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• **Teconex**
4610 Beyne-Heusay (BE)

(72) Inventors:
• **Van Steelant, Jean-Marie**
9250 Waasmunster (BE)
• **Bervoets, Axel**
4610 Beyne-Heusay (BE)

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(74) Representative: **Calysta NV**
Lambroekstraat 5a
1831 Diegem (BE)

(71) Applicants:
• **Viva Company**
9250 Waasmunster (BE)

(54) **SYSTEM FOR CONTROLLING A SERIES OF LIGHTING FIXTURES**

(57) The invention relates to a system for controlling a series of lighting fixtures comprising a luminaire control module, a bus communication interface and at least one lighting driver, said luminaire control module designed to receive a set of input signals and generate a signal comprising an instruction for said series of lighting fixtures, the bus communication interface being connected to said luminaire control unit and comprising a current amplifier designed to amplify said signal comprising an instruction without modifying its characteristics and providing an amplified signal at an output terminal of said amplifier connected to one lighting fixture, the system allowing to control a large set of lighting fixtures.

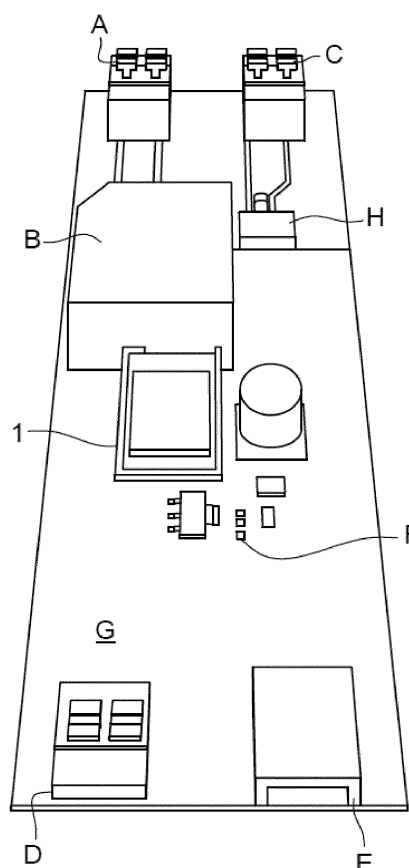


Fig. 1

Description

Technical Domain

[0001] The present invention relates to illumination, electronics and communication. In particular, the present invention concerns the controlling of luminaires and further enhancements of lighting controllers and preferably a system for controlling a series of lighting fixtures for illumination in an environment.

Technological background of the invention.

[0002] Home automation or generally building automation incorporates various aspects relating to the integrated, typically centralized and computerized control of different electric and electronic appliances, amongst other lighting. In the automation of lighting, users are seeking after optimization of lighting with respect to many different factors, such as having different lighting conditions depending on time period, occupation of rooms, timers, etc...

[0003] Technically, industrial-scale solutions for lighting automation systems require the use of special luminaires and conducting preparatory actions prior to or, at the latest, upon installation thereof through pre-wiring the walls and related other fixed structures in the target environment, i.e. hardware-based solutions.

[0004] When it relates to private home, smart lighting solutions have been developed, offering more and more integrated solutions and software-based solutions to be used with ready-to use lighting devices, thereby offering competitive solutions to the consumer, but are typically either brand specific or technology-based.

[0005] In view of the need to work with different brand and technology, especially for domestic application, several luminaire control modules are currently available on the market, used to control a wide range of available lighting fixtures by communicating with the lighting driver (one or more) of said lighting fixtures, upon an instruction, such as a instructions given by a user or a sensor. This communication is done by passing instructions between the luminaire control modules and the lighting drivers controlling these lighting fixtures.

[0006] These instructions are sent according to one the available lighting protocols i.e. DALI 1, DALI 2, 0-10V, etc.

[0007] While control modules are more and more used for domestic application, smart lighting solutions remain developed to a lesser extend in professional and industrial environment, especially because a large amount of lighting fixtures should be controlled and the lighting fixture can be separated to each other by long distance, thereby keeping preference for hardware-based solutions. Some solutions have been designed in the prior art to control a plurality of lighting fixtures.

[0008] DE102004047345A1 discloses the use of an amplifier between a DALI controller and DALI participants

to increase the number of DALI participants and to increase the length of the possible DALI bus. The use of an amplifier in addition to the DALI controller increases installation complexity. The disclosed system is not versatile for different protocols and has due to the additional amplifier an increased need of installation space. In addition, it is not configured for smart lighting applications which require often wireless networks to communicate between each other.

[0009] Therefore, some smart lighting solutions provide a luminaire control module with a wireless control interface. The luminaire control module communicates wirelessly with smartphone applications and/or other luminaire control modules to establish a smart lighting network. However, current solutions for such wireless smart lighting provide for each lighting driver one luminaire control module to allow the smart lighting network to communicate between the lighting drivers. The DALI network is thus replaced by a wireless network, e.g. a wireless mesh network. Each lighting driver receives the instruction from its respective luminaire control module via a 0-10V connection or via a DALI connection, depending on the lighting driver. However, this solution is not well applicable for large scale applications like industrial applications with a large number of lighting drivers as each lighting driver requires a separate luminaire control module. Also it is difficult to retrofit the wireless smart lighting functionalities to existing wired DALI or 0-10V lighting installations with a larger number of lighting drivers.

[0010] The system known from US9736914 describes a method for controlling a plurality of luminaire units. The control unit comprises a wireless transceiver module, allowing the formation of mesh networks between several control units, and to control a larger amount of lighting fixtures at bigger distances. However, this means that a large amount of control units has to be installed, representing a high cost, as this is the most expensive part of a lighting system, and increasing the amount of programming, installation and maintenance time required.

[0011] US2016286628 concerns a modular wireless light control for light fixtures. The device includes a modular wireless lighting control device that includes a wireless transceiver, a first controller and a main power supply. The wireless transceiver is connected by wire to the control device, and the control device is further connected to the lighting fixtures. This system represents the drawback of having one of said modular wireless light controls for each unique lighting driver to be controlled in the system. Another drawback for industrial usage is the wireless communication, as the signal needs to be strong enough to cover large distances and pass through walls, floors and ceilings.

[0012] The system described by US2017273164 concerns a luminaire control system with a microcontroller embedded. The microcontroller can receive different input signals in several different communication protocols (Wi-Fi, Zigbee, ...). Based on that signal different output signals can be generated (DALI, I²C, 0-10V). The micro-

controller has the possibility to switch between different kind of in- and output signals and a hierarchy can be defined to switch between output signal depending on the input. Unfortunately, the microcontrollers are not able to form a mesh network between each other and do not provide the possibility to amplify the output signal. This makes industrial applications, where many lighting drivers are needed to be control, nearly impossible.

[0013] Another example is the Casambi® CBU-ASD control module foreseen to be connected to a series of lightening fixture. This device provides both a wireless input interface and a wired one and communicates with the lighting drivers over a wired connection by using the DALI or 0-10V protocol. However, the output current is limited to only 7mA, allowing only 2-3 lighting drivers to be connected per control module. This implies the installation of many control modules and thus an installation which is expensive and requires more programming.

[0014] Due to these limitations, industrial applications of these type of lighting control modules implies a high amount of luminaire control units to be bought and carefully put in place at the appropriate positions so that the entire set of lighting fixtures can be controlled. As these control modules often have to support a various type of protocols to control the lighting fixtures and need to be able to handle input signals coming from different type of input devices (lighting switches, smartphone applications, movement sensors, ...) they are often expensive and require programming and maintenance.

[0015] There is thus a need for a control system that is more suitable in these kinds of implementations than prior art control modules, providing a reliable, less maintenance requiring, easier to manufacture, small in space and versatile solution.

Brief summary of the invention

[0016] It is foreseen according to one embodiment of the present invention a system for controlling a series of lighting fixtures and a luminaire control device for controlling a series of lighting fixtures according to the independent claims.

[0017] It is foreseen according to one embodiment of the present invention a system for controlling a series of lighting fixtures for illumination in an environment as mentioned in the beginning, characterized in that the system comprises: a) A luminaire control module comprising a plurality of first input ports and at least one first output port, said luminaire control module being provided to receive at least one first input signal at one of the first input ports and to read the instruction comprised in said first input signal and to generate a corresponding output signal containing the appropriate instruction for the series of lighting fixtures; b) A bus communication interface comprising at least one current amplifier module, at least one second input port and at least one second output port, said at least one current amplifier module comprising an input terminal connected to said at least one second input

port, which is connected to one of said at least one first output port, a series of electrical current amplifier circuits comprising bipolar transistors, and an output terminal connected to one of said at least one second output port, said current amplifier module being provided for amplifying the current level of said corresponding output signal received at said input terminal through said at least one second input port and for providing an amplified version of said corresponding output signal at said output terminal connected to said second output port, c) at least one lighting driver provided for controlling at least one lighting fixture of said series of lighting fixtures, for example an LED, said second output port of the bus communication interface being further connected to said at least one lighting driver.

[0018] It has been indeed realized according to the present invention that it is possible through the integration of a bus communication interface comprising a current amplifier module to solve at least a part of the aforesaid drawbacks by providing a device in which an output signal (second output signal) towards a lighting driver according to one of the protocols mentioned before, i.e. DALI, 0-10V, 1-10V, ... is amplified without modifying the characteristic values of the signal. The amplified version of the first signal further being transferred towards multiple lighting drivers over wires, providing a stable and industrial proof communication between the control system and the plurality of lighting drivers. Accordingly, the system of the present invention avoids the need of expensive components and maintenance overheads and offer a software-based solution without requiring to multiply the control module even when long distances exist between several lighting drivers. Indeed, thanks to the present invention, it is now possible to have one or a limited number of control module thereby limiting the overall costs of the system. This allow to bring a system which can be also implemented at industrial or professional scale.

[0019] The following embodiments show further developments of the invention.

[0020] In one embodiment said at least one first output ports of said luminaire control module is a plurality of first output ports, a first one of the first output ports being provided for issuing the first transformed signal being a different transformed signal with respect to a second transformed signal being provided from a second one of the first output ports, said system further comprising a switching module having at least two third input ports and a third output port, a first one of said at least two third input ports being connected to the first one of the first output ports of the luminaire control module, a second one of the third input ports being connected to the second one of the first output ports of the luminaire control module, wherein the switching module is configured to decide on which signal, received at one of the third input ports of the switching module, will be passed on and/or made available on the third output port of said switching module. This allows to use the same output port (the third

output port) for giving out to the lighting drivers certain instructions following either a first protocol (DALI) which is amplified for longer distances or a second protocol (e.g. 0-10V). Preferably, the first transformed signal being a DALI control signal. Preferably, the second transformed signal being a 0-10V control signal. This allows to keep the housing of the device small notwithstanding the additional amplifier and allows the same device to be used with different lighting protocols. Preferably, the at least two third input ports comprise further a mode selection port for providing a communication mode selection signal. This electrical switching allows also to keep the housing small. Preferably, the mode selection port being connected to a third one of the first output ports of the luminaire control module. Thus, a user could configure over the luminaire control module which output signal is put on the lighting bus connector. In another embodiment, the mode selection port being connected to a near field communication interface configured to generate the communication mode selection signal based on a signal received on the near field communication interface.

[0021] In one embodiment, the first one of the third input ports of said switching module is connected to the second output port of the bus communication interface and/or is connected through the bus communication interface to the first one of the first output ports of the luminaire control unit.

[0022] In one embodiment, the system/luminaire control device comprising a further bus communication interface connected between the second one of the first output ports of the luminaire control module and the second one of the third input ports of the switching module. Preferably, the 0-10V control signal is a pulse width modulation signal whose pulse width corresponds to the desired voltage level for the lighting drivers of the lighting fixtures, wherein the further bus communication interface is configured to transfer the pulse width modulation signal into a 0-10V signal.

