(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 January 2018 (11.01.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/007282 A1

(51) International Patent Classification:
H05B 37/02 (2006.01)

(21) International Application Number:
PCT/EP2017/066427

(22) International Filing Date:
03 July 2017 (03.07.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
16177698.4 04 July 2016 (04.07.2016) EP

(71) Applicant: **PHILIPS LIGHTING HOLDING B.V.** [NL/NL]; High Tech Campus 45, 5656 AE Eindhoven (NL).

(72) Inventors: **BEIJ, Marcel**; c/o High Tech Campus 45, 5656 AE Eindhoven (NL). **DE BRUYCKER, Patrick, Alouisius, Martina**; c/o High Tech Campus 45, 5656 AE Eindhoven (NL).

(74) Agent: **VAN EEUWIJK, Alexander, Henricus, Walterus** et al.; Philips Lighting B.V. - Intellectual Property High Tech Campus 45, 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, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, 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, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, 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, 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).

Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

(54) **Title:** CONTROLLING AN ILLUMINATION SOURCE

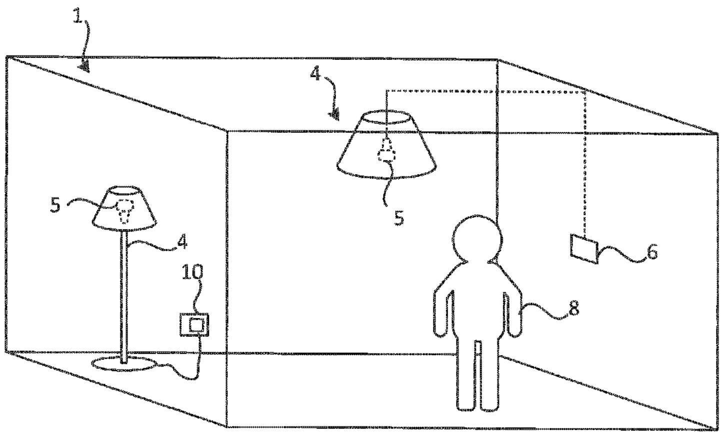

FIG. 1

(57) **Abstract:** An illumination controller for an illumination source comprises a receiver and a transmitter. It monitors the receiver in a configuration phase, and if an initial master beacon message is received at the receiver in the configuration phase, it assigns the illumination source a slave role, and if no master beacon message is received at the receiver in the configuration phase, it assigns the illumination source a master role. It operates in the slave role by controlling the illumination source according to at least one subsequent message which is received at the receiver and conveys an illumination state. It operates in the master role by controlling the transmitter to transmit messages. At least a first of the transmitted messages is a master beacon message. At least a second of the transmitted messages conveys a current state of the illumination source.

WO 2018/007282 A1

[Continued on next page]

Published:

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

Controlling an illumination source

TECHNICAL FIELD

The present invention relates to controlling an illumination source.

BACKGROUND

A lighting system may comprise multiple luminaires, each of which comprises at least one light source. The lighting system may be installed in a space so as to illuminate the space. Traditionally, the illumination sources in a lighting system were controlled by using one-off switches or dimmer switches to adjust an amount of electrical power supplied to the illumination sources, thereby modifying their light level (i.e. luminance). The switch may for example be incorporated in a wall panel, or in the luminaire itself, e.g. in a power cord, casing or support of the luminaire.

To create a desired ambiance or "scene" in a space (for example, a living room) multiple light sources may be installed and set at a certain light level. In a “traditional” installation several light sources, for example in those in ceiling, wall-mounted or otherwise integrated luminaires, may be switched on with a wall switch to which they are connected, for example a dimmer switch. Free-standing luminaires, such as floor or table lamps, may be switched off and on using a switch in, say, a power cord of the luminaire connected to the mains through a wall plug, or otherwise integrated in the luminaire. The desired light level of these individual light sources may for example be adjusted with a phase cut dimmer, for example a wall dimmer or a cord dimmer.

In more modern "connected" lighting systems, the light sources may be controlled using network communication technology, for example via ZigBee, Bluetooth, Wi-Fi, Ethernet or any combination thereof. A user can install a wireless control system, such as the Philips HUE control system, and control all the lamps via an application (app) on a user device (smartphone, tablet etc.) or install a separate wireless switch. With these kind of systems scenes can be programmed and recalled with a simple click on the wireless switch or pressing a button on the app. Retrofit bulbs having self-contained connected lighting functionality are available, which can be fitted in a standard installation in order to incorporate connected lighting functionality into an existing lighting system.

