating the position of the device (2);

5 a transmitter (24) configured to transmit the position information to a remote apparatus (4) using a communication network (6),

and

a beacon (25) configured to broadcast Wi-Fi or Bluetooth signals to facilitate short range location of the device.

10 2. The vehicle tracking device (2) of claim 1, wherein the information collector (23) is configured to collect satellite position information, preferably global positioning system, GPS, position information.

3. The vehicle tracking device (2) of any one of claim 1 or 2, wherein the remote apparatus (4) comprises a server operated by a provider of a vehicle tracking service.

15 4. The vehicle tracking device (2) of any one of claims 1 to 3, wherein the communication network (6) is a cellular or a satellite network, preferably a global system mobile communications, GSM, network.

5. The vehicle tracking device (2) of any one of claims 1 to 4, wherein the Wi-Fi or Bluetooth signals are configured to facilitate location of the device with greater accuracy than with the position information alone, preferably within a range of 0.1 to 100 metres, preferably within 1 to 10 metres.

6. The vehicle tracking device (2) of any one of claims 1 to claim 5, wherein

the strength of the Wi-Fi or Bluetooth signals when received at a user terminal (40) is indicative of the distance between the user terminal (40) and the tracking device (2); and/or

25 the direction detection of the Wi-Fi or Bluetooth signals is indicative of the location direction of the user terminal (40) with respect to the tracking device (2).

7. A vehicle tracking device (2) adapted to be mounted on a vehicle (20), comprising:

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an information collector (23) configured to collect position information, the position information indicating the position of the device (2); and

a beacon (25) configured to broadcast Wi-Fi or Bluetooth signals to facilitate short range location of the device;

5 wherein the beacon comprises a Wi-Fi access point (250), adapted to communicate with a remote Wi-Fi access point within the transmission range of the beacon.

8. A vehicle tracking device (2) adapted to be mounted on a vehicle (20), comprising:

an information collector (23) configured to collect position information, the position information indicating the position of the device (2); and

10 a beacon (25) configured to broadcast Wi-Fi or Bluetooth signals to facilitate short range location of the device;

wherein the beacon comprises a Bluetooth device (251), adapted to communicate with a remote Bluetooth terminal within the transmission range of the beacon.

9. The vehicle tracking device (2) of any one of claims 7 or 8, wherein the Wi-Fi access point
15 and/or the Bluetooth device is configured to transmit the position information to any remote Wi-Fi access point or to any paired Bluetooth terminal within the transmission range.

10. The vehicle tracking device (2) of any one of claims 7 to 9, wherein the Wi-Fi access point and/or the Bluetooth device of the vehicle tracking device is further configured to send and receive data, preferably commands and responses.

20 11. The vehicle tracking device (2) of claim 10, wherein the commands include:

commands to activate one or more systems of the vehicle tracking device or of the vehicle itself, such as a camera or a microphone located in a suitable position in the vehicle, and/or

commands to request the one or more systems to send back data to a user terminal,
25 such as images from the camera or sound recordings from the microphone;

and/or wherein the responses include:

images from a camera and/or sound recordings from a microphone.

12. A terminal (40) adapted to operatively cooperate with a device (2) adapted to be mounted on a vehicle (20), comprising:

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a receiver (401) configured to receive position information from a remote apparatus (4) using a communication network (6),

the position information indicating the position of the tracking device (2); and

a module (400) configured to

5 receive Wi-Fi or Bluetooth signals from a beacon (25) of the device (2), and
detect the direction and/or the strength of the Wi-Fi or Bluetooth signals;

in order to facilitate short range location of the device (2).

13. The terminal of claim 12, further adapted to:

receive position information or other data from a Wi-Fi access point (250) and/or a
10 Bluetooth device (251) of the beacon Bluetooth terminal within the transmission range;
and/or

send and receive data, preferably commands and responses, wherein the commands
include commands to activate one or more systems of the vehicle tracking device or of the
vehicle itself, such as a camera or a microphone located in a suitable position in the vehicle,
15 and/or commands to request the one or more systems to send back data to a user terminal,
such as images from the camera or sound recordings from the microphone; and/or wherein
the responses include images from a camera and/or sound recordings from a microphone.

14. A method of tracking a vehicle (20), comprising:

collecting position information, the position information indicating a long range
20 position of a tracking device (2) adapted to be mounted on a vehicle (20);

transmitting the long range position information to a remote apparatus (4) using a
communication network (6) to locate the device (2) within the long range;

broadcasting Wi-Fi or Bluetooth signals from the tracking device to facilitate location
of the device.

25 15. A method of tracking a vehicle (20), comprising:

collecting position information, the position information indicating a long range
position of a tracking device (2) adapted to be mounted on a vehicle (20);

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locating the device (2) within the long range;

broadcasting Wi-Fi or Bluetooth signals from the tracking device to facilitate location of the device; and

communicating information and/or data via Wi-Fi with a remote Wi-Fi access point.

5 16. A method of tracking a vehicle (20), comprising:

collecting position information, the position information indicating a long range position of a tracking device (2) adapted to be mounted on a vehicle (20);

locating the device (2) within the long range;

10 broadcasting Wi-Fi or Bluetooth signals from the tracking device to facilitate location of the device; and

communicating information and/or data via Bluetooth with a remote paired Bluetooth terminal.

17. The method of any one of claims 15 or 16, wherein the information is the position information and/or the data are commands and responses.

15

18. The method of claim 17, wherein the commands include:

commands to activate one or more systems of the vehicle tracking device or of the vehicle itself, such as a camera or a microphone located in a suitable position in the vehicle, and/or

20 commands to request the one or more systems to send back data to a user terminal, such as images from the camera or sound recordings from the microphone;

and/or wherein the responses include:

images from a camera and/or sound recordings from a microphone.

19. A communications apparatus configured to:

25 provide an interface configured to enable

the registration of a user of a terminal (40) to an apparatus (4) defining operation parameters for a vehicle tracking service; and

the submission and/or update of identity parameters of the user; and

the download of an application from the apparatus (4) comprising program

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instructions to program a module (400) of the terminal (40) of the user to provide a terminal according to claims 12 or 13 or to carry out data processing of a method according to any one of claims 14 to 18.

5 20. An application configured to work on a terminal (40), comprising instructions for carrying out a method according to any one of claims 14 to 18.

21. A computer program, computer program product or computer readable medium comprising instructions for carrying out a method according to any one of claims 14 to 18.

10

22. A vehicle tracking device (2) configured to be mounted on a vehicle (20),
wherein the device is configured to have a normal operating mode and an energy saving operating mode,

wherein the device further comprises a detection module (28) for detecting, in the
15 energy saving mode of the device, at least one of a linear acceleration and an angular acceleration corresponding to a physical displacement of the device (2), and

wherein the detection module (28) is configured to provide an operating mode instruction to the device, responsive to the detecting, wherein the instruction is adapted to trigger the device to operate in the normal mode if the detected linear acceleration or
20 the angular acceleration of the device is greater than a threshold of at least one of 0.3m.s^{-2} and $0.3^{\circ}.\text{s}^{-2}$.

23. The device according to claim 22, comprising:

an information collector (23) configured to collect position information indicating the position of the device (2); and/or

25 a transmitter (24) configured to transmit the position information to a remote apparatus (4) using a communication network (6), and wherein

the information collector (23) and/or the transmitter (24) are configured to operate:

in an energy saving operating mode when the device operates in the energy saving operating mode; and

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in a normal operating mode when the device operates in the normal operating mode.

24. The device according to claim 23, comprising:

a controller (26) of the device configured to:

5 control the detection module (28) when the device operates in both the energy saving operating mode and the normal operating mode, wherein the controller is configured to operate in a specific energy saving mode when controlling the detection module (28) when the device operates in the energy saving operating mode; and

control the information collector (23) and/or the transmitter (24) in the normal
10 operating mode of the device.

25. The device according to any one of claims 23 or 24, wherein the information collector (23) is further configured to validate the trigger responsive to the collection of the position information once operating in the normal operating mode.

15 26. The device (2) according to any one of claims 23 to 25, wherein the information collector (23) is configured to collect satellite position information, preferably global positioning system, GPS, position information.

27. The device according to any one of claims 22 to 26, wherein the detection module
20 (28) comprises an accelerometer and/or a gyrometer.

28. The device (2) of any one of claims 22 to 27, comprising a rechargeable battery (29).

29. A method of tracking a vehicle (20), comprising:

detecting, in an energy saving mode of a device (2) configured to be mounted on a vehicle (20) and to have a normal operating mode and an energy saving operating
25 mode, at least one of a linear acceleration and an angular acceleration corresponding to a physical displacement of the device (2);

providing an operating mode instruction to the device, responsive to the detecting,

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wherein the instruction is adapted to trigger, responsive to the detecting, the device to operate in the normal mode if the detected linear acceleration or the angular acceleration of the device is greater than a threshold of at least one of 0.3m.s^{-2} and 0.3°s^{-2} .

5 30. The method according to claim 29, comprising:

collecting position information indicating the position of the device (2) when the device operates in the normal operating mode; and/or

transmitting the position information to a remote apparatus (4) using a communication network (6) when the device operates in the normal operating mode.

10 31. The method according to claim 30, comprising:

controlling the detection when the device operates in both the energy saving operating mode and the normal operating mode, wherein controlling is performed in a specific energy saving mode when the device operates in the energy saving operating mode; and

15 controlling the collecting of the position information indicating the position of the device (2) and/or the transmitting of the position information to the remote apparatus (4) when the device operates in the normal operating mode.

32. The method according to any one of claims 30 or 31, comprising:

validating the trigger responsive to the collecting of the position information once
20 operating in the normal operating mode.

33. The method (2) according to any one of claims 30 to 32, wherein collecting the information (23) comprises collecting satellite position information, preferably global positioning system, GPS, position information.

25

34. A computer program, computer program product or computer readable medium comprising instructions for carrying out a method according to any one of claims 29 to 33.

35. A vehicle tracking device (2) configured to be mounted on a vehicle (20),

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wherein the device is configured to have a normal operating mode and an energy saving operating mode,

wherein the device further comprises a heading measurement module (29) for detecting, in the energy saving mode of the device, a variation of a heading of the vehicle in
5 a predetermined period of time, and

wherein the heading measurement module (29) is configured to provide an operating mode instruction to the device, responsive to the detecting, wherein the instruction is adapted to trigger the device to operate in the normal mode if the variation of a heading of the vehicle is greater than a threshold corresponding to 30° per minute.

10 36. The device according to claim 35, further comprising a detection module (28) for detecting, in the energy saving mode of the device, at least one of a linear acceleration and an angular acceleration corresponding to a physical displacement of the device (2), and

wherein the detection module (28) is configured to provide an operating mode instruction to the device, responsive to the detecting, wherein the instruction is adapted to
15 trigger the device to operate in the normal mode if the detected linear acceleration or the angular acceleration of the device is greater than a threshold of at least one of 0.3m.s^{-2} and $0.3^\circ.\text{s}^{-2}$.

37. The device according to any one of claims 35 or 36, comprising:

an information collector (23) configured to collect position information indicating the
20 position of the device (2); and/or

a transmitter (24) configured to transmit the position information to a remote apparatus (4) using a communication network (6), and wherein

the information collector (23) and/or the transmitter (24) are configured to operate:

in an energy saving operating mode when the device operates in the energy saving
25 operating mode; and

in a normal operating mode when the device operates in the normal operating mode.

38. The device according to any one of claims 35 to 37, comprising:

a controller (26) of the device configured to:

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control a heading measurement module (29) when the device operates in both the energy saving operating mode and the normal operating mode, wherein the controller is configured to operate in a specific energy saving mode when controlling a heading measurement module (29) when the device operates in the energy saving operating mode;
5 and

control the information collector (23) and/or the transmitter (24) in the normal operating mode of the device.

39. The device according to claims 36 to 38, wherein the controller (26) is further configured to control the detection module (28) when the device operates in both the energy saving
10 operating mode and the normal operating mode, wherein the controller is configured to operate in a specific energy saving mode when controlling the detection module (28) when the device operates in the energy saving operating mode.

40. The device according to any one of claims 37 to 39, wherein the information collector (23) is further configured to validate the trigger responsive to the collection of the position
15 information once operating in the normal operating mode.

41. The device (2) according to any one of claims 37 to 40, wherein the information collector (23) is configured to collect satellite position information, preferably global positioning system, GPS, position information.
20

42. The device according to any one of claims 36 to 41, wherein the detection module (28) comprises an accelerometer and/or a gyrometer.

43. The device according to any one of claims 35 to 42, wherein the heading measurement module (29) comprises a compass and/or a heading indicator.

25 44. The device (2) of any one of claims 35 to 43, comprising a rechargeable battery (29).

45. A method of tracking a vehicle (20), comprising:

detecting, in an energy saving mode of a device (2) configured to be mounted on a vehicle (20) and to have a normal operating mode and an energy saving operating mode, a variation of a heading of the vehicle;

30 providing an operating mode instruction to the device, responsive to the detecting,

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wherein the instruction is adapted to trigger, responsive to the detecting, the device to operate in the normal mode if the variation of a heading of the vehicle is greater than a threshold corresponding to 30° per minute.

46. The method according to claim 45, further comprising:

- 5 detecting, in an energy saving mode of a device (2), at least one of a linear acceleration and an angular acceleration corresponding to a physical displacement of the device (2);

providing an operating mode instruction to the device, responsive to the detecting,

- 10 wherein the instruction is adapted to trigger, responsive to the detecting, the device to operate in the normal mode if the detected linear acceleration or the angular acceleration of the device is greater than a threshold of at least one of $0.3\text{m}\cdot\text{s}^{-2}$ and $0.3^\circ\cdot\text{s}^{-2}$.

47. The method according to any one of claims 45 or 46, comprising:

collecting position information indicating the position of the device (2) when the device operates in the normal operating mode; and/or

- 15 transmitting the position information to a remote apparatus (4) using a communication network (6) when the device operates in the normal operating mode.

48. The method according to claim 47, comprising:

- controlling the detection when the device operates in both the energy saving operating mode and the normal operating mode, wherein controlling is performed in a specific energy saving mode when the device operates in the energy saving operating mode; and
- 20

controlling the collecting of the position information indicating the position of the device (2) and/or the transmitting of the position information to the remote apparatus (4) when the device operates in the normal operating mode.

- 25 49. The method according to any one of claims 47 or 48, comprising:

validating the trigger responsive to the collecting of the position information once operating in the normal operating mode.

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50. The method (2) according to any one of claims 47 to 49, wherein collecting the information (23) comprises collecting satellite position information, preferably global positioning system, GPS, position information.

5 51. The device of any one of claims 35 to 44 or the method of any one of claims 45 to 50, wherein the threshold corresponding to 30° per minute, is at least one of: 0.5° in a predetermined period of one second; 3° in a predetermined period of 6 seconds; 15° in a predetermined period of 30 seconds; 30° in a predetermined period of one minute.

10 52. A computer program, computer program product or computer readable medium comprising instructions for carrying out a method according to any one of claims 45 to 51.

53. A lighting interface (21) for a vehicle (1) and trailer (2) combination,
wherein the trailer has a plurality of lighting circuits (22, 23, 24) including at least
15 one of a stop signal and direction indicator signals to be powered by the vehicle,
wherein the vehicle is arranged to detect the presence of the trailer by detecting a
path to ground through a bulb of at least one of the lighting circuits,
the interface comprising circuitry (100, 63) for providing a path to ground for at
least one circuit within a predetermined resistance range, irrespective of the condition of
20 the lighting circuit.

54. The interface of claim 53, wherein the circuitry (100, 63) is arranged for providing a path to ground for each of the stop and two direction indicator circuits.

25 55. The interface of any one of claims 53 or 54, wherein the circuitry is arranged to provide a current load (100) when a short duration pulse is applied to the interface in order to detect the presence of the trailer.

56. The interface of any one of claims 53 to 55, wherein the circuitry is arranged to
30 provide a current load (100) when a low voltage, insufficient to power the lighting circuits (22, 23, 24) significantly, is applied to the interface in order to detect the presence of the trailer.

57. The interface of any one of claims 53 to 56, wherein the circuitry comprises a

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depletion mode transistor (63) in series with a resistor (100), whereby the transistor is configured to remain in a conducting state if insufficient power is applied to power logic controlling said transistor.

5 58. The interface of any one of claims 53 to 57, wherein the interface is further arranged to provide a load (100) to simulate a filament bulb when the trailer light circuit comprises a light emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb.

10 59. A lighting interface (21) for a vehicle (1) and trailer (2) combination,
wherein the trailer has a plurality of lighting circuits (22, 23, 24) including at least one of a stop signal and direction indicator signals to be powered by the vehicle, and
wherein the interface further comprises circuitry (100, 63) arranged to provide a
load (100) to simulate a filament bulb when the trailer light circuit comprises a light
15 emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb.

60. The interface of any one of claims 53 to 59, wherein the circuitry is arranged to signal
a fault to the vehicle by providing a high resistance path to ground or open circuit on
20 detection of a fault in the trailer lighting circuit.

61. A lighting interface (21) for a vehicle (1) and trailer (2) combination,
wherein the trailer has a plurality of lighting circuits (22, 23, 24) including at least one of a stop signal and direction indicator signals to be powered by the vehicle,
25 wherein the vehicle is arranged to detect a path to ground through at least one of the lighting circuits,
wherein the interface further comprises circuitry (52) arranged to signal a fault to the vehicle by providing a high resistance path to ground or open circuit on detection of a fault in the trailer lighting circuit.