[0023] In one embodiment, the system/luminaire control device comprises a power supply module configured to convert an AC mains current into a plurality of DC supply voltages, the plurality of DC supply voltages comprises a first supply voltage for the current amplifier of the bus communication interface, a second supply voltage for the further bus communication interface and a third supply voltage for the luminaire control module, wherein the first supply voltage is larger than the second supply voltage, and the second supply voltage is larger than the third supply voltage. Preferably, the first supply voltage is larger than twelve Volt and wherein the second supply voltage is ten Volt. Even if the DALI voltage can range from 9 to 22 Volt, most of the DALI buses are operated in the range of 9-12V. Considering that for the 0-10V anyway a 10V supply voltage is needed, it would have been obvious to use the 10V supply voltage also for the amplified DALI signal. However, for applications with long DALI buses, a voltage drop could lead to the fact that the last drivers will see a DALI signal voltage

below the min 9 V provided by the DALI protocol. Therefore, to chose the supply voltage for the bus communication interface higher than for the 10V, preferably than 12V allows the use of long cables/lighting buses.

[0024] In one embodiment, the luminaire control module comprises a wireless control interface, wherein the wireless control interface is configured to act as one of the one or more first input ports for receiving at least one of the first input signal, wherein the wireless control interface is configured to build a wireless mesh network with other lighting devices. Luminaire control modules with wireless control interfaces connecting in mesh networks are used to easily connect a large number of lighting drivers in a mesh network, e.g. in smart lighting applications like in home automation. The luminaire DALI control module with a subsequent amplifier on the other side is used for the case, when a large number of lighting drivers shall be used in a DALI bus. The combination of the two ideas allows to incorporate the smart lighting features provided by the wireless mesh network into the DALI controlled driver network without the need to provide each driver with a luminaire control module with a wireless control interface. This method brings the smart lighting functions into the industrial or large-scale applications.

[0025] In one embodiment, system comprising a luminaire control device.

[0026] In one embodiment, the luminaire control device comprises the luminaire control module, the bus communication interface and a lighting bus connector, wherein the second output port of the bus communication interface is connected or connectable to the lighting bus connector. Preferably, in the system, the at least one lighting driver is connected over the lighting bus connector to the luminaire control device.

[0027] In one embodiment, the luminaire control module comprises a wireless control interface, wherein the luminaire control device comprises further a switching means configured to switch the luminaire control device between a DALI Master mode and a DALI slave mode. As explained above, existing luminaire control modules with a wireless control module are designed to control just one driver over the lighting bus and are thus only designed to be in the Master mode. In industrial applications with existing DALI buses or with some lighting drivers not reachable by the DALI bus, the luminaire control device switched in a DALI Slave mode could allow to extend the DALI network wirelessly to a remote lighting driver and/or allow to add the smart lighting functionalities on an existing DALI network already having a DALI Master. Preferably, the switching means is further configured to switch the luminaire control module in a 0-10V mode. In the 0-10V mode, the second transformed output signal or the 0-10V signal is provided on the lighting bus connector based on the instructions received from the wireless control interface. Thus, the same device can be used for controlling 0-10V networks, DALI networks with a large number of participants (DALI Master) and/or with

long network cables or as a DALI slave e.g. for extending the DALI network wirelessly and/or for extending an existing DALI control network with smart lighting functionalities provided by the luminaire control module with the wireless control interface.

[0028] Preferably, in the DALI Slave mode, a) the luminaire control device is configured to receive a DALI message addressed to the DALI Slave address of the luminaire control device on the lighting bus connector and/or containing an instruction for controlling at least one further driver controlling at least one further lighting fixture/driver, and/or b) the wireless control interface being configured to send the instruction of the received DALI message wirelessly to the at least one further lighting driver. Thus, the Preferably, when the luminaire control device is switched in the DALI Slave mode, the system comprises a DALI Master device connected over the lighting bus connector to the luminaire control device to provide the DALI voltage on the DALI bus connected to the lighting bus connector. Thus, the luminaire control device can in the DALI Slave mode be used as a wireless gateway to connect an existing DALI bus (or an existing DALI control system) wirelessly with a further lighting driver (which may be difficult to reach with a DALI bus).

[0029] In one embodiment, in the DALI Slave mode, the control module sends DALI messages to the lighting bus connector by interrupting a supply voltage provided by the lighting bus based on a DALI control signal received from the luminaire control module.

[0030] Preferably, when the luminaire control device is switched in the DALI Slave mode, the system comprises the at least one further lighting driver, a further lighting bus and a further luminaire control module. The at least one further lighting driver is connected over the further lighting bus to the further luminaire control module, wherein the further luminaire control module comprises a further wireless control interface for receiving the instructions from the wireless control interface of the luminaire control module. Preferably, the further luminaire control module is configured to read out the instructions received at the further wireless control interface and to provide a further control signal on the further lighting bus corresponding to the read instructions to control the at least one further lighting driver. The further control signal being a 0-10V signal or a DALI signal. Preferably, the wireless control interface and the further wireless control interface constitute a wireless mesh network.

[0031] In one embodiment, the switching means for switching between the DALI Master mode and the DALI Slave mode is further configured to switch in a 0-10V mode in which the second transformed output signal or the 0-10V signal is given out to the lighting bus connector.

[0032] In one embodiment, the switching means comprises a NFC wireless switching interface for receiving a wireless switching control signal comprising information about the switching mode being a DALI Master mode or the DALI Slave mode and, in the SLAVE mode, about the DALI Slave address of the luminaire control device.

[0033] In one embodiment, the luminaire control module receives a DALI slave signal, when the switching means is switched to the DALI slave mode.

[0034] Preferably, in the DALI Master mode, a) the wireless control interface is configured to act as one of the one or more first input ports for receiving at least one of the first input signal, b) the luminaire control module is configured to read the instruction comprised in said at least one first input signal and to generate a corresponding first transformed output signal containing the appropriate instruction for the series of lighting fixtures, and/or c) the bus communication interface is configured to provide the amplified version of said first transformed output signal at said lighting bus connector for controlling the at least one lighting fixture connected to the lighting bus connector.

[0035] In one embodiment, luminaire control device comprises a printed circuit board, wherein the luminaire control module, the bus communication interface, the switching module, the further bus communication interface and/or the power supply module are mounted on the printed circuit board, wherein the luminaire control module comprises a luminaire control chip connected to the printed circuit board. Preferably the luminaire control chip comprises the wireless control interface.

[0036] In one embodiment, the luminaire control module/chip comprises a wireless control interface for receiving a first one of the at least one first input signal, wherein the at least one first input signal comprises a first one and a second one of the at least one first input signal, wherein the first one of the at least one first input is received at a first one of the one or more first input ports being the wireless control interface and the at least one second one of the at least one first input signal is received at a second one of the one or more first input ports being at least one pin of the luminaire control chip. Preferably, the pin is not the pin for receiving DALI messages from the lighting. Preferably, the pin is connected with an input connector of the luminaire control device. Preferably, the system comprises an input device (preferably a motion and/or light sensor) connected via a cable to the input connector. This has the advantage that the instructions from the first input signal can be received wirelessly and over direct interface of the luminaire control device. This allows a full flexibility about which input devices are used. The luminaire control device can be controlled by a user via the wireless control interface and can receive user input from sensors (preferably for motion and/or light) directly over a cable connection as those sensors are less complex than wireless sensors or DALI sensors. Either wireless input devices or simpler input devices connected by a direct cable connection.

[0037] In one embodiment, the printed circuit board comprises a control socket, wherein the luminaire control module is removably connected to the printed circuit board. Preferably, the luminaire control module comprises an adapter, wherein the luminaire control chip is soldered on the adapter, wherein the adapter comprises a

connector removably connected with or plugged in the control socket, wherein the connector is connected to the luminaire control chip. This allows to easily assemble the luminaire control device, to use the PCB of the luminaire control device for multiple luminaire control chips of different wireless control protocols and to easily replace and reprogram the luminaire control chip by removing the luminaire control module from the control socket.

[0038] In one embodiment, the bus communication interface comprises a first transistor connected on its first terminal with ground and on its second terminal to a supply voltage (preferably the first supply voltage) to the second output port and on its gate terminal to the first one of the at least one first output port providing the first output signal (DALI control signal).

[0039] In one embodiment, the one or more first input ports of the luminaire control module comprise a first input port configured to receive DALI messages, wherein the bus communication interface comprises a further second output port connected to the first input port configured to receive DALI messages, wherein the bus communication interface comprises a voltage divider between the second output port and the further second output port. This converts the DALI signal from the bus (with the bus voltage) down to a DALI signal with the voltage level of the third supply voltage. This is a very simple circuit for transferring the DALI messages from the lighting bus connector to the luminaire control module with the respective reduced voltage.

[0040] In one embodiment, the one or more first input ports of the luminaire control module comprise a first input port configured to receive DALI messages, wherein the bus communication interface comprises a further second output port connected to the first input port configured to receive DALI messages, wherein the bus communication interface comprises a second transistor connected on its first terminal with ground and on its second terminal to the further second output port and to the third supply voltage and on its gate terminal to the second output port. This circuit is independent from the voltage of the bus and is thus preferred for the slave configuration.

[0041] In one embodiment, the first supply voltage connected to the second terminal of the first transistor is switched off in the DALI slave mode and the second output port remains connected to the lighting bus connector in the DALI slave mode (as in the DALI Master mode). Due to the amplifier in the bus communication interface, it is difficult to realize a DALI slave mode. This realization allows to use the bus communication interface for the DALI slave and master mode.

[0042] In one embodiment, the switching module connects the lighting bus connector in the DALI Master mode to the second output port of the bus communication interface and in the DALI Slave mode to a DALI slave bus communication interface, wherein the DALI slave bus communication interface is connected to the luminaire control module to receive from and/or send to the lighting bus connector DALI messages, when the luminaire con-

trol device is in the DALI slave mode. The luminaire control module can comprise a further first output port for sending out DALI messages in the slave mode and a further first input port for receiving DALI message in the slave mode, wherein the further first output and input port are connected to the DALI slave bus communication interface. The DALI slave bus communication interface can be designed as described above the bus communication interface for the DALI slave mode.

[0043] Preferably, according to the present invention, said bus communication interface is a DALI bus communication interface.

[0044] In this case, when more than 64 different addresses are required, the number of control module is higher than 1.

[0045] In a preferred embodiment, said control module is connected to a power supply circuit comprising at least two input pins, an AC/DC converter, and at least one voltage regulator, said at least two input pins being both connected to a voltage source, said power supply circuit comprising at least one voltage regulator, connected to at least one power input pin present in said control module.

[0046] As it can be seen, the device according to the present invention further comprises a power supply circuit comprising at least two input pins, an AC/DC converter, and at least one voltage regulator, said at least two input pins being both connected to a voltage source providing the standard 220-240 AC voltage level, said voltage regulator module providing a stable DC voltage output for said bus communication interface, said power supply further connected to said control module to provide the power necessary for normal operation of said control module.

[0047] In a preferred embodiment according to the present invention, said at least one first output ports of said control module is a plurality of first output ports, one first output port being provided for issuing a transformed signal, being a different transformed signal with respect to another first output port of said plurality of first output port, said system further comprising a switching module having at least three third input ports A, B and C and a third output port, said third input port A being connected to one first output port, said third input port B being connected to another first output port and said third input port C being connected to yet another first output port for providing a communication mode selection signal.

[0048] The configuration of the input A, B and C according to the present invention allows to provide different kind of transformed signals and compatibility with various known lighting protocols, preferably at least DALI, 0-10V, 1-10V, ... , with the switching module switching between the signals provided at the input terminals based on a switching mode selection signal received at said communication mode selection terminal.

[0049] In a particular embodiment according to the present invention, said switching module comprises an analog switching module having a number of third input

ports equal to the number of first output ports.