U.S. Patent application 2015/0189725 A1 relates to a lighting control system which includes a controllable light source and a faceplate remote control device that may be configured to control the controllable light source. The controllable light source may further include a control circuit and a wireless communication circuit. One of the controllable light sources may be configured to operate as a control entity, such as a master device. The master device may operate to at least partially control functionality of the other controllable light sources. The other controllable light sources may be configured to assume slave roles to the master device, such that the subservient devices will perform commands issued by the master device. For example, upon association with the lighting control system, a controllable light source may poll the other controllable light sources of the load control system to determine if the lighting control system currently has a master device. If the polling load control device does not receive an answer that another device of the lighting control system is the master device, the polling controllable light source may assume the role of the master device. A plug-in load control device, in the role of the master device, may be configured such that if at least one lighting load is in an on state when the faceplate remote control device transmits one or more change of state messages, the plug-in load control device may cause other lighting loads of the lighting control system to be operated from the on state to the off state, or left in the off state.

U.S. Patent application 2013/0027176 A1 discloses a communication protocol for a lighting control system having a plurality of control devices coupled to a communication link. The protocol uses a polling technique to coordinate the transmission of digital messages between the control devices. The startup procedure comrpises starting a timer, and if the control device has a Poll ID stored in a memory at, the controller sets a first time. Next, the control device listens for communication (i.e., link activity) on the communication link until the timer exceeds the first time. If the timer exceeds the first time, the control device begins to operate as the master device. If the control device detects link activity, the control device simply operates as a slave device.

SUMMARY

In a traditional installation, when multiple light sources need to be controlled in a room, the user has to switch on each of these individual light sources one-by-one (or point-by-point) and set them also at the desired level. A typical living room can have up to five individual light points, each of which is connected to one or more light sources and needs to be set its own specific light level. Switching over to another scene or ambiance needs adjustment for one or more of the light points, which is burdensome for the user, particularly if he has to walk, craw or climb over furniture and other obstacles.

Connected lighting systems have solved this problem by controlling the light sources with an app or a separate wireless controlled switch installed in the system. In this way multiple light sources can be controlled with only one device. However in the case of a retro-fit to incorporated connected lighting functionality into an existing “legacy” lighting system, this in turn, gives rise to another problem, which is the existing dimmers or wall switches can no longer be used as controllers. For the system to function correctly, any wall switches generally need to be set in the on state and any dimmers need to be set at full dimming level (i.e. no dimming). As such, an additional device, either a user device (e.g. smartphone, tablet etc.) or wireless switch is needed to adjust the light levels. A user wishing to adjust the light levels may not have his smartphone or tablet to hand. The wireless switch doesn’t have the same look and feel as the existing wall switch; moreover, the fact that the existing controllers can no longer be used can be a source of irritation for users.

One option would be to rewire the electrical installation in such a way that these multiple light source can be controlled by one wall switch or dimmer, e.g. having connected lighting functionality. However, this requires an electrician/installer, and is not flexible in case the interior is changed in a manner that results in a re-ordering of scenes and light points.

This invention overcomes the disadvantages of having to set each individual light source in a traditional system or in case of a wireless controlled system the need for an additional control device. The invention allows one existing control unit, such as an existing wall switch or wall dimmer, to control multiple light sources without the need of rewiring of the existing mains voltage installation, and without the need for an App or e.g. a smartphone or newly installed wireless RC (radio control) switch. That is, it allows a user set a desired ambiance for multiple light points (scene) with only one existing wall switch or dimmer.

This is achieved by assigning master and slave roles to the illumination sources. A first of the illumination sources connected to and controlled by the existing unit is assigned a master role, and the other illumination sources are assigned a slave role. Illumination settings applied at the existing control unit are conveyed to the slave lighting sources, so that they can apply matching illumination settings.

A first aspect of the present invention is directed to an illumination controller for an illumination source, the illumination controller comprising: an interface for connecting to an illumination source; a receiver; a transmitter; a configuration module; a master module and a slave module. The configuration module is configured to monitor the receiver in a configuration phase, and if an initial master beacon message is received at the receiver in the configuration phase, assign the illumination source a slave role, and if no initial master beacon message is received at the receiver in the configuration phase, assign the illumination source a master role. The slave module is configured to operate, if the illumination device has been assigned the slave role in the configuration phase, by controlling the illumination source according to at least one subsequent message which is received at the receiver and conveys an illumination state. The master module is configured to operate, if the illumination source has been assigned the master role in the configuration phase, by controlling the transmitter to transmit messages. At least a first of the transmitted messages is a master beacon message. At least a second of the transmitted messages conveys a current state of the illumination source.

A second aspect of the present invention is directed to an illumination device comprising an illumination controller according to the first aspect, and an illumination source connected to the interface of the illumination controller.