30

62. The interface of any one of claims 53 to 61, comprising circuitry (100, 63) arranged to disconnect a path to ground for a trailer detection signal from the vehicle, optionally wherein the circuitry (100, 63) comprises a depletion mode transistor (63) in series with a

- 68 -

current load (100), whereby the transistor is configured to open if a filament bulb is detected.

63. The interface of any one of claims 60 or 61, arranged not to connect said further load 5 (100) if a filament bulb is detected in the trailer lighting circuit.

64. A lighting interface (21) for a vehicle (1) and trailer (2) combination,
wherein the trailer has a plurality of lighting circuits (22, 24) including indicator to be flashed by spaced apart power pulses provided by the vehicle,
10 wherein the vehicle is arranged to detect a path to ground through at least one of the lighting circuits,
wherein the interface comprises:
energy storage circuitry (53) for storing energy provided by the power pulses, for a time period at least equal to the expected spacing between adjacent power pulses, and
15 latching circuitry (70) arranged, on detection of a fault during a first pulse of power from the vehicle, to signal the detected fault to the vehicle by providing a high resistance path to ground or open circuit at the next pulse of power.

65. The interface of claim 64, wherein the energy storage circuitry (53) is arranged for
20 storing energy for a time period sufficient to power the latching circuitry (70) in order to signal the detected fault at the next pulse of power, such as for at least two seconds.

66. A lighting interface (21) for a vehicle (1) and trailer (2) combination,
wherein the trailer has a plurality of lighting circuits (22, 23, 24) including at least a
25 stop signal circuit (23) and a tail signal circuit (26, 27) which are interconnected,
to detect a path to ground through at least one of the lighting circuits,
wherein the interface comprises circuitry (65) arranged to detect a fault condition in the stop circuit, irrespective of whether the tail circuit is powered.

30 67. The interface of claim 66, comprising circuitry (46, 47) providing a voltage drop between the stop signal circuit (23) and the tail signal circuit (26, 27), in order to facilitate discrimination of the power voltage of the stop signal circuit (23) and the tail signal circuit (26, 27) for the fault detection.

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68. The interface of any one of claims 60 to 67, wherein the fault comprises an open circuit or failure of an LED light, based on an LED light current threshold.

5 69. The interface of any one of claims 60 to 68, wherein the fault comprises an open circuit or failure of a filament light.

70. The interface of any one of claims 60 to 69, wherein the fault comprises an overload or short circuit based on an overload current threshold.

10

71. The interface of any one of claims 52 to 70, arranged to disconnect the trailer lighting circuit (22, 23, 24) in an overload condition, optionally comprising an enhancement mode transistor (52) arranged to be in series with the lighting circuits (22, 23, 24), whereby the transistor is configured not to conduct if an overload condition is detected.

15

72. A lighting interface (21) for a vehicle (1) and trailer (2) combination,
wherein the trailer has a plurality of lighting circuits (22, 23, 24) including at least one of a stop signal and direction indicator signals to be powered by the vehicle,

wherein the vehicle is arranged to detect the presence of the trailer by detecting a
20 path to ground through a bulb of at least one of the lighting circuits,

the interface comprising circuitry (100, 63) comprising a depletion mode transistor (63) in series with a current load comprising a resistor (100), whereby the transistor is configured to remain in a conducting state if insufficient power is applied to power logic controlling said transistor;

25 wherein the circuitry (100, 63) is arranged for providing, for at least one circuit:

a path to ground through the resistor (100), when a short duration pulse or a low voltage insufficient to power the lighting circuits (22, 23, 24) significantly is applied to the interface, irrespective of the condition of the lighting circuit, to enable trailer detection by the vehicle; and

30 a current load through the resistor (100) in order to simulate a filament bulb when the trailer light circuit is powered by the vehicle and comprises a light emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb.

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73. The interface of claim 72, wherein the transistor is configured to open if a filament bulb is detected and/or if a fault in the trailer lighting circuit is detected.

- 5 74. A lighting interface (21) for a vehicle (1) and trailer (2) combination,
wherein the trailer has a plurality of lighting circuits (22, 24) including at least one of a stop signal and direction indicator signals to be powered by the vehicle,
wherein the vehicle is arranged to provide power supply to the interface and to detect the presence of a path to ground through at least one of the lighting circuits;
10 the interface comprising circuitry (100, 63) comprising a depletion mode transistor (63) in series with a resistor (100), whereby the transistor is configured to remain in a conducting state if insufficient power is applied to power logic controlling said transistor;
wherein the circuitry (100, 63) is arranged for providing a current load through the resistor (100) in order to simulate a filament bulb when the trailer light circuit comprises a
15 light emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb; and
wherein the interface is arranged, on detection of a power supply voltage drop below a predetermined threshold, to keep the transistor in series with the resistor (100) for at least a predetermined time period, such as at least two seconds, in order to avoid
20 detection of a fault in the trailer lighting circuit due to short term transient voltage drops.

75. The interface of claim 74, wherein the power supply is comprised in a predetermined nominal voltage supply range of [+18V; +32V], and the predetermined threshold is +18V.

- 25 76. A lighting interface (21) for a vehicle (1) and trailer (2) combination,
wherein the trailer has a plurality of lighting circuits (22, 24) including at least one of a stop signal and direction indicator signals to be powered by the vehicle,
wherein the vehicle is arranged to detect a path to ground in at least one of the lighting circuits;
30 wherein the interface further comprises circuitry (100, 63) arranged to provide a load (100) to simulate a filament bulb when the trailer light circuit comprises a light emitting element with a lower current draw, such as an LED light, to enable bulb detection logic in the vehicle to detect a bulb;

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wherein the interface further comprises circuitry (62, 52) arranged to, on detection of a current draw of the light emitting element below a predetermined LED light current threshold, signal a fault in the light emitting element of the trailer lighting circuit to the vehicle by providing a high resistance path to ground or open circuit, irrespective of the
5 current draw in other elements of the interface.

77. The interface of any one of claims 53 to 76, connected to each of the stop and two direction indicator circuits.

10 78. A lighting interface (21) for a vehicle (1) and trailer (2) combination,
wherein the trailer has a plurality of lighting circuits (22, 23, 24) including at least a stop signal and direction indicator signals to be powered by the vehicle,
wherein the vehicle is arranged to detect the presence of the trailer by detecting a path to ground through a bulb of at least one of the lighting circuits;
15 the interface comprising circuitry (100, 63) for providing
a path to ground for the or each circuit within a predetermined resistance range, irrespective of the condition of the lighting circuit, and
a load (100) to simulate a filament bulb when the trailer light circuit comprises a light emitting element with a lower current draw, such as an LED light, to
20 enable bulb detection logic in the vehicle to detect a bulb, whilst not providing a further load if a filament bulb is detected in the lighting circuit;
wherein the circuitry (100, 63) optionally comprises a depletion mode transistor (63) in series with a resistor (100), whereby the transistor is configured to
remain in a conducting state if insufficient voltage is applied to power logic
25 controlling said transistor and arranged to disconnect a path to ground for a trailer detection signal from the vehicle, and
to open if a filament bulb is detected;
the interface further comprising circuitry (52) arranged to signal fault to the vehicle by providing a high resistance path to ground or open circuit on detection of a fault in the
30 trailer lighting circuit;
wherein the trailer has a plurality of lighting circuits (22, 24) including indicator to be flashed by spaced apart power pulses provided by the vehicle;
wherein the interface comprises:

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energy storage circuitry (53) for storing energy provided by the power pulses, for a time period at least equal to the expected spacing between adjacent power pulses, and

latching circuitry (70) arranged, on detection of a fault during a first pulse of power from the vehicle, to signal the detected fault to the vehicle by providing a high resistance path to ground or open circuit at the next pulse of power.

79. The lighting interface (21) of claim 78, wherein the trailer has a plurality of lighting circuits (22, 23, 24) including at least a stop signal circuit (23) and a tail signal circuit (26, 27) which are interconnected,

10 wherein the vehicle is arranged to detect the presence of a bulb in at least one of the lighting circuits,

wherein the interface comprises circuitry (65) arranged to detect a fault condition in the stop circuit, irrespective of whether the tail circuit is powered.

15 80. The interface of any one of claims 55, 56, 72 or 78, wherein the current load is equivalent to a cold bulb resistance.

81. The interface of any one of claims 57, 62, 72, 74 or 78, wherein the depletion mode transistor (63) is a MOSFET.

20

82. The interface of any one of claims 58, 59, 72, 74, 76 or 78, wherein the load is equivalent to a 21W filament lamp powered by nominal 24V, preferably comprising a resistor (100) having a resistance of about $30\Omega \pm 50\%$.

25 83. The interface of claim 68, wherein the LED light current threshold is comprised between 2mA and 500mA.

84. The interface of any one of claims 70 or 71, wherein the overload current threshold is comprised between 2.5A and 7.5A, preferably 4.2A.

30

85. The interface of any one of claims 62 or 63 or 78, wherein a filament bulb is detected in the trailer lighting circuit on detection of a current draw superior or equal to a current representative of a filament bulb through the lighting circuits (22, 24), the current draw

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being comprised between 0.5A and 2A, preferably 0.8A.

86. The interface of any one of claims 53 to 85, comprising a logic arranged on a Printed Circuit Board placed in a housing (216).

5

87. The interface of any one of claims 53 to 86, comprising a heat sink (213), the heat sink (213), preferably comprising radiating fins (2131) and preferably fitted on a housing (216) of the unit using an elastomer O-ring.

10 88. The interface of any one of claims 53 to 87, comprising a housing (216) comprising:
an input (214) from the at least one lamp circuit (22, 23, 24) of the trailer (2); and
an output (215) to the controller (11) adapted to be fitted on the vehicle (1),
wherein the housing is filled with potting compound to seal the input (214) and the output (215).

15

89. The interface of any one of claims 53 to 88, comprising a housing (216) adapted to be fitted on the trailer (2).

90. The interface of any one of claims 58, 59, 62, 63 or 78, wherein the load (100) has a
20 variable resistance, whereby the load is arranged to be configurable with a plurality of
sets of lighting circuits (22, 23, 24), the load being configured to a specific set of lighting
circuits (22, 23, 24) by setting the resistance of the load (100).

91. The interface of claim 90, wherein the load is arranged to be manually configured.

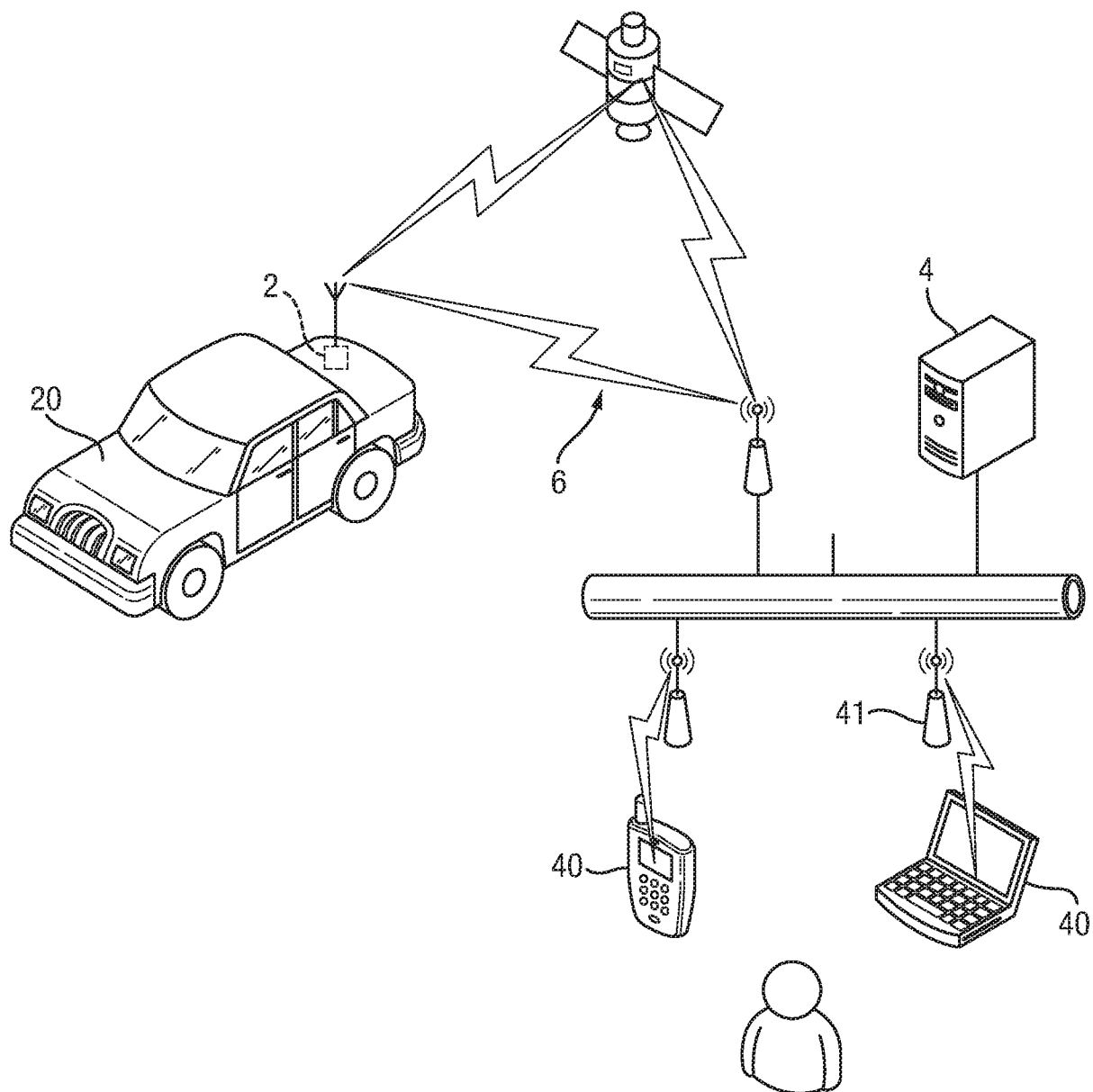
25

92. The interface of claim 90, comprising logic adapted to measure a level of a working current of the plurality of lighting circuits (22, 23, 24) of the trailer when powered by the vehicle and to automatically configure the load.

30 93. The interface of any one of claims 53 to 92, wherein the interface is built-in with the lighting circuits (22, 23, 24) of the trailer.

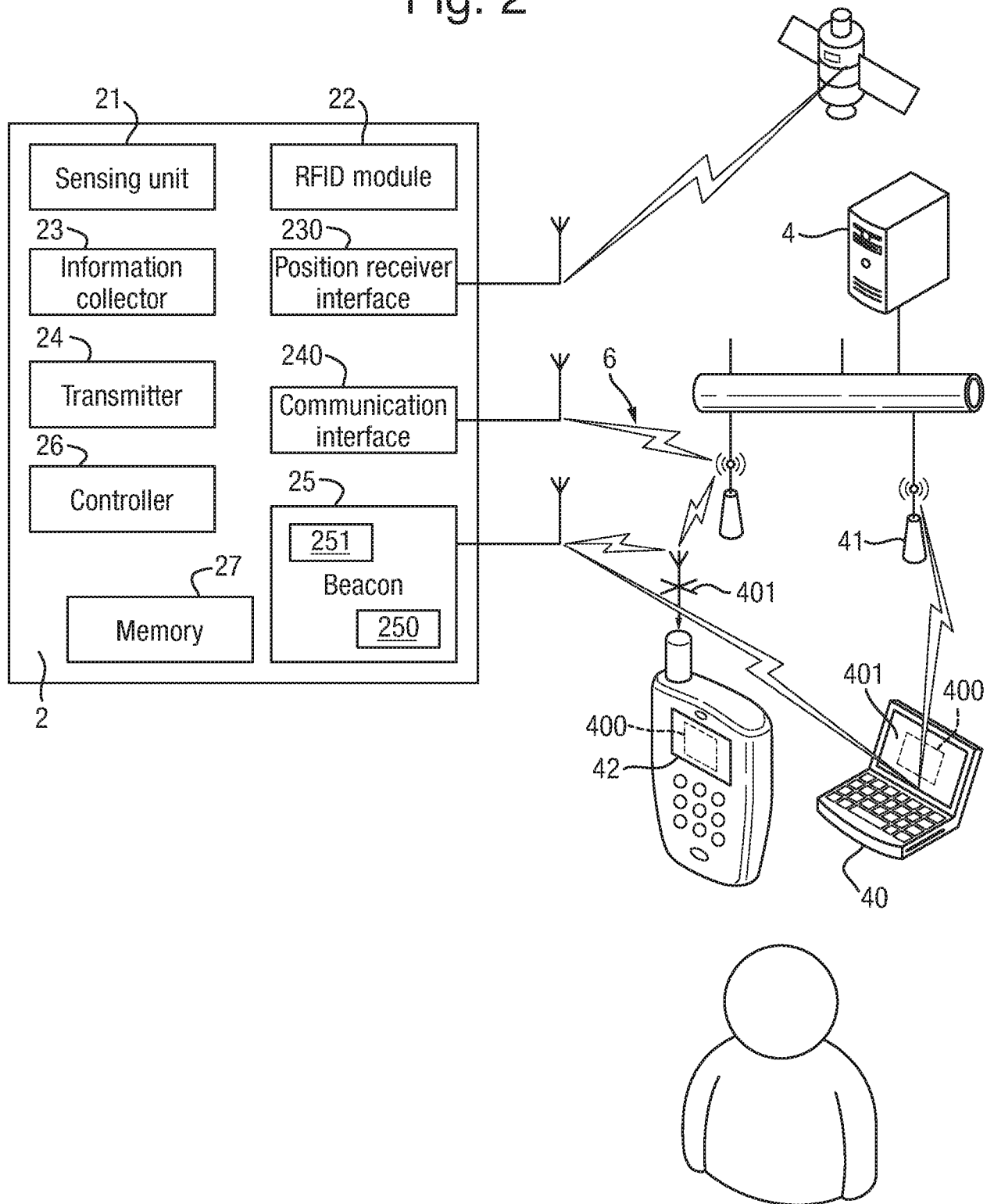
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Fig. 1



