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(54) LED DRIVER WITH SELF-TEST CAPABILITIES

(57) A driver device comprises a converter circuit configured to generate and output a load current for driving an electric load and a control circuit configured to control operation of the converter circuit. The control circuit is configured to perform a functional test for testing electronic circuitry of the driver device that includes the converter circuit. The driver device may be a light driver device, preferably for proving the load current to a LED lighting device. The control circuit is configured to perform the functional test by executing a test routine for testing at least one electrical parameters of the driver device.

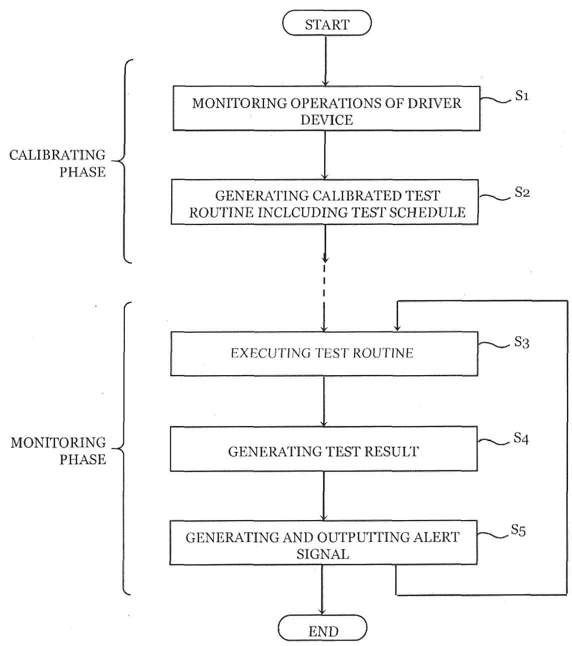

FIG. 3

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Description

[0001] The invention relates to the field of driver devices, in particular to light driver devices for driving lighting devices, in the general field of building infrastructure. The invention concerns a driver device, a method for controlling a driver device, and a building management system.

[0002] The technical building infrastructure referred under the term building management system (BMS) or building automation system (BAS), includes a computer-based control system installed in a building that controls and monitors the building's mechanical and electrical equipment. The BMS may include subsystems providing functionalities such as heating, ventilation, lighting, power supply, fire alarm, and security. The subsystems linked to a BMS typically represent a large proportion of the energy consumption of the building, in particular when lighting is included. BMS systems are a critical component to managing energy demand. The BMS, its subsystems and their components require regular maintenance, identification and replacement of defective equipment, and add further work and significant cost to maintaining the building infrastructure.

[0003] One key component of any BMS are driver devices which generate a DC load current from an AC mains supply provided by the energy grid of the building. The DC load current may be required for driving actuators such as lighting modules for providing ambient lighting, illuminating of workplaces or emergency lighting for providing guidance and assistance in case of an emergency.

[0004] In the specific field of emergency lighting, the emergency lighting driver devices have the capability to perform predefined self-tests of an emergency lighting module and of a connected battery providing emergency power supply as prescribed in the applicable technical standards such as IEC 62034. Generally, it is required that the emergency lighting in the building is available at any time for a required minimum duration providing a required minimum light level in case of a mains supply failure. IEC 62034 stipulates that once a week a functional self-test is performed, which tests whether the emergency lighting driver is functioning properly. The functional self-test tests a switchover process to the battery-backed supply instead of the mains supply, and whether the emergency lighting module is generally emitting light. The functional self-test focuses on the emergency lighting module and the operation of the emergency lighting driver in the event of the mains supply failure. The emergency driver performs a duration test for driving the emergency lighting module from the battery, for example for a predetermined duration of one or three hours, at longer time intervals, for example once a year. The duration test focusses on testing a battery capacity. In case of the emergency lighting driver is failing the functional self-test or the duration test, the emergency lighting driver will output a warning. Both, the functional self-test and the duration test may be initiated by using an external test switch connected to a test switch interface of the emergency lighting driver. Alternatively, the emergency lighting driver may receive a start signal via a communication interface, which initiates the functional self-test or the duration test respectively.

[0005] The functional self-test and the duration test provide the information whether the emergency lighting driver device is capable to operate according to the required functions or not. Neither the functional self-test nor the duration test provide information on functioning of the electronic circuitry and specific electric parameters of the emergency driver device, which may reveal more in-depth information beyond the basic functional information provided by the self-test of the emergency lighting driver, which is particular to the role of providing emergency lighting in the building.

[0006] Thus, the tested functionalities of the current driver devices in building infrastructure systems regard only functional features of the driver device as whole, and these limited test capabilities only concern the safety relevant part of the building infrastructure systems such as emergency lighting.

[0007] Therefore, it is an object to improve an overall availability of the building infrastructure, and in particular of driver devices included in the building infrastructure by providing the capability of detecting failures early, preferably in advance of a fatal failure of the driver device.

[0008] In a first aspect, the driver device according to independent claim 1 provides a solution to the problem. The method for controlling the driver device according to a second aspect, the program according to third aspect, and the building management system according to the fourth aspect provide further advantageous solutions to the problem.

[0009] In the first aspect, the driver device, in particular a light driver device, comprises a converter circuit configured to generate and output a load current for driving an electric load, and a control circuit configured to control operation of the converter circuit. The control circuit is configured to perform automatically a functional test for testing electronic circuitry of the driver device including the converter circuit.

[0010] The driver device according to the first aspect is advantageous since it offers the capability of automatically performing a self-test of its electronic circuitry. The test covers the electronic circuitry of the driver device and is not limited to a test of the function of driver device and equipment external to the driver device and connected via an interface to the driver device, e.g. a battery or a lighting module. Automatically means that the test is initiated and executed by the control circuit of the driver device itself. The control circuit is therefore enabled to determine timing and scope of the test, e.g. which electric parameters of the electric circuit to test, how to test, and when to test. Adding a self-test capability to the control circuit of the driver device enhances the test and monitoring capabilities of a key component of the building infrastructure system, thereby generating a basis for implementing procedures of predictive maintenance in the building infrastructure system. This increases reliability and availability of the building infrastructure system.

[0011] The dependent claims define further advantageous embodiments of the invention.

[0012] The driver device may include the control circuit configured to perform the functional test by executing a test routine for testing at least one electrical parameter of the driver device.

[0013] Using a test routine executed by the control circuit for testing the electrical parameters of the driver device, in particular of the converter circuit, enables to test the electrical parameters in a flexible manner, and to adapt the test routine to the specific test requirements of the driver device under test, contrary to a built-in test based on hardware.

[0014] The driver device according to an embodiment comprises the control circuit configured to calibrate the test routine for testing the at least one electrical parameter of the driver device in a calibration phase.