An advantage of assigning the master or slave role in this manner in the configuration phase is that it simplifies commissioning. Commissioning refers to an initial, "one-off" process performed to render a lighting system operational. When commissioning a lighting system incorporating two or more such illumination controllers, each of which is controlling a respective illumination source (or set of multiple illumination sources), a user can cause a desired one of these illumination sources (or sets) to be assigned the master role simply by instigating its configuration phase first; the absence of any master beacon message from another illumination controller during this phase will cause this to happen automatically. Then, when the configuration phase is subsequently instigated at the remaining illumination controller(s), these will receive at least one master beacon message (i.e. the first message) from what is now the master illumination controller and thus be automatically assigned the slave role. The second transmitted message that conveys the current illumination state is for use by a slave module of that other controller in controlling an illumination source of that other controller.

For example, in the described embodiments, the master module is configured to transmit a sequence of master beacon messages, each conveying a current state of the illumination source, and the slave module is configured to operate, if the illumination device has been assigned the slave role in the configuration phase, by controlling the illumination source according to a sequence of subsequent master beacon messages received at the receiver. That is, the master beacon messages themselves convey the current illumination state at the master controller. In this context, all description pertaining to the at least one received message and the transmitted second message applies individually to each message in the received and transmitted sequences of master beacon messages respectively.

Note, however, the invention is not limited to this and, in general, the second message may or may not be a master beacon message. Likewise, the at least one received subsequent message may or may not be a master beacon message.

For example, the master module may transmit two types of message: master beacon messages i.e. of the kind to which the configuration module is configured to respond in the configuration phase to influence role assignments (which may be transmitted repeatedly – see below) and separate illumination control messages that convey the current illumination state i.e. of the kind to which the slave module is configured to respond once the illumination source has been assigned the slave role, but which do not influence the role assignments *per se* (which may be transmitted upon detecting a new slave, upon receiving a user input at the light switch, etc.). In this case, master beacon messages may for example be transmitted irrespective of whether the illumination source of the master is currently emitting or not, and separate illumination control messages may convey when the master illumination source stop and starts emitting, for example.

A third aspect of the present invention is directed to a method of commissioning a lighting system comprising at least two illumination devices, each of which is configured according to the second aspect. The method comprises the following steps:

- instigating the configuration phase at a first of the illumination devices, thereby causing it to be assigned the master role; and
- once the first lighting device has been assigned the master role, instigating the configuration phase at a second of the illumination devices, thereby causing it be assigned the slave role in response to a master beacon message received from the first illumination device.

Note the terms "light source" and "illumination source" are used interchangeably herein, to refer to a component that is capable of emitting not just any light but specifically illumination, i.e. light on a scale suitable for contributing to the illuminating of a physical space occupied by one or more humans, so that the human occupants can see within the physical space as a consequence.

In the embodiments of the first, second or third aspects of the present invention, the illumination source may be assigned the slave role by storing an identifier derived from the initial master beacon message in electronic storage. The slave module may be configured to compare messages received at the receiver with the electronically stored identifier and select the at least one subsequent message (e.g. the sequence of master beacon messages) therefrom based on the comparison. The (or each of the) master beacon message(s) transmitted by the master module may comprise an identifier of the illumination controller.

This is beneficial, as it ensures that, when assigned the slave role, the illumination controller will only act on messages from a single master controller that is identified by the identifiers therein.

The illumination controller may comprise a power input for receiving electrical power for powering the illumination source.

The configuration phase may be instigated in response to an initial receipt of electrical power at the power input at a time when none of said roles (master/slave) has been assigned to the illumination source. This is advantageous, as it allows for particularly simple commissioning process: in order to cause a desired one of the illumination sources to be assigned the master role, the user need only power-up that illumination controller first; from then on, the role assignment process proceeds entirely automatically.

The master module may be configured to constantly transmit a sequence of messages, each conveying a current illumination state of the illumination source, once the illumination source has been assigned the master role for as long as the illumination source remains in an emitting state (switched on), those messages ceasing upon the illumination source transitioning to a non-emitting state (switched off). The slave module may be configured to control the illumination source to operate in an emitting state for as long as a sequence of subsequent messages, each conveying an illumination state, is being received at the receiver, and in a non-emitting state upon cessation of thereof.

"Constantly" means often enough to prevent a slave receiving the control messages from switching off. That is, where the slave module is configured (when assigned the slave role) to switch off the illumination source if no such message is received within a predetermined time interval T1 (e.g. 1 second), "constantly" means the master module transmits such messages at a frequency of $f1 \geq 1/T1$ (i.e. at least one message every interval T1 e.g. one message every second) i.e. to keep its slaves switched on. For example, T1 may be about 500ms, such that f1 is at least two messages per second, but preferably greater. For example, for T1=500ms, preferably f1 is at least ten messages per second (i.e. one message every 100ms), to provide robustness to message loss caused by, say, interference, noise or other transient disruptions.

An advantage of this approach is that it when assigned the master role, the illumination controller does not need to send any message to convey a switching-off of it illumination source – that is conveyed instead by the absence of messages.