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Fig. 2



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Fig. 3A

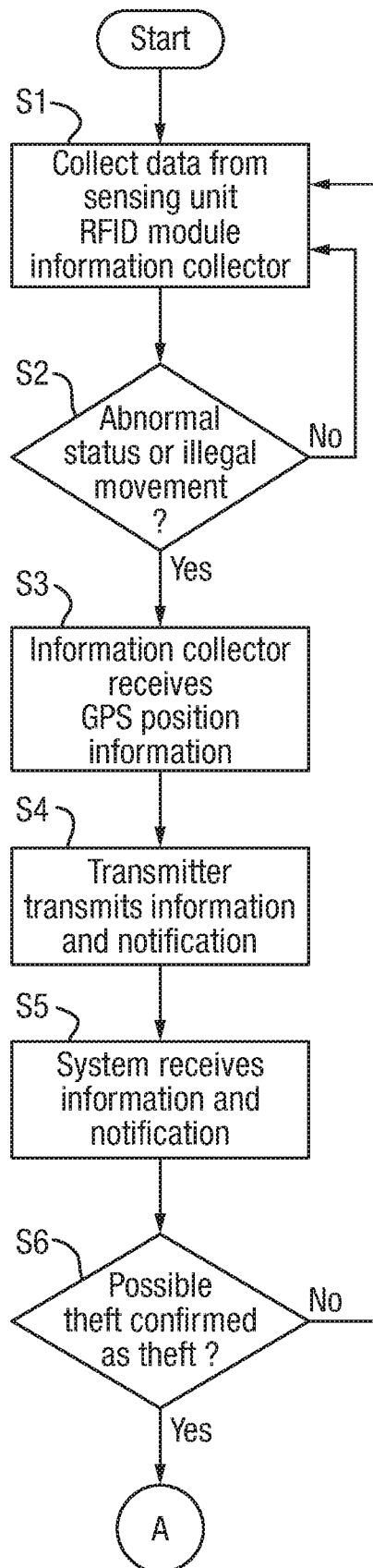


Fig. 3B

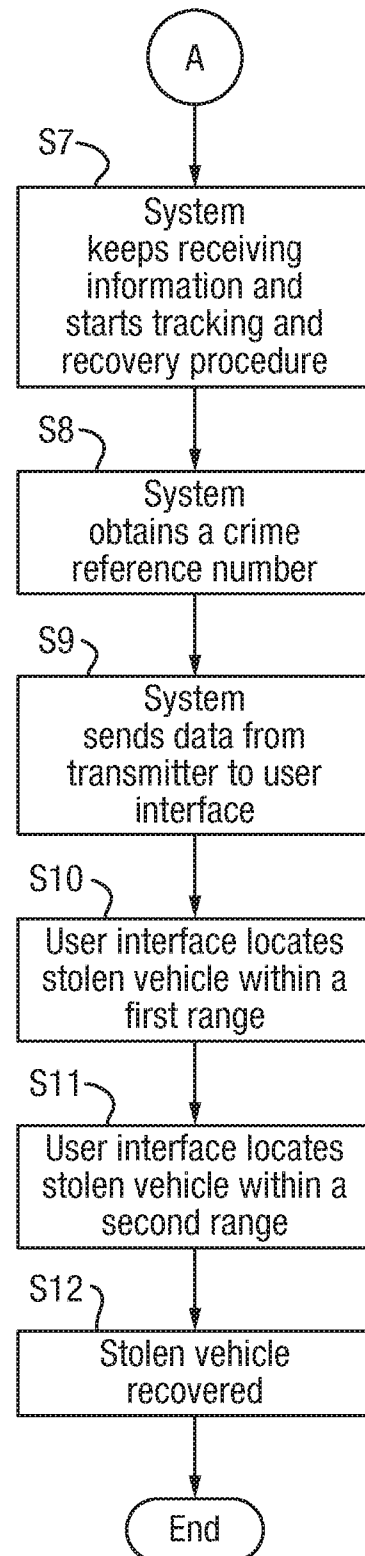
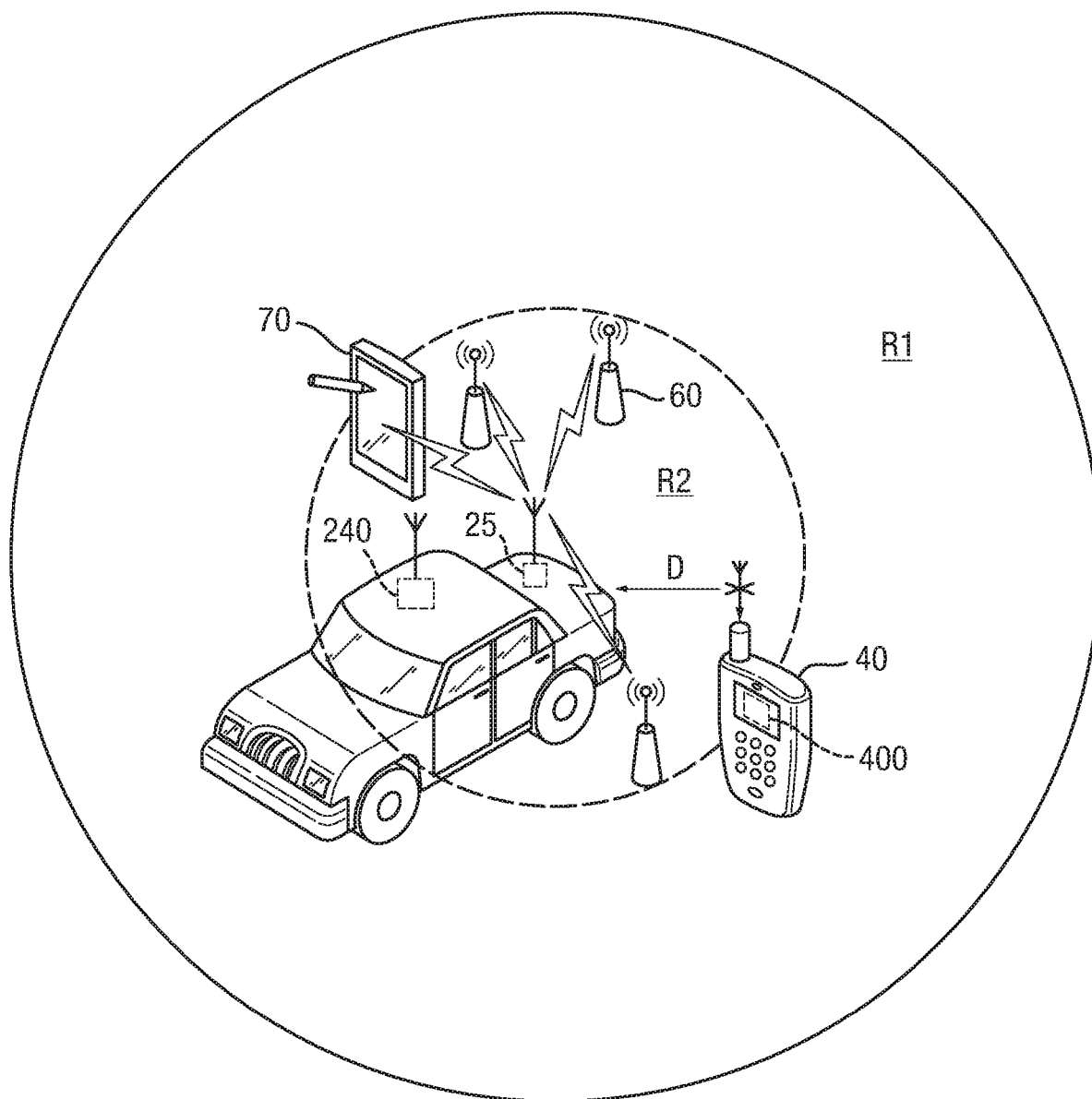
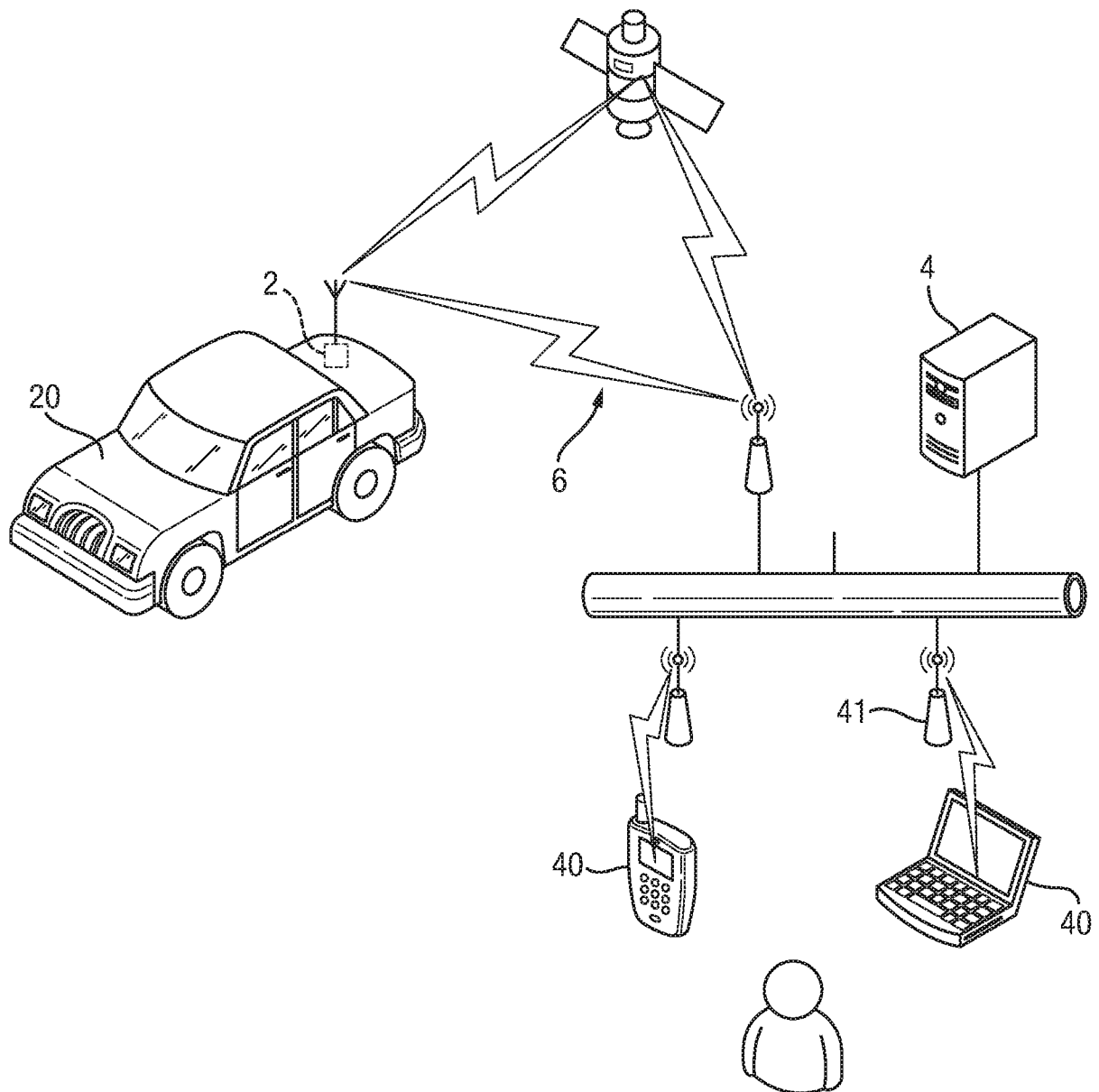


