

- (51) International Patent Classification:
H05B 47/115 (2020.01) F21V 23/04 (2006.01)
- (21) International Application Number:
PCT/EP2024/064483
- (22) International Filing Date:
27 May 2024 (27.05.2024)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
PCT/CN2023/098600
06 June 2023 (06.06.2023) CN
23182954.0 03 July 2023 (03.07.2023) EP
- (71) Applicant: SIGNIFY HOLDING B.V. [NL/NL]; High Tech Campus 48, 5656 AE Eindhoven (NL).
- (72) Inventors: ZIJLMAN, Theo, Gerrit; c/o High Tech Campus 7, 5656 AE Eindhoven (NL). ABBO, Anteneh, Alemu; c/o High Tech Campus 7, 5656 AE Eindhoven (NL). BUKKEMS, Peter, Johannes, Martinus; c/o High Tech Campus 7, 5656 AE Eindhoven (NL). PAN, Xin; c/o High Tech Campus 7, 5656 AE Eindhoven (NL). ZHOU, Liwen; c/o High Tech Campus 7, 5656 AE Eindhoven (NL).
- (74) Agent: VAN EEUWIJK, Alexander, Henricus, Waltherus et al.; High Tech Campus 7, 5656 AE Eindhoven (NL).
- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

(54) Title: LIGHTING DEVICE WITH MOTION SENSING CAPABILITY

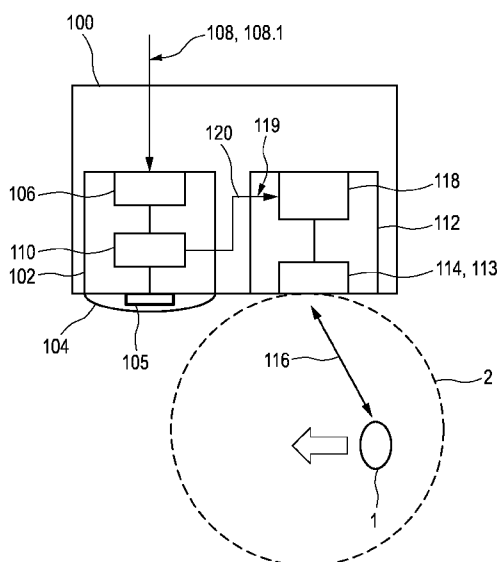


FIG. 1

(57) Abstract: The invention is directed to a lighting device (100) with motion sensing capability, which comprises a lighting module (102) comprising a lighting unit (104), a control-signal input unit (106) configured to receive lighting control signals (108) and a lighting control unit (110) for controlling the lighting unit bases on the received lighting control signals. It further includes a motion sensing module (112) comprising a sensing-signal input unit (114) for receiving sensing signals (116), and a sensing control unit (118) for determining a motion of a subject or object (1) within a sensing volume (2) using the RF-sensing signals. The lighting control unit, upon receiving a predetermined lighting control signal (108.1), is configured to generate and provide a sensing-module control signal. Upon receiving the sensing module control signal (119), the motion-sensing module is configured to operate in a low power operation mode ensuring the functionality of the lighting module.

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

- *with international search report (Art. 21(3))*

Lighting device with motion sensing capability

FIELD OF THE INVENTION

The present invention is directed to a lighting device with integrated motion sensing capability. The invention is further directed to a method for controlling operation of such a lighting device and to a computer program.

5

BACKGROUND OF THE INVENTION

Lighting control systems, also referred to as “smart lighting”, incorporate communication between various system inputs and outputs related to lighting control with the use of one or more central computing devices. Lighting control systems are widely used on both indoor and outdoor lighting of commercial, industrial, and residential spaces.

10

US 2022/0295621 A1 describes a radar-based motion detection systems to achieve power reduction of a radar sensor by operating the radar sensor in a sub-sampling manner in an illumination control system. By combining the information related to the detection area and the state of a lighting device, the sampling frequency of a radar sensor is configured. A balance between power reduction and motion detection performance is achieved therefrom.

15

SUMMARY OF THE INVENTION

Motion detection, for instance, fall detection for elderly care, is extremely important for future health care. This functionality can be integrated with smart lighting in lamps and luminaires and as such will find its way in professional health care institutes and homes of consumers. The integration with smart lighting in one device will give challenges for optimal functionality in the power domain.

20

The inventors have realized that, when a smart lighting compatible lighting device is used together with a motion detection module in one device, reliable operation could be hampered as the algorithms of the motion detection tend to consume a lot of processing power. It would therefore be beneficial to provide lighting devices that improve a control of the lighting device with integrated motion sensing capability.

25

According to a first aspect of the present invention, a lighting device with motion sensing capability is disclosed. The lighting device comprises a lighting module that includes a lighting unit configured to provide light, in particular for illuminating a volume or a room, a control-signal input unit that is configured to receive lighting control signals for
5 controlling an operational state of the lighting unit, and a lighting control unit configured to control the operational state of the lighting unit in dependence on the received lighting control signals. For realizing the motion sensing, the lighting devices includes a motion sensing module that comprises a sensing-signal input unit configured to receive sensing signals, and a sensing control unit connected to the sensing-signal input unit and configured
10 to determine a motion of a subject or object within a sensing volume using the received sensing signals. The sensing volume is therefore define as the region of space in which a motion of the subject or object causes a detectable impact on the r sensing signals.

According to the invention, the lighting control unit, upon receiving a predetermined lighting control signal, is configured to generate and provide to the motion
15 sensing module a sensing-module control signal for operating the motion sensing module in a low power operation mode for a low-power time span. Further, the motion sensing module, upon receiving the sensing module control signal, is configured to operate, in particular the sensing control unit, in the low power operation mode for the low power time span.

Therefore, when the lighting module receives one of a set of one or more
20 predetermined lighting control signals, in particular a lighting control signal indicative of a control operation of the lighting module requiring a given power amount that is not compatible with a power amount required by the motion sensing module for determining the motion of the subject or object in the sensing volume, the lighting control unit provides the sensing-module control signal instructing the motion sensing module to operate in the low
25 power operation mode. Non compatible is to be understood as the impossibility to perform both the lighting control operation and the motion sensing operation at the same time due to the limited available power. Thus, when the expected control operation of the lighting module specified by the received lighting control signal may enter in conflict with the determination of motion carried out by the motion sensing module, the provision of the
30 sensing-module control signals puts the motion sensing module in a low power mode that enables the lighting control unit to control the operation of the lighting module with the necessary power resources.

In the following, embodiments of the lighting device of the first aspect of the invention will be discussed.

In a preferred embodiment, the predetermined lighting control signal or signals, which, when received at the lighting control unit, triggers or trigger the generation and provision of the sensing module control signal for operating the motion sensing module in the low power operation mode include all available lighting control signals. In an embodiment, the start of the reception of a lighting control signal triggers the generation and provision of the sensing module control signal, without the need to wait for full reception and command decoding before providing the sensing module control signal. The low power time span is, for instance, at least a time span necessary for receiving and decoding the lighting control signal, in a case where the currently received lighting control signal is compatible with the operation of the motion sensing module.