[0015] If the control circuit is able to calibrate the test routine, the actual test performed by running the calibrated test routine may be adapted to the specific environment of the particular driver device under test, the requirements of a specific customer, and the specific environment of the building management system, of which the driver device is a part. The relevant parameter ranges of the electrical parameters characteristic for the driver device in the building infrastructure system may be taken into account, and a time of the test schedule may even be adapted to a particular usage profile of the driver device which may vary over time.

[0016] According to an embodiment of the driver device, the driver device comprises a test data storage. The control circuit is configured to determine a parameter range for the at least one electrical parameter of the driver device during execution of the calibrating procedure for the test routine, and to store the determined parameter range in the data storage.

[0017] Calibrating the test parameter range and storing the calibrated test parameter range enables to define tests in the test routine, which provide information exceeding beyond the general test whether the driver device is operating correctly or not. The data storage may also serve to store test data generated by executing the test routine in a log file. An operator may access the test routine offline and inspect the test data stored therein.

[0018] The driver device may comprise a sensor circuit, and the control circuit may determine at least one electric parameter value based on sensor data obtained by the sensor circuit, and determine whether the obtained parameter value is in the parameter range.

[0019] The sensor circuit measuring the current value of the electric parameter, and the control circuit determining whether the measured parameter value is in the parameter range enables to use a computationally efficient comparison for the test routine and to acquire data on the electronic circuitry of the driver device.

[0020] The control circuit of an embodiment of the driver device is configured to determine at least one characteristic parameter of a dimming curve for the driver device during calibrating the test routine. The at least one characteristic parameter of the dimming curve includes at least a time for running the at least one dimming curve and a dimming level difference value for running the at least one dimming curve.

[0021] Using a dimming curve, as it is typical for operations of a lighting devices and light driver devices for testing the driver device enables to generate meaningful test data on the operation of the driver device operation and the functioning of the electronic circuitry.

[0022] The driver device may comprise a sensor circuit, and the control circuit may determine at least one electric parameter value based on sensor data obtained by the sensor circuit, and determine whether the obtained parameter value is in the parameter range.

[0023] The control circuit of the driver device offers the possibility to process sensor data, and perform basic sensor data evaluation in the driver device. This local processing of sensor data reduces load on a control network of the building infrastructure and its underlying communication network, as only test results may be transmitted using the available communication bandwidth effectively, and instead of transmitting unprocessed sensor data for a remote evaluation.

[0024] The control circuit may be configured to determine a test time frame for executing the test routine during execution of the calibrating procedure for the test routine.

[0025] Determining the test time frame enables to select a time for performing the test, at which a person in the environment of a luminaire including the driver device is not disturbed. This may, for example be the case when the light driver device executes the test routine, which may include controlling lighting modules of the luminaire to emit light of a varying intensity according to a predefined dimming curve.

[0026] The control circuit of an embodiment of the driver device is configured to determine the test time frame to correspond to a time of a determined lowest dimming level per day based on a monitored mean dimming level during execution of the calibrating procedure for the test routine.

[0027] This embodiment enables the calibrating procedure to define a particularly suitable time slot for testing the driver device, thereby minimizing disturbances for persons occupying the building.

[0028] The driver device according to one embodiment has the control circuit configured to generate and output an alert signal based on the executed test routine. The alert signal comprises at least one of a perceivable warning of a detected failure and failure data identifying the detected failure. The alert signal is adapted to control at least one of outputting the alert by a visual or acoustical output means of the driver device, outputting the alert signal via a communication circuit of the driver device to a building management server, and storing the alert signal in a data storage of the driver device.

[0029] The control circuit generating the alert signal enables to both locally output the test results, or to aggregate the locally generated test results at a higher level, e.g. a lighting management server and/or a building infrastructure server.

[0030] According to one embodiment, the at least one electrical parameter includes at least one of a start time defining a time required by the driver device for a start-up, a shut-down time required by the driver device for powering down into an off-state, or a required time for running a predefined dimming profile.

[0031] The electrical parameter enables to judge a current state of the driver device and its capability to perform its operational function of outputting a load current with a predetermined range of current values by the driver device to drive an actuator, e.g. a lighting module.

[0032] The driver device according to an embodiment has the control circuit configured to generate a start signal for starting executing the test routine based on at least one of a time interrupt signal generated internally by the control circuit and a test start signal received via a communication circuit of the driver device externally from a lighting management server or a building management server.

[0033] Thus, executing the test routine may be triggered in a time slot, which is determined internally in the driver device, thereby reducing the need for external trigger signalling via a communication network. Providing the trigger signal from external reduces the processing load in the driver device, and has the advantage that information on presence of users acquired by presence detectors in the vicinity of the driver device may be taken into account. This may help in reducing disturbances due to running the test routine.

[0034] A building management system according to the second aspect comprises at least one driver device according to the first aspect and a building management network configured to connect the at least one driver device with a building management server of the building management system. The building management server is configured to initiate executing the test procedure by the at least one driver device by generating and transmitting the test start signal to the at least one driver device.

[0035] The building management system may include a lighting system, and a lighting management server, and the at least one driver device is a light driver device.

[0036] The test capability provided by the driver device according to the first aspect is particularly advantageous in a lighting system. Present lighting control systems, such as DALI® may implement the capability to provide the alert signal to the central instances of the building management system, e.g. the building management server and the lighting management server. The building management server and the lighting management server may use the alert signal and the information conveyed by alert signals received from a plurality of light driver devices to determine a current state of the system and its components. The building management server and the lighting management server may further implement measures of predictive maintenance and thereby increase availability of the building management system.

[0037] A method for controlling a driver device according to the third aspect concerns the driver device comprising a converter circuit for generating and outputting a load current driving an electric load, in particular outputting the load current to a lighting device. The method comprises performing automatically, by a control circuit of the driver device, a functional test for testing electronic circuitry of the driver device including the converter circuit. The method may proceed by outputting a warning signal to a lighting management system or a building management system in case of detecting a failure based on the performed functional test.

[0038] A program according to the fourth aspect comprises instructions, which when the program is executed by a computer or signal processor, cause the computer or digital signal processor to carry out the method according to the second aspect.

[0039] The description of embodiments refers to the enclosed figures, in which

Fig. 1 is a schematic view of a LED driver device for driving a lighting module according to an embodiment;

Fig. 2 provides an overview of a building management system including LED driver devices according to an embodiment; and

Fig. 3 is a simplified flowchart of a method for controlling the LED driver device according to an embodiment.

[0040] In the figures, corresponding or same elements have same reference signs. The discussion of the different figures waives discussing same reference signs in different figures wherever deemed possible without adversely affecting comprehensibility.