Fig. 4



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Fig. 5



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Fig. 6

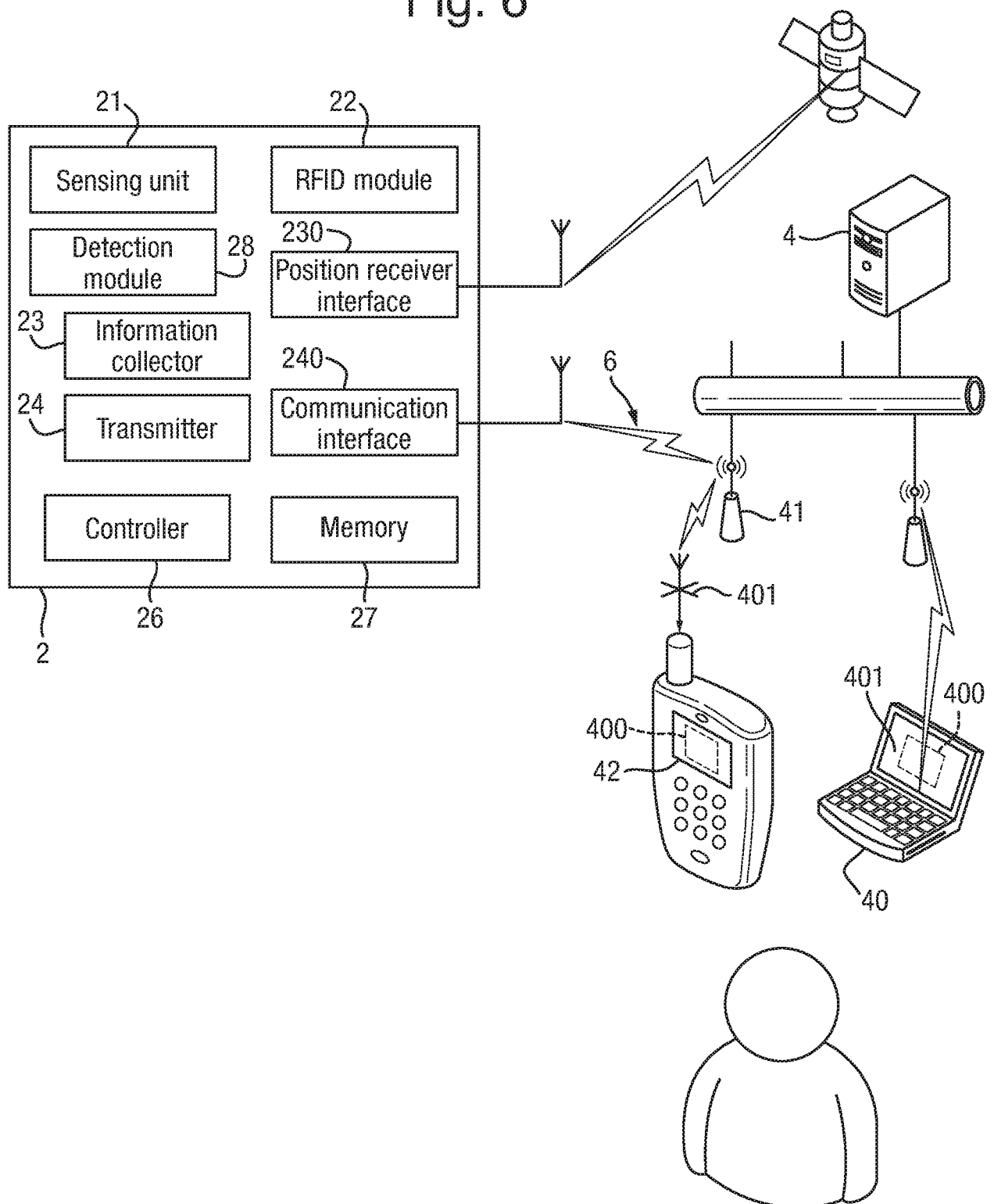


Fig. 7A

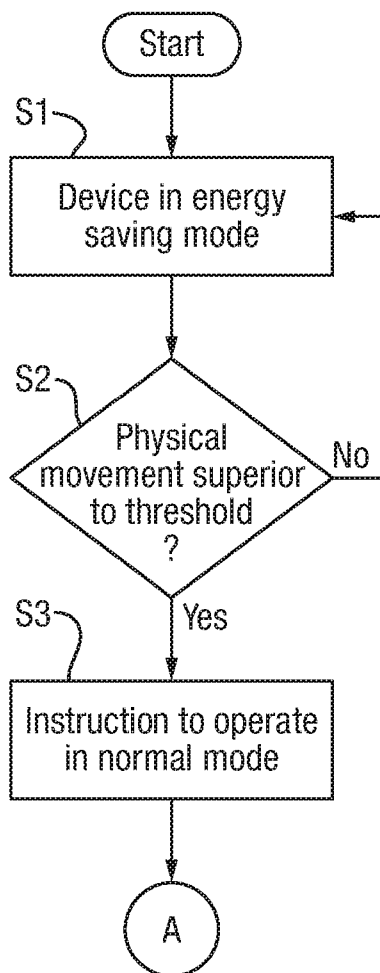
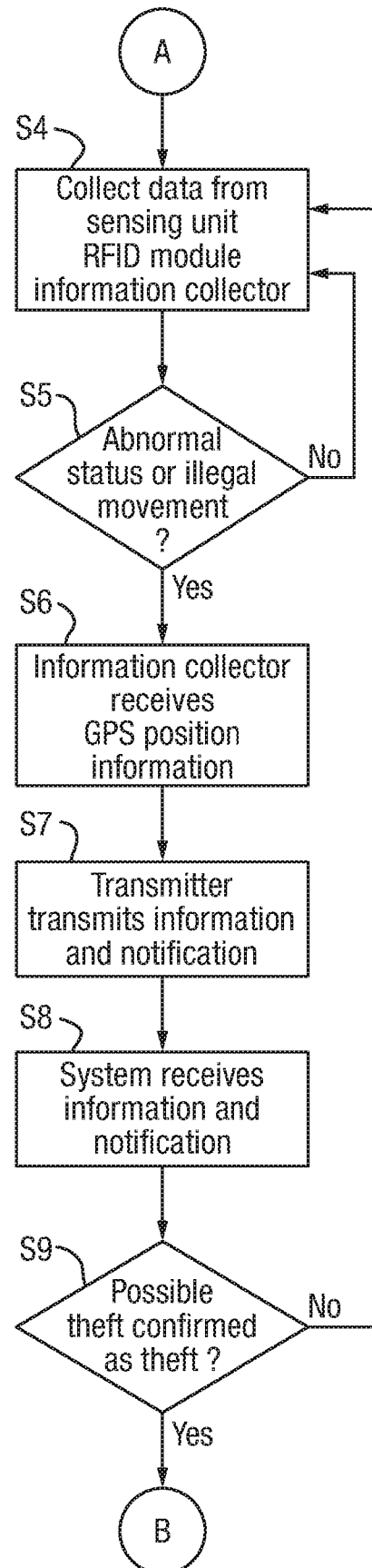
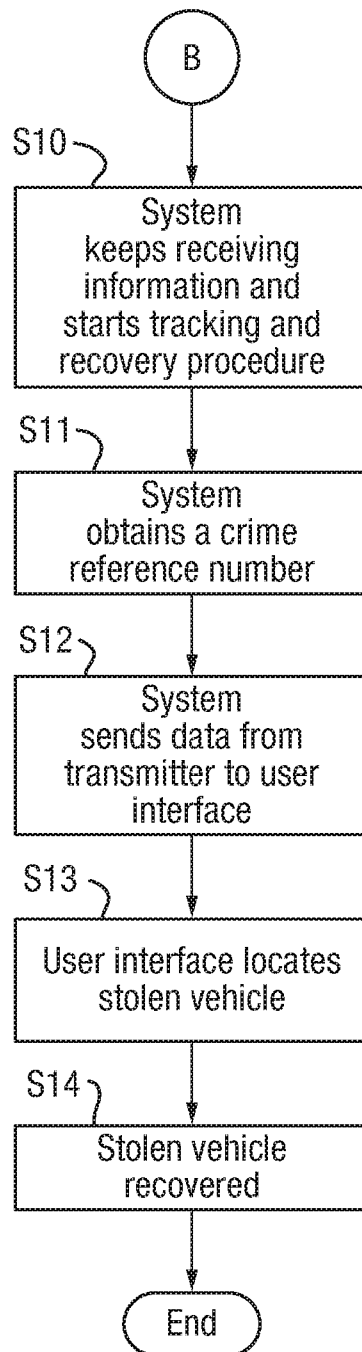


Fig. 7B



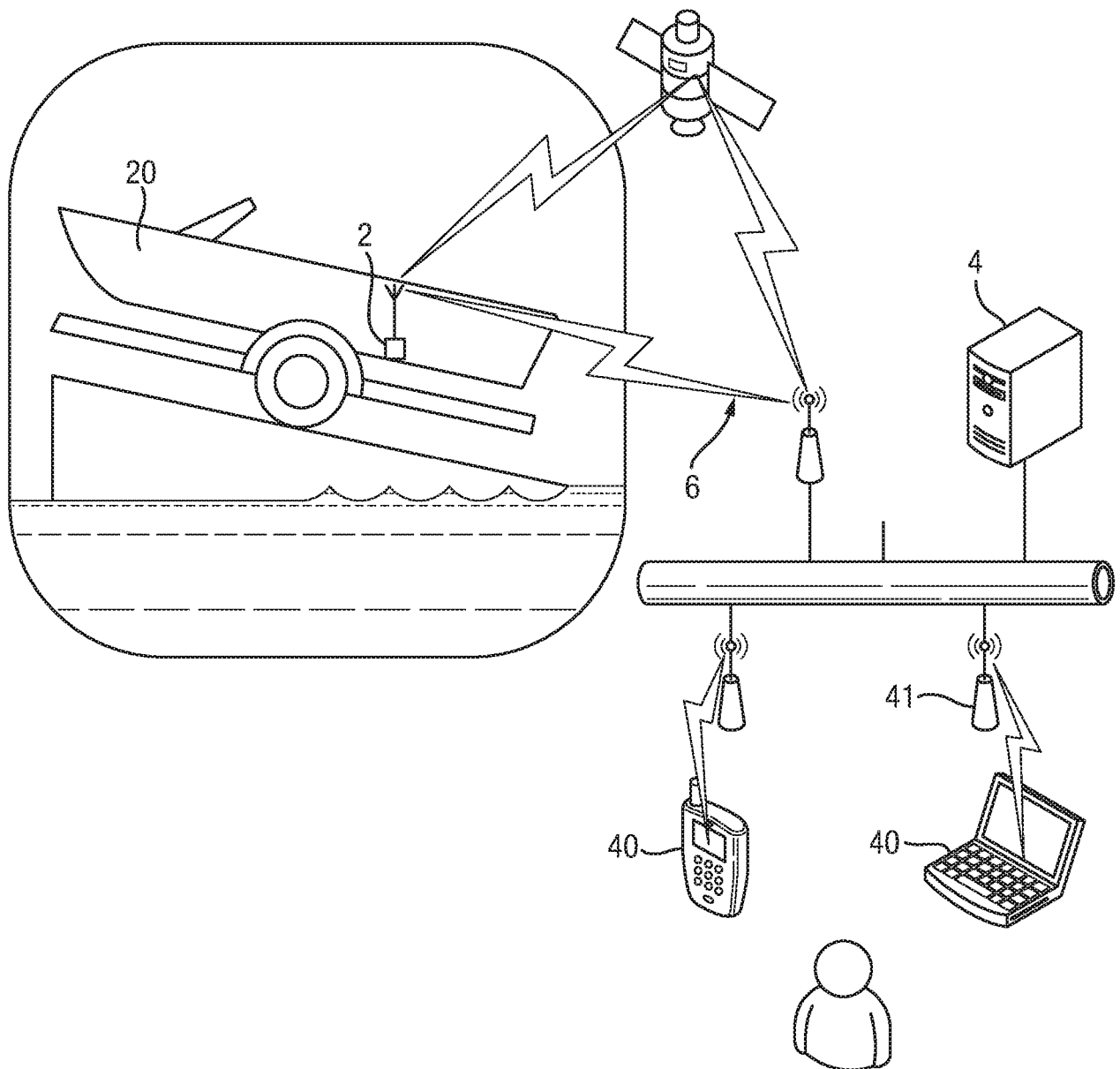
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Fig. 7C



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Fig. 8



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Fig. 9

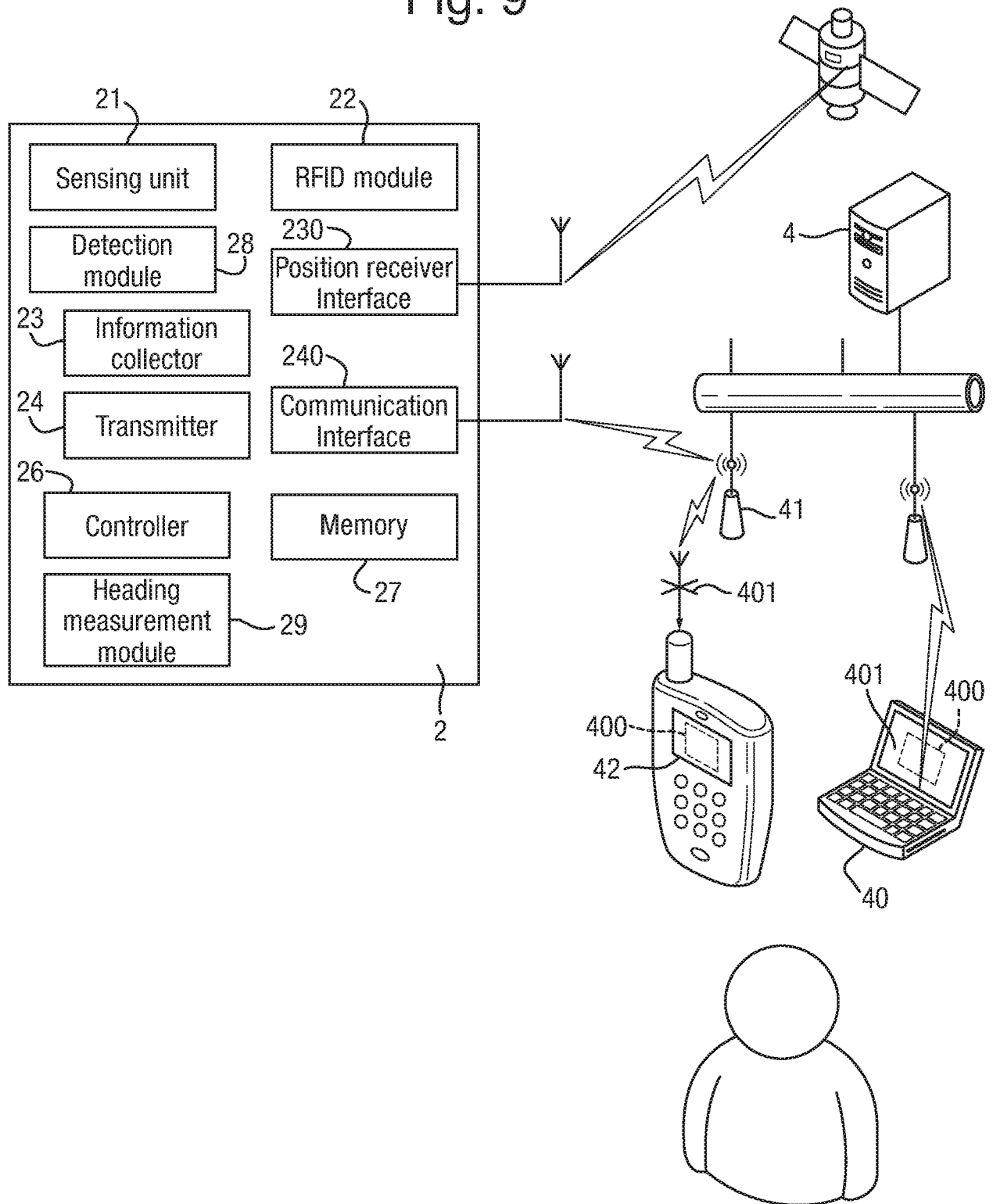


Fig. 10A

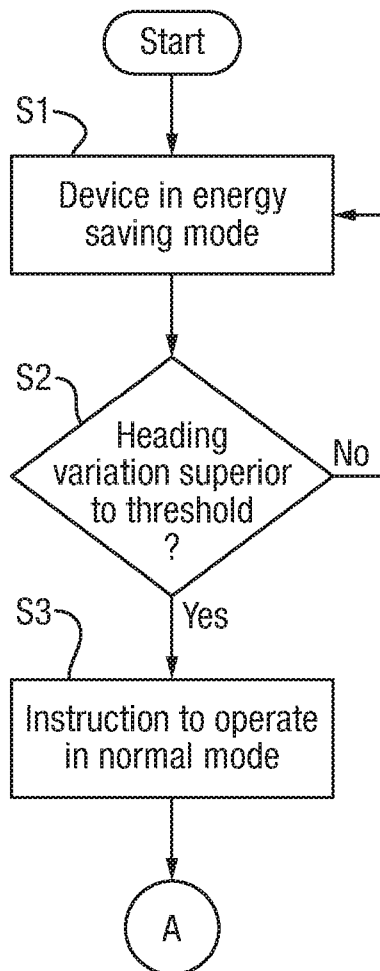
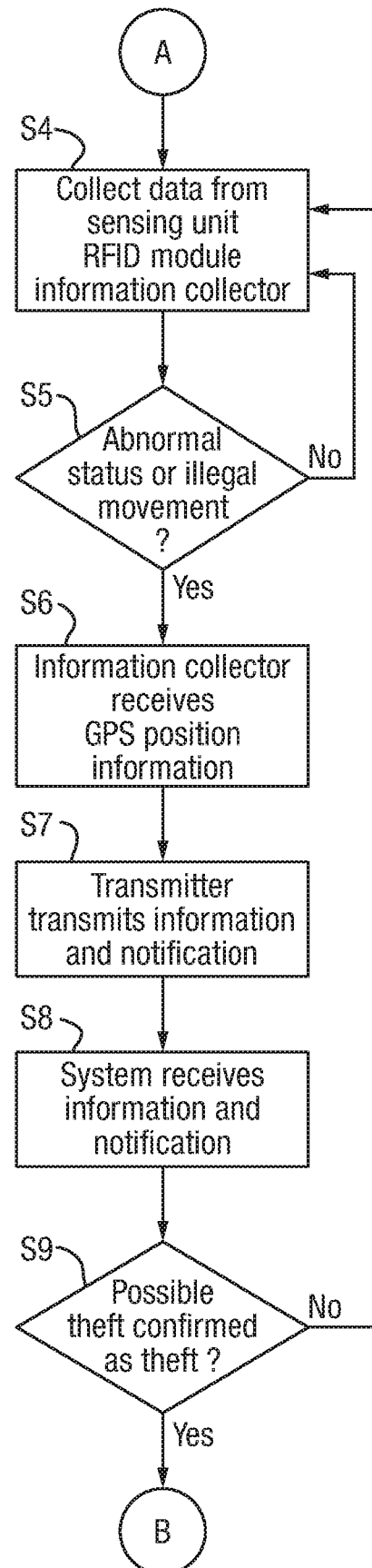


Fig. 10B



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Fig. 10C

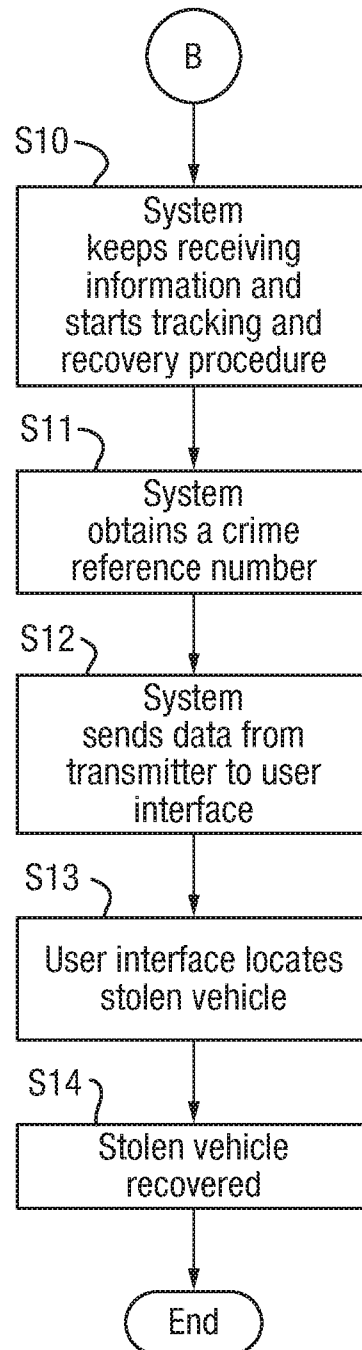


Fig. 11A

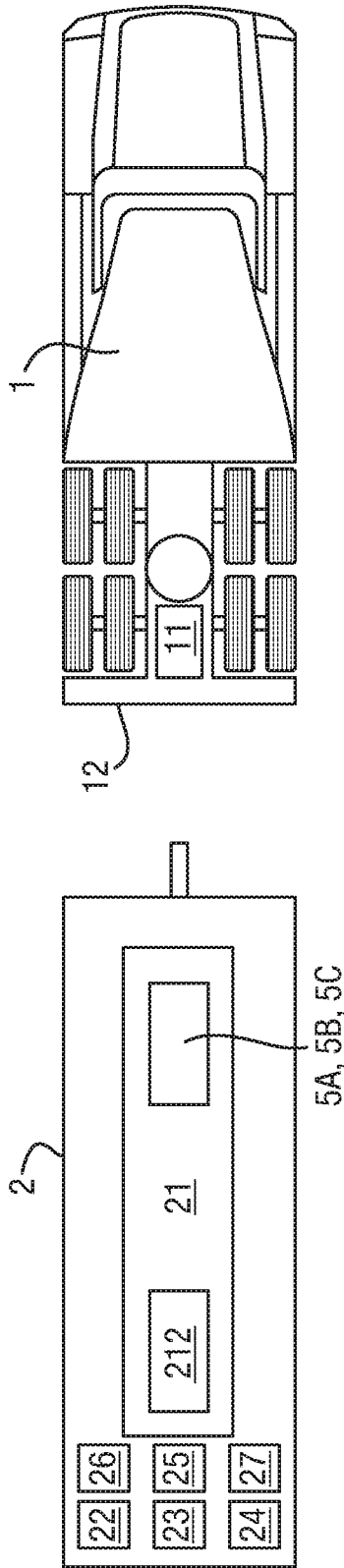
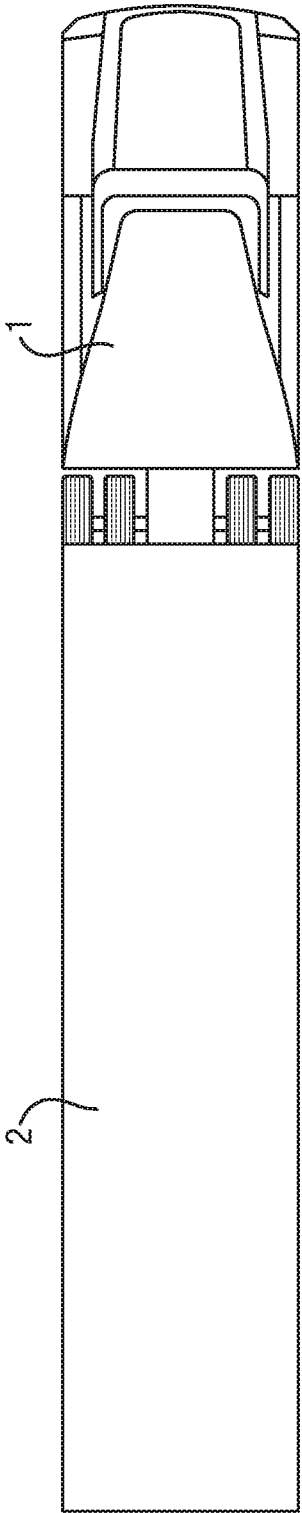