In an embodiment, the lighting device is an, at least partially, wirelessly controlled lighting device. The operation of the lighting module can be controlled by providing wireless lighting control signals in according with a suitable wireless communication protocol, such as, for example WiFi, Zigbee, Bluetooth, BLE, Thread, or any other suitable wireless communication protocol. The lighting device may be signally coupled to other lighting devices or lighting control units via a digital addressable lighting interface (DALI). In another embodiment, the lighting device may additionally or alternatively be controlled by so-called smart switching techniques based on detection of interruption in a power line and controlling the light accordingly.

The predetermined time span can be a fixed time span that depends on the lighting control signal received or the lighting control unit, upon determining that the operation instruction has been carried out may be configured to generate and provide to the motion sensing module a sensing-module control signal for operating the motion sensing module in a normal power operation mode, thereby finishing the low-power time span.

In an embodiment, the lighting device further comprises a wired connection between the lighting module and the motion sensing module, in particular between the lighting control unit and the sensing control unit. The wired connection is configured to transmit the sensing module control signal from the lighting control unit to the motion sensing module. A wired connection is preferred because of the low power impact compared to a wireless connection.

In another embodiment, wherein the motion sensing module comprises a radar sensor configured to detect motion in the sensing volume. Radar is a well-known detection system that uses radio waves to determine the distance, angle, or velocity of moving objects. A radar system works by radiating energy into space and monitoring the echo or reflected

signals from the objects in the surround area, or the detection area. Typically, a radar sensor system has a transmitter that emits radio waves, or radar signals, into space in predetermined directions. When the radar signals come into contact with an object or a subject, they are usually reflected back or scattered in many directions, depending on the material and surface of the object or subject and also the injection angles of the radar signals. Some of the radar signals penetrate into the target or are absorbed by the target, to certain levels. Some of the radar signals that are reflected back towards the radar system are captured by a receiver in the radar system, which are the desirable ones that make the radar sensor system work. If an object or subject within the sensing volume is moving either toward or away from the transmitter, there is a corresponding change in the frequency of the reflected radio waves, caused by the Doppler effect. In a simple example, by comparing the frequency shifts between the emitted signals and the received echoes from the detection area, the radar system can derive the relative speed between the radar system and the moving object based on the Doppler effect. In addition to speed measurement, distance from a moving target and orientation of the moving target can also be derived. Depending on the operation mechanism, different methods may be used to derive a certain type of information. For a pulse radar, distance measurement can be based on the time-of-flight principle, whereas for a continuous wave radar the frequency shift of the received signal as compared to the transmitted signal is proportional to the distance travelled. An orientation of a moving target with regard to the radar sensor may be derived by employing certain kinds of antennas or antenna array.

In an alternative embodiment, the motion sensing module is configured to determine the motion within the sensing volume by analyzing a signal quality parameter of the received sensing signals, such as a received signal strength indication (RSSI) of the received signals or a channel state information (CSI) of a communication link between a signal emitter and a signal receiver.

In another embodiment, the lighting device further comprises a power supply unit for connection to an AC mains supply on one side, and to the lighting module and the motion sensing module on the other side. The power supply unit, for example, in an embodiment, a AC/DC converter, is configured to provide operative DC power for operation of the lighting device in an operation mode, and stand-by DC power for operation of the lighting device in a stand-by mode.

In a preferred embodiment, the motion sensing module, upon receiving the sensing module control signal, in particular from the lighting control unit, is configured to operate in a stand-by mode using the stand-by DC power provided by the power supply unit.

The motion sensing module can be configured as an infrared sensing module, an ultrasound sensing module or any other suitable sensing module. In a preferred embodiment, the motion sensing module is configured as a radiofrequency based sensing module having a sensing-signal input unit configured to receive radiofrequency sensing signals and a sensing control unit connected to the sensing-signal input unit and configured to determine the motion of the subject or the object within the sensing volume using the received radiofrequency sensing signals. Preferably, the motion sensing module, when operating in the low power mode, is configured to receive the sensing signals, in particular the RF-sensing signals, and store signal data pertaining to the received sensing signals, in particular for processing after the low-power time span has lapsed and the motion sensing module returns to normal operation.

Preferably, during the low-power time span where the motion sensing module is operating in the low power mode, the motion sensing module, in particular the sensing control unit, is configured to stop the reception of the sensing signals and/or a processing of the received sensing signals for the determination of the motion of a subject or object within the sensing volume using the received sensing signals, in particular the received RF-sensing signals. Since the evaluation of the data associated with the received sensing signals is particularly intense in terms of power consumption, stopping the evaluation of the sensing signals for determining the motion enables the use of the necessary power to perform the control of the operational state of the lighting unit. This can be done by stopping reception of the sensing signals or by stopping the evaluation of the received sensing signals, which are preferably stored and evaluated at a later time when the motion sensing module is no longer being operated in the low power operation mode.

In an embodiment, the lighting control unit is preferably configured to monitor a reduction of a power amount provided for operating the lighting device and to provide the sensing module control signal upon determining that a detected reduction has exceeded a predetermined threshold amount.

This is particularly advantageous for lighting devices that can be to some extent controlled using smart switching, which is based on phase detection i.e. detecting interruptions in the power supply and controlling the lighting unit accordingly. Preferably, at least a subset of the lighting control signals for controlling operation of the lighting unit are received via a power line for providing operational power, such as operational DC power or stand-by power from a power supply to the lighting device. In the case of smart switching the operational state of the lighting unit can be controlled by performing a predetermined number

of power off-power on cycles within a predetermined time span. For lighting devices without motion sensing capabilities the power decay time before full shut down in the lighting unit is normally very long because of the low power consumption of the lighting control unit.

However, with the extra power consumption of the motion sensing module, the smart switch functionality can be hampered as the control logic for controlling the operation of the lighting unit, which is based on the duration of mains switch-off intervals, is affected.

For instance, in an embodiment, the subset of lighting control signals include as a predetermined number of off-on cycles during a predetermined time span of a power signal received via the power line. Thus, in this particular embodiment of the lighting device, the lighting control unit is configured to control operation of the lighting unit in dependence on a number of power off-power on cycles, wherein two consecutive cycles have to be performed within a predetermined time span to be considered part of the same lighting control signal. For instance a single power off-power on cycle can be associated to a lighting control signal to operate the lighting unit according to first lighting parameters (e.g., a first light intensity, a first color temperature and/or a first light spectrum. Two power off-power on cycles can be associated to a lighting control signal to operate the lighting unit according to second lighting parameters and three cycles can be associated to a lighting control signal to operate the lighting unit in a stand by-mode, e.g. to turn off the lighting unit but operate the lighting control unit for monitoring reception of further lighting control signals.