Drawings

[0050]

Fig. 1 shows a printed circuit board of a first embodiment of a luminaire control device,
 Fig. 2 shows a circuit diagram of the first embodiment of the luminaire control device,
 Fig. 3 shows a circuit diagram of an embodiment of a bus communication interface of the first embodiment of the luminaire control device,
 Fig. 4 shows a circuit diagram of an embodiment of a switching module of the first embodiment of the luminaire control device,
 Fig. 5 shows an embodiment of a system including a luminaire control device,
 Fig. 6 shows a circuit diagram of an embodiment of a further bus communication interface of the first embodiment of the luminaire control device.
 Fig. 7 shows a circuit diagram of a second embodiment of the luminaire control device.
 Fig. 8 shows an exemplary circuit diagram of the DALI slave bus communication interface of the second embodiment.

Detailed description of the invention

[0051] Other characteristics and advantages of the present invention will be derived from the non-limitative following description, and by making reference to the drawings.

[0052] Fig. 5 shows an embodiment of a system comprising preferably a luminaire control device 14, lighting bus 21, at least one lighting driver 16, at least one lighting fixture 17 and at least one input device 18, 20.

[0053] The at least one lighting fixture shall include any fixture for receiving lighting means. The lighting means can be removably fixed in the lighting fixture (like light bulbs) or could be (not-removably) fixed with the fixture. Preferably, the lighting means comprises preferably a Light Emitting Diode (LED) lamp. However, it could include also other lighting means like fluorescent lamp, halogen lamp, discharge lamp, a filament lamp or any other type of lamp.

[0054] The lighting driver 16 is configured to control at least one, preferably a plurality of lighting fixtures 17. The lighting driver 16 receives a lighting control signal. The lighting control signal is received either wirelessly or wired, preferably by the lighting bus 21. The lighting control signal transmitted over the lighting bus 21 is preferably a DALI signal or a 0-10V signal. The lighting driver 16 provides the lighting fixtures 17 connected to the lighting driver 16 with a power signal corresponding to the received lighting control signal. Depending on the control signal and/or the provided power signal, the lighting means can emit different intensities and/or different col-

ours and/or other lighting effects. The lighting driver is preferably an LED driver. The lighting driver is preferably connected to one, preferably a plurality of lighting fixtures. The lighting driver can be included in a lighting fixture 17. It could be that some lighting drivers 16 of the system receive the lighting control signal wirelessly and some others over the lighting bus 21.

[0055] The lighting bus 21 is a bus network connecting a plurality of lighting fixtures and/or a plurality of lighting drivers. The lighting bus 21 comprises preferably two conductor lines for transmitting two polarities of a DC signal. Each lighting driver 16 connected to the lighting bus 21 is connected between the two conductor lines of the lighting bus 21.

[0056] A 0-10V signal is a standardized lighting control signal for controlling lighting drivers and/or lighting fixtures. The 0-10V standard corresponds to an analogue control signal having a voltage between 0V and 10V. 10V corresponds to a maximum intensity of the connected lighting driver(s) and/or connected lighting fixture(s). 0V corresponds to a zero intensity of the connected lighting driver(s) 16 and/or connected lighting fixture(s) 17 or their switched-off state. The 0-10V standard shall include also the 1-10V standard which provides as a minimum voltage 1V instead of 0V. In this case, often a relay circuit is used for switching of the lighting drivers 16. All lighting drivers 16 and/or all lighting fixtures 17 connected to the same lighting bus 21 receive the same 0-10V signal and are controlled all in the same way.

[0057] A DALI signal is another standardized lighting control signal. The DALI stands for Digital Addressable Lighting Interface. The DALI standard allows to address up to 64 DALI participants connected on the same lighting bus. Thus, each of the 64 DALI participants can be controlled in a different way. The DALI signal contains a number of bits which are transferred by a kind of amplitude or on-off modulation. The DALI signal is preferably a signal which has either an upper voltage value or a lower voltage value. In the DALI signal, a first bit type (0) is a sequence of the upper voltage value followed by the lower voltage value, and a second bit type (1) is a sequence of the lower voltage value followed by the upper voltage value. Each of the upper and lower value lasting for a certain time period e.g. 416µs with the time period for a bit being the double. The DALI signal in the IDLE state is preferably an upper value allowing the DALI slaves or other DALI participants like the lighting drivers 16 to create messages using the upper voltage value of the IDLE state. The DALI signal shall comprise signals under the DALI1 standard, the DALI2 standard or any future development of the DALI standard. The DALI standard allows also a two-way communication on the lighting bus.

[0058] The at least one input device is configured to create a lighting input signal for the system, in particular for the luminaire control device 14. The at least one input device comprises one or more of a switch, a dimmer and at least one sensor. The at least one sensor can comprise

one or more of a motion sensor and a (day) light sensor. The at least one input device can further comprise a general processing device with a lighting control software installed on the general processing device. The general processing device can be for example a personal computer, a smartphone 20, a tablet, a special lighting controller etc. The at least one input device can be connected by a wired connection (wired input device) or by a wireless connection. It is also possible that at least one wired input device 20 is connected by a wired connection (light and/or motion sensor) and others are connected by a wireless connection (e.g. the general processing device). Preferably, the wired connection is not via the lighting bus 21 and/or is via the input connector E. Preferably, the wired input device 20 with a motion sensor for detecting motion and a light sensor for detecting (day) light.

[0059] The luminaire control device 14 is configured to receive a lighting input signal from the at least one input device, generate at least one lighting control signal and to give out the at least one lighting control signal to the at least one lighting driver 16. The lighting control signal can be given out to the lighting driver(s) 16 over the lighting bus 21 or wirelessly. It is also possible that a first lighting control signal is send to a first group of lighting drivers (comprising at least one lighting driver 16) over the lighting bus 21 and that a second lighting control signal is send to a second group of lighting drivers (comprising at least one lighting driver 16) wirelessly.

[0060] Fig. 1 to 4 and 6 show a first embodiment of the luminaire control device 14. The luminaire control device 14 comprises a luminaire control module 1 and a bus communication interface 2. The luminaire control device 14 comprises preferably further a switching module 3, a further bus communication interface 4, a power supply module 5 and a relay module H (see circuit diagram in Fig. 2).

[0061] The luminaire control device 14 comprises preferably further a printed circuit board (PCB) G supporting and connecting the above mentioned parts of the luminaire control device 14 as shown for example in Fig. 1. The luminaire control device 14, preferably the PCB G comprises preferably further a power connector A, a relay connector C, a lighting bus connector 15 and/or an input connector E. The power connector A can be a wire clamp for clamping to ends of two wires conducting the AC mains current. The relay connector C is preferably a connector for AC mains, preferably also a wire clamp. The lighting bus connector 15 is preferably configured to connect the two power lines of the lighting bus. The lighting bus connector 15 is preferably a wire clamp. The input connector E can be any connector, preferably a standard connector like an Ethernet connector or an USB connector. The input connector E is configured to connect the wired input device 20. Obviously other connector types can be used for the connectors A, C, E, 15 than the described ones.

[0062] The power supply module 5 is preferably configured to receive input power from the power connector

A and/or to provide at least one supply voltage. The input power is preferably an AC current, preferably the AC mains current, e.g. 220 AC voltage (VAC) or 110 VAC. The provided at least one supply voltage is preferably a DC voltage. The power supply module 5 is preferably configured to provide two, preferably three supply voltages of a first supply voltage Vcc1, a second supply voltage Vcc2, a third supply voltage Vcc3. The first supply voltage Vcc1 is preferably larger than 9 Volt (V), preferably larger than 10V, preferably larger than 11V, preferably larger than 12 V, preferably larger than 13V, preferably larger than 14V, preferably larger than 15V, preferably larger than 16V and/or is preferably smaller than 22V, preferably smaller than 21V, preferably smaller than 20V. The first supply voltage Vcc1 is preferably 18V. The first supply voltage Vcc1 is preferably used for the bus communication interface 2. The second supply voltage Vcc2 is preferably 10V. The second supply voltage Vcc2 is preferably used for the further bus communication interface 4. The third supply voltage Vcc3 is preferably larger than 1V, preferably larger than 2V, preferably larger than 2.5V and/or is preferably smaller than 5V, preferably smaller than 4V, preferably smaller than 3.6V. The third supply voltage Vcc1 is preferably 3.3V. The third supply voltage Vcc3 is preferably used for the luminaire control module 1. Preferably, the first supply voltage Vcc1 is larger than the second supply voltage Vcc2 and/or the third supply voltage Vcc3. Preferably, the third supply voltage Vcc3 is smaller than the second supply voltage Vcc2 and/or the first supply voltage Vcc1. Preferably, the second supply voltage Vcc2 is larger than the third supply voltage Vcc1 and/or smaller than the third supply voltage Vcc3. The power supply module 5 comprises preferably a power converter, preferably a rectifier (also called AC/DC converter) for converting the AC current from the power connector A into a DC current of the at least one supply voltage. The power supply module 5 preferably converts the AC current into the first supply voltage Vcc1. The remaining supply voltages Vcc2 and/or Vcc1 can be retrieved from the first supply voltage by voltage dividers. The power supply module 5 or the PCB G comprises preferably a (big) power capacitor for buffering power for the case of a power loss some power/charge. Therefore, the power capacitor is connected preferably to one of the supply voltages, preferably the smallest one of the supply voltages, preferably the supply voltage of the luminaire control module 1, preferably the third supply voltage Vcc3. If the power supply at the power connector A drops, the power capacitor is not charged any more by the power supply module 5, but has enough energy to supply the luminaire control device 14, preferably the luminaire control module 1 for an ordered shut down and/or for informing other devices of the power drop. The supply voltage module 5 is preferably further configured to detect a power loss at the power connector A or the power supply module 5. This can here be easily realized by comparing the first or second supply voltage with the third supply voltage Vcc1 connected to the capacitor. When the pow-

er supply drops, the first and second supply voltages will also drop immediately while the third supply voltage V_{cc1} is kept stable for a while due to the power capacitor. Thus, when the first or second supply voltage drops below the third supply voltage, a power loss can be detected. The power supply module 5 is preferably configured to provide a power presence signal to the luminaire control module 1 including the information of a power presence or absence on the power connector A. The power supply module 5 provides preferably the at least one, preferably the two, preferably the three supply voltages to the PCB G, preferably each to a different conductor track of the PCB. The conductor tracks of the PCB with the different supply voltages are then connected to the modules and parts of the luminaire control device 14 requiring the respective supply voltage. The power supply module 5 can be connected to a general 220 volt outlet, available in almost every industrial application, and will transform the alternating voltage/current (AC) to the different levels of direct voltage/current (DC). These different levels being the input voltage needed for the modules 1, 2, 3.

[0063] The luminaire control module 1 is configured to receive at least one first input signal for controlling the lighting drivers 16 (and/or lighting fixtures 17). The luminaire control module 1 is configured to generate and/or give out at least one transformed output signal based on an instruction contained in the at least one first input signal.

[0064] The luminaire control module 1 is preferably realised as a PCB mountable chip or comprises a PCB mountable chip. The PCB G comprises preferably at least one control socket or control slot for receiving the PCB mountable chip or luminaire control module 1. The control slot or socket is preferably soldered on the PCB G. The control socket is preferably a socket (preferably a female socket) for plugging in a corresponding connector, preferably a male connector, preferably a pin connector. In one embodiment, the PCB mountable chip or luminaire control module 1 is plugged in the control slot or socket. Preferably, the PCB mountable chip or luminaire control module 1 is arranged/plugged removably on the PCB G or the control slot or socket. In a more preferred embodiment, the luminaire control module 1 comprises an adapter. The PCB mountable chip is preferably soldered on the adapter and the adapter has a plug connector which can be removably plugged into the control socket/slot. This allows to removably plug the luminaire control module 1 in the control socket. Thus, the PCB mountable chip or the luminaire control module 1 can be removed from the control slot or socket for reprogramming of the chip, for maintenance purposes and/or for replacing the chip. In addition, the assembling process is much easier as the chip/module 1 must just be plugged in the control socket. In another embodiment, the PCB mountable chip or luminaire control module 1 can be soldered in the control slot or socket or directly on the PCB G. The use of a control slot or socket on the PCB G has the advantage that the same PCB G can be used for different

luminaire control modules 1. Such luminaire control modules 1 are offered by Casambi, Google, Apple (all registered trademarks) or others. Depending on the system preferred by the client, the corresponding luminaire control module 1 can be mounted always on the same PCB G. The PCB G will be described in more detail below. The PCB mountable chip or the luminaire control unit 1 has thus preferably a plurality of pins to be connected or connected with the PCB G or the control slot or socket.