This is particularly beneficial in circumstances in which the illumination controller is unable to transmit messages once the illumination source is switched off, for example when the illumination controller and illumination source are powered from the same source of electrical power.

In this respect, the master module may be configured to constantly transmit the sequence of messages once the illumination source has been assigned the master role for as long as electrical power is being received at the power input, those messages ceasing when electrical power stops being received at the power input.

Thus, in the case that power is cut off suddenly, e.g. by the user switching off a wall switch thereby cutting off power to the illumination source assigned the master role and its controller, the master illumination source stops emitting, the sequence of messages ceases, and the slave illumination source(s) stop emitting also as a result of the cessation of the messages.

The configuration module may be configured to terminate the configuration phase automatically if no master beacon message is received within a predetermined duration (T2), the master role being assigned upon said termination in that event. Alternatively, the configuration phase can be terminated e.g. manually.

In this respect, the master module may be configured to transmit master beacon messages repeatedly, i.e. at a frequency of at least 1/T2 i.e. at least one master beacon message every interval T2. The interval T2 may for example be 1 second, such that the configuration phase has a maximum duration of about 1 second.

Alternatively, in the case that master beacon messages and illumination control messages are sent separately (the former conveying presence, the latter exerting control), the master module may be configured, once assigned the master role, to repeatedly transmit master beacon messages for a duration T3 (e.g. two minutes or so), and to cease transmitting master beacon messages upon expiry of that duration T3. In this case, any other controllers must be switched on within that duration T3 if they are to bind to the master. This can make it easier to set-up multiple, independent lighting networks (controlled by different masters) in the same environment.

The second message (e.g. each message in the transmitted sequence of master beacon messages where applicable) may convey a current local dimming level. This is beneficial as, in response to a change in the local dimming level at the master, a matching change can be applied at the slave(s) using the master beacon messages.

The slave module may be configured to determine a composite dimming level by combining a dimming level conveyed by the at least one received message with a local dimming level, and apply the composite dimming level to the illumination source. This is beneficial as it allows dimming levels to be set individually at the slave(s), by setting their local dimming level(s), whilst also tracking changes in the master dimming level at the slave(s), thereby providing the user with greater flexibility, i.e. both individual and system-wide dimming control options.

The composite dimming level may for example be no greater than the local dimming level. This is beneficial as it provides certainty for the user when it comes to the maximum light level of the slaves

Note that the terms "higher" and "lower" in relation to a dimming level correspond to greater and lesser illuminance respectively, irrespective of how the dimming level is represented.

The illumination controller may comprise a dimming module configured to derive the local dimming level from the received electrical power. For example, based on a magnitude of the received electrical power (or a voltage providing it) or its phase out or duty cycle, in the case of phase cut dimming. The benefit of this is that it allows the illumination device to function correctly even when an external dimmer that is not controllable by the illumination source is used to set the dimming level.

The slave module may be configured to control the transmitter to re-transmit a copy of the at least one received subsequent messages (e.g. each of the received subsequent master beacon messages where applicable). This allows slave controllers that are out-of-range of the master controller, and thus unable to receive messages from it directly, to still be controlled by the master.

A fourth aspect of the present invention is directed to a method of controlling an illumination source, the method comprising implementing by an illumination controller the following steps: monitoring a receiver of the illumination controller in a configuration phase, and if an initial master beacon message is received at the receiver in the configuration phase, assigning the illumination source a slave role, and if no initial master beacon message is received at the receiver in the configuration phase, assigning the illumination source a master role; if the illumination device has been assigned the slave role in the configuration phase, controlling the illumination source according to at least one subsequent message which is received at the receiver and conveys an illumination state; and if the illumination source has been assigned the master role in the configuration phase, controlling the transmitter to transmit messages, at least a first of which is a master beacon message, and at least a second of which conveys a current state of the illumination source.

In embodiments of the fourth aspect, any feature of any embodiment of the first, second or third aspects may be implemented.

A fifth aspect of the present invention is directed to a computer program product comprising code stored on a computer readable storage medium and configured when executed to implement the method of any preceding claim. The computer readable storage medium can for example comprise one or more electronic storage units (e.g. magnetic storage, optical storage, solid-state storage etc.).

A sixth aspect of the present invention is directed to an illumination controller for an illumination source, the illumination controller comprising: an interface for connecting to an illumination source; a receiver; a transmitter; a configuration module; a master module and a slave module. The configuration module is configured to monitor the receiver in a configuration phase, and if an initial master beacon message is received at the receiver in the configuration phase, assign the illumination source a slave role, and if no master beacon message is received at the receiver in the configuration phase, assign the illumination source a master role. The slave module is configured to operate, if the illumination device has been assigned the slave role in the configuration phase, by controlling the illumination source according to a sequence of subsequent master beacon messages received at the receiver. A master module configured to operate, if the illumination source has been assigned the master role in the configuration phase, by controlling the transmitter to transmit a sequence of master beacon messages, each conveying a current state of the illumination source.