Fig. 11B



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Fig. 12A

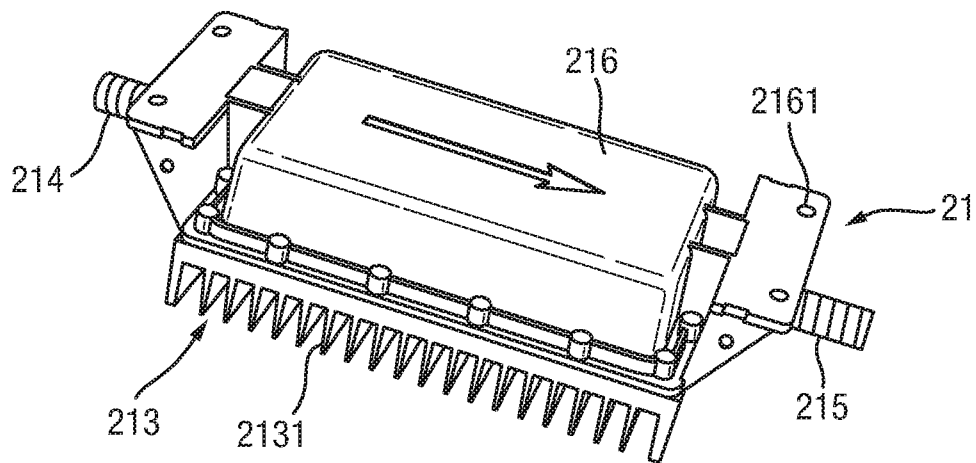
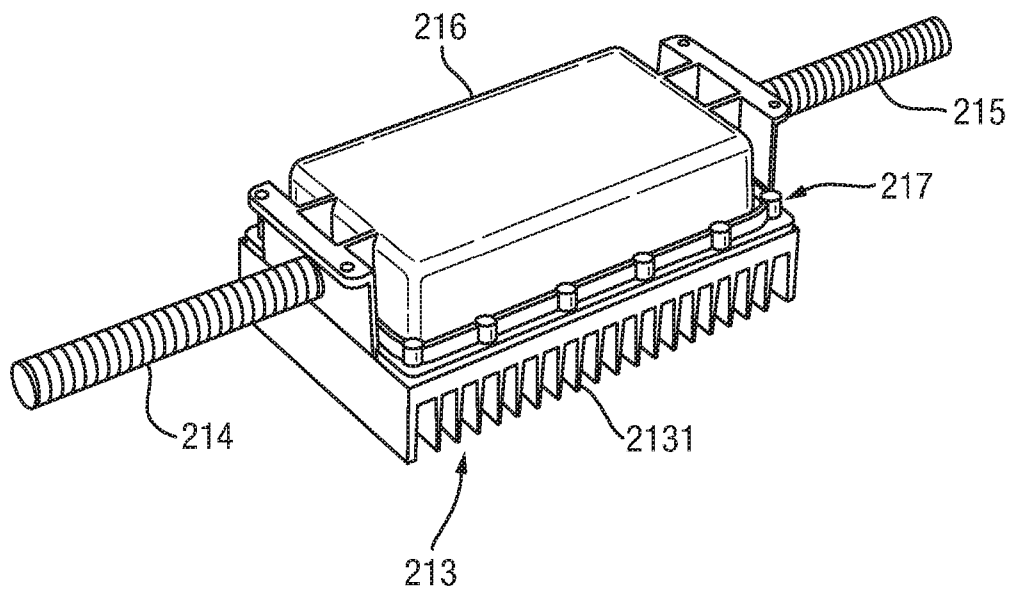
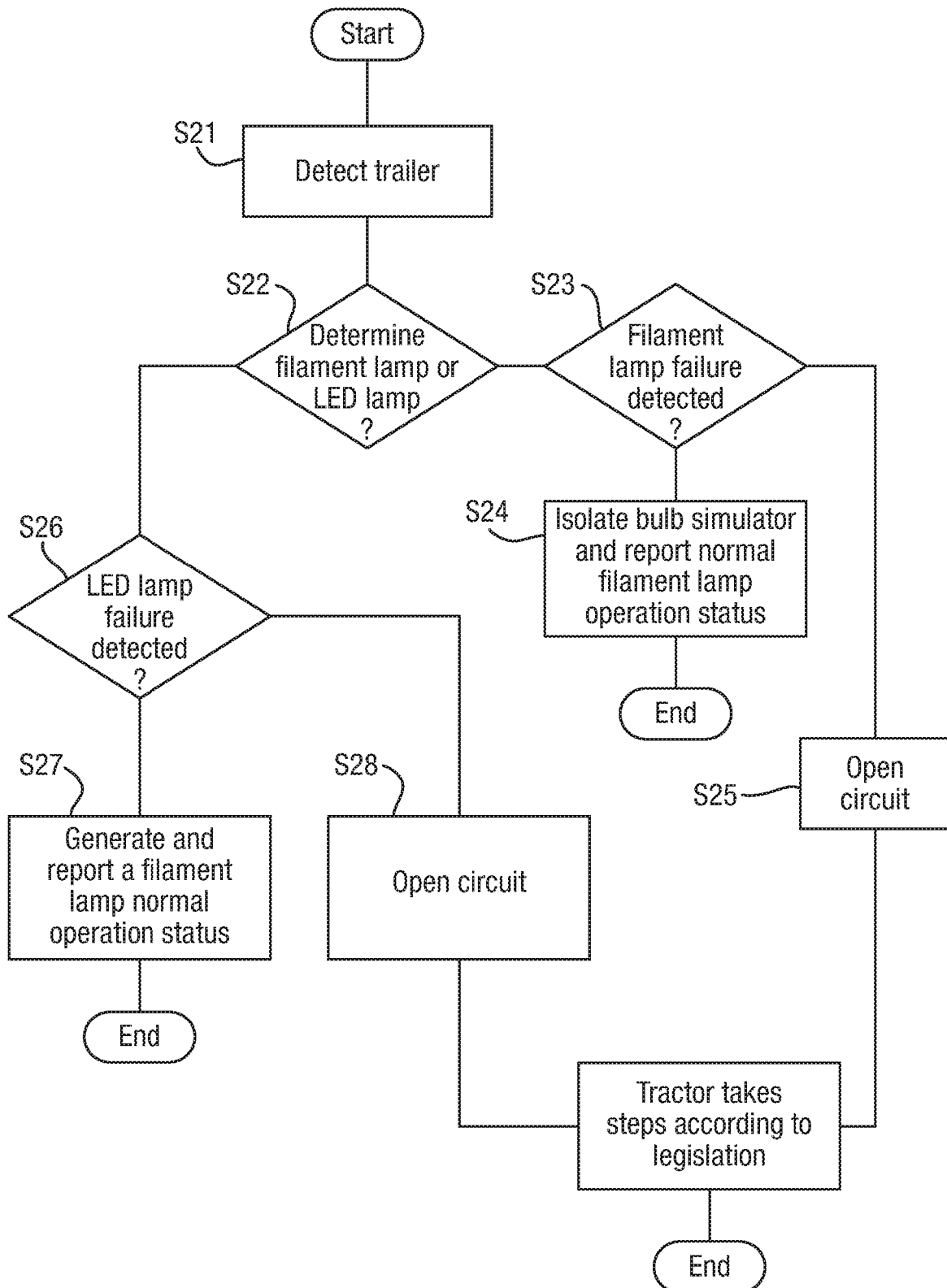


Fig. 12B



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Fig. 13



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Fig. 14A

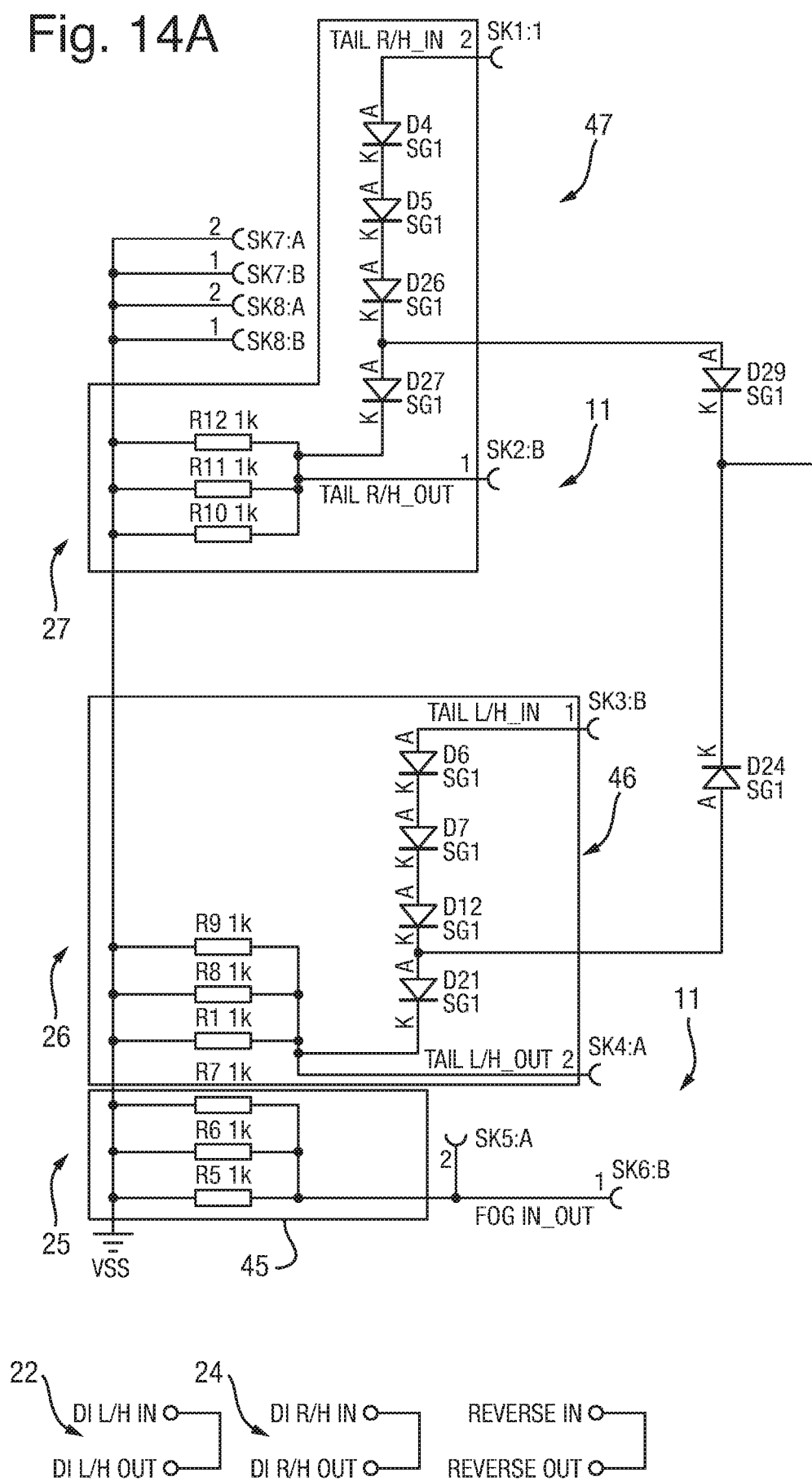
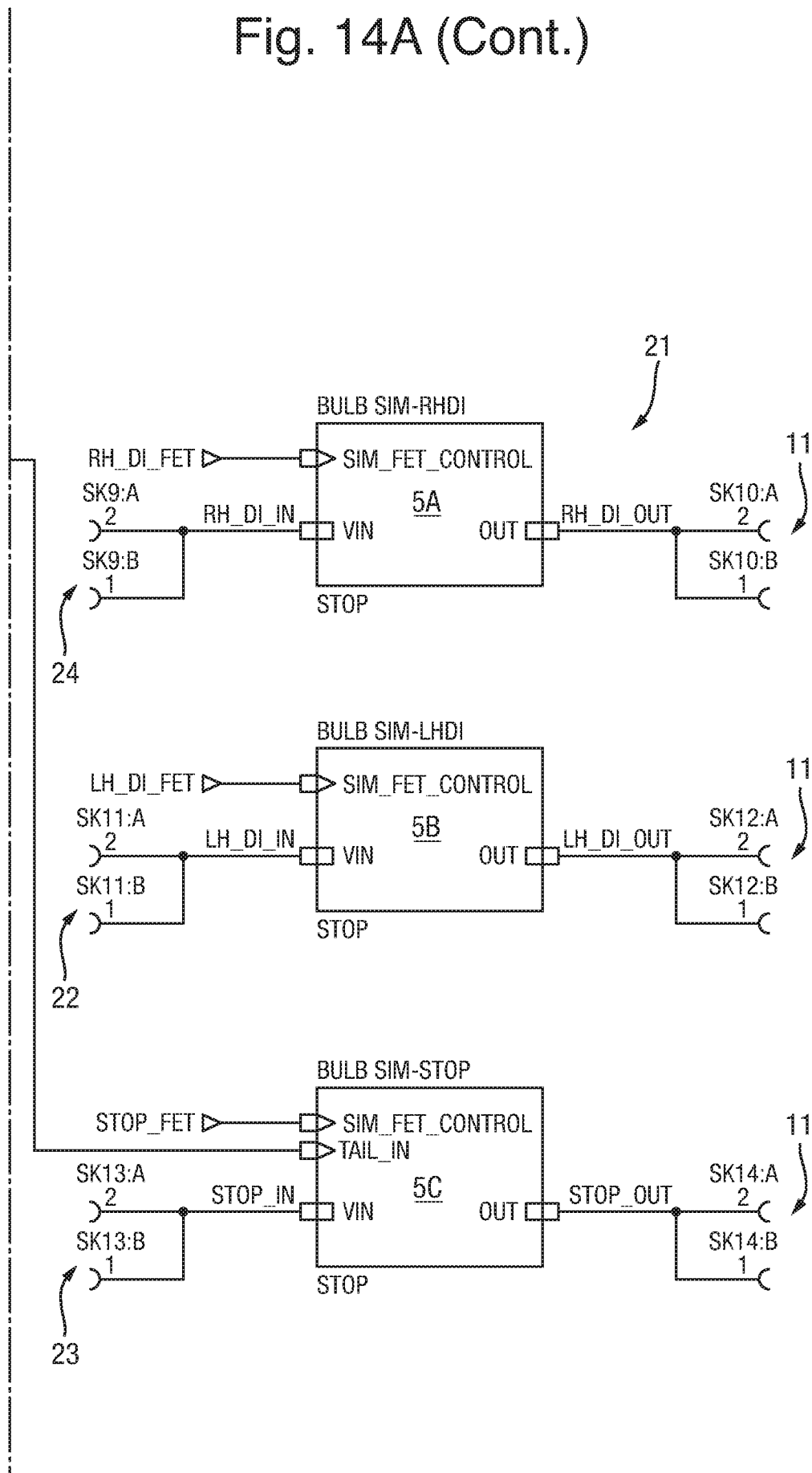


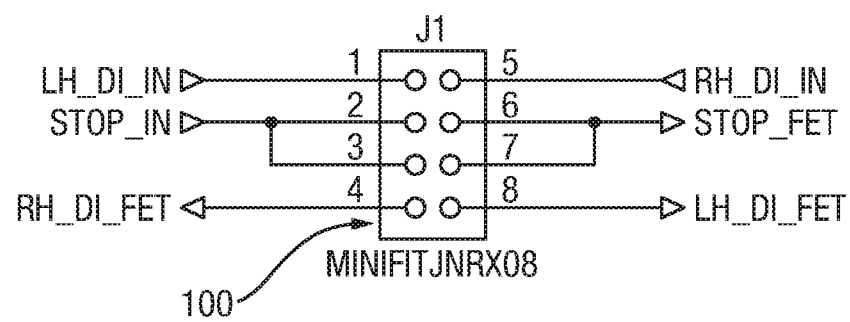
Fig. 14A (Cont.)