[0041] Fig. 1 is a schematic view of a LED driver device as an example of a driver device for driving a lighting module 9 according to an embodiment.

[0042] The light driver device 1 is a specific example for a building management device. The light driver device 1 may form part of a luminaire. Nevertheless, the invention is not restricted to a light driver device 1, the driver device may alternatively drive an actuator, such as a door opener or a window opener. Other examples of actuators and usages of the driver device will be discussed with reference to fig. 2.

[0043] The light driver device 1 comprises an AC/DC converter circuit 2 (converter circuit 2), a control circuit 3, and a communication circuit 4.

[0044] The light driver device 1 may be an LED driver, which generates and outputs a load current I_{LED} to the lighting module 9. The lighting module 9 may include one or a plurality of individual LEDs emitting light. A light level of the emitted light is dependent on a current value of the load current I_{LED}.

[0045] The light driver device 1 arranges its subassemblies AC/DC converter circuit 2, control circuit 3, and communication circuit 4 on one or more printed circuit boards (PCB). The subassemblies include essentially electronic circuits including a plurality of active and passive electronic components linked via electric connections arranged on surfaces and within the PCB. The at least one PCB is located within a housing providing mechanical protection for the subassemblies of the light driver device 1.

[0046] The light driver device 1 has a plurality of interfaces.

[0047] A mains supply interface 6 of the light driver device 1 connects the light driver device 1 to a mains supply 7 of the building providing an AC mains supply to the light driver device 1.

[0048] The light driver device 1, in particular the AC/DC converter circuit 2, generates a DC load current I_{LED} based on the AC mains suppl$_y$ and outputs the generated DC load current I_{LED} via a LED interface 8 of the light driver device 1 to the lighting module 9.

[0049] The AC/DC converter circuit 2 may include electric circuitry, which is configured to perform as a rectifier circuit, e.g. implemented as a bridge or half-bridge rectifier. The AC/DC converter circuit 2 may include electric circuitry, which is configured to perform power factor correction (PFC), and to generate a DC bus voltage based on the AC mains voltage input to the mains supply interface 6. The AC/DC converter circuit 2 may include electric circuitry, which is configured to perform DC/DC-conversion to convert the generated DC bus voltage to at least one DC output voltage U_{LED} for supplying the lighting module 9 via the LED interface 8.

[0050] The AC/DC converter circuit 2 in particular and the light driver device 1 may be configured to implement an SELV barrier providing galvanic isolation, e.g. between the main supply interface 6 and the LED interface 8.

[0051] The AC/DC converter circuit 2 may include at least one switched mode power supply circuit (SMPS) including a switch controlled by the control circuit 3 with a control signal 11.

[0052] The AC/DC converter circuit 2 may include at least one low voltage power supply circuit (LVPS) for generating supply voltages for the electric circuits included in the light driver device 1, e.g. the control circuit 3 and the communication circuit 4.

[0053] The control circuit 3 may receive sensor signals 12 from the AC/DC converter circuit 2. These sensor signals 12 may in particular include sensor signals currently measured in the light driver device 1, e.g. presence of the AC mains supply voltage at the mains supply input 6, the load current I_{LED}, a current through a transformer winding or over a closed switch of a SMPS circuit of the AC/DC converter circuit 2.

[0054] The light driver 1 may be an emergency light driver. The emergency light driver monitors presence or absence of the mains supply voltage at the mains supply interface 6. In case of detecting failure of the mains supply voltage based on the sensor signal 12, the control circuit 3 controls switching of the AC/DC converter circuit 2 to an alternate electric power source, e. g. to a DC energy storage such as a battery. Thereby, the emergency light driver maintains a continuing load current I_{LED} for a predetermined time with a predetermined current value at the LED interface 8 based on current drawn from the alternate electric power source acting as an emergency power supply.

[0055] The control circuit 3 may receive external control commands in a driver control signal 13 for the light driver device 1 via the communication circuit 4 connected to a communication network. The communication network may include a communication bus 5.

[0056] The control circuit 3 may generate and output an output signal 14 from the light driver device 1 to other devices in a lighting system and the building management system via the communication circuit 4 connected to the communication network.

[0057] The control circuit 3 may generate and output a further output signal 14 including data on the results generated by executing the test routine via an interface 16, e.g. an indicator LED interface, to an external output device 17. The output device 17, e.g. including at least one indicator LED, may be adapted for visual or acoustic output of data on the results generated by the test routine to a human operator.

[0058] The interface 16 may be an indicator LED interface connecting at least one indicator LED. The at least one indicator LED may signal the data on the results generated by the test routine via modulated light emission, e.g. varying an intensity of the emitted light over time in order to communicate a specific failure code for a particular failure detected by executing the test routine.

[0059] Fig. 1 displays the communication circuit 4 configured for wired communication via a communication interface 10 of the light driver device 1 to the communication bus 5. The communication bus 5 also connects other devices of a light infrastructure system and the building management system 20 with the light driver device 1.

[0060] Alternatively, or even additionally, the communication circuit 4 of the light driver device 1 may be adapted to perform wireless communication using a transceiver via one or more antennas with other devices of the building management system 20 and the lighting system.

[0061] The control circuit 3 may be implemented using an integrated circuit (IC), e.g. a microcontroller, a microprocessor or an application specific integrated circuit (ASIC) or a field-programmable gate array (FPGA) or any combination of these elements. The control circuit 3 may form an integral part of the AC/DC converter circuit 2.

[0062] The control circuit 3 may include a data storage 15 (memory) providing data storage capacity.

[0063] The data storage 15 may store program data, including program data implementing at least parts of the test routine (self-testing procedure) in the light driver device 1. The data storage 15 may also store application data generated when executing an application, in particular the test routine.

[0064] The data storage 15 may in particular store usage profile data of the light driver device 1. Usage profile data includes data on electrical parameter values of the electric circuitry referenced to the time. This includes, for example parameter data on dimming levels and dimming curves over time for the load current I_{LED}.

[0065] The data storage 15 may store a log data file including parameter data generated during operation of the light driver device 1 and obtained by the control circuit 3, e.g. based on sensor data provided by a sensor circuit 2.1.

[0066] The AC/DC converter circuit 2 may include the at least one sensor circuit 2.1.

[0067] The sensor circuit 2.1 is configured to obtain electrical parameter data (physical parameter data) during a calibrating phase, in which the test routine is calibrated for the light driver device 1, and electrical parameter data (current parameter data) during the monitoring phase on at least one physical parameter of the light driver device 1. The parameter data may in particular be obtained by measuring the at least one physical parameter, or by computing or estimating the parameter data based on one or measurements of the at least one physical parameter.