[0065] The luminaire control module 1 comprises preferably a wireless control interface 19 configured for receiving one, some or all of the at least one first input signal (from the at least one input device) and/or for communicating with other luminaire control modules 1/devices 14 and/or with the lighting driver(s) 16 connected to these other luminaire control modules 1/devices 14. The wireless control interface 19 is preferably configured to communicate with at least one input device connected wirelessly, i.e. can receive from and send messages to the input device(s). For example, the luminaire control device 14/module 1 receives instructions from the at least one input device and sends status and error messages to the at least one input device. The wireless control interface 19 and the luminaire control module 1/chip follow preferably a certain wireless control protocol. The wireless control protocol defines preferably a wireless control standard for controlling light/home applications like Casambi, Apple HomeKit or Google. Those wireless control protocols include often smart lighting functions and are then also called smart lighting protocols. Each wireless control protocol allows interoperability with other devices and software/applications of the same wireless control protocol. Preferably, each control protocol provides at least one control application/software (for a general purpose computing device like a smartphone or personal computer) for controlling/programming the luminaire control module 1/chip over the wireless control interface 19. The wireless control protocol defines preferably at least one wireless communication protocol. The wireless communication protocol refers to the standard used for wirelessly transferring data between devices and/or for initializing the wireless network. The wireless communication protocol is preferably at least one of Bluetooth, ZigBee, WiFi or others. The wireless control protocol defines the interoperability of the wirelessly connected devices by defining the wireless communication protocol and other interoperability aspects beyond the pure data exchange aspects (e.g. on an application level). The wireless control protocol and/or luminaire control module 1 could be configured to support different wireless communication protocols. The luminaire control module 1/chip, the wireless control interface 19, the wireless control protocol and/or the wireless communication protocol allows preferably to create a wireless mesh network between different wireless communication interfaces 19 of different devices. The mesh network comprises preferably a plurality of luminaire control modules 1 and/or a plurality of luminaire control devices 14 each

being connected to at least one light driver over a 0-10V or DALI connection and/or each having a wireless control interface 19 according to the same wireless control protocol. The wireless mesh network allows that a plurality of luminaire control modules 1/devices 14 form together a wireless network without the necessity of a gateway. The wireless mesh network can be a Bluetooth mesh. The wireless control interface 19 comprises preferably all parts necessary for wirelessly transmitting and receiving information, like a transmitter, a receiver, an antenna, etc. The wireless control interface 19 can act as one of the at least one first input port.

[0066] The luminaire control module 1 comprises at least one first input port for receiving the at least one first input signal. The first input signal contains instructions for controlling all or some lighting driver 16 of the system. The instructions can be contained in the first input signal in analogue or digital way, i.e. the first input signal can be an analogue or digital signal. The instructions can be any input information relevant for controlling the lighting fixtures 17 or lighting drivers 16 like a detected motion, a detected light, a message from a lighting fixture 17 or a driver 16 or a user input from an input device like a dimmer or colour selector or a switch. The at least one first input signal can comprise different first input signals coming from different input devices and/or received at different first input ports and/or containing different instructions. The different input signals/instructions could control different groups of lighting drivers 16 or could provide different instructions (switch, lighting sensor, motion sensor) for controlling the same of the lighting driver(s). The different input signals can come from different input devices.

[0067] Preferably, the luminaire control module 1 is configured to receive a plurality of first input signals at a plurality of first input ports.

[0068] Preferably, the plurality of first input ports comprise at least one first type input port of first input ports and at least one second type input port of first input ports. The at least one first type input port of first input ports is preferably a connector (e.g. a pin) of the luminaire control chip to the PCB G, preferably pin and/or is connected to a connector of the luminaire control device 14 like the input connector E. Preferably, there is a plurality of first type input ports, preferably connected to different pins of the input connector E. The at least one second type input port is preferably the wireless control interface 19 configured to receive a wireless signal. Preferably, the plurality of first input signals comprise at least one first type input signal of first input signals received at the at least one first type input port and at least one second type input signal of first input signals received at the at least one second type input port.

[0069] The at least one first type input signal is preferably an analogue signal. The signal can be high for motion or light detected or low otherwise or vice versa. The at least one first type input signal can however also be a digital signal like for the DALI input received from the

lighting bus. The at least one first type input signal can however also be a digital signal. Preferably, each first type input signal received from each input device (in wired form) connected to the luminaire control device 14 is received at a different first type input port of the luminaire control module 1. One, some or all first type input ports might be connected to connectors of the luminaire control device 14 like to the lighting bus connector 15 or the input connector. There might be different first type input ports might be connected different pins of the input connector E. For example, the first type input ports 1.5 and/or 1.6 are connected to different pins E.4 and/or E.1, respectively. The first type input port 1.5 and/or the pin E.4 of the input connector E is preferably connected to a motion sensor. The first type input port 1.6 and/or the pin E.1 of the input connector E is preferably connected to a light sensor. The first type input port 1.2 is preferably connected to the lighting bus connector 15 (at least, when the switching module 3 connects the lighting bus connector 15 over the bus communication interface 2 to the luminaire control module 1). The first type input port 1.2 is preferably configured to receive messages from the lighting drivers 16 and/or lighting fixtures 17 connected to the lighting bus 21. One or some first type input ports might be connected to internal parts of the luminaire control device 14 like to the power supply module 5. For example, the first type input port 1.8 is preferably connected to the power supply module 5 for receiving the power presence signal from the power supply module 5. Some of the first type input signals might be digital (like the messages from the lighting drivers 16 and/or fixtures 17) or analogue (preferably the others). All those first type input signals can instructions used for controlling the lighting drivers 16 and/or fixtures 17.

[0070] The at least one second type input signal is received at the second type input port being the wireless control interface 19. Different input devices can be connected to the same second type input port or wireless control interface 19 for receiving the instructions from the input devices. The second type input signal is preferably a digital signal comprising the instructions in a digital form modulated on the signal. The second type input signal is preferably a signal following the wireless control protocol. This second type input signal can be a wireless signal received from a software / application of a general computing device 20 communicating with the luminaire control module 1. This second type input signal can be a wireless signal received from an other input device wirelessly communicating with the luminaire control module 1, like a motion sensor, a daylight sensor, etc.. The mentioned software or other input device sending the second type input signal to the luminaire control module follows preferably the same wireless control protocol. The luminaire control module 1 can receive over the wireless control interface 19 also other signals, e.g. for programming the luminaire control module 1, for updating a firmware, etc.

[0071] The luminaire control module 1 is configured to

generate at least one transformed output signal containing appropriate instructions for the lighting fixtures 17 and/or for the lighting drivers 16. The luminaire control module 1 is configured to read out instructions received on the at least one first input port (e.g. from the input device). The luminaire control module 1 is configured to prepare at least one transformed output signal for the at least one lighting fixture 17 and/or for the lighting driver 16 based on the instructions read out from the at least one first input signal. The luminaire control module 1 contains a logic for controlling the at least one lighting fixture 17 and/or for the lighting driver 16 based on the instructions received from the at least one first input signal. The result of this logic is an appropriate instruction for the at least one lighting fixture 17 and/or for the lighting driver 16. In one embodiment, the logic can be programmed. This programming of the logic can be done by putting the connector of the adapter of the luminaire control module 1 into a programming socket connected with a computer. After the programming, the luminaire control module 1 can be plugged again into the control socket of the PCB G. In another embodiment, the logic can be programmed by a user via the wireless control interface 19. The luminaire control module 1 is configured to prepare the at least one transformed output signal containing the appropriate instruction for the at least one lighting fixture 17 and/or for the lighting driver 16.

[0072] The at least one transformed output signal comprises preferably a plurality of transformed output signals. Thus, the luminaire control module 1 is configured to prepare a first transformed output signal and a second transformed output signal. The first, second and third transformed output signals contain all the appropriate instruction for the at least one lighting fixture 17 created based on the instructions read out from the at least one first input signal (and based on the logic of the luminaire control module 1). The first, second and third output signal distinguish however in their transmission protocols. The appropriate information of the three transformed output signals might also vary a bit depending on the transmission protocol. E.g. for the DALI protocol, each lighting driver 16 on the lighting bus 21 can be addressed independently, while in a 0-10V protocol all lighting drivers 16 on the lighting bus 21 are controlled in the same way. This could cause a difference in the appropriate instruction for the first and second output signal.

[0073] Preferably, the first transformed output signal is a DALI control signal, i.e. a signal following the DALI standard or a signal configured to generate a DALI signal by corresponding amplification. The first transformed output signal is a DALI signal with the lower voltage value being ground and/or the upper voltage value being the third supply voltage Vcc3 or the supply voltage provided to the luminaire control module 1. The maximum current of the DALI signal is preferably smaller than 50 milliamperes (mA), preferably smaller than 20 mA, preferably smaller than 10 mA, preferably smaller than 8mA.

[0074] Preferably, the second transformed output signal

is a 0-10V control signal, i.e. a signal directly following the 0-10V standard or a signal configured to generate a 0-10V signal by corresponding signal processing. In the shown embodiment, the second transformed output signal is a signal configured to generate a 0-10V signal by corresponding signal processing. In the shown embodiment, the second transformed output signal is a pulse width modulation (PWM) signal whose pulse width simulates a constant voltage value between a lower voltage value and an upper voltage value of the 0-10V control signal. The upper voltage value corresponds preferably to the third supply voltage Vcc3 or the supply voltage provided to the luminaire control module 1 or to 10V, if this supply voltage is higher than 10V. The lower voltage value is zero (for 0-10V) or the supply voltage provided to the luminaire control module 1 divided by 10 (for 1-10V). The PWM signal switches with a PWM switching frequency between a low voltage level (preferably ground) and a high voltage level (preferably the third supply voltage Vcc3 or the supply voltage provided to the luminaire control module 1) with the width of the high voltage level depending on the desired voltage value between 0-10V desired.

[0075] The luminaire control module 1 comprises at least one first output port for sending out the at least one transformed output signal. Preferably, the at least one first output port comprises a plurality of first output ports. Preferably, a first one 1.1 of the first output ports (the DALI output port 1.1) is configured to send out the first transformed output signal. Preferably, the second one 1.3 of the first output ports (the 0-10V output port 1.3) is configured to send out the second transformed output signal. Another one 1.4 of the first output ports is configured to give out or to provide a communication mode selection signal indicating, if the first transformed output signal or the second transformed output signal shall be given out to the lighting bus connector 15 or to the lighting bus 21 or if a DALI signal or 0-10V signal shall be given out to the lighting bus connector 15 or to the lighting bus 21.

[0076] The luminaire control module 1 will receive the data coming from several wired input devices such as movement sensors, lighting switches but also wireless signals coming from other luminaire control modules 1, smartphone applications and many other. These input signals will then be analyzed according to the logic and rules programmed on the said luminaire control module 1 and transformed into the appropriate output signals.

[0077] The bus communication interface 2 comprises a second input port 6 and a second output port 8. The bus communication interface 2 comprises a current amplifier. The current amplifier comprises an input terminal and an output terminal. The input terminal is connected to the second input port 6. The input terminal in the shown embodiment corresponds actually to the second input port 6. The output terminal is connected to the second output port 8. In the shown embodiment, the output terminal corresponds actually to the second output port 8.