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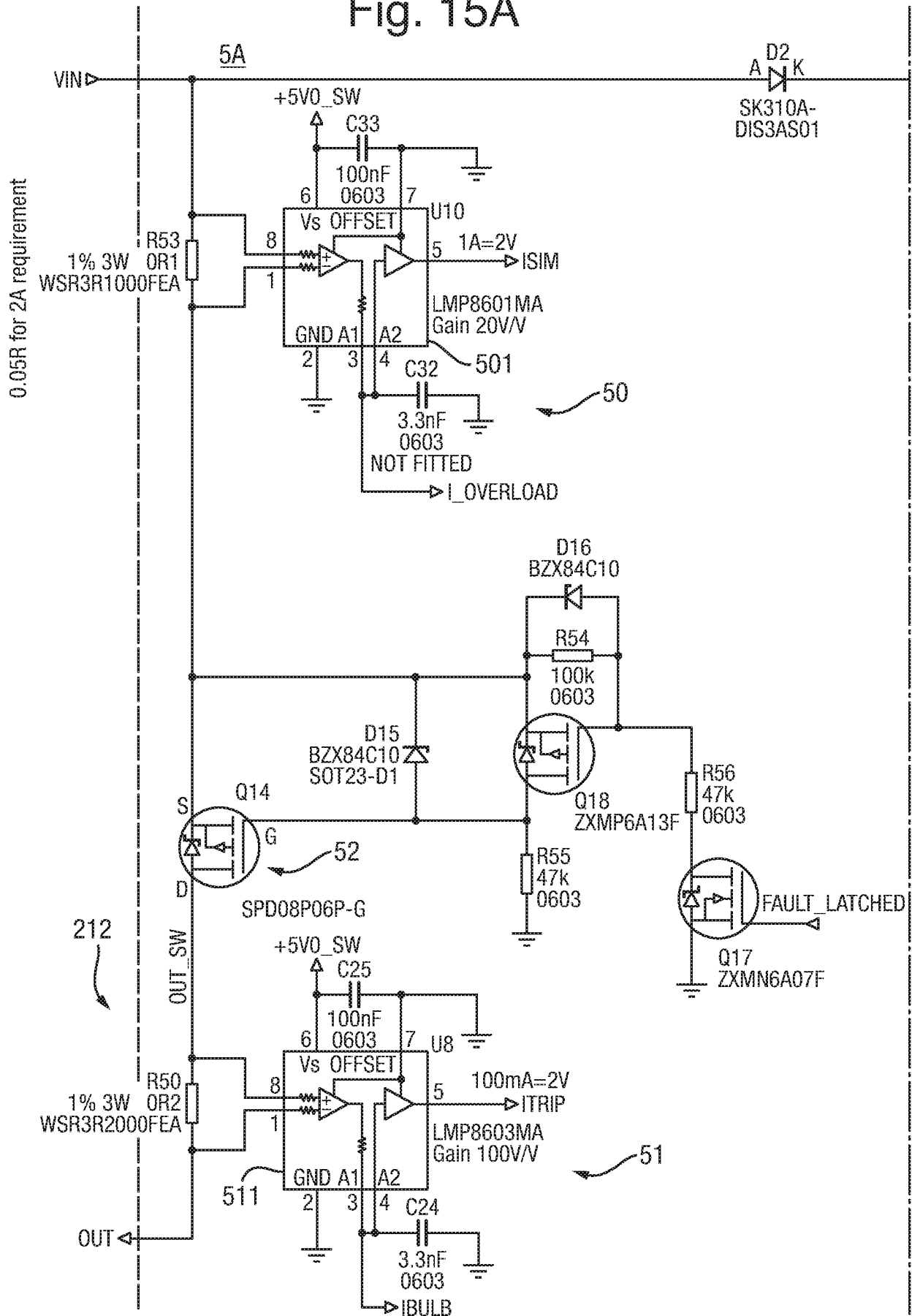
Fig. 14B

TO/FROM SIMULATION RESISTORS



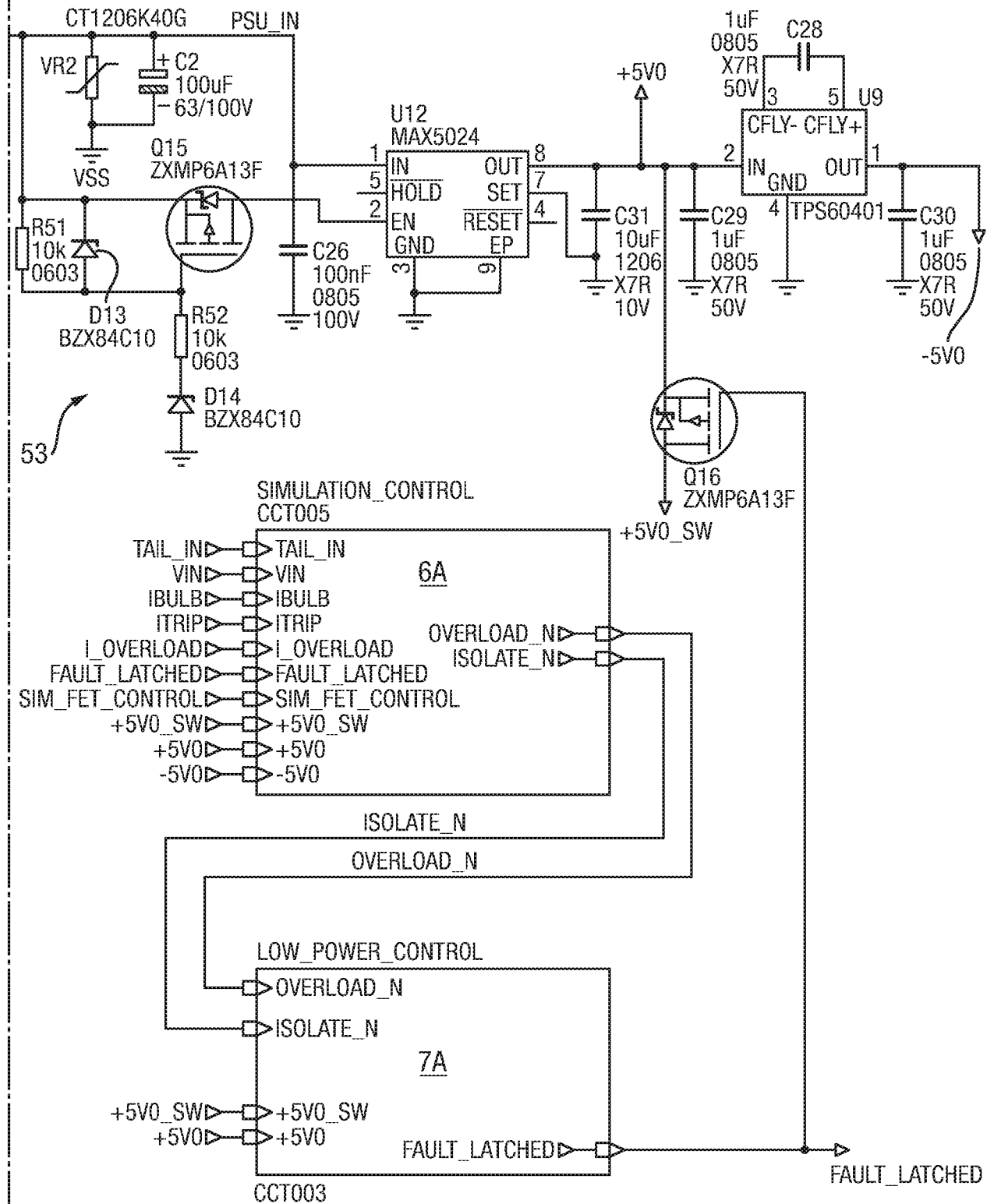
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Fig. 15A



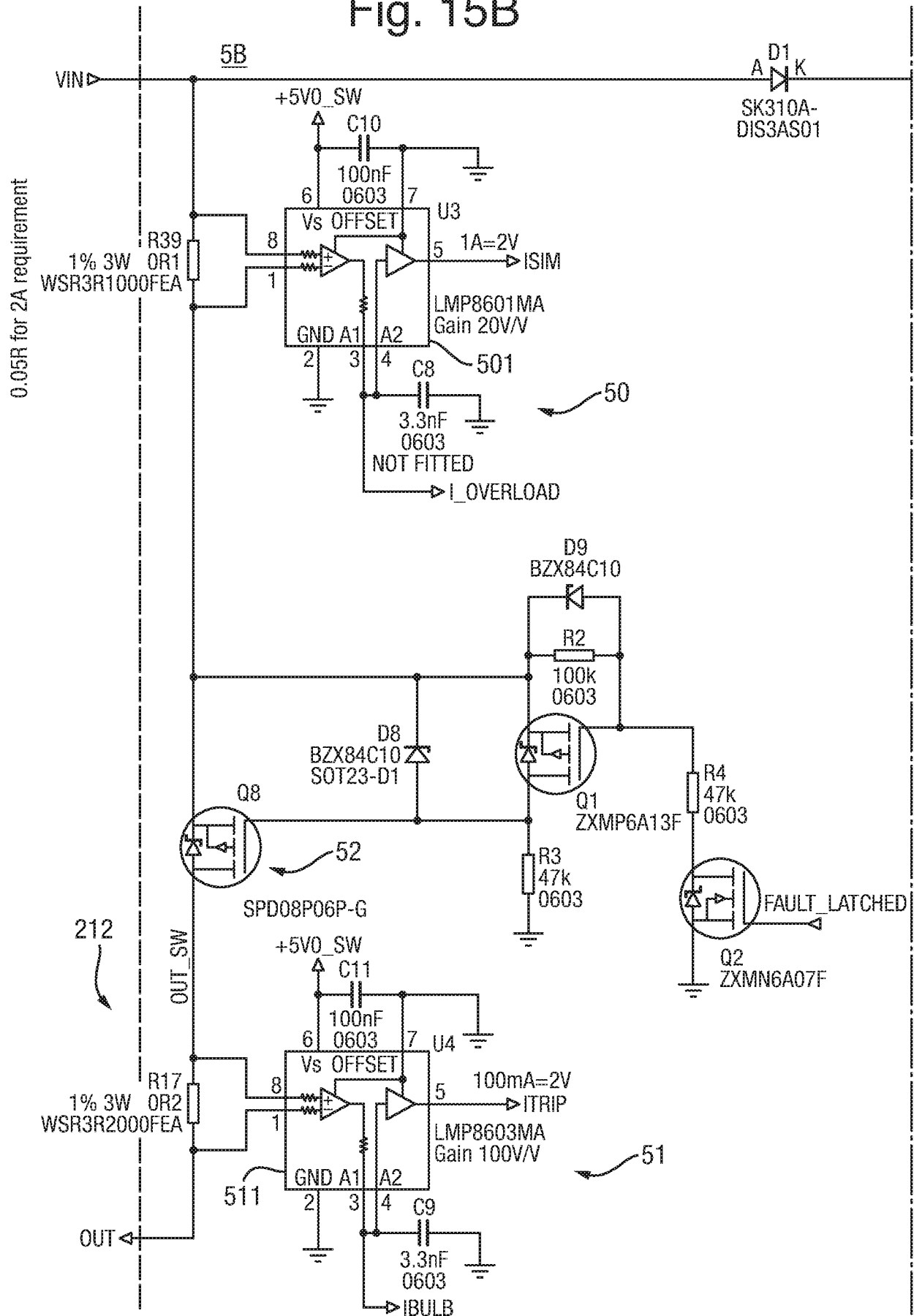
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Fig. 15A (Cont.)



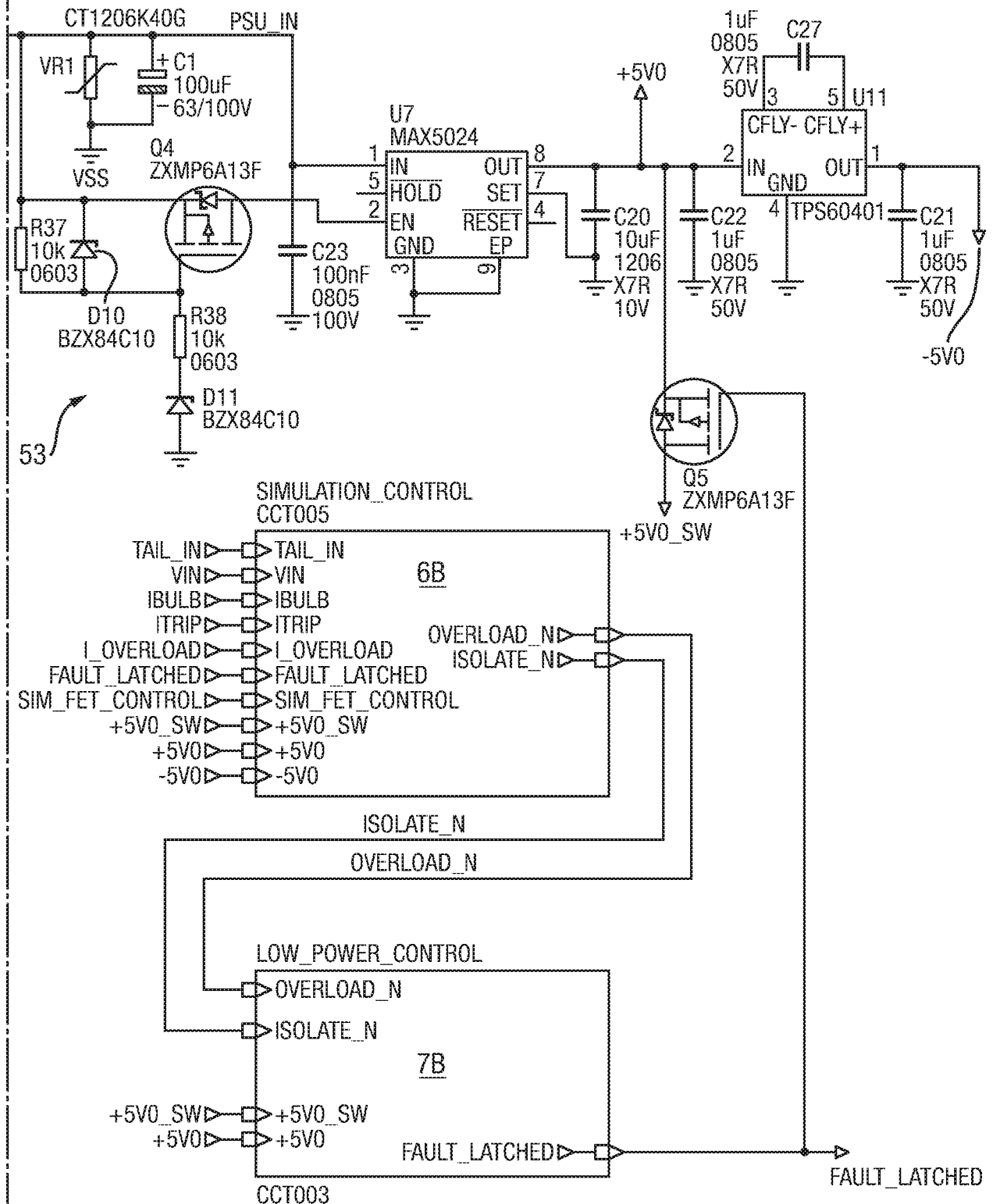
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Fig. 15B



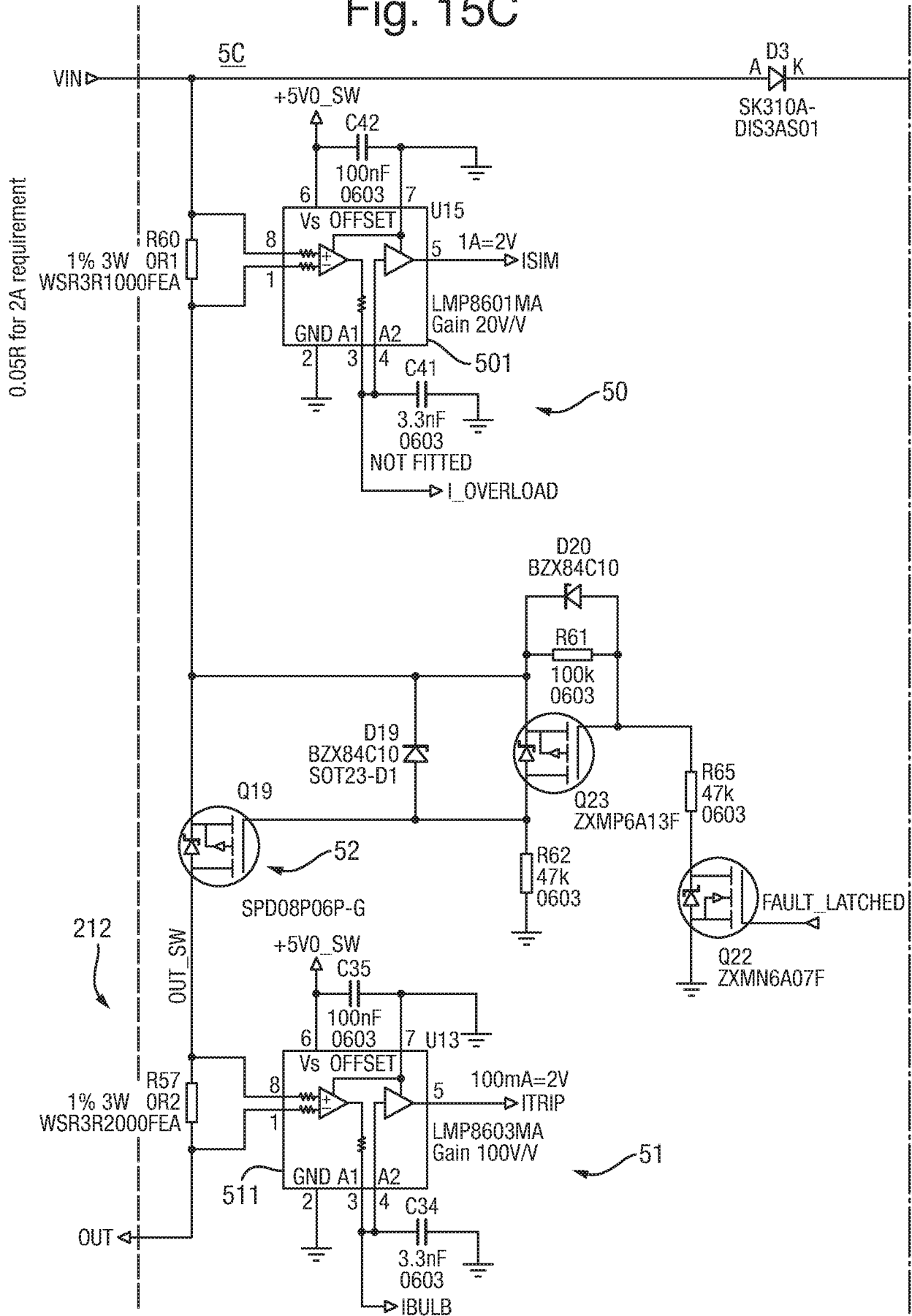
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Fig. 15B (Cont.)