[0068] The at least one physical parameter may include at least one electrical parameter characterizing the operation of the light driver device 1, and in particular the AC/DC converter circuit 2 in the building infrastructure system 20. Examples for the electrical parameter are

- an average power output for a time period provided by the light driver device 1 via the LED interface 8,
- a load voltage provided by the light driver device 1at the LED interface 8,
- a load current I_{LED} provided by the light driver device 1 via the LED interface 8,
- a mains supply voltage provided to the light driver device 1 at the mains supply interface 6,
- a mains supply current provided to the light driver device 1 at the mains supply interface 6,
- a mains frequency of the mains supply at the mains supply interface 6,
- an average power consumption of the light driver device 1,
- a power loss of the light driver device 1,
- an energy conversion efficiency of the light driver device 1,
- an average rectifier half-bridge frequency in the light driver device 1, and
- an internal DC bus voltage ripple value in the light driver device 1.

[0069] The electrical parameter, in particular including a voltage, a current or a frequency may be available in the control circuit 3, e.g. the control circuit 3 configured to control the AC/DC converter circuit 2, or may be measured by the sensor circuit 2.1. The sensor circuit 2.1 may include a shunt resistor and/or a measuring bridge to provide suitable measurement signals, which may be processed in the control circuit 3 further in order to generate the parameter data.

[0070] The power loss of the light driver device 1 may be computed by subtracting an electrical output power of the light driver device 1 from the electrical input power of the light driver device 1.

[0071] The energy conversion efficiency of the light driver device 1 may be computed by dividing the electrical output power of the light driver device 1 by the electrical input power of the light driver device 1.

[0072] The at least one physical parameter may include at least one operation parameter of the light driver device 1. The operation parameter may include one or more parameters for setting an operation state of the light driver device 1. The one or more operation parameters may correspond to control parameters for controlling operation of the light driver device 1. In the example of the light driver device 1 and the AC/DC converter circuit 2 providing the load current I_{LED} at the LED interface 8 to the lighting module 9, the at least one operation parameter may include a dimming level at which the lighting means 9 is controlled to operate. The diming level may have a percentage value ranging from 0% to 100%. A value of 0% for the dimming level corresponds to the LED module 9 emitting no light, and a value of 100% for the dimming level corresponds to the lighting means 9 emitting a maximum of light. The at least one operation parameter may be known in the control circuit 3 controlling operation of the AC/DC converter circuit 2. Additionally or alternatively, the at least one operation parameter is received, e.g. via the communication circuit 4 and provided to the control circuit 3 in the control signal 13.

[0073] Additionally or alternatively, the at least one physical parameter may comprise at least one of a temperature parameter, e.g.

- a temperature of a control circuit 3 of the light driver device 1,
- a temperature on the printed circuit board of the light driver device 1, and

- a temperature within a housing of the light driver device 1.

[0074] The temperature may be measured by the control circuit 3, by an internal temperature sensor if available, or may be measured by the sensor circuit 2.1.

[0075] Fig. 2 provides an overview of a building management system including a plurality light driver devices 1 according to an embodiment.

[0076] The technical building infrastructure referred under the term building management system (BMS) or building automation system (BAS), includes a computer-based control system installed in a building that controls and monitors the mechanical and electrical equipment of the building including heating, ventilation, lighting, power systems, fire alarm systems, and security systems. A BMS consists of software and hardware components, wherein the software is usually configured in a hierarchical manner.

[0077] Moreover, the technical building infrastructure includes systems that typically arrange a large number of devices over an extensive area in and around the building, which require regular maintenance, identification and replacement of defective equipment, and add further significant cost to maintaining the building infrastructure.

[0078] The lighting system forms an important element of the BMS. The most significant elements of the lighting system may include luminaires, lighting modules for emitting light, and light driver devices 1 for driving the lighting modules by providing a load current I_{LED}. The lighting system may include other devices, e.g. presence detectors 25, switches 23, further control gear, and a light system management server 22, linked via dedicated communication equipment, e.g. for a DALI® or ZigBee® based control network (lighting control network, building control network).

[0079] The building management system 20 may include emergency power supply including batteries for storing electric energy.

[0080] Current light driver devices 1 form a key element of the light system often provide basic operational data, collected by the light driver device 1 and transmitted via a DALI® interface to the central lighting management server 22. The operational data may be utilized in several ways, for example, the provided operational data may be used for tracking the power consumption of the individual devices in the entire lighting system, for monitoring a current LED current (load current I_{LED}) and the set dimming level of the light driver device 1, as well as a reporting failure modes (failure states) of the light driver device 1. Thus, the operational data may be used for tracking the current state of the lighting system.

[0081] Fig. 2 illustrates the hierarchical structure of a building management system 20 including or corresponding to a lighting system with a plurality of light driver devices 1 in the lighting system according to an embodiment.

[0082] The building management system 20 comprises a building management server 21. In the example of fig. 2, the building management server 21 is connected with a light management server 22. The light management system server 22 forms part of the lighting system, which furthermore includes a plurality of light driver devices 1.

[0083] The building management server 21 may connect to a plurality of other devices not forming part of the lighting system.

[0084] For example, the other devices may comprise, but are not limited to, a luminaire, a dimming device for shading a window, such as an electrical blind, a sensor device, e. g. a movement detector or a presence detector, a security camera (CCTV), a smoke detector, an ambient light sensor, a humidity sensor, a temperature sensor, an audio sensor, e.g. microphone. The other devices may also include a sprinkler device, an alarm device, a door locking device, window locking device, or a roll shutter. The other devices may comprise an information output device, e.g. a display, a security sign, or a loudspeaker.

[0085] The other devices may comprise an actuator, e.g. a door opener, or a window opener.

[0086] The other devices may include a heating, venting and/or cooling device, for example an air conditioner, an air ventilator, a fan, a heating device or a humidifier.

[0087] The other devices may further comprise a cleaning device, such as an autonomous cleaning device, a window cleaner; a control module for controlling one or more of the building management devices, a user interface for controlling one or more building management devices, such as a switch, e.g. an ON/OFF-switch, a dimming module, a touch panel, a numeric input device.

[0088] The other devices may include any combination of the aforementioned examples of other devices.

[0089] The embodiment shown in figure 2 provides further detail on the lighting system as a portion (subsystem) of the building management system 21.

[0090] The light driver device 1 may have the structure of the LED driver device discussed with reference to fig. 1 above. The light driver devices 1 are connected via an edge gateway device 26 to the light management server 22.

[0091] The edge gateway device 26 not only connects the light driver devices 1, but also other devices such as switches 23 (ON/OFF switch), dimming devices 24, and presence detectors 25 with the light management server 22 into the lighting system.

[0092] The lighting system may alternatively or additionally arrange a number of driver devices 1 directly connected with a light management system server 32. Moreover, the lighting system may include a plurality of other devices, which also connect to the light management system server 22.