The input/output terminal and/or the second input/output port 6/8 can be actual terminals to be connected to the PCB G, but could also be virtual terminals/ports on the PCB G like a position on a conductor track of the PCB G. In the shown embodiment, the bus communication interface 2 corresponds actually to the current amplifier. The current amplifier is a power amplifier configured to amplify the voltage and/or the current of the signal received on the input terminal / the second input port 6 to generate an amplified signal and/or to give out the amplified signal to the output terminal / the second output port 8. The second input port 6 is connected with the first output port 1.1. Thus, the bus communication interface 2 or the current amplifier receives from the first output port 1.1 the DALI control signal, generates an amplified DALI control signal (also called the DALI signal) and gives out the amplified DALI control signal. The current amplifier preferably amplifies the voltage and the current of the DALI control signal. Preferably, the upper voltage level of the DALI signal corresponds to the first support voltage Vcc1. Preferably, the upper voltage level of the DALI signal is preferably larger than 9V, preferably larger than 10V, preferably larger than 11V, preferably larger than 12 V, preferably larger than 13V, preferably larger than 14V, preferably larger than 15V, preferably larger than 16V and/or is preferably smaller than 22V, preferably smaller than 21V, preferably smaller than 20V. Preferably, the upper voltage level of the DALI signal conducts a current of more than 50mA, preferably more than 100 mA, preferably more than 150 mA, preferably more than 200 mA. This allows to use the DALI signal on a lighting bus 21 over large distances and with a high number of lighting drivers 16.

[0078] Fig. 3 shows an embodiment of the bus communication interface and/or of the current amplifier which comprise a switch T1. The switch comprises a first terminal, a second terminal and a control terminal. The switch T1 can be transistor, e.g. a MOSFET or a bipolar transistor. In this case the control terminal corresponds to the gate of the transistor. The input terminal or the second input port 6 is connected to the control terminal of the switch T1. If necessary, a resistor R1 adapts the voltage and/or current level of the high voltage level of the DALI control signal to a suitable voltage and/or current level for switching the switch T1. The first terminal is connected to ground. The second terminal is connected to the output terminal (or second output port 8) and to the first supply voltage Vcc1. When the switch T1 is closed, the second output port 8 is connected with ground and a low voltage level of the DALI signal is created on the second output port 8. When the switch T1 is opened, the second output port 8 is (separated from the ground and is) connected with the first supply voltage Vcc1 and a high voltage level of the DALI signal is created on the second output port 8. The switch T1 is closed, when the DALI control signal on the second input port 6 has a low voltage level, and/or is opened, when the DALI control signal on the second input port 6 has a high voltage level.

[0079] A current protection circuit 22 of the current amplifier protects the current amplifier from an current peak from the power supply module 5. The current protection circuit 22 comprises another switch T2, preferably a transistor, preferably bipolar transistor, which interrupts the connection between the first supply voltage Vcc1 and the output terminal or the transistor T1, if the first supply voltage Vcc1 provides a current increasing above a threshold level. The threshold level is defined by the resistor R4. The resistor R5 is configured to avoid a connection between Vcc1 and ground, if the transistor T1 closes.

[0080] The bus communication interface 2 or the current amplifier comprises preferably a further second output port 7 connected over a voltage divider to the second output port 8. The voltage divider is configured to provide the signal of the second output port 8 on the further second output port 7, but with a reduced voltage level. The voltage is reduced such that the high voltage level of the DALI signal on the second output port 8 corresponds on the further second output port 7 to the high voltage level of the DALI control signal or to the third supply voltage Vcc3. The further second output port 7 is connected with the first input port 1.2 for receiving DALI messages from the lighting bus 21. Thus, (when the second output port 8 is connected to the lighting bus 21,) the DALI messages from the lighting bus 21 are conducted to the second output port 8 with the DALI voltage of the lighting bus 21 corresponding to the third supply voltage. The voltage divider reduces the DALI voltage to the third supply voltage and/or converts the DALI signal back to a DALI control signal which is sent over the further second output port to the luminaire control module 1. This solution with the voltage divider is very easy and stable. The voltage divider is realized by a first resistor R2 between the second output port 8 and the further second output port 7 and by a second resistor R2 between the further second output port 7 and ground.

[0081] Thus, the current amplifier of this embodiment shown in Fig. 3 provides a series of electrical current amplifier circuits comprising bipolar transistors. The current amplifier or the bus communication interface 2 comprises an electrical circuit comprising a set of transistors (at least one, preferably two), resistors (at least one, preferably more) and diodes being designed to amplify the signal coming from the luminaire control module 1 at its input terminal. In order to provide the amplified version of the input signal (from the input terminal) at the output terminal a connection with a voltage source is required. Said voltage source connection being made with the power supply module 5 as explained on Fig. 3. The bus communication interface 2 will receive the output signal provided at the output port of said luminaire control module 1 and will provide an amplified signal at its output terminal, without modifying the characterizing elements of the signal.

[0082] The input/output terminal and/or the second input/output port 6/8 and/or the further second output port 7 can be actual terminals/ports to be connected to the

PCB G, but could also be virtual terminals/ports on the PCB G like any position on a conductor track of the PCB G.

[0083] The further bus communication interface 4 is configured to process the second transformed output signal (from the first output port 1.3) into a bus signal, preferably is configured to process 0-10V control signal into a 0-10V signal. The further bus communication interface 4 comprises preferably an input 4.1 connected with the first output port 1.3 and/or comprises preferably an output 4.2 connected (over the switching module 3) to the lighting bus connector 15 and/or to the lighting bus 21. Fig. 6 shows an embodiment of the further bus communication interface 4.

[0084] The further bus communication interface 4 comprises preferably a low-pass filter 23, here realized as RC filter with the resistor R6 in the line between the input 4.1 and the output 4.2 and a capacitor C1 connected between ground, the resistor R6 and the output 4.2 or the amplifier circuit 24. The low-pass filter 23 smooths the PWM signal of the 0-10V control signal resulting in the constant voltage level between the lower voltage value and an upper voltage value of the 0-10V control signal inferred by the PWM signal.

[0085] The further bus communication interface 4 comprises preferably an amplifier circuit 24 for amplifying the voltage and/or current of the constant voltage level received from the low pass filter 23. The amplifier circuit 24 preferably amplifies the voltage such that the upper voltage value of the PWM signal or the 0-10V control signal corresponds to 10V to obtain the 0-10V signal. Therefore, preferably a amplifier 25 is used. The amplifier 25 uses preferably the second supply voltage Vcc2 for the voltage (and preferably current) amplification. The amplifier 25 can be an operational amplifier. The resistors R7 and R8 are defined by the upper voltage value of the PWM signal and Vcc2.

[0086] The further bus communication interface 4 can comprise a capacitor C2 for stabilizing the constant voltage level of the 0-10V signal. The 0-10V signal provided by the further bus communication interface 4 is given out at the output 4.2.

[0087] The switching module 3 provides a switch for switching either the 0-10V signal or the DALI signal to the bus connector 15 or to the bus 21. The switching module 3 provides a switch for connecting either the second output port 8 of the bus communication interface 2 (DALI mode or DALI Master mode) or the output 4.2 of the further bus communication interface 4 to the bus connector 15 or the bus 21 (0-10V mode). The switching module 3 provides a switch for connecting either DALI output port 1.1 (over the bus communication interface 2) or the 0-10V output port 1.3 (over the further bus communication interface 4) to the bus connector 15 or the bus 21.

[0088] The switching means 3 is preferably controlled by a communication mode selection signal. The communication mode selection signal can be generated by the

luminaire control module 1 (as shown in Fig. 2). However, the communication mode selection signal can be generated/controlled also by other parts of the luminaire control device 14. The communication mode selection signal can be generated by a wireless switching interface mounted on the PCB or outside of the luminaire control module (as shown in the second embodiment in Fig. 7). The wireless switching interface 28 is preferably a near field communication device. The wireless switching interface can be passive, i.e. a transponder. The second embodiment of the luminaire control device shown in Fig. 7 shows such a wireless switching interface for controlling the switching state of the switching means 3. The communication mode selection signal can be generated also be a mechanical user input device like a push button, a mechanical switch or a knob. Instead of controlling the switching means by a signal, the switch could be controlled directly mechanical (not preferred as difficult to realize in a small housing).

[0089] The switching module 3 comprises preferably at least three third input ports 11, 12, 13 and one third output port 10. Fig. 4 shows an exemplary embodiment of the switching module 3. The third output port 10 is connected to the bus connector 15 and/or to the bus 21. A first one 11 of the third input ports (DALI input port 11) is connected to the second output port 8 of the bus communication interface 2. A second one 13 of the third input ports (0-10V input port 13) is connected to 0-10V output port 1.3 of the luminaire control module 1 (via the further bus communication interface 4). Preferably, the 0-10V input port 13 is connected to the output 4.2 of the further bus communication interface 4. Thus, the DALI input port 11 receives the (amplified) DALI signal and the 0-10V input port 13 receives the 0-10V signal. The switching means 3 comprises preferably a (2-way) switch 26 which connects either the DALI input port 11 or the 0-10V port 13 to the third output port.

[0090] The switching means 3 is preferably controlled by a communication mode selection signal at the third output port 12 (mode selection port). Based on the communication mode selection signal received on its mode selection port, it will decide on which signal, received at one of the third input ports 11, 12, 13, will be passed on and made available on the third output port 10 of said switching module 3. This third output port 10 will be then provide the output message to the connected lighting drivers 16. Thus, the switching module 3 will, according to the instruction received on the mode selection port 12, determine which of the received signals at its input ports 11, 13 will be put on its output port 10. Thus, the switching means 3 or the switch 26 is controlled electrically, not mechanically. This has the advantage that the housing can be kept small and does not require space for a mechanical actuator for actuating the switch. In the shown embodiment, the mode selection port 12 is connected to the (output port 1.4 of the) luminaire control module 1. Thus, the switching means 3 or the switch 26 is controlled by the luminaire control module 1.

[0091] Fig. 4 is an electronic schema representing the switching module 3 of the first embodiment of the luminaire control device 14. As it can be seen on this example, 11 & 13 are output signals coming from either the luminaire control module 1 or the bus communication interface 2. The mode selection port is represented by 12, receiving a mode selection signal coming from the luminaire control module 1, indicating which output protocol should be used to communicate with the external Lighting drivers 16. The number of instructions that can be comprised in the mode selection signal is equal or higher than the amount of input ports available on the switching module 3. The desired signal received on one of the input ports of the switching module 3 will then become available on its output port 10 as well.

[0092] The switching module 3 allows to reduce the number of external connectors of the luminaire control device 14 or its housing so that the luminaire control device 14 can be realized very small.

[0093] The lighting bus connector 15 comprises preferably two connection terminals for connecting the two wires of the lighting bus 21. One of the two terminals of the lighting bus connector 15 is connected to the third output port 10 of the switching module 3. The other of the two terminals of the lighting bus connector 15 is connected to ground. Thus, when the switching module 3 connects the third input port 11 and the third output port 10, the further second output port 7 of the bus communication interface 2 is connected via the voltage divider to both terminals of the bus connector 15 (one terminal via the switching module 3, the other terminal via ground).

[0094] The relay module H is configured to control a relay (external to the luminaire control device 14) which is connected between the power supply and one or more of the lighting drivers 16. For some configurations, e.g. for the 1-10V protocol, relays are often used. The luminaire control module 1 can be programmed/configured to control such a relay. In this case, the luminaire control module 1 gives out a relay control signal on its output port 1.7. The relay control signal is received at the relay module H which provides in response to receiving the relay control signal a power signal on the output connector C. The power signal is preferably the AC mains power from the power connector A. If the relay module H does not receive the relay control signal (or a relay control signal which indicate no relay configuration), the AC mains power is not any more given out to the connector C.

[0095] The input connector E is preferably configured to connect an external input device with a cable to the luminaire control device 14/module 1. The input connector E is preferably configured to receive input signals from the input device and/or to provide the input device with power. The input connector E is here an Ethernet connector (also called RJ-45). However, other connectors are equally possible. The connection of the pins E.1 and E.4 already described. The pin E.3 is connected to ground. The pin E.5 is connected to one of the supply voltages, preferably the third supply voltage Vcc3. The

pins E.3 and E.5 provide the power to the input device. The pin E.6 is connected to the output port 1.9 which gives out a presence LED signal for switching on an LED in the input device, when a motion was detected in the motion sensor. The pin E.2 is not used.