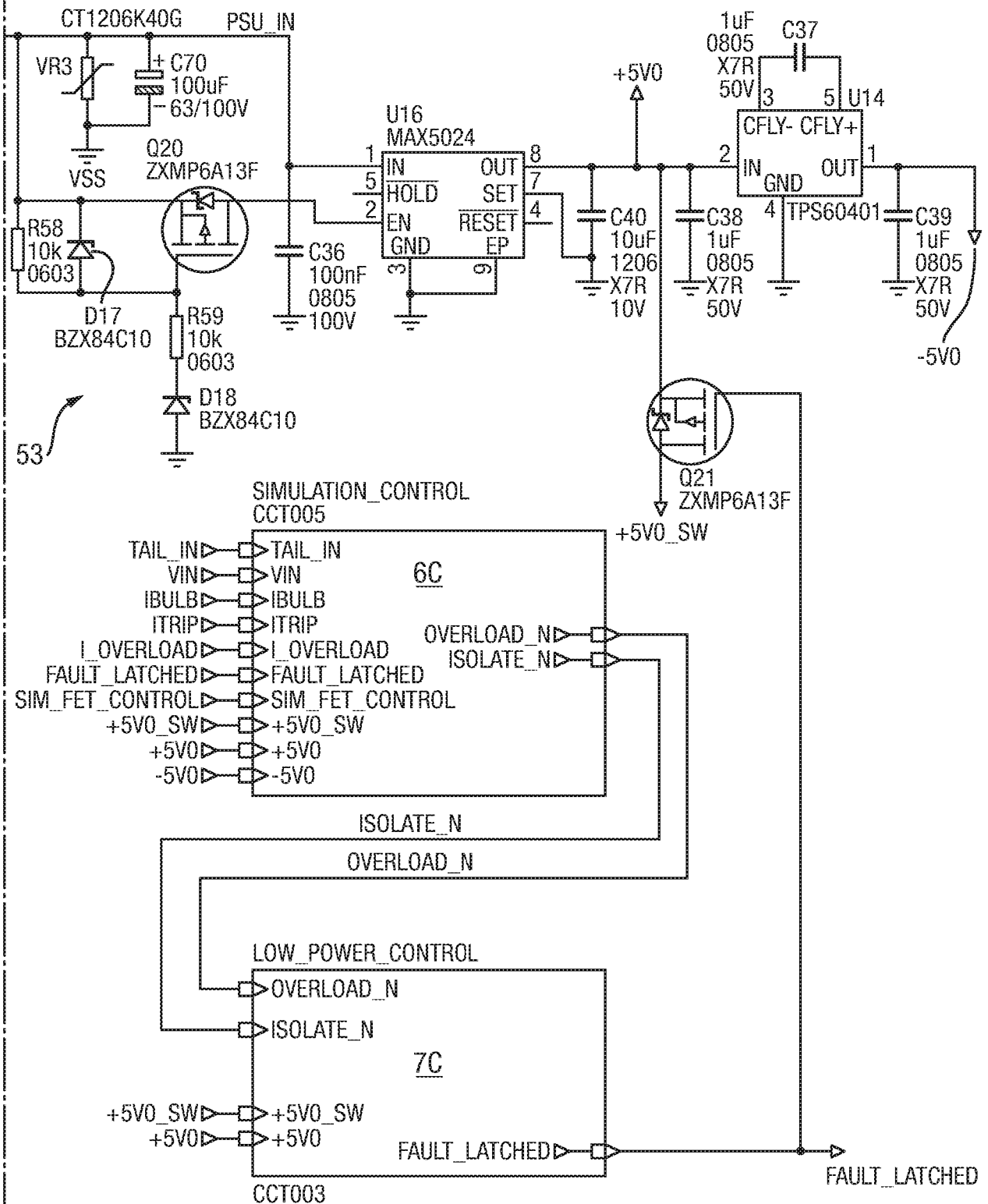
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Fig. 15C



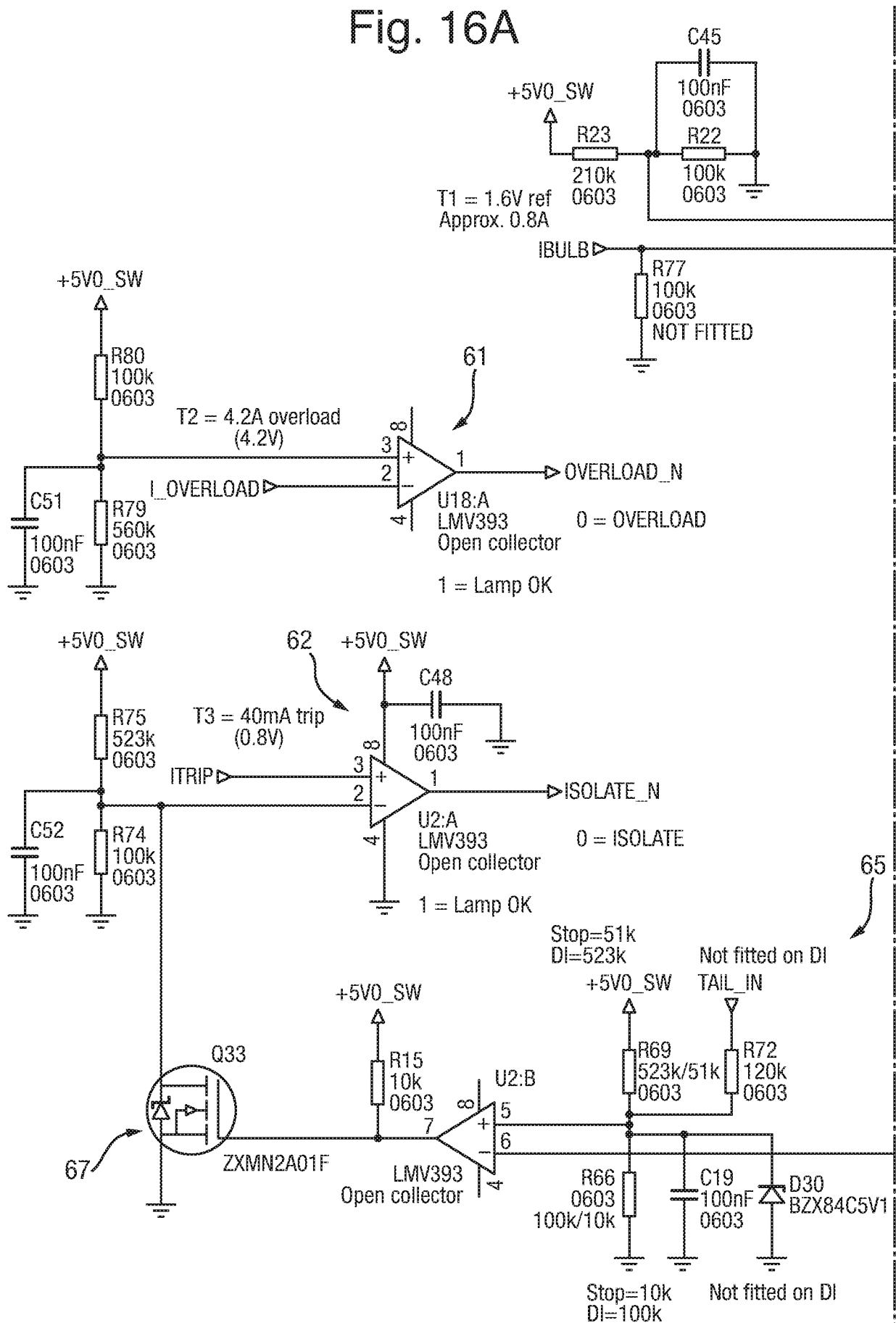
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Fig. 15C (Cont.)



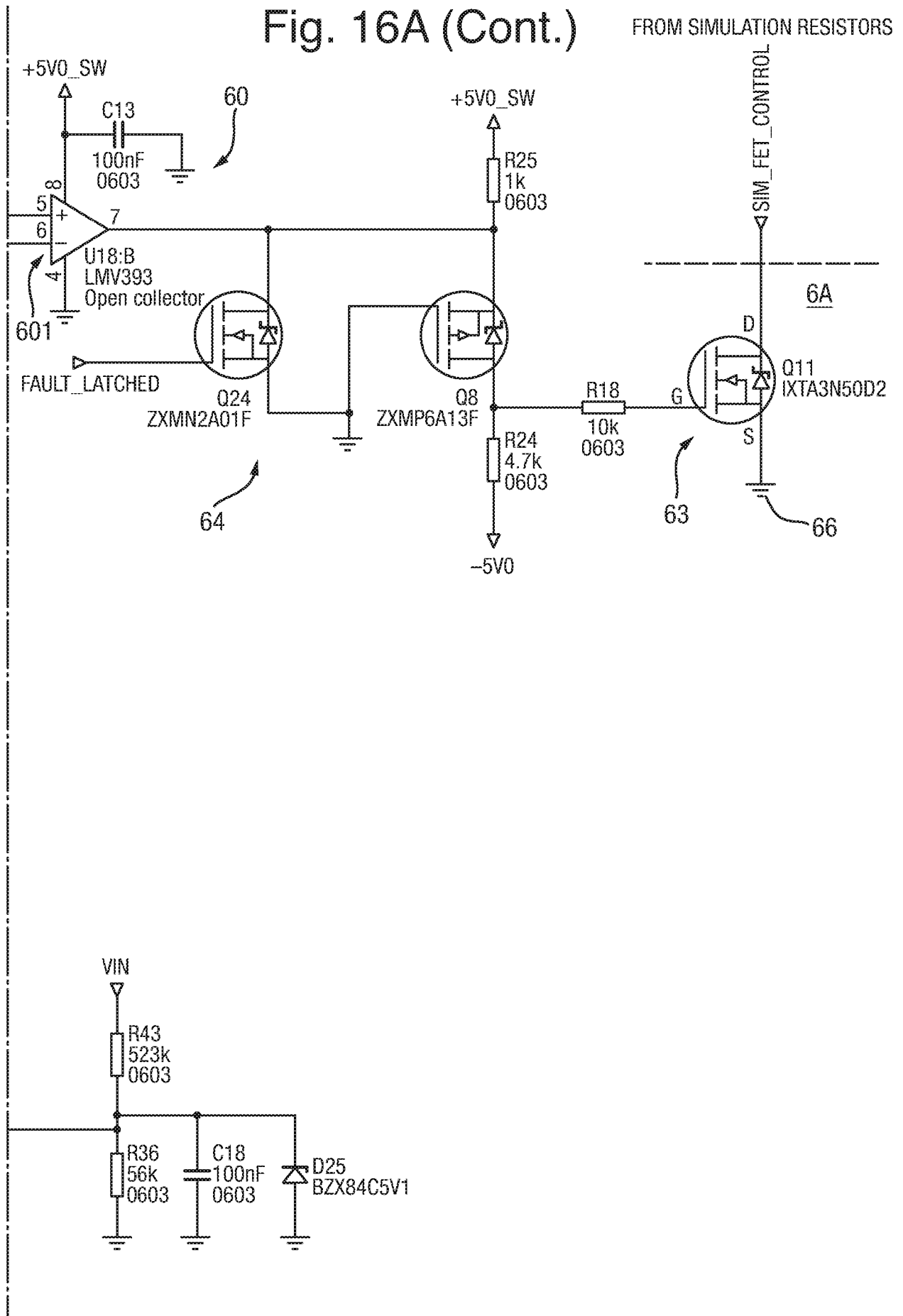
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Fig. 16A



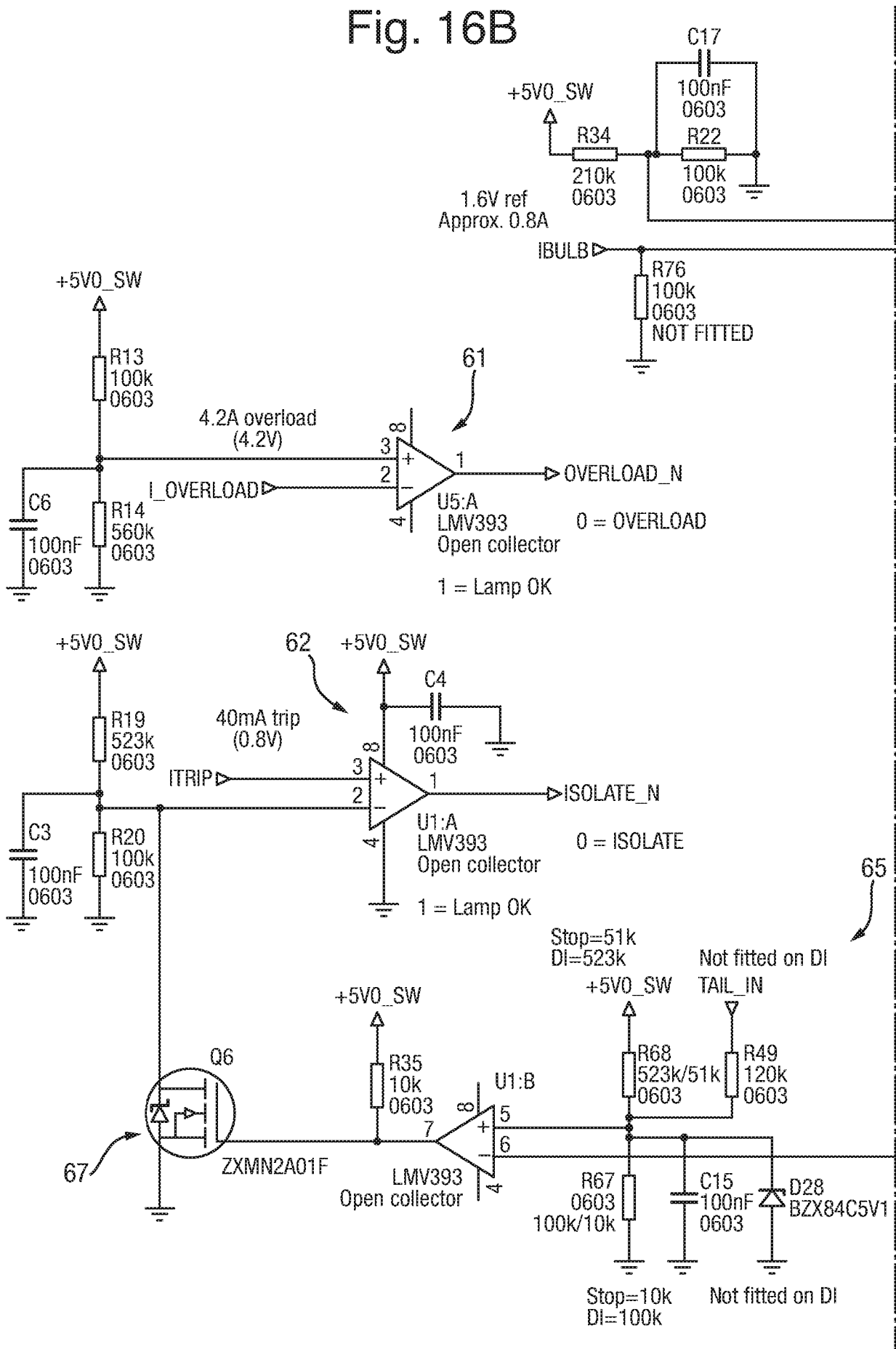
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Fig. 16A (Cont.)