In another embodiment, the lighting control unit is further configured to monitor a time that lapses between two power off-power on cycles and to control the lighting parameters based thereof.

Therefore, in order to keep smart lighting functionality in a lighting device with motion sensing capabilities (e.g. with a radar module integration) a simple interface to control the motion sensing module (e.g. radar module) in standby or deep sleep while keeping functionality is provided.

According to a second aspect of the invention, a method for controlling operation of a lighting device with motion sensing capability is disclosed. The method comprises:

- receiving lighting control signals for controlling an operational state of the lighting unit;
- controlling the operational state of the lighting unit in dependence on the received lighting control signal;
- receiving sensing signals, in particular radiofrequency sensing signals.

- determining motion of a subject or object within a sensing volume using the received sensing signals; and

- upon receiving a predetermined lighting control signal at a lighting control unit, generating and providing to a motion sensing module a sensing module control signal for operating the motion sensing module in a low power operation mode for a low-power time span; and

- upon receiving the sensing module control signal, operating the motion sensing module in the low power operation mode for the low power time span.

Thus, the method of the second aspect shares the advantages of the lighting device with motion sensing capability of the first aspect of the present invention.

In the following, embodiments of the method of the second aspect will be described.

In an embodiment, the method further comprises, upon receiving the sensing module control signal from the lighting control unit, operating the motion sensing module in a stand-by mode using stand-by DC power provided by a power supply unit.

In another embodiment, the method additionally or alternatively comprises monitoring a reduction of a power amount provided for operating the lighting device and providing the sensing module control signal upon determining that a detected reduction has exceeded a predetermined threshold amount.

In yet another embodiment the method further comprises receiving at least a subset of the lighting control signals via a power line for providing operational power from a power supply to the lighting device.

A third aspect of the present invention is formed by a computer program comprising instructions which, when executed by a lighting device (i.e. by the lighting control unit in combination with the sensing control unit) according to the first aspect of the invention, cause said lighting device to carry out the method of the second aspect of the invention.

It shall be understood that the lighting device of claim 1, the method of claim 10, and the computer program of claim 15, have similar and/or identical preferred embodiments, in particular, as defined in the dependent claims.

It shall be understood that a preferred embodiment of the present invention can also be any combination of the dependent claims or above embodiments with the respective independent claim.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

5 In the following drawings:

Fig. 1 shows a schematic block diagram of a lighting device with motion sensing capability according to a first embodiment of the invention,

Fig. 2 shows a schematic block diagram of a lighting device with motion sensing capability according to a second embodiment of the invention,

10 Fig. 3 shows power vs. time curves for known lighting devices with and without motion sensing capabilities in response to an input consisting of two consecutive power off-power on cycles,

Fig. 4 shows a flow diagram of a method for controlling operation of a lighting device in accordance with an embodiment of the invention, and

15 Fig. 5 shows a flow diagram of a method for controlling operation of a lighting device in accordance with another embodiment of the invention

DETAILED DESCRIPTION OF EMBODIMENTS

Fig. 1 shows a schematic block diagram of a lighting device 100 with motion
20 sensing capability according to a first embodiment of the invention. 1. The lighting device 100 comprises a lighting module 102 for illuminating a space or room and a motion sensing module 112 for performing the motion sensing operation, which involves determining whether an object or subject 1 is moving within a sensing volume 2. The sensing volume 1 is defined as that volume in space in which a motion of an object or subject affects the sensing
25 signals 116 that are received in a discernible manner. In this particular example, the motion sensing module is a RF-based motion sensing module. In other examples, the motion sensing module is an infrared motion sensing module, and ultrasound motion sensing module, a camera-based motion sensing module or any other suitable motion sensing module.

The lighting module 102 comprises a lighting unit 104 that is configured to
30 provide the light for illuminating the space around the lighting device. The lighting unit 104 may comprise a LED-based light source, a halogen light source, a fluorescent light source or any other suitable light sources 105. Particularly in the case of LED-based light sources, the parameters of the light emitted by the lighting module may be controlled. The parameters may include light intensity, color temperature and light spectrum. A given combination of

parameters is referred to as a light setting. The parameters may be varied in time to create a light effect. The lighting module 102 also comprises a control-signal input unit 106 that is configured to receive lighting control signals 108, 108.1 for controlling an operational state of the lighting unit 104 and a lighting control unit 110 that is signally connected to the control-signal input unit and configured to control the operational state of the lighting unit 104 in dependence on the received lighting control signals 108. The control-signal input unit may comprise an antenna for receiving wireless lighting control signals, in the case of wirelessly controllable lighting devices. It may also comprise a wired connection for receiving lighting control signals via the wired connection, as it will be explained below.

The lighting device 100 also offers integrated motion sensing capability. This is achieved by including the radiofrequency based motion sensing module 112, which comprises a sensing-signal input unit 114 configured to receive the radiofrequency sensing signals 116, and a sensing control unit 118 connected to the sensing-signal input unit 114 and configured to determine a motion of the subject or object 1 within the sensing volume 2 using the received radiofrequency (RF) sensing signals 116. Preferably, the motion sensing module includes a radar-based sensor 113, that uses radio waves as RF sensing signals to determine the distance, angle, or velocity of moving objects or subjects 1. A radar-based sensor works by radiating energy into space and monitoring the echo or reflected signals from the objects in the surround area, referred to as sensing volume 1. Typically, a radar sensor system has a transmitter that emits radio waves, or radar signals, into space in predetermined directions. When the radar signals come into contact with an object or a subject, they are usually reflected back or scattered in many directions, depending on the material and surface of the object or subject and also the injection angles of the radar signals.

In general, the power requirements of lighting devices with motion sensing capabilities, compared to a lighting device without motion sensing capability, are higher, since processing the received RF-sensing signals for determining the motion of the object or subject 1 requires a relatively high amount of power. This requirement may interfere with the operation of the lighting module 102, especially when reception of a predetermined lighting control signal 108.1 is associated with a high power requirement. Thus, in the lighting device 100 according to the invention, when a predetermined lighting control signal 108.1 is received, the lighting control unit 110 is configured to generate and provide to the motion sensing module 112, in particular to the sensing control unit 118, a sensing-module control signal 119 indicative of a requirement for operating the motion sensing module 112 in a low power operation mode for a low-power time span. The motion sensing module 112, upon

receiving the sensing module control signal 119, is configured to operate in the low power operation mode for the low power time span. Preferably, as indicated in Fig. 1, the lighting device 100 comprises a wired connection 120 between the lighting control unit 110 and the sensing control unit 118 that is configured to transmit the sensing module control signal 119.

5 By using an extra communication line, the motion sensing module can be switched off or put into deep sleep keeping the smart lighting functionality. The reception, and also storage of the received RF-sensing signals 116 may be kept active because typically only data processing will require extensive power.