[0096] The described luminaire control device 14 is thus a polyvalent connection box. It allows to unite the functions of wireless gateway to receive wireless commands from smartphones, computers or other luminaire control devices 15, an amplified DALI signal controller for controlling a large amount of DALI lighting drivers 16 connected over the bus connector 15 controlled by the wireless control interface of common smart lighting applications, an amplified 0-10V or 1-10V controller for controlling a large amount of 0-10V lighting drivers 16 connected over the bus connector 15 having the option for a relay as well and controlled by the wireless control interface of common smart lighting applications. The same polyvalent connection box can thus be used in nearly any lighting protocol configuration available and can nevertheless be easily programmed and controlled over the wireless control interface 19. The amplification of the DALI signal and/or the 0-10V signal allows to connect a large number of lighting drivers 16 to the bus. The input connector allows to connect very simply input device 18 via a cable directly on the luminaire control device 14 without complex sensors communicating wirelessly or over the bus 21. The PCB G with the control slot/socket allows to use the same PCB G for many luminaire control chips/modules depending on the preferred wireless control interface and their user interface apps. Notwithstanding the large amount of functions, the luminaire control device 14 is small and very easy to assemble. Thanks to the amplification, long distances between the different lighting drivers 3 can be covered and a higher amount of said lighting drivers 3 can be controlled by one single luminaire control module 1/one single luminaire control device 14. Thus, the described luminaire control device 14 provides a versatile, small, easy to assembly and powerful luminaire control device 1.

[0097] In the above described embodiment, the luminaire control device is operated in the DALI mode in a DALI Master mode. The same DALI bus 21 can have only one DALI participant being in the DALI Master mode, while all other DALI participants must be in the DALI Slave mode. Thus, the luminaire control device 14 described above cannot be used for DALI buses which contain already an DALI Master.

[0098] In a second embodiment of the luminaire control device 14, a DALI slave mode is added compared to the operation modes (DALI Master mode and 0-10V mode) of the above described embodiment. The second embodiment of the luminaire control device is realized as described in the first embodiment, if not mentioned otherwise. The description of the DALI mode above corresponds to the functioning of the DALI Master mode of the second embodiment. Fig. 7 shows an exemplary circuit of the second embodiment of the luminaire control

device.

[0099] The switching module 3' is configured to switch the luminaire control device 14 between the 0-10V mode, the DALI Master mode and the DALI slave mode. In an alternative embodiment, it is also possible to switch only between the DALI Master mode and the DALI Slave mode. In the shown embodiment, the switching module 3' is realized like the switching module 3 of the first embodiment, just the 2-way switch of the first embodiment is replaced by a three way switch, wherein a fourth third input port 29 is added which is connected to the third output port 10 in the DALI slave mode. The mode selection signal is received from a near field communication (NFC) module 28. Preferably, the NFC module 28 stores also the DALI Slave address of the luminaire control device 14, when operated in the DALI Slave mode. Therefore, an output port 28.1 of the NFC module 28 is connected with the mode selection port 12 of the switching module 3'. Instead of a three-way switch, the switching module could also be realized by a first switch (e.g. as shown in the first embodiment switching between DALI and 0-10V) and a second switch switching between Master and Slave, when the first switch is in the DALI mode. Other realizations of the switching module are possible.

[0100] The fourth third input port 29 of the switching module 3' is connected with a first output 8' of a DALI Slave bus communication interface 2' which is used for sending and/or receiving DALI messages in the Slave mode. The input 6' of the DALI Slave bus communication interface 2' is connected to a first output port (DALI TX port) of the luminaire control module 1 and second output 7' of the DALI Slave bus communication interface 2' is connected to a first input port 1.2' (DALI RX port) of the luminaire control module 1. In this embodiment, the first input port 1.2 is different from the first input port 1.2', i.e. they correspond to different pins of the luminaire control chip. In this embodiment, the first output port 1.1 is different from the first output port 1.1', i.e. they correspond to different pins of the luminaire control chip. It would however also be possible to use the same output and input ports for the bus communication interfaces 2 and 2'. Just the programming of the luminaire control module 1 would become more complex.

[0101] The DALI slave bus communication interface 2' works for the sending of DALI messages to the lighting bus 21 as described in Fig. 3 (see Fig. 8), just without the first supply voltage Vcc1 as the bus voltage from the DALI Master is used as supply voltage. Instead of a voltage divider, the voltage level of the DALI signal from the bus is down converted by a second transistor T2 which connects the second output port 7' either with ground (if lower voltage level of DALI signal is on the first output port 8' and on the gate) or with the third supply voltage Vcc3 (if higher voltage level of DALI signal is on the first output port 8' and on the gate).

[0102] The system comprises preferably one or more further luminaire control modules, at least one further lighting driver and at least one further lighting fixture. The

further luminaire control module is preferably realized as a luminaire control device 14 as described above in the first embodiment or in the second embodiment (in the latter case in the DALI master or 0-10V mode). Each of the one or more further luminaire control modules are connected with a further lighting bus to at least one further lighting driver which is connected each to at least one lighting fixture.

[0103] The luminaire control module 1 in the DALI slave mode is configured to forward the content of the DALI messages received at the luminaire control device 14 (i.e. addressed to the DALI Slave address of the luminaire control device) via the wireless control interface 19 to one or more further luminaire control modules with respective wireless control interfaces 19. The one or more further luminaire control modules or their wireless addresses in the wireless control protocol are associated in the luminaire control module 1. So, the luminaire control module 1 knows that all DALI messages received shall be forwarded to the one or more further luminaire control modules 1. Each associated further luminaire lighting control module will receive the content of the DALI message over its/their wireless control interface and generate a DALI signal or a 0-10V signal on the further lighting bus with the content of the received DALI message to control the at least one further lighting driver connected over the further lighting bus with the respective further luminaire control module.

[0104] The parts and modules of the luminaire control device 14 described are preferably arranged all in the same device 14. In another embodiment, it is however also possible that they are distributed over more than one device of the system.

[0105] It should be understood that the present invention is not limited to the described embodiments and that variations can be applied without going outside of the scope of the appended claims.

Claims

1. A system for controlling a series of lighting fixtures for illumination in an environment, the system comprising:
 - a. A luminaire control module (1) comprising one or more first input ports (1.5, 1.6) and at least one first output port (1.1, 1.4, 1.3), said luminaire control module (1) being provided to receive at least one first input signal at one of the one or more first input ports (1.5, 1.6) and to read the instruction comprised in said at least one first input signal and to generate a corresponding first transformed output signal containing the appropriate instruction for the series of lighting fixtures (17),
 - b. A bus communication interface (2) comprising at least one current amplifier module, a second

- input port (6) and a second output port (8), said current amplifier module being provided for amplifying the current level of said corresponding first transformed output signal received through said second input port (6) and for providing an amplified version of said corresponding first transformed output signal at said second output port (8),
- c. at least one lighting driver (16) provided for controlling at least one lighting fixture (17) of said series of lighting fixtures (17), said second output port (8) of the bus communication interface being further connected to said at least one lighting driver (16).
2. The system according to claim 1, wherein said at least one first output ports (1.1, 1.3, 1.4) of said luminaire control module (1) is a plurality of first output ports (1.1, 1.3, 1.4), a first one (1.1) of the first output ports (1.1, 1.3, 1.4) being provided for issuing the first transformed signal being a different transformed signal with respect to a second transformed signal being provided from a second one (1.3) of the first output ports (1.1, 1.3, 1.4), said system further comprising a switching module (3) having at least two third input ports (11, 12, 13) and a third output port (10), a first one (11) of said at least two third input ports (11, 12, 13) being connected to the first one (1.1) of the first output ports (1.1, 1.3, 1.4) of the luminaire control module (1), a second one (13) of the third input ports being connected to the second one (1.3) of the first output ports of the luminaire control module (1), wherein the switching module (3) is configured to decide on which signal, received at one of the third input ports (11, 13) of the switching module (3), will be passed on and/or made available on the third output port of said switching module (3).
 3. The system according to the previous claim, wherein the first one (11) of the third input ports (11, 12, 13) of said switching module (3) is connected to the second output port (8) of the bus communication interface (2) and/or is connected through the bus communication interface (2) to the first one (1.1) of the first output ports (1.1, 1.3, 1.4) of the luminaire control unit (1), wherein the first transformed signal being a DALI control signal, wherein the second transformed signal being a 0-10V control signal.
 4. The system according to one of claims 2 to 3 comprising a further bus communication interface (4) connected between the second one (1.3) of the first output ports (1.1, 1.3, 1.4) of the luminaire control module (1) and the second one (13) of the third input ports (11, 12, 13) of the switching module (3).
 5. The system according to one of the claims 2 to 4, wherein the system comprises a power supply module (5) configured to convert an AC mains current into a plurality of DC supply voltages, the plurality of DC supply voltages comprises a first supply voltage (Vcc1) for the current amplifier of the bus communication interface (2), a second supply voltage (Vcc2) for the further bus communication interface (4) and a third supply voltage (Vcc3) for the luminaire control module (1), wherein the first supply voltage (Vcc1) is larger than the second supply voltage (Vcc2), and the second supply voltage (Vcc2) is larger than the third supply voltage (Vcc3).
 6. The system according to the previous claim, wherein the first supply voltage (Vcc1) is larger than twelve Volt and wherein the second supply voltage (Vcc2) is ten Volt, wherein the first transformed signal being a DALI control signal, wherein the second transformed signal being a 0-10V control signal.
 7. The system according to one of the previous claims, wherein the luminaire control module (1) comprises a wireless control interface (19), wherein the wireless control interface (19) is configured to act as one of the one or more first input ports (1.5, 1.6, 19) for receiving at least one of the first input signal, wherein the wireless control interface (19) is configured to build a wireless mesh network with other lighting devices.
 8. The system according to one of the previous claims comprising a luminaire control device (14), wherein the luminaire control device (14) comprises the luminaire control module (1), the bus communication interface (19), a switching means (3') and a lighting bus connector (15), wherein the at least one driver (16) is connected over the lighting bus connector (15) to the luminaire control device (14), wherein the second output port (2) of the bus communication interface (2) is connected or connectable to the lighting bus connector (15), wherein the luminaire control module (1) comprises a wireless control interface (2), wherein the wherein the switching means (3') is configured to switch the luminaire control device (14) between a DALI Master mode and a DALI slave mode, wherein, in the DALI Master mode, the wireless control interface (19) is configured to act as one of the one or more first input ports (1.5, 1.6, 19) for receiving at least one of the first input signal, the luminaire control module (1) is configured to read the instruction comprised in said at least one first input signal and to generate a corresponding first transformed output signal containing the appropriate instruction for the series of lighting fixtures (17), and the bus communication interface (2) is config-