[0093] The building management server 21, the light management system server 22, the edge gateway device 34, the driver devices 1, and the other devices may be linked via one or more communication networks, which may include wired and wireless communication networks based on a same or on different communication standards. The communication network enables to perform lighting control. The lighting control enables to monitor a status of the individual driver devices 1 and the other devices linked via the communication network.

[0094] The communication circuit 4 and the communication interface 10 of the driver device 1 may communicate with the other devices of the lighting system based on at least one of the lighting control standards DSI®, DALI®, DALI-2®, D4i®, matter (recently published standard for smart home applications) and KNX enabling a digital control of the lighting system using a wired lighting control system.

[0095] The communication circuit 4 and the communication interface 10 may communicate with the other devices of the light infrastructure system based on at least one of the lighting control standards DALI+® enabling a digital control of the lighting system using a wireless lighting control system. Additionally or alternatively, the wireless lighting system may base on a wireless communication protocol defined by a wireless communication standard, e.g. ZigBee®, Bluetooth Mesh®, matter, and Bluetooth LE®.

[0096] DALI+ devices communicate using existing DALI commands, but transmit and receive these commands over a wireless and/or IP-based medium rather than the dedicated pair of wires used by DALI-2 and D4i.

[0097] A standard for the lighting control system may base on the technologies defined in the series of technical standards known under IEC 62386.

[0098] Fig. 3 is a simplified flowchart of a method for controlling the light driver device 1 according to an embodiment. Controlling the light driver device 1 include operating the driver device in the building management system 20 and monitoring the operation of the driver device 1 by automatically performing a test routine according to the embodiment.

[0099] The method for controlling the driver device 1 includes calibrating phase and a monitoring phase.

[0100] The calibrating phase comprises steps S1 and S2. In the calibrating phase, the method generates a test routine that is tailored particularly to the driver device 1 in the building infrastructure system 20 and the particular usage profile of the light driver device 1 in the building infrastructure system 20..

[0101] In step S1, the method monitors operations of the light driver device 1 for a predetermined time period. The predetermined time period may include several days or even several weeks. It is particularly advantageous when the predetermined time period extends over at least one typical usage cycle of the driver device 1. Characteristic usage cycles may differ for different driver devices 1 of the building management system 20. A characteristic usage cycle for a driver device 1 controlling lighting in an office environment may extend for a week, which comprises workdays on the one hand and a Sunday with a usually reduced presence in the office environment.

[0102] Monitoring operations of the light driver device 1 in step S1 may include determining characteristic dimming profiles of the light driver device 1 during the predetermined time period.

[0103] Alternatively or additionally, monitoring operations of the light driver device 1 in step S1 may further include obtaining electric parameters of the light driver device 1 during a start-up operation of the driver device 1. A start-up operation of the light driver device 1 includes the time interval of the light driver device 1 transiting from a standby state into an ON-state of the light driver device 1, in which the light driver device 1 provides a defined load current I_{LED} at predefined output voltage U_{LED} to a load, e.g. the lighting module 9.

[0104] Alternatively or additionally, monitoring operations of the driver device 1 in step S1 may further include obtaining parameter data on electric parameters of the driver device 1 during a shut-down operation of the driver device 1. A shut-down operation of the driver device 1 includes the time interval of the driver device 1 transiting from the ON-state of the light driver device 1, in which the light driver device 1 provides a defined load current I_{LED} at predefined output voltage U_{LED} to a load, e.g. a lighting module 9 to the standby state.

[0105] The at least one electrical parameter may include at least one of a start time defining a time required by the driver device for a start-up, a shut-down time required by the driver device for powering down into an off-state, or a required time for running a predefined dimming profile.

[0106] Alternatively or additionally, monitoring operations of the driver device 1 in step S1 may include generating a usage profile of the driver device 1. The usage profile of the driver device 1 may include usage data including the times, e.g. times of the day, times of the week, during which the light driver device 1 is operating, and the corresponding electrical parameters of the driver device 1 obtained for these times. The electrical parameters may include the respective dimming level, which the load current I_{LED} output by the light driver device 1 sets for the corresponding time.

[0107] In step S2, the method generates the calibrated test routine based on the parameter data obtained by the driver device 1 while monitoring usage of the driver device 1 during step S1.

[0108] The calibrated test routine includes in particular test data for executing the test routine. The test data may include data specifying the parameter data to be set by the light driver device 1 when performing the test routine. The test data may specify a particular dimming profile to be executed by the light driver device 1 under control of the control circuit 3 when performing the test routine.

[0109] In addition, the calibrated test routine includes data on a particular test schedule for the monitoring phase. The data for the test schedule includes a time frame for executing the test routine. The time frame may include a start time and a time duration for performing the test routine. The time frame may represent a time slot, during which performing the test routine may be most convenient for the user, and disturbances to the environment are deemed acceptable.

[0110] When performing the calibration procedure, the control circuit 3 may determine the test time frame to correspond to a determined time of a determined lowest dimming level per day or per week based on a monitored mean dimming level during the predefined time period of execution of the calibrating procedure for the test routine.

[0111] The calibrated test routine for the driver device 1 includes parameter ranges for the electrical parameters. The parameter ranges represent ranges of values for the electrical parameters, which represent an expected reaction of the electronic circuitry of the light driver device 1 when performing the test routine.

[0112] Performing the calibration procedure includes the control circuit 3 determining a parameter range for the at least one electrical parameter of the light driver device 1, and to store the determined parameter range in the data storage 15.

[0113] Performing the calibration procedure includes the control circuit 3 determining at least one characteristic parameter of a dimming curve for the driver device during execution of the calibrating procedure for the test routine. The at least one characteristic parameter of the dimming curve includes at least a time for running the at least one dimming curve and a dimming level difference value for running the at least one dimming curve.

[0114] The monitoring phase comprises steps S3, S4, and S5 and includes the light driver device 1 operating and performing its respective function in the building infrastructure system 20.

[0115] The light driver device 1 initiates the test routine when reaching the time frame for performing the test routine as defined in the test schedule.

[0116] The control circuit 3 may generate a start signal for starting executing the test routine based on at least one of a time interrupt signal generated internally by the control circuit 3 and a test start signal received via a communication circuit 4 of the light driver device 1 externally from the lighting management server 22 or the building management server 21.

[0117] The control circuit 3 may generate the time interrupt signal based on an internal timer and the test schedule determined when executing the calibration procedure in the calibration phase.

[0118] In step S3, the light driver device 1 performs the test routine based on the test schedule determined in the calibrating phase and performs the parameter tests according to the calibrated test routine generated in step S2.