Fig. 2 shows a schematic block diagram of a lighting device 100b with motion
10 sensing capability according to a second embodiment of the invention. Those technical feature of the lighting device 100b of Fig. 2 that have an identical or similar functionality to those of lighting device 100 of Fig. 1 will be referred to using the same reference numbers. The following discussion will be focused on those technical features distinguishing the lighting device 100b of Fig. 2 from lighting device 100 of Fig. 1.

15 The lighting device 100b further comprises a power supply unit 122 for connection to an AC mains supply 124, on one side, and to the lighting module 102 and the motion sensing module 112, on the other side. The power supply unit 122 is in this example configured as an AD/DC converter that is configured to provide operative DC power for operation of the lighting device 100b in an operation mode, and stand-by DC power for
20 operation of the lighting device 100b in a stand-by mode.

Stand-by mode, also referred to as sleep mode, is a low power mode for electronic devices. These modes save significantly on electrical consumption compared to leaving a device fully on and, upon resume, allow the user to avoid having to reissue instructions or to wait for a machine to reboot.

25 In the lighting device 100b, the motion sensing module 112, upon receiving the sensing module control signal 119 from the lighting control unit 110 is configured to operate in a stand-by mode using the stand-by DC power provided by the power supply unit 122.

Preferably, when operating in the low power mode, the motion sensing module
30 112 is configured to receive the radiofrequency sensing signals 116 and store signal data SD pertaining to the received radiofrequency sensing signals 116. The signal data SD is the indicative of the information comprised by the radiofrequency sensing signal which is useful for the determination of the motion. More preferably, the motion sensing module 112, when operating in the low power mode, is configured to stop the determination of the motion of a

subject or object 1 within the sensing volume 2 using the received radiofrequency sensing signals 116. During start-up and normal operation, the motion sensing module 112 is connected to the power supply 122 and functionality is guaranteed. Only during operation of the lighting module as indicated by a predetermined light control signal 108.1 e.g. during smart switching, as it will be explained in the following, motion sensing module 112 is “stalled” via the enable/data connection 120. Via this simple interface the total lighting device power consumption is radically reduced during smart switching and as such will not disturb the smart lighting functionality. This enables simple integration into smart lighting platforms of the standalone modules that re-uses the power interface of the lighting device.

Preferably, at least a subset of the lighting control signals 108.1 are received via a power line 126 for providing operational power from a power supply 122 to the lighting device 100b. Further, the subset of lighting control signals preferably include a predetermined number of off-on cycles during a predetermined time span of a power signal received via the power line. This will be further explained with reference to Fig. 3 below.

Fig. 3 shows power vs. time curves for lighting devices with and without motion sensing capabilities in response to an input consisting of two consecutive power off-power on cycles. In the upper diagram, the state of a switch is indicated. When the switch is closed, power is provided from the AC mains supply to the lighting device. When the switch is open, transmission of power is interrupted.

The middle curve shows the impact of power interruption on a lighting device without motion sensing capability. The power decay time before full shut down in the lamp is normally very long because of the low power consumption of the controller micro. Therefore, if the switch is closed again within a given time window, the DC power available P_{DC} for the lighting device suffices, i.e. it remains above a minimum required DC power (P_{Min}) and its operation is not interrupted. This fact is used for the so-called smart switching functionality, where a number of power off-power on cycles where the power is switched between P_{ON} and P_{OFF} is monitored. A given number of cycles is associated to a command for operation of the lighting device, or in other words, to a lighting control signal. The variation of the power amount with time is therefore a suitable lighting control signal received via the power line 126.

However, if motion sensing functionality is added, which requires a higher power for operation, the same power off-power on cycle results in the available DC power P_{DC} decreasing below the minimum required DC power P_{Min} , and the number of cycles

cannot be longer monitored, thereby interfering with the intended control of the lighting module via smart switching.

Preferably, a lighting control unit 110 of the lighting device 100 or lighting device 100b is therefore configured to monitor a reduction ΔP_{DC} of the power amount P_{DC} provided for operating the lighting device 100 and to provide the sensing module control signal 119 upon determining that a detected reduction has exceeded a predetermined threshold amount ΔP_{th} . The threshold amount should be set at a value large enough to filter out minor power variations due to fluctuations in the supply. Further, the maximum values of t_{off1} and t_{off2} are set as those time values for which the available DC power P_{DC} reaches the minimum required power P_{Min} and the maximum value of t_{on1} is selected to be, for example 0.5 seconds, 1 second, 2 seconds or 5 seconds.

Fig. 4 shows a flow diagram of a method 200 for controlling operation of a lighting device with motion sensing capability in accordance with an embodiment of the invention. The method comprises, in a step 202, receiving lighting control signals for controlling an operational state of a lighting unit. The method further comprises, in a step 204, controlling the operational state of the lighting unit in dependence on the received lighting control signal. The method also comprises, in a step 206, receiving radiofrequency sensing signals and, in a step 208, determining motion of a subject or object within a sensing volume using the received radiofrequency sensing signals. Thus, steps 202 and 204 are for controlling the lighting function of the lighting device and steps 206 and 208 are for controlling the motion sensing function of the lighting device. The method further comprises, in a step 210, determining whether a received lighting control signal is one of a predetermined set of lighting control signals that are associated with a predetermined power requirement. In this case, the method includes, in a step 212, generating and providing to a motion sensing module, a sensing module control signal for operating the motion sensing module in a low power operation mode for a predetermined low-power time span. Preferably, in an exemplary method, step 210 comprises determining whether a lighting control signal is received. Thus, in this alternative method, every receivable lighting control signal belongs to the predetermined set of lighting control signals and the mere reception of a lighting control signals causes the generation and provision of the sensing module control signal without the need to wait to receive and decode the lighting control signal, which in some cases could result in a depletion of the available DC-power. Finally, the method includes, in a step 214, receiving (in particular via a wired connection, the sensing module control signal, and, in response to its reception, and in a step 216, the method comprises operating the motion

sensing module in the low power operation mode for the predetermined low power time span. Preferably, the step 216 is performed using stand-by DC power provided by a power supply unit.

Fig. 5 shows a flow diagram of a method 200b for controlling operation of a lighting device in accordance with another embodiment of the invention. In the method 200, the step 202b includes receiving the lighting control signals via a power line, for example as discussed with reference to Fig. 3. Optionally, the method comprises, in a step 204b controlling operation of the lighting unit using smart switching techniques, where a given number of interruptions of the power supply is indicative of a predetermined instruction. The method also comprises, in a step 210b, monitoring a reduction of a power amount provided for operating the lighting device and providing the sensing module control signal upon determining that a detected reduction has exceeded a predetermined threshold amount.