BRIEF DESCRIPTION OF FIGURES

For a better understanding of the present invention, and to show how embodiments of the same may be carried into effect, reference is made to the following figures in which:

Figure 1 shows a perspective view of a space in which a lighting system is installed;

Figure 2 shows a schematic block diagram of an illumination device;

Figures 2A-2C illustrate different types of lighting device in which an illumination controller can be incorporated;

Figure 2D shows two illumination controllers communicating within a lighting system via a wireless channel;

Figure 3 shows a flowchart for a method of controlling an illumination source;

Figures 4A-4C illustrate certain steps of the method of figure 3;

Figure 5 shows how a slave lamp may function as a master beacon relay;

Figures 6A to 6B illustrate an extension of the present techniques to accommodate a dimming level; and

Figure 7 illustrates a further extension to accommodate multiple dimming levels.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

Figure 1 shows a schematic block diagram of a lighting system 1.

The lighting system 1 comprises a plurality of luminaires 4 arranged to selectively emit light in order to illuminate a space 2. Each of the luminaires 4 comprises at least one respective light emitting device 5 (lamp) such as an LED-based lamp, gas-discharge lamp or filament bulb, plus any associated housing or support.

By way of example, two luminaires 4 are shown. A first of the luminaires 4 is connected to a wall panel 6 via a dedicated electrical cable, which may for example be set in plaster of the wall and ceiling, or otherwise concealed such that it is hard to access. Using the wall panel 6, an amount of electrical power delivered to the first luminaire via the electrical cable can be adjusted. A second of the luminaires 4 has a power cord with a plug fitting, by which the second luminaire can be connected to a conventional, general-purpose wall socket 10. The wall socket 10 and wall panel 6 both selectively supply power to the first and second luminaires respectively from a mains electricity system (42, figure 2). However, they are otherwise unconnected i.e. power is delivered by the wall socket 10 independently of any settings applied at the wall panel 6 and *vice versa*. The wall socket 10 and wall panel 6 thus constitute separate light points.

As will be apparent in view of the following, this particular set-up is shown and described to provide a simplified context for demonstrating certain features of the example embodiments. However, in general, these described techniques can be applied to any lighting system with two or more light points, i.e. independent power points, to which one or more respective luminaires are connected. In general, the luminaires 4 can take any suitable form such as a ceiling or wall mounted luminaire, a free standing luminaire (e.g. table lamp, desk lamp or floor lamp etc.), a wall washer, or a less conventional form such as an LED strip, a luminaire built into a surface or an item of furniture, or any other type of illumination device for emitting illumination into the space 2 so as to illuminate the space 2.

Figure 2 shows a schematic block diagram of an illumination controller 20 for controlling an illumination source 40. The illumination controller 20 comprises a configuration module 26, a master module 32, and a slave module 34. It also comprises electronic storage in the form of a memory 28, to which the configuration module 26 has access such that it can store data therein. The master module 32 and slave module 34 both have access to this data stored in the memory 28. In some embodiments, the LED controller 20 also comprises a dimming module 33, whose functionality is described below. The configuration module 26, master module 32, dimming module 33 and slave module 34 can be implemented in any suitable manner. For example, they may be code (i.e. software) modules executed on a processor of the illumination controller 20, or they may be implemented using dedicated hardware for example, an application specific integrated circuit or an FPGA, or any combination of hardware and software. The software can, for example, comprise firmware, and/or higher level software.

The illumination controller 20 also comprises a transmitter 22 and a receiver 24. That is, the illumination controller 20 comprises a transceiver (comprising transmitter 22 and receiver 24) for communication with other illumination controllers. These are preferably wireless components, i.e. configured to transmit and receive data embedded in wireless signals respectively, preferably RF (radio frequency) signals. The configuration module 26 has access to both the transmitter 22 and receiver 24 such that it can perform an initial configuration phase (S6, Figure 3 – see below), in which it assigns a master role or a slave role to the illumination source 40. An indication 27 of the assigned role is stored in the memory 28, and is accessible to the master and slave modules 32, 34.

The illumination controller 20 also comprises a power input 36 for receiving electrical power from an electrical mains system 42 It also comprises an interface 41 via which it connects to the illumination source 40. The power input 36 is connected to the interface 41 via a power regulator 38 of the illumination controller, which may for example comprise a switch. This allows electrical power to be selectively supplied from the mains system 42 to the illumination source 40 by controlling the power regulator 38, which is one of the functions of the slave module 34 as described in further detail below.