- ured to provide the amplified version of said first transformed output signal at said lighting bus connector for controlling the at least one lighting fixture (17) connected to the lighting bus connector (15);
 wherein, in the DALI Slave mode,
 a DALI Master device is connected over the lighting bus connector (15) to the luminaire control device (14),
 the luminaire control device is configured to receive a DALI message addressed to the DALI Slave address of the luminaire control device on the lighting bus connector (15), wherein the DALI message contains an instruction for controlling at least one further lighting driver,
 the wireless control interface (19) being configured to send the instruction of the received DALI message wirelessly to the at least one further lighting driver.
9. The system according to claim , wherein the switching means comprises a NFC wireless switching interface for receiving a wireless switching control signal comprising information about the switching mode being a DALI Master mode or the DALI Slave mode and, in the SLAVE mode, about the DALI Slave address of the luminaire control device.
10. The system according to one of the previous claims, comprising a luminaire control device (14) with a printed circuit board (G), the luminaire control device (14) is connected over a lighting bus (21) with the at least one lighting driver (16), wherein the luminaire control module (1) and the bus communication interface (2) are mounted on the printed circuit board (G), wherein the luminaire control module (1) comprises a luminaire control chip connected to the printed circuit board (G), wherein the luminaire control module/chip (1) comprises a wireless interface (19) for receiving a first one of the at least one first input signal.
11. The system according to the previous claim, wherein the at least one first input signal comprises a first one and a second one of the at least one first input signal, wherein the first one of the at least one first input is received at a first one of the one or more first input ports being the wireless control interface (19) and the at least one second one of the at least one first input signal is received at a second one of the one or more first input ports being at least one pin of the luminaire control chip.
12. The system according to one of claims 10 to 11, wherein the printed circuit board (G) comprises a control socket, wherein the luminaire control module (1) is removably connected to the printed circuit board (G).
13. The system according to one of the previous claims, wherein the one or more first input ports (1.5, 1.6) of the luminaire control module (1) comprise a first input port (1.2) configured to receive DALI messages, wherein the bus communication interface (2) comprises a further second output port (7) connected to the first input port (1.2) configured to receive DALI messages, wherein the bus communication interface (2) comprises a voltage divider between the second output port (8) and the further second output port (7).
14. A luminaire control device for controlling a series of lighting, the system comprising:
- A luminaire control module (1) comprising one or more first input ports (1.5, 1.6) and at least one first output port (1.1, 1.4, 1.3), said luminaire control module (1) being provided to receive at least one first input signal at one of the one or more first input ports (1.5, 1.6) and to read the instruction comprised in said at least one first input signal and to generate a corresponding first transformed output signal containing the appropriate instruction for the series of lighting fixtures (17),
 - A bus communication interface (2) comprising at least one current amplifier module, a second input port (6) and a second output port (8), said current amplifier module being provided for amplifying the current level of said corresponding first transformed output signal received through said second input port (6) and for providing an amplified version of said corresponding first transformed output signal at said second output port (8),
 - at least one lighting driver (16) provided for controlling at least one lighting fixture (17) of said series of lighting fixtures (17), said second output port (8) of the bus communication interface (2) being further connected to said at least one lighting driver (16).