In summary, the invention is directed to a lighting device with motion sensing capability, which comprises a lighting module comprising a lighting unit, a control-signal input unit configured to receive lighting control signals and a lighting control unit for controlling the lighting unit based on the received lighting control signals. It further includes a RF-based motion sensing module comprising a sensing-signal input unit for receiving radiofrequency sensing signals, and a sensing control unit for determining a motion of a subject or object within a sensing volume using the RF-sensing signals. The lighting control unit, upon receiving a predetermined lighting control signal, is configured to generate and provide a sensing-module control signal. Upon receiving the sensing module control signal, the motion-sensing module is configured to operate in a low power operation mode ensuring the functionality of the lighting module

Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality.

A single unit or device may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

A computer program may be stored/distributed on a suitable medium, such as an optical storage medium or a solid-state medium, supplied together with or as part of other

hardware, but may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems.

Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS:

1. Lighting device (100, 100b) with motion sensing capability, the lighting device (100) comprising:

- a lighting module (102) comprising a lighting unit (104) configured to provide light, a control-signal input unit (106) configured to receive lighting control signals (108) for controlling an operational state of the lighting unit (104), and a lighting control unit (110) configured to control the operational state of the lighting unit (104) in dependence on the received lighting control signals (108); and

- a motion sensing module (112) comprising a sensing-signal input unit (114) configured to receive sensing signals (116), and a sensing control unit (118) connected to the sensing-signal input unit (114) and configured to determine a motion of a subject or object (1) within a sensing volume (2) using the received sensing signals (116);

wherein the lighting control unit (110), upon receiving a predetermined lighting control signal (108.1), is configured to generate and provide to the motion sensing module (112) a sensing-module control signal (119) for operating the motion sensing module (112) in a low power operation mode for a low-power time span, and,

wherein the lighting control unit (110) is configured to monitor a reduction (ΔP_{DC}) of a power amount (P_{DC}) provided for operating the lighting device (100) and to provide the sensing module control signal (119) upon determining that a detected reduction has exceeded a predetermined threshold amount (ΔP_{th}), and

wherein the motion sensing module (112), upon receiving the sensing module control signal (119), is configured to operate in the low power operation mode for the low-power time span.

2. The lighting device (100) of claim 1, further comprising a wired connection (120) between the lighting control unit (110) and the sensing control unit (118) configured to transmit the sensing module control signal (119).

3. The lighting device (100) of claim 1 or 2, wherein the motion sensing module (112) comprises a radiofrequency based motion sensing module configured to receive radiofrequency sensing signals.

5 4. The lighting device (100b) of any of the preceding claims, further comprising a power supply unit (122) for connection to an AC mains supply (124) and to the lighting module (102) and the motion sensing module (112), the power supply unit (122) configured to provide operative DC power for operation of the lighting device (100) in an operation mode, and stand-by DC power for operation of the lighting device in a stand-by mode.

10 5. The lighting device (100b) of claim 4, wherein the motion sensing module (112), upon receiving the sensing module control signal (119) from the lighting control unit (110), is configured to operate in a stand-by mode using the stand-by DC power provided by the power supply unit (122).

15 6. The lighting device (100, 100b) of any of the preceding claims, wherein the motion sensing module (112), when operating in the low power mode, is configured to receive the sensing signals (116) and store signal data (SD) pertaining to the received sensing signals (116).

20 7. The lighting device (100, 100b) of any of claims 1-5, wherein the motion sensing module (112), when operating in the low power mode, is configured to stop a reception of the sensing signals and/or a processing of the received sensing signals for the determination of the motion of a subject or object (1) within the sensing volume (2) using the
25 received sensing signals (116).

8. The lighting device (100) of any of the preceding claims, wherein the lighting control unit (110) is configured to receive at least a subset of the lighting control signals (108) via a power line (126) for providing operational power from a power supply (124) to
30 the lighting device (100).

9. The lighting device (100) of claim 8, wherein the subset of lighting control signals include a predetermined number of off-on cycles during a predetermined time span of a power signal received via the power line.

10. Method (200) for controlling operation of a lighting device (100) with motion sensing capability, the method comprising:

- receiving (202) lighting control signals for controlling an operational state of
5 a lighting unit;
- controlling (204) the operational state of the lighting unit in dependence on the received lighting control signal;
- receiving (206) sensing signals;
- determining (208) motion of a subject or object within a sensing volume using
10 the received sensing signals;
- upon receiving (210) a predetermined lighting control signal at a lighting control unit, generating and providing (212) to a motion sensing module a sensing module control signal for operating the motion sensing module in a low power operation mode for a predetermined low-power time span;
- 15 - monitoring (210b) a reduction (ΔP_{DC}) of a power amount (P_{DC}) provided for operating the lighting device (100b) and providing the sensing module control signal (119) upon determining that a detected reduction has exceeded a predetermined threshold amount (ΔP_{th}), and
- upon receiving (214) the sensing module control signal, operating (216) the
20 motion sensing module in the low power operation mode for the predetermined low power time span.

11. The method (200, 200b) of claim 10, further comprising, upon receiving the sensing module control signal (119) from the lighting control unit (110), operating (216) the
25 motion sensing module in a stand-by mode using stand-by DC power provided by a power supply unit.

12. The method (200b) of any of the preceding claims 10 to 11, further comprising receiving (202b) at least a subset of the lighting control signals via a power line (126) for
30 providing operational power from a power supply (124) to the lighting device (100).

13. Computer program comprising instructions which, when executed by a lighting device according to any of the preceding claims 1 to 9, cause the lighting device to carry out the method of any of the claims 10 to 12.