An illumination controller 20 can be incorporated in a lighting device of the lighting system 1 in a number of different ways. Figures 2A-2C each show a different example configuration of a lighting device incorporating the illumination controller 20 and illumination source 40. For example, the illumination controller 20 and illumination source 40 may both be components of a light emitting device 5 (i.e. lamp), such as a retrofit bulb to be fitted in a legacy lighting system as shown in Figure 2A. Alternatively, as shown in Figure 2B, the illumination controller 20 may be a component of a luminaire 4 that is not part of the light-emitting device 5 as such. For example, the illumination controller 20 may be integrated in a housing or support of the luminaire 4 to which the lighting device 5 comprising the illumination source 40 is a detachable component. Alternatively, as shown in Figure 2C, the illumination controller 20 may be an external component, such as a modular component, that connects to the lighting source 5 to implement the described functionality in any suitable manner.

Note the lamp 5 of Figure 2A incorporating the illumination controller 20 and illumination source 40; the combination of the luminaire 4 incorporating the illumination controller 20 and the lamp 5 of Figure 2B, and the combination of the external illumination controller 20 and lamp 5 of Figure 2C all constitute different lighting devices, as that term is used herein.

Figure 2D shows two such illumination controllers 20A, 20B, which are able to communication with each other by a wireless communication channel using their respective transmitters and receivers. As explained in further detail below, this allows the illumination controllers 20A, 20B to communication initially to establish their respective roles (master or slave), and thereafter to operate in accordance with their assigned roles.

The arrangement of Figure 2A in which the illumination controller 20 and illumination source 40 are incorporated in a lamp 5, such as a retro-fit lamp, is preferred in some contexts, as it allows easy retrofitting of an existing lighting system with the present functionality. The following is described with reference to the configuration of Figure 2A, however it will be appreciated that this applies equally to other configurations, such as those shown in Figures 2B and 2C. A lamp 5 configured with the functionality of the illumination controller 20 as in Figure 2A, is referred to herein as a smart home lamp (SHL).

Returning to Figure 2, the power input 36 of the illumination controller 20 is shown connected to the mains 42 via an external mains switch 44. The mains switch 44 is external in the sense that it is not controllable by the illumination controller 20. The mains external switch 44 is operated manually by the user 8, and may for example, be integrated in the wall panel 6 or wall socket 10 or one of the luminaires 4, for example, in a power cord, support or housing. When operating in the master role, a function of the master module 32 is to convey control actions performed as the mains switch 44 to any slaves of the master controller via the transmitter 22. The switch 44 can for example be a simple on/off switch or it may be a dimmer switch. In any event, the switch 44 allows the user 8 to regulate an amount of electrical power supplied to the LED controller 20 for controlling the light level of the illumination source 40.

A particular advantage of this configuration of the LED controller 20 is that the external switch 44 can be part of an existing lighting system such as an existing wall switch or wall panel.

Figure 3 shows a flow chart for a method of controlling a lighting device, both to effect an initial configuration phase and subsequent operational phase. That is, the set up of wireless network connections between the lamps 5, thereby creating a new lighting network, and subsequent use of the lighting network.

In the examples described below multiple lamps 5 each have the same hardware and firmware with the same stock-keeping unit (SKU). Each lamp has a transceiver (transmitter 22 and receiver 24) for communication between other lamps. Once installed the lamp 5 which is operated by the existing wall switch or wall dimmer 44 will act as the master lamp. Other lamps are configured as "slave/repeaters" so that they can both be controlled by the same switch 44, and extend the range of the wireless lighting network. These slave/repeater lamps need to be continuously powered, for example, by keeping their original wall switch closed or their phase cut dimmer active on.

Three modes of operation are described which can be summarised as follows.

Operation with a single wall switch (Figures 4A-4C)

Once the master lamp is switched on it sends out an "ON" signal to the slave lamps. These lamps will then turn "ON" and when the master lamp is switched "OFF" the slave lamps will also switch "OFF".

Operation with a single wall dimmer (Figure 6)

Once the master lamp is switched on it sends out an "ON" signal and its e.g. light level. The "ON" signal and the light level is communication to the other lamps and their light level is adjusted to the requested light level as well.

Operation when slave lamps are connected to a dimmer (Figure 7)

If slave lamps are connected to a dimmer, the dimmer can be used to set the maximum light level. If for instance the dimmer of the slave is set to 80%, the maximum light level when the master lamp is set at 100% will be 80%. If the master is set at lower light level e.g. 50% the slave output will be 40% (50% of 80%).

By way of example, the method of Figure 3 is described with reference to the SHL 5 of Figure 2A and is implemented by the illumination controller 20 of the SHL 5. However, the network steps can be implemented by the illumination controller 20 when incorporated in a different type of lighting device, such as those of Figures 2B and 2C.

Steps S2-S10 are initial steps, that need only be performed once as part of a commissioning process, in order to assign a role (master or slave) to the SHL 5.

A new network of multiple SHLs 5 is created by each of those SHLs performing steps S2-S10 during the commissioning. As will become apparent, the first SHL to perform these steps becomes the master and all other SHLs in range of the master that perform these steps later become slaves.