[0119] For example, the light driver device 1 enters the test routine in a standby state according to the test routine, enters a start-up phase, runs at least one dimming profile and subsequently performs a shut-down operation. During execution of the test routine, the control circuit 3 outputs the respective control signals 11 to the AC/DC converter circuit 2. The sensing circuit 2.1 provides the respective sensor signals 12 to the control circuit 3, which reflect a reaction of the AC/DC converter circuit 2 to the applied control signals 11.

[0120] In step S4, the light driver device 1 proceeds with generating a test result based on the executed test routine.

[0121] For example, the control circuit 3 generates parameter data based on the obtained sensor signals 12, and compares the parameter data for electrical parameters with the parameter ranges for the electrical parameters defined in the calibrated test routine for the driver device 1. Based on the comparison, the light driver device 1 generates the test result.

[0122] When executing the test routine, the control circuit 3 is configured to determine at least one electric parameter value based on sensor data obtained by the sensor circuit 2.1, and to determine whether the obtained parameter value is in the predetermined parameter range defined in the calibrated test routine.

[0123] The test result may be stored in the data storage 15 of the control circuit 3, e.g. in a log data file for the test.

[0124] Based on the generated test result from step S4, the light driver device 1 generates and outputs in step S5 an alert signal.

[0125] The control circuit 3 generates and outputs the an alert signal based on the executed test routine.

[0126] The alert signal comprises at least one of a perceivable warning of a detected failure and failure data identifying the detected failure.

[0127] The alert signal is adapted to control at least one of outputting the alert by the visual or acoustical output means 17 of the light driver device 1, outputting the alert signal via the communication circuit 4 of the light driver device 1 to the building management server 21, and storing the alert signal in the data storage 15 of the light driver device 1.

[0128] The light driver device 1 executes the test loop including steps S3, S4, and S5 at regular or irregular intervals automatically while the light driver device 1 is operating. The timing, e. g .the time frame, for executing the test loop is defined in the test schedule.

[0129] During the monitoring phase, the light driver device 1 may perform a (re-) calibration of the test routine.

[0130] Recalibrating the test routine may include adapting the test schedule based on an amended usage profile of the light driver device 1.

[0131] Additionally or alternatively, recalibrating the test routine may include adapting the test schedule based on an operator input, e.g. by an operator input provided by a customer operating the building infrastructure system 20 including the light driver device 1.

[0132] Additionally or alternatively, recalibrating the test routine may include adapting the test schedule based on an operator input, e.g. by an operator input provided by a manufacturer of the light driver device 1. This may be advantageous in case operating experiences with light driver devices 1 of a same or similar type as the light driver device 1 with other customers recommend adapting the test routine to the operating experiences.

[0133] Recalibrating the test routine may include using information obtained externally from the driver device 1, and externally from the building infrastructure system 20, e.g. obtained via the communication circuit 4 and the communication interface 10.

[0134] All steps which are performed by the various entities described in the present disclosure as well as the functionalities described to be performed by the various entities are intended to mean that the respective entity is adapted to or configured to perform the respective steps and functionalities. In the description of the embodiments, the terms "comprising" or "including" do not exclude the presence of other structural elements or steps in addition to the structural elements or steps explicitly mentioned.

[0135] The indefinite article "a" or "an" does not exclude a plurality. A single structural element or unit may fulfill the functions of several entities recited in the claims. The mere fact that different dependent claims recite certain measures and features of the driver device does not exclude that a combination of these measures and features cannot combined in an advantageous implementation.

Claims

1. A driver device, in particular a lighting driver device, the driver device comprising

a converter circuit (2) configured to generate and output a load current (I_{LED}) for driving an electric load;
a control circuit (3) configured to control operation of the converter circuit (2); and **characterized in**
that the control circuit (3) is configured to automatically perform a functional test for testing electronic circuitry of the driver device including the converter circuit (2).

2. The driver device according to claim 1, wherein the control circuit (3) is configured to perform the functional test by executing a test routine for testing at least one electrical parameter of the driver device.

3. The driver device according to claim 2, wherein the control circuit (3) is configured to calibrate the test routine for testing the at least one electrical parameter of the driver device by executing a calibration procedure in a calibration phase.

4. The driver device according to claim 3, wherein

the driver device comprises a data storage (15); and
the control circuit (3) is configured to determine a parameter range for the each of the at least one electrical parameter of the driver device during execution of the calibrating procedure for the test routine, and to store the determined parameter range(s) in the data storage (15).

5. The driver device according to at least one of claims 4, wherein

the driver device comprises a sensor circuit (2.1); and
the control circuit (3) is configured to determine at least one electric parameter value based on sensor data obtained by the sensor circuit (2.1), and to determine whether the obtained parameter value is in the predetermined parameter range.

6. The driver device according to claim 3 or 4, wherein

the control circuit (3) is configured to determine at least one characteristic parameter of a dimming curve for the driver device during execution of the calibrating procedure for the test routine, wherein the at least one characteristic parameter of the dimming curve includes at least a time for running the at least one dimming curve and a dimming level difference value for running the at least one dimming curve.

7. The driver device according to one of claims 2 to 6, wherein
the control circuit (3) is configured to determine a test time frame for executing the test routine during execution of the calibrating procedure for the test routine.

8. The driver device according to claim 7, wherein the control circuit (3) is configured to determine the test time frame to correspond to a time of a determined lowest dimming level per day based on a monitored mean dimming level during execution of the calibrating procedure for the test routine.

9. The driver device according to one of the claims 2 to 8, wherein

the control circuit (3) is configured to generate and output an alert signal based on the executed test routine,
wherein the alert signal comprises at least one of a perceivable warning of a detected failure and failure data identifying the detected failure, and
wherein the alert signal is adapted to control at least one of outputting the alert by a visual or acoustical output means (17) of the driver device, outputting the alert signal via a communication circuit (4) of the driver device to a building management server (21), and storing the alert

signal in a data storage (15) of the driver device.

10. The driver device according to one of the claims 2 to 8, wherein

the at least one electrical parameter includes at least one of
a start time defining a time required by the driver device for a start-up, a shut-down time required by the driver device for powering down into an off-state, or a required time for running a predefined dimming profile.

11. The driver device according to one of the claims 2 to 10, wherein

the control circuit (3) is configured to generate a start signal for starting executing the test routine based on at least one of
a time interrupt signal generated internally by the control circuit (3) and a test start signal received via a communication circuit (4) of the driver device externally from a lighting management server (22) or a building management server (21).

12. A building management system comprising at least one driver device (1) according to one of claims 1 to 11, a building management network (5) configured to connect the at least one driver device (1) with a building management server (21) of the building management system, wherein
the building management server (21) is configured to initiate performing the test procedure by the at least on driver device (1) by generating and transmitting the test start signal to the at least one driver device (1).