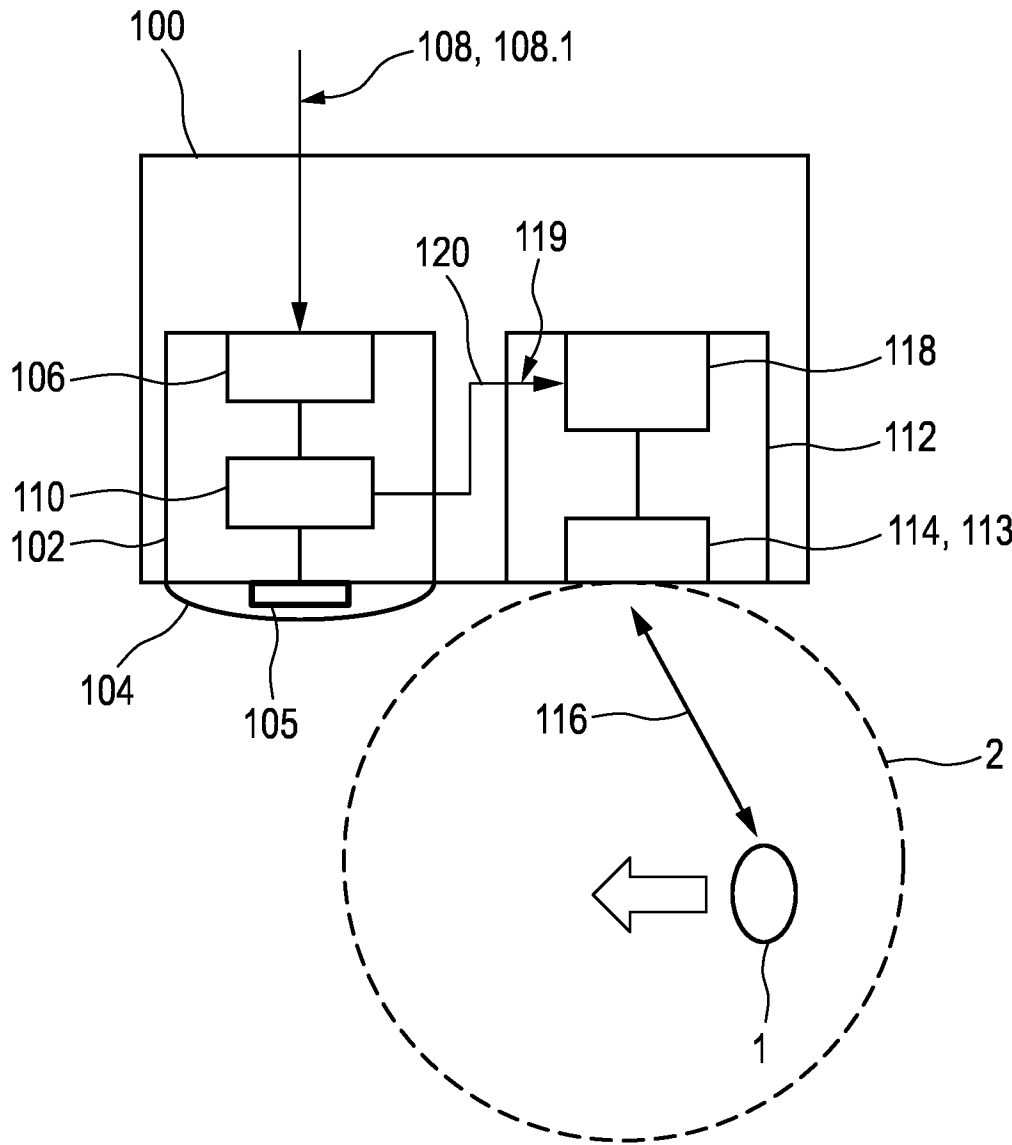


FIG. 1

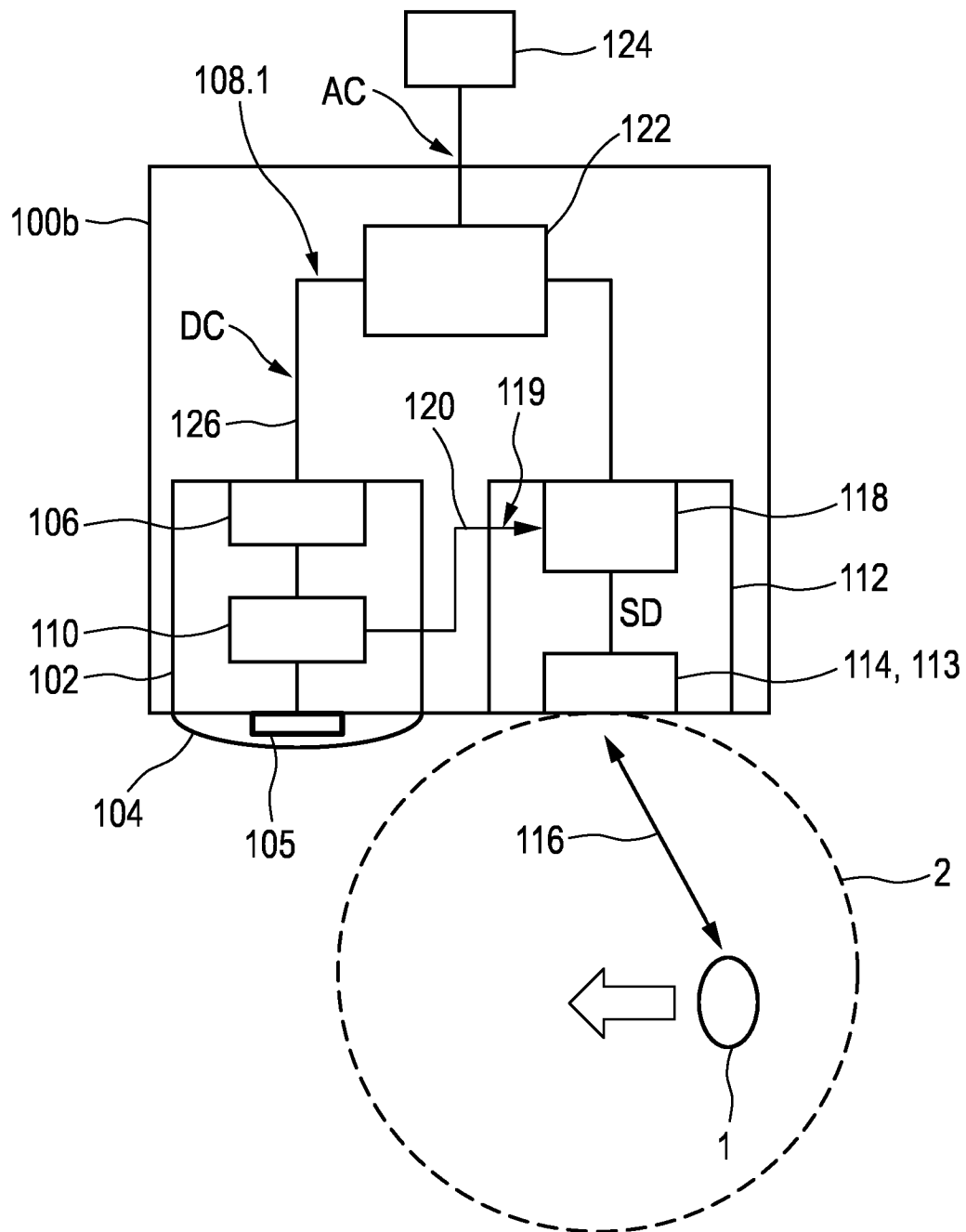


FIG. 2

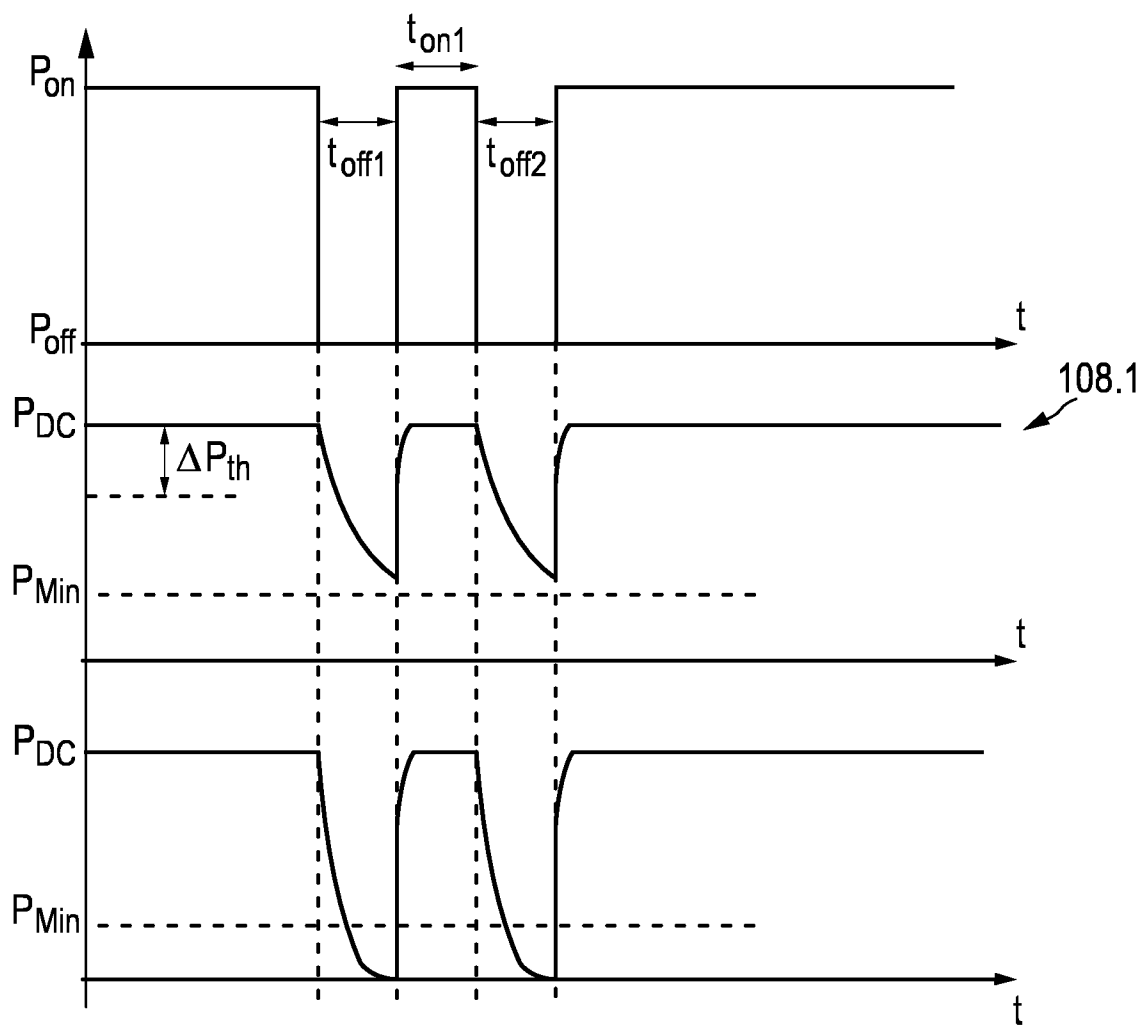


FIG. 3

4/5

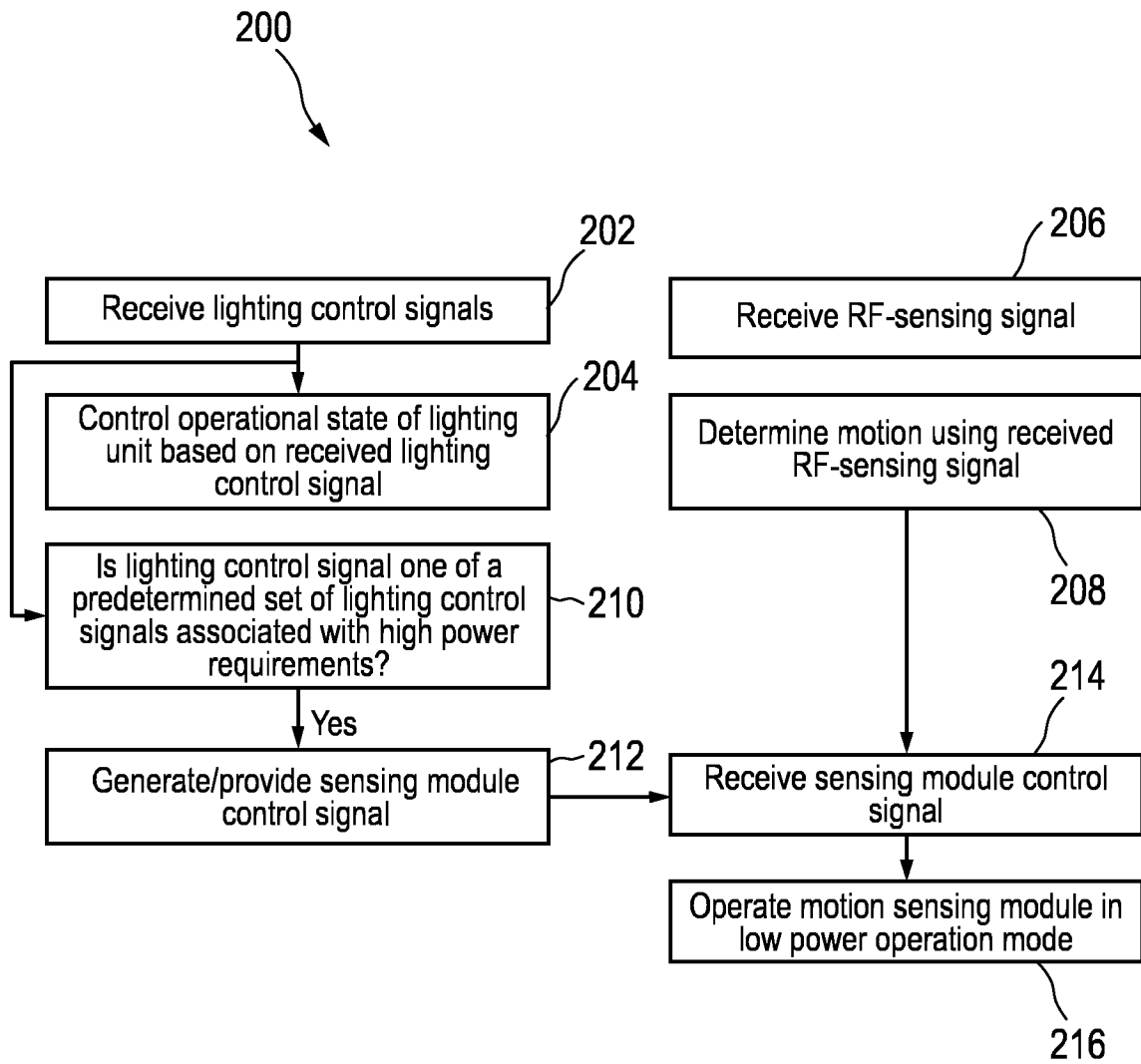


FIG. 4

5/5

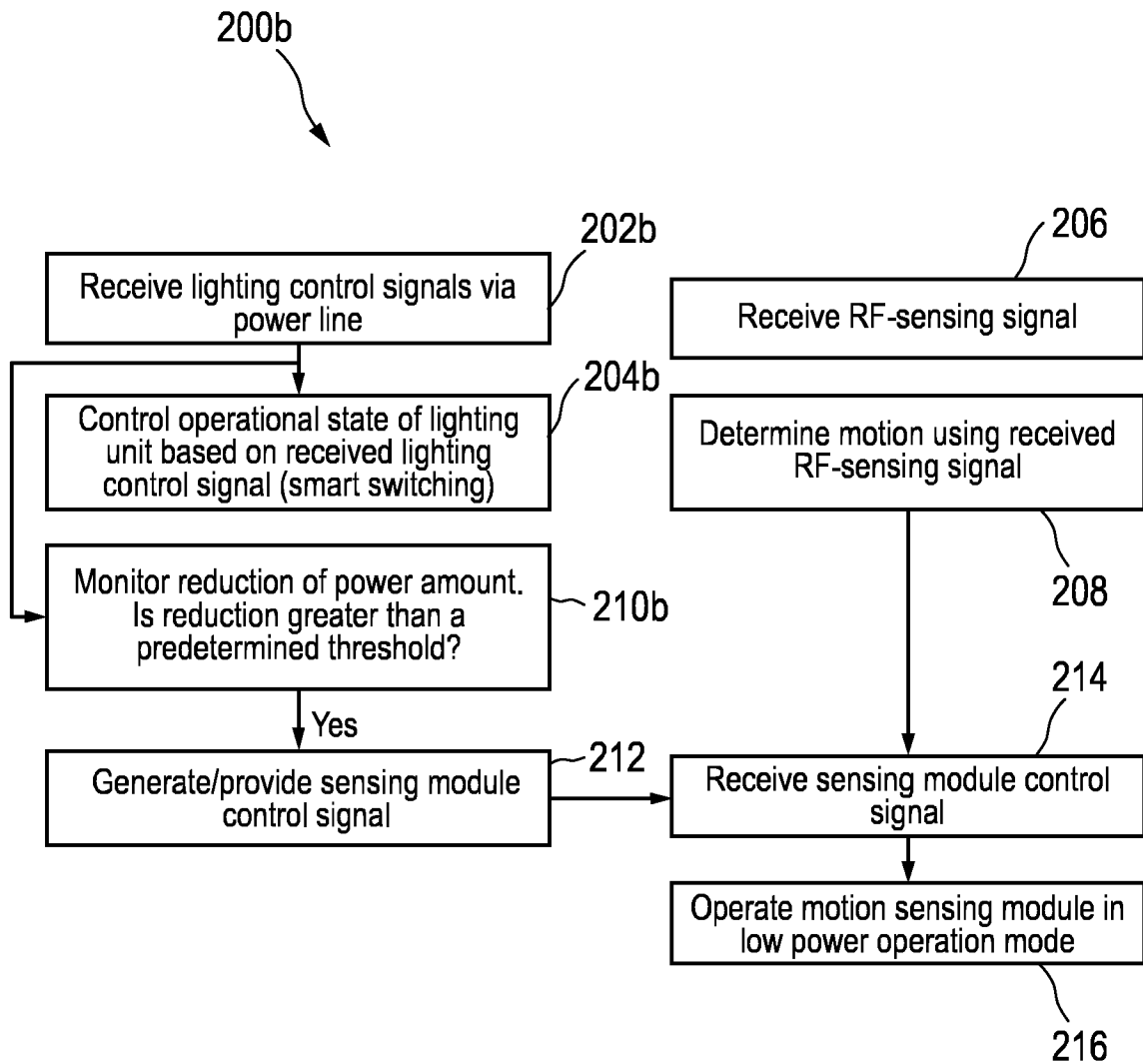


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/064483

A. CLASSIFICATION OF SUBJECT MATTER

INV. H05B47/115 F21V23/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H05B F21V G01S G08C H04L H04W A61N

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

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

EPO-Internal, WPI Data, INSPEC, COMPENDEX, FSTA, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2011 129318 A (PANASONIC ELEC WORKS CO LTD) 30 June 2011 (2011-06-30) the whole document -----	1 - 13
A	EP 3 832 986 A1 (ENLIGHTED INC [US]) 9 June 2021 (2021-06-09) column 1, paragraphs 1, 7-9; figures 1-14 column 3, paragraph 12 - column 21, paragraph 101 -----	1 - 13