The method commences when the SHL 5 is switched “ON” on using mains 44 switch to the mains 42, causing an initial receipt of electrical power at the power input 36 (S2). In response, the configuration module 26 performs an initial check of the memory 28 to see if a role has already been assigned (S4). If not, the SHL 5 starts scanning the RF environment for other SHL beacons at step S6, which constitutes a configuration phase.

If no SHL beacon(s) is or are found in the configuration phase, the configuration module 26 assigns the SHL 5 the master role (S8). That is, the SHL 5 assigns itself the master role if it does not receive any master beacon message at step S6. In response, the master module 28 starts transmitting a master beacon, i.e. a series (in time) of master beacon messages, each comprising a unique identifier (ID) of that SHL (S12). As will become apparent in view of the following, this causes any additional SHLs that bind themselves to the master SHL 5 as slaves to mirror the master’s illumination settings (S14).

The master beacon is transmitted constantly, so as long as the master is powered by the mains 42. That is, new master beacon messages are constantly transmitted.

On the other hand, if at least one master beacon message is received in the configuration phase of step S6 from another SHL, the configuration module 26 assigns the SHL 5 the slave role (S10). That is, the SHL 5 assigns itself the slave role.

In the case that master beacon messages from multiple sources are received at step S6, i.e. comprising non-matching identifiers, the slave module can for example bind to the "closest" source, i.e. the source from which master beacon message(s) are received with the greatest signal strength.

Whichever role is assigned, as noted above, the configuration module 26 stores an indication 27 of the assigned role in the memory 28. If the assigned role is the slave role, this indication 27 comprises an identifier of the other SHL derived from the master beacon message that caused the SHL to assign itself the slave role, i.e. the identifier is stored in the memory 28, thereby identifying the other SHL as the master. In this manner, the slave SHL 5 binds itself to the other SHL, which is the master in this scenario.

As noted, step S6 is a configuration phase, which in this example is instigated in response to an initial receipt of power and may for example terminate if no master beacon massage is received within a predetermined duration T2, at which point the master role is assigned. This provides a configuration time window after first time mains power-on, during which a master beacon message must be received to prevent a lamp from assigning itself the master role.

Figures 4A-4C illustrate an example, in which three such SHLs are assigned roles in this manner. A first of these (denoted 5M) is powered-up initially (figure 4A), and hence assigned the master role. The remaining SHLs (denoted 5S) are powered up after the first SHL has been assigned the master role (figure 4B). These SHLs 5S start scanning the RF environment for already available beacons. Because the fist master SHL 5M is switched “ON” it also transmits its beacon, and this beacon is received during scanning by other SHLs 5S in their respective configuration phases (S6). The second SHLs 5S will bind themselves to the master 5M, as they are within range of and are scanning for the master 5M (Figure 4C). The second SHLs 5S will now act as slaves to the master 5M as a result.

Returning to figure 3, if the SHL 5 is assigned the slave role at step S10, for as long as it is powered, it constantly monitors the wireless channel for a master beacon from the master to which it is bound, by comparing received messages with the identifier of that master stored in the memory 28 (S18). For as long as the master beacon is being received from the master to which it is bound (i.e. for as long as master beacon messages comprising matching identifiers are being received), the slave module 34 controls the power regulator 38 to keep the illumination source 40 ON i.e. powered and emitting (S20). If and when master beacon messages with matching identifiers cease, in response the slave module 34 controls the power regulator 38 to switch the illumination source 40 off, so that it stops emitting (S22).

In this respect, the master beacon messages are transmitted "constantly" in the sense that they are transmitted frequently enough to prevent slaves from switching off whilst the master is still emitting.

For example, the slave 5S may be configured to switch off its illumination source when no master beacon messages (with the identifier to which that slave 5S is bound) are not received within a certain time interval T1. To ensure responsive behaviour by the slave(s) 5S from the perspective of the user, this time frame should be not too long due e.g. T=500ms may be appropriate meaning that slaves 5S switch off within 500ms of their master 5M being switched off.

This means that at least one master beacon message should be send by the master 5M and received by the slave 5S every 500ms. In practice, the master 5M may send its beacon message at least, say, 10 times a second (i.e. every 100ms) in case of a collision with other messages or disturbances that cause the slave module 5S to miss a message. Accordingly, in this case, five messages in a row have to be absent before the slave lamp 5S will switch itself off.

In this example, the maximum duration T2 of the configuration time window should be, say, at least 500ms to allow for message loss in the same way. It should also not be so long that a user think the lamp 5 is broken – e.g. T2=1000ms (1s) may be appropriate.

Accordingly, with reference to Figure 4C, should the master SHL 5M be powered-down by the user 8 using mains switch 44, its master beacon messages cease, causing the slaves 5S bound to that master 5M to stop emitting as desired.