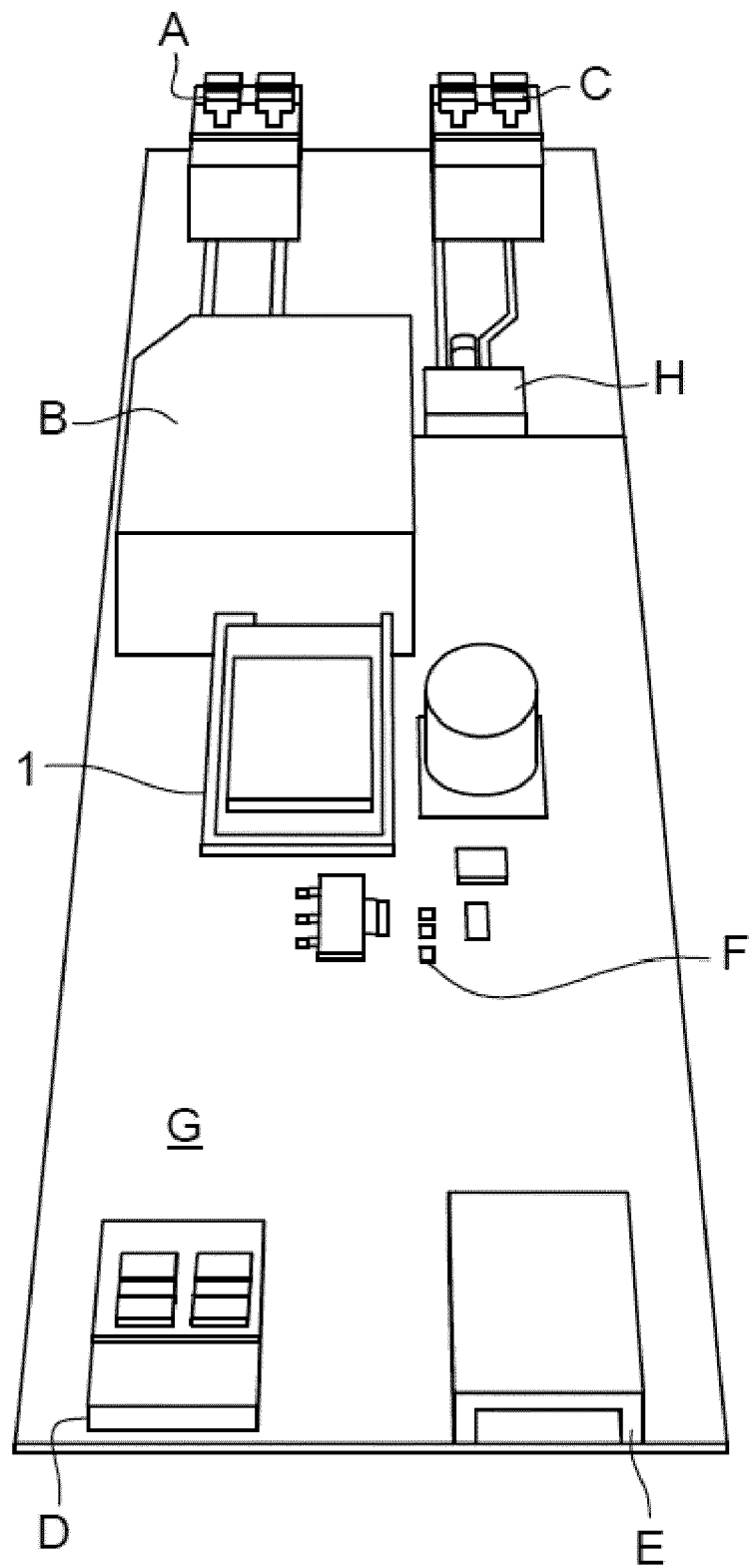


Fig. 1

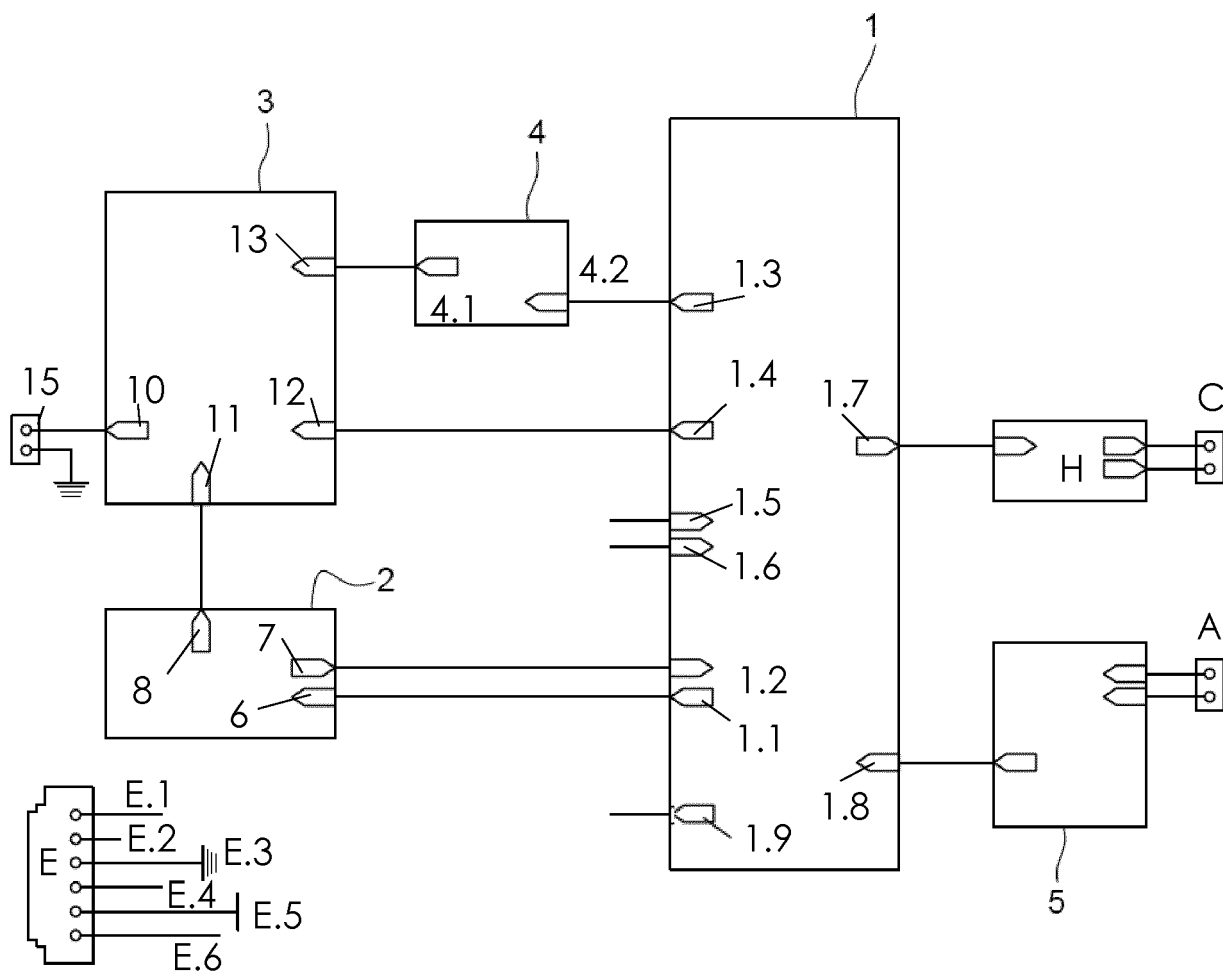


Fig. 2

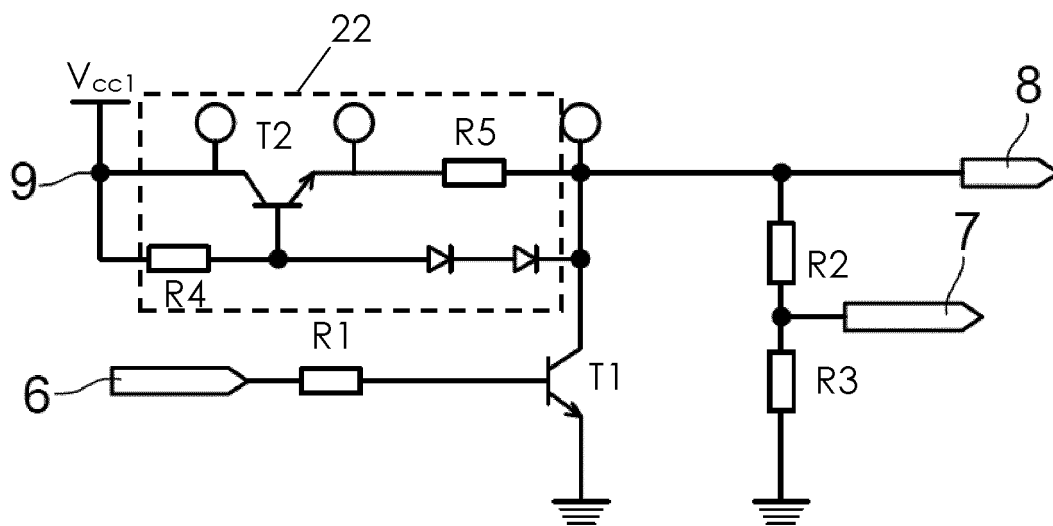


Fig. 3

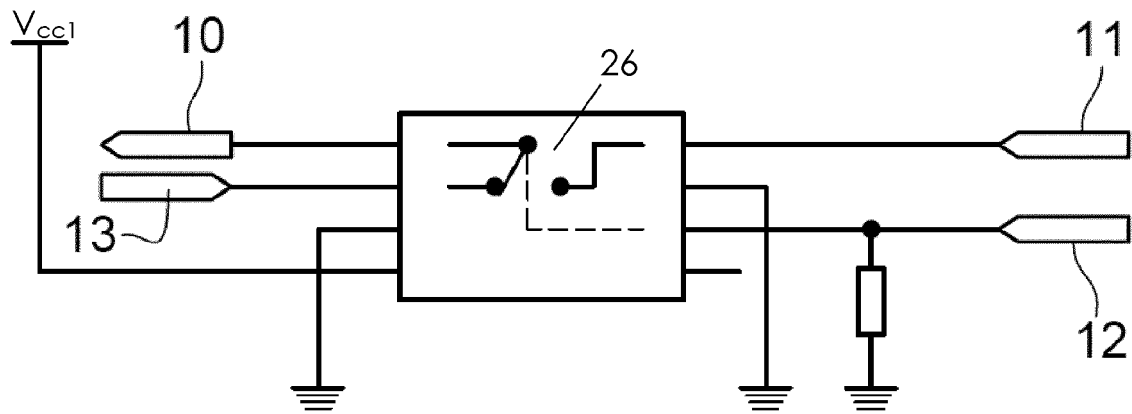


Fig. 4

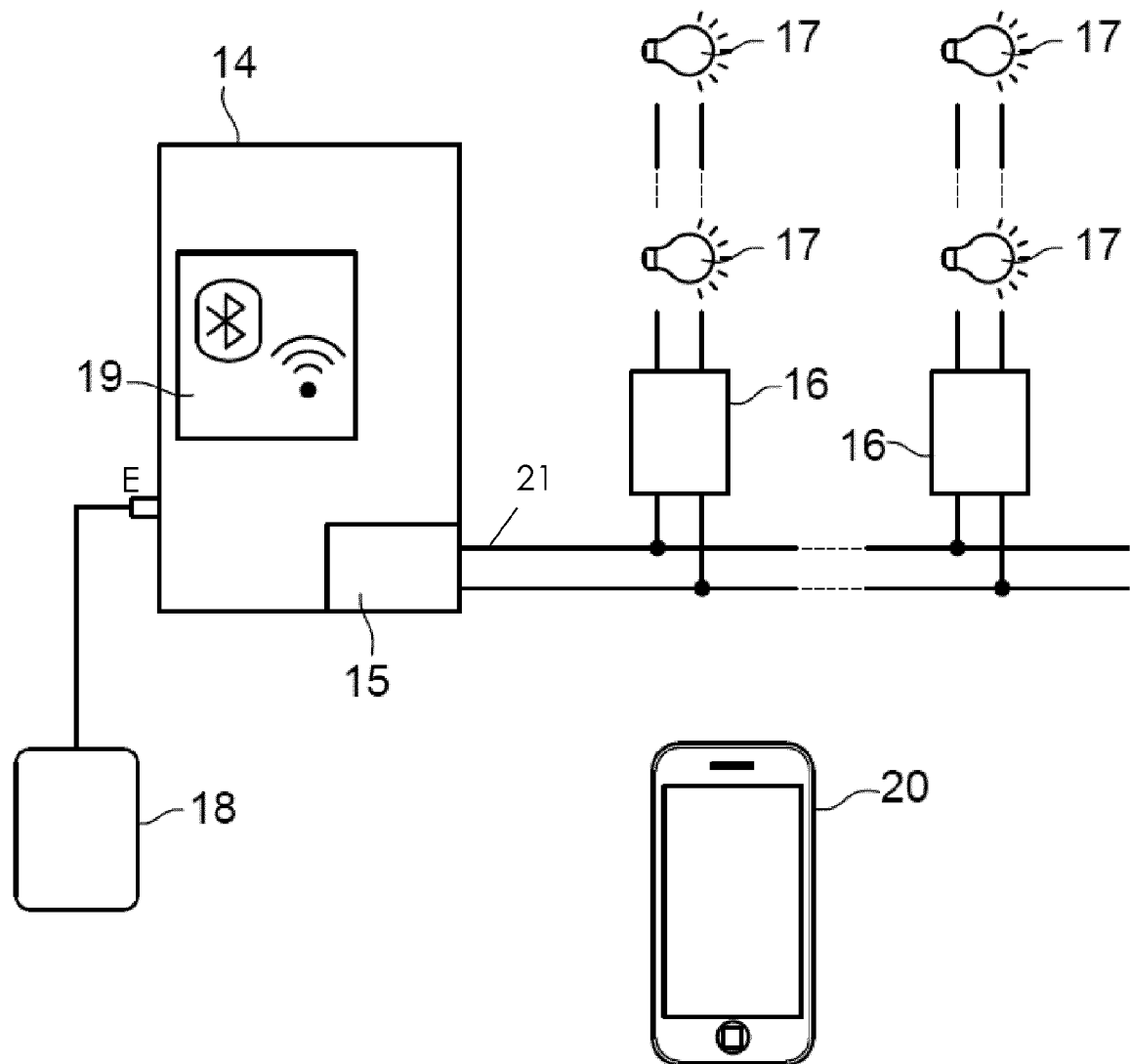


Fig. 5

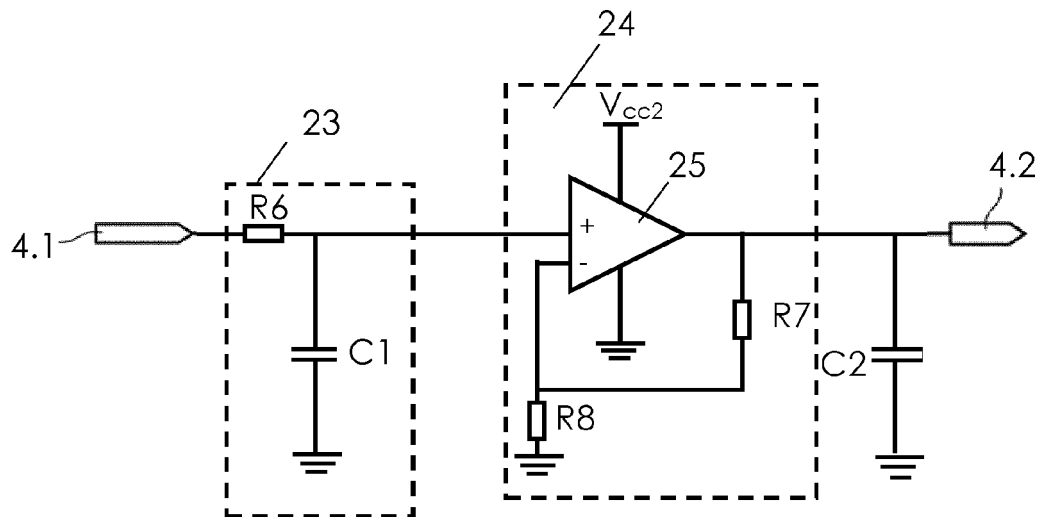


Fig. 6

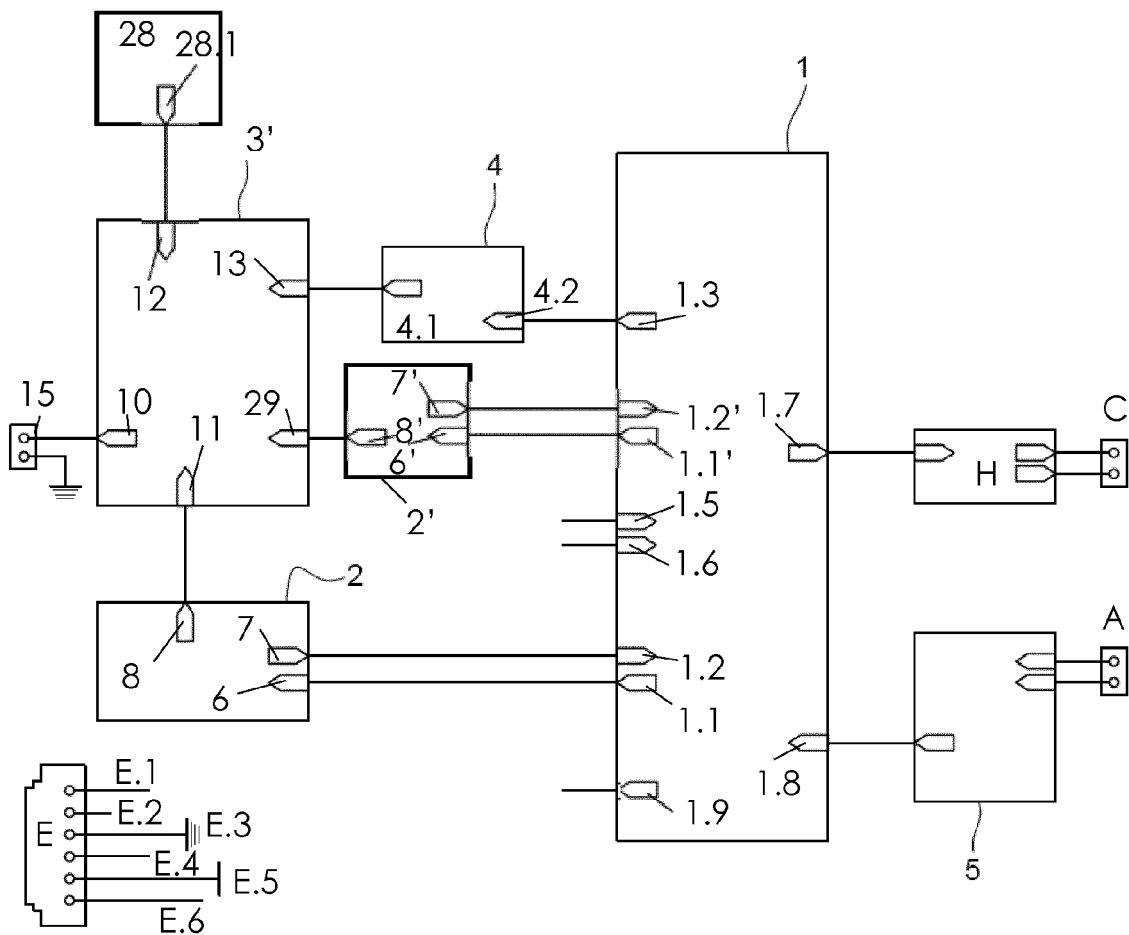


Fig. 7

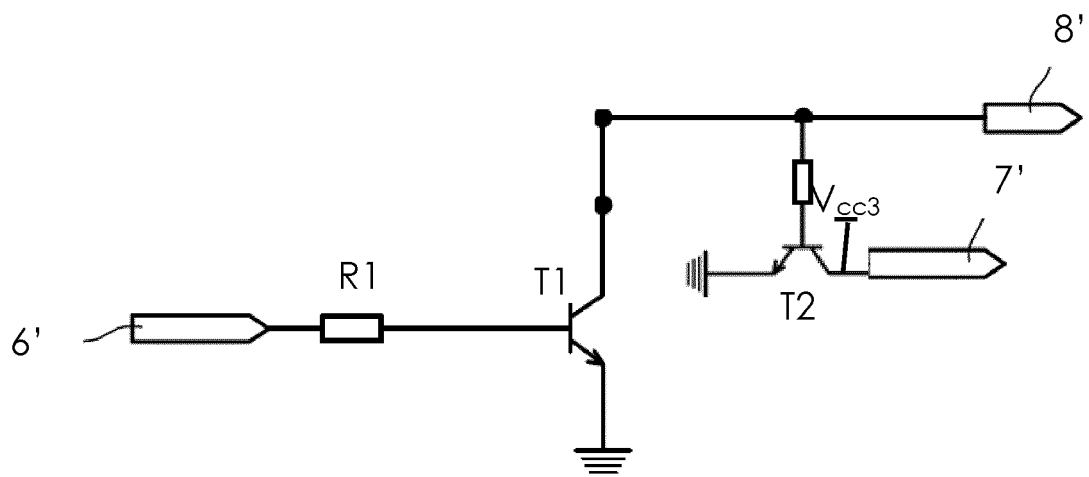


Fig. 8



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Place of search Munich		Date of completion of the search 3 September 2020	Examiner Henderson, Richard
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