A	WO 2015/184019 A1 (INNOSYS INC [US]) 3 December 2015 (2015-12-03) page 2, paragraph 4; figures 1-46 page 5, paragraph 33 - page 64, paragraph 207 esp. pars. [0071], [0081], [0090], [0111] ----- - / - -	1 - 13



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

10 July 2024

Date of mailing of the international search report

23/07/2024

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Brosa, Anna-Maria

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/064483

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2017/076680 A1 (PHILIPS LIGHTING HOLDING BV [NL]) 11 May 2017 (2017-05-11) page 1, paragraph 1; figures 1-4 page 2, paragraph 1 - page 5, paragraph 2 page 6, paragraph 1 - page 26, paragraph 1 esp. page 9, first paragraph; from page 24, fourth paragraph to page 25, first paragraph; Figs. 2, 3 -----	1 - 13
A	US 2022/295621 A1 (DE JONGH FRITS TOBI [NL] ET AL) 15 September 2022 (2022-09-15) cited in the application the whole document -----	1 - 13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2024/064483

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2011129318 A	30-06-2011	NONE	

EP 3832986 A1	09-06-2021	AU 2017241824 A1	25-10-2018
		CN 109644538 A	16-04-2019
		CN 115190676 A	14-10-2022
		EP 3437438 A1	06-02-2019
		EP 3832986 A1	09-06-2021
		JP 6930999 B2	01-09-2021
		JP 2019511821 A	25-04-2019
		SG 10202100384U A	25-02-2021
		SG 11201808638V A	30-10-2018
		WO 2017173170 A1	05-10-2017

WO 2015184019 A1	03-12-2015	US 2017105265 A1	13-04-2017
		WO 2015184019 A1	03-12-2015

WO 2017076680 A1	11-05-2017	CN 108353487 A	31-07-2018
		EP 3372055 A1	12-09-2018
		JP 6758372 B2	23-09-2020
		JP 2018538665 A	27-12-2018
		US 2018332691 A1	15-11-2018
		WO 2017076680 A1	11-05-2017

US 2022295621 A1	15-09-2022	CN 114207466 A	18-03-2022
		EP 4014069 A1	22-06-2022
		JP 2022538934 A	06-09-2022
		US 2022295621 A1	15-09-2022
		WO 2021028332 A1	18-02-2021