Returning to step S4 of Figure 3, the role indication 27 persists in the memory 28. Should the SHL 5 be powered down, upon subsequent power up, step S4 is repeated, only this time the indication 27 is located in the memory 28. The role indicated by the indicator 27 is determined (S16) and if the indicated role is master, the method proceeds directly to S12, at which the master module 32 begins transmitting the master beacon once again, which in turn causes any slaves powered by that master to start emitting (S14). If the indicated role is slave, slave behaviour is resumed immediately by proceeding directly to step S18. This means that roll assignments are not lost when the SHL 5 loses power.

The illumination controller 20 may incorporate a mechanism to remove or ignore an existing mode indication 27 to "reset" the SHL if desired. For example, a straightforward way is for the SHL 5 to responds to the SHL 5 being switched “on” and “off” several times from the mains power (mains power cycling), by restoring of its factory settings in response.

Preferably, as illustrated in Figure 5, each slave lamp 5S transmits a copy of any master beacon messages it receives from the master to which it is bound, thereby acting as a master beacon relay to extending the spatial range of the master 5M. This slave 5S may add no extra data to the message, i.e. it may be an exact copy. If the master is switched off the slave stops relaying its master's messages which in turn causes any other slave connected to the network and receiving the relayed messages to stop emitting.

Each master beacon message conveys a current state of the master illumination source 40 at the time it is transmitted. For instance, in the example described above, each master beacon message conveys by its very existence the fact that the master illumination source is currently in an emitting state. That is to say, in this case, the content of the messages is immaterial – it is the presence and absence of these messages that coveys a current emitting and non-emitting illumination state respectively.

However, the techniques can be extended to incorporate variable dimming levels, as illustrated in Figures 6A and 6B, to convey additional illumination state information. In this example, the mains switch connecting the master lamp 5M to the mains 42 is a mains dimmer, denoted 44D, e.g. a mains wall dimmer. The master lamp 5M is dimmed to a light level set at the mains dimmer 44D (local dimming level) – outside of the control of the illumination controller 20. The master module 32 derives the local dimming level from the electrical power received at the power input 36, and includes an indication of the current local dimming level in each master beacon message. Master light level information is then included in the SHL beacon of the master 5M for receiving by all slaves listen to that beacon. These slaves 5S set their light level to the same value in the examples of Figures 6A and 6B, e.g. Figure 6A corresponds to "ON" a local dimming level of 100% at the master 5M, and figure 6B to "ON" with a local dimming level of 45%. In this example, each of the slaves sets 5S its own dimming level to be the same as the master 5M at least approximately.

The messages are RF messages, transmitted and received using the transmitter 22 and receiver 24 respectively.

Figure 7 shows a further extension of these techniques, in which the slaves 5M are connected to the main 42 via their own respective dimmer switches 54 (corresponding to 44 in Figure 2), which set their own respective local dimming levels that is determined by the slave's dimming module 37 in the same manner. This is independent of the local dimming level of the master 5M, which is set via its dimmer 44D. A composite dimming level is actually applied to the slave SHL which is set as a multiplication of its own local diming level with the received dimming level from the master beacon. This is applied by the slave module 34, accounting for the fact that a lower amount of average electrical power may be received at its power input 36, as set by the external dimmer 54 outside of the control of the illumination controller 20.

For example, if the master 5M is set to a diming level by its mains wall dimmer to 80% light level and the slave SHL 5S has only a wall switch (=100% light output) then the slave SHL will set its light output also to 80%. However, if the slave SHL has a dimmer 54 connected to its mains 44 and that dimmer 54 is set to 40% dimming level, then the slave SHL 5S applied to its illumination source a dimming level that is a multiplication of its local and received dimming levels: 32% in this example (80% of 40%), as for the first slave 5S in Figure 7. The second SHL local dimming level is set to 40% resulting in an applied dimming level of 32% (40% * 80%) and the third SHL lamp's dimmer is set to 70% resulting in an applied dimming level of 56% (70% * 80%).

If a user wishes to set-up another network in, say, his house he can switch any other already configured master lamps off and only switch on only the lamp he wishes to be the master in the new network. This keeps the commissioning simple and easy to understand. That is, networks can be easily set up by setting up a first network, then switching it OFF by switching OFF of the master's power switch. Due to the fact that the master is down, all slaves connected to that master will also shut OFF and stop relaying the master beacon from the master to which they are bound. A new SHL will start scanning the RF environment, will not find any SHL activity and starts acting as master for its new network. Multiple slaves can be added in the same way as for setting up the first network.

Multiple networks can function through each other due to the fact that each master of each network has its own unique identifier in its beacon on which their slave will respond.

In some implementations, the illumination controller 20 may incorporate an override mechanism by which the user can force the SHL 5 to assume the master role, bypassing step