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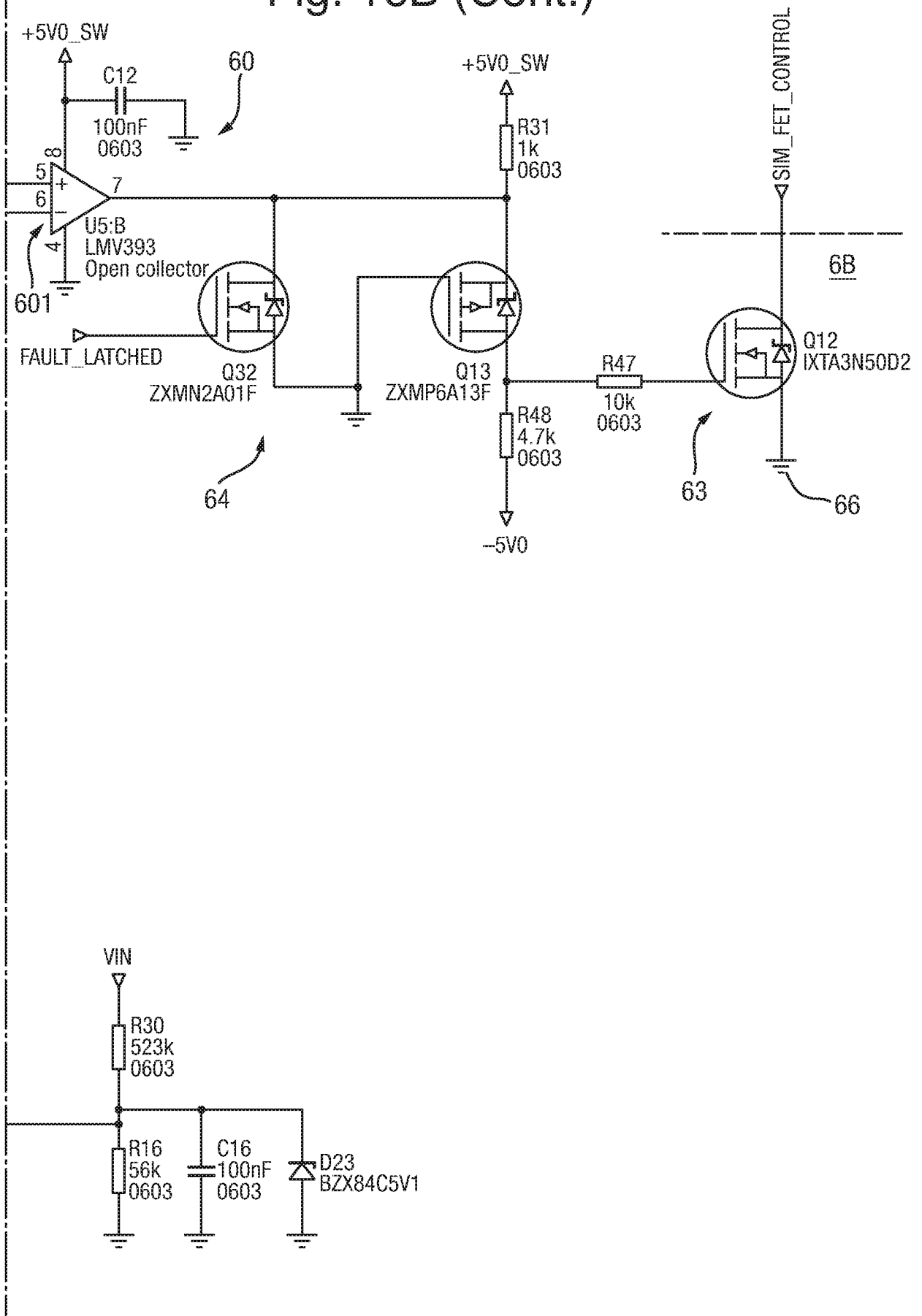
Fig. 16B



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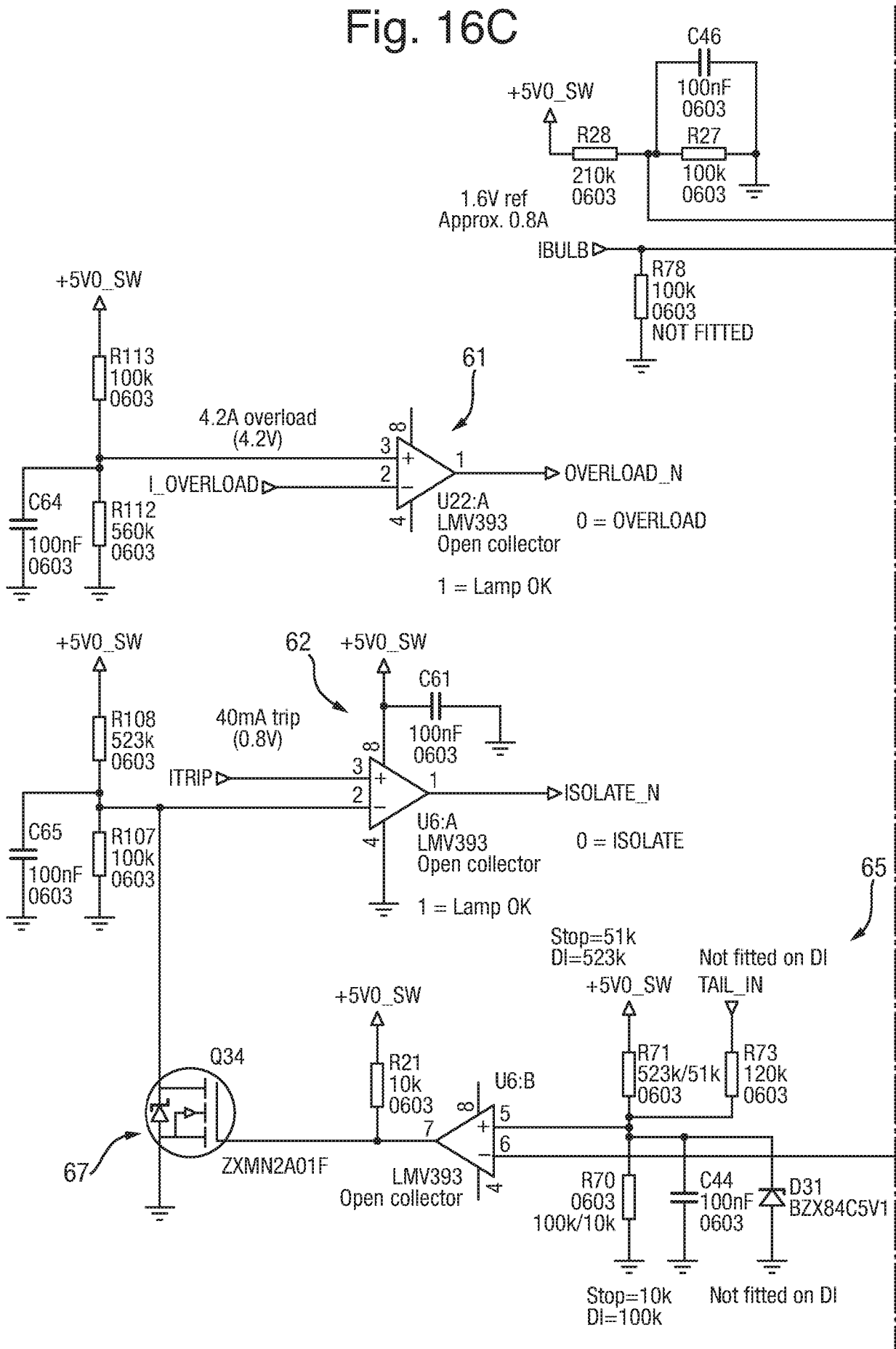
Fig. 16B (Cont.)

FROM SIMULATION RESISTORS



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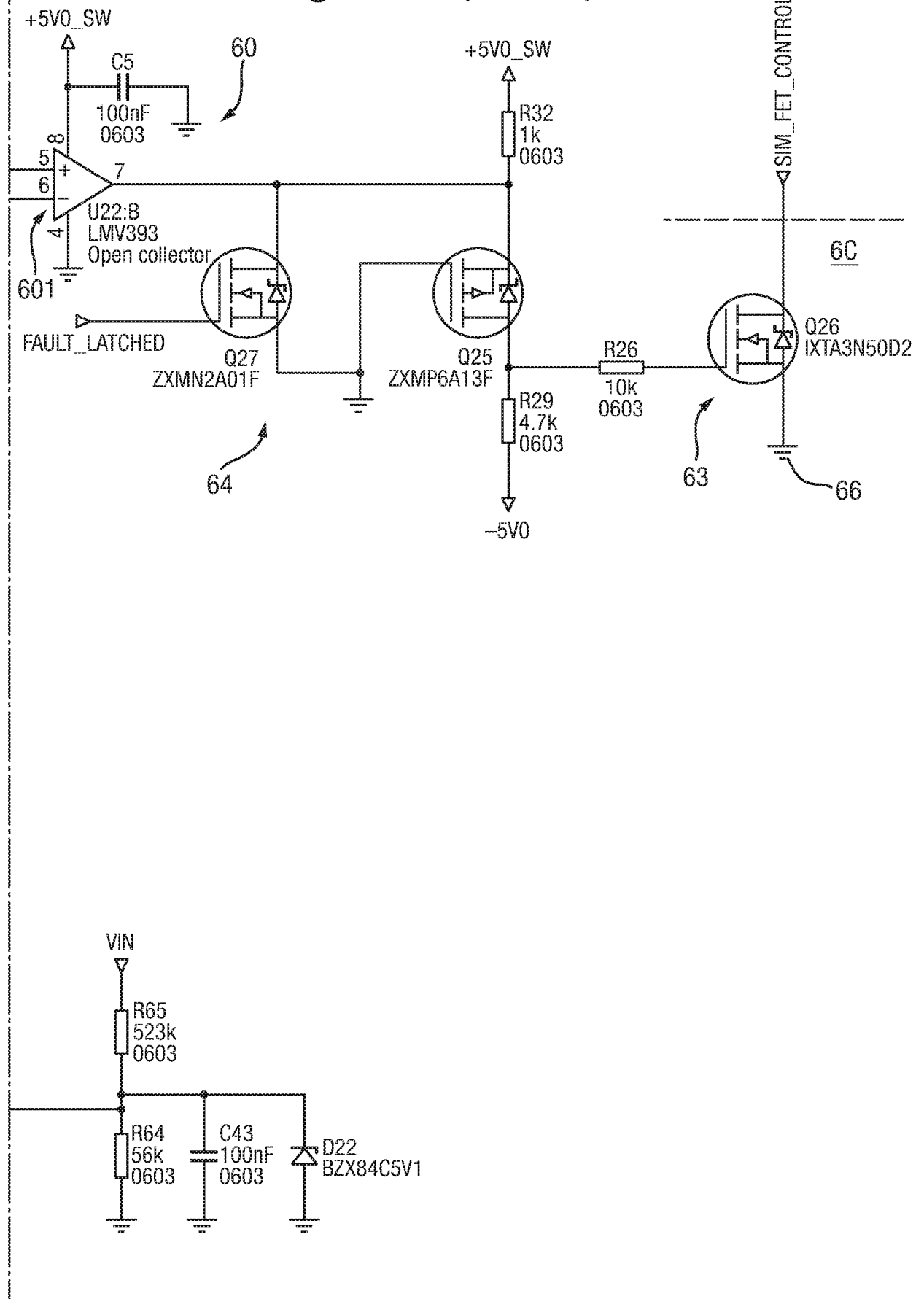
Fig. 16C



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Fig. 16C (Cont.)

FROM SIMULATION RESISTORS



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Fig. 17A

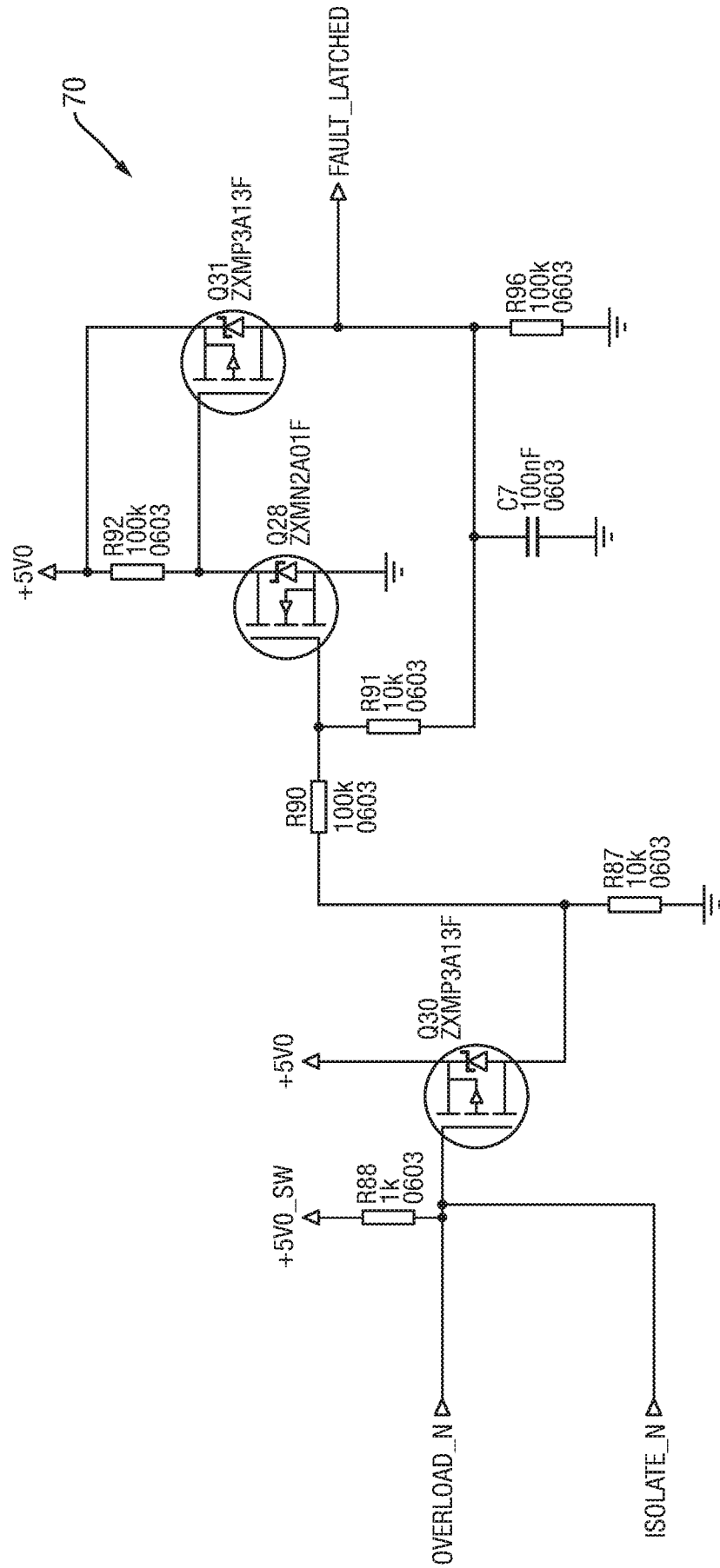


Fig. 17B

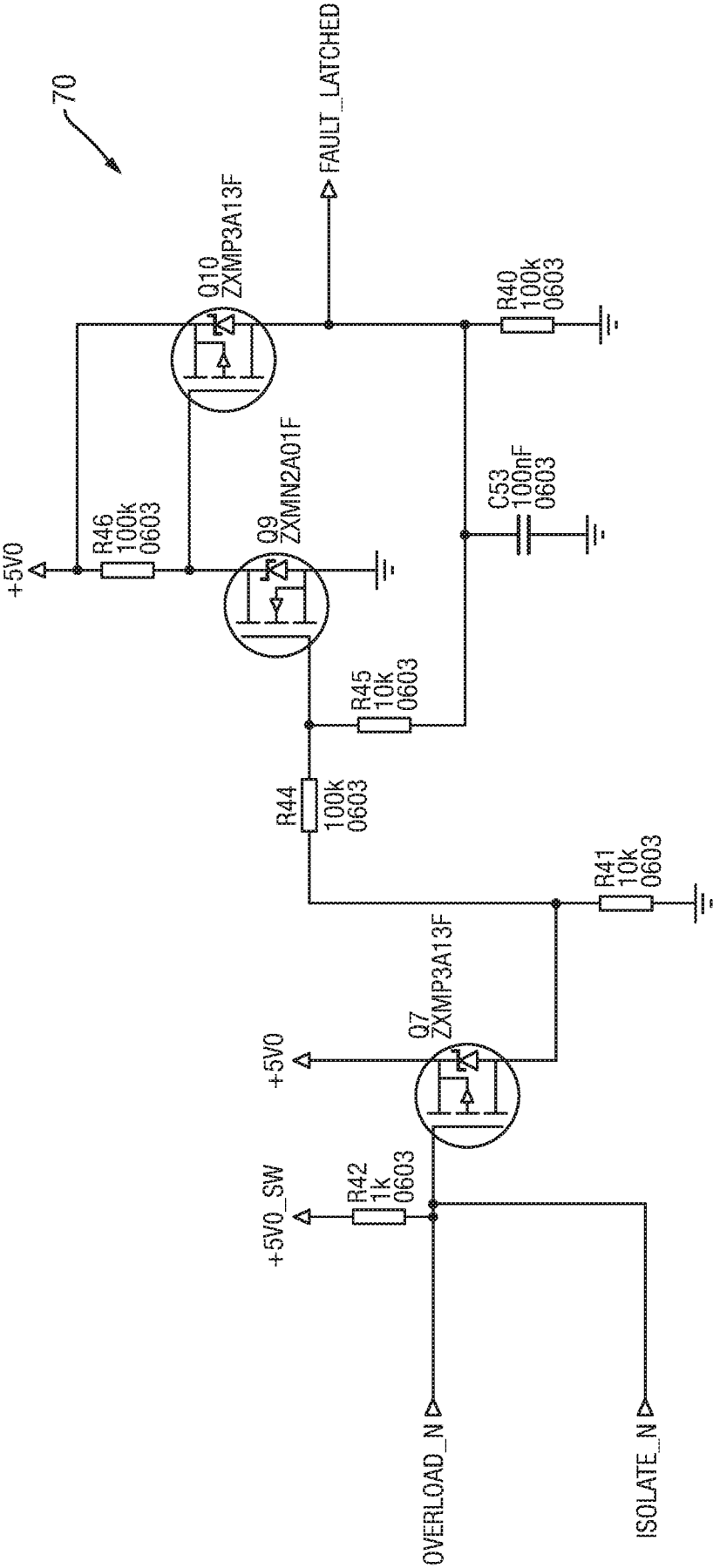


Fig. 17C