13. The building management system according to claim 12, wherein
the building management system includes a lighting system and a lighting management server (21), and the at least one driver device (1) is a light driver device.

14. A method for controlling a driver device (1), the driver device (1) comprising a converter circuit (2) for generating and outputting a load current (I_{LED}) driving an electric load, in particular to a lighting device (LED), wherein the method comprises

performing automatically, by a control circuit (3) of the driver device (1), a functional test for testing electronic circuitry of the driver device (1) including the converter circuit (2), and
outputting an alert signal to a lighting management system or the building management system (20) in case of detecting a failure based on the performed functional test.

15. A program comprising instructions, which when the program is executed by a computer or signal processor, cause the computer or digital signal processor to carry out the method of claim 14.

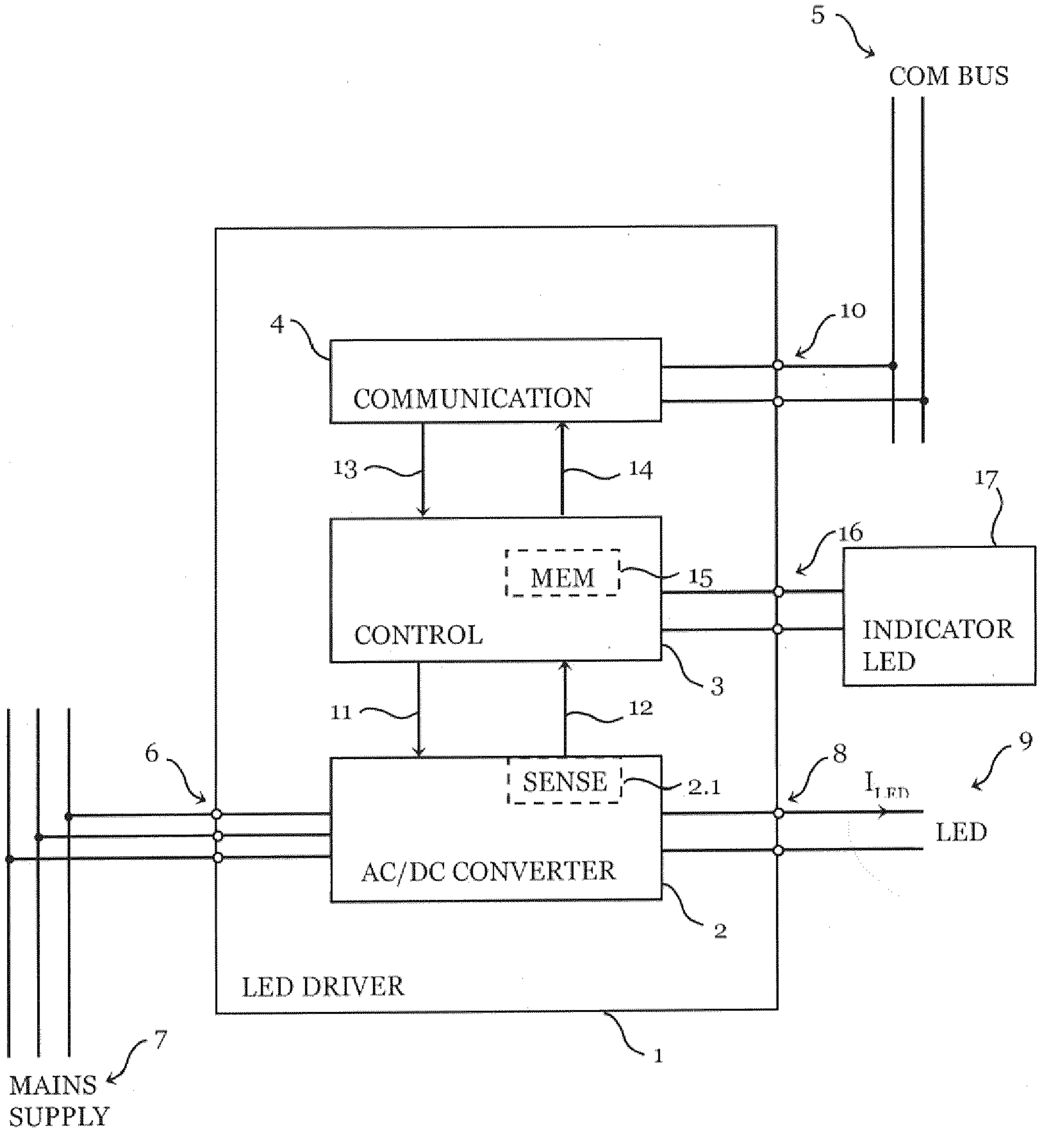
5
COM BUS
4
COMMUNICATION
10
13
14
17
16
MEM
15
CONTROL
INDICATOR
LED
3
11
12
6
SENSE
2.1
8
9
I_{LED}
LED
AC/DC CONVERTER
2
LED DRIVER
1
7
MAINS
SUPPLY

FIG. 1

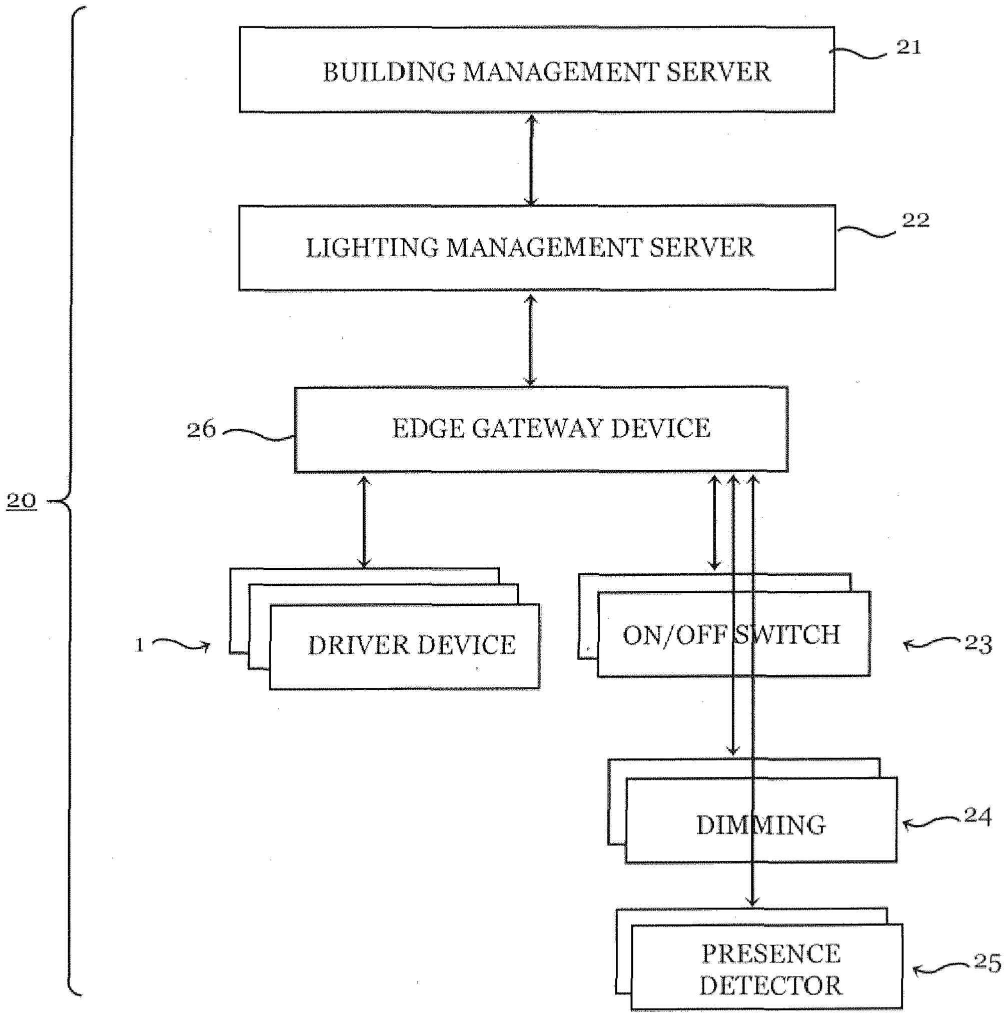
BUILDING MANAGEMENT SERVER
21
LIGHTING MANAGEMENT SERVER
22
EDGE GATEWAY DEVICE
26
20
DRIVER DEVICE
1
ON/OFF SWITCH
23
DIMMING
24
PRESENCE DETECTOR
25

FIG. 2

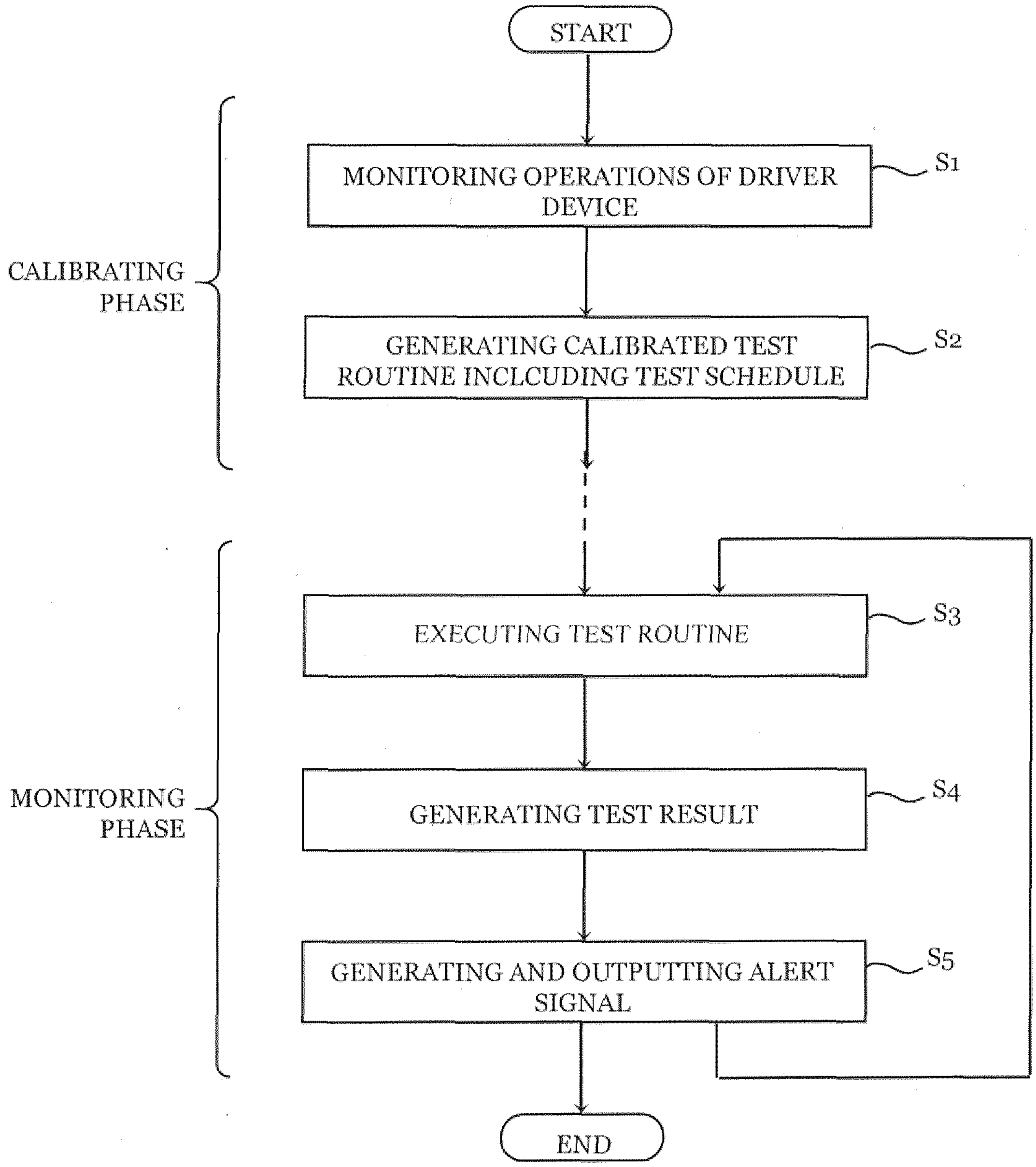
START
MONITORING OPERATIONS OF DRIVER DEVICE
S1
CALIBRATING PHASE
GENERATING CALIBRATED TEST ROUTINE INCLCUDING TEST SCHEDULE
S2
EXECUTING TEST ROUTINE
S3
MONITORING PHASE
GENERATING TEST RESULT
S4
GENERATING AND OUTPUTTING ALERT SIGNAL
S5
END

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 22 17 0538

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2018/092191 A1 (SIEFER MICHAEL J [US] ET AL) 29 March 2018 (2018-03-29) * paragraph [0021] - paragraph [0035] * -----	1-15	INV. H05B45/50
X	US 2018/128437 A1 (COOMBES SIMON [US] ET AL) 10 May 2018 (2018-05-10) * [0003], [0067]-[0078], [0092]; figures 3,4 * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

H05B

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	20 October 2022	Garavini, Elisa

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20-10-2022

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US 2018128437 A1	10-05-2018	US 2018128437 A1	10-05-2018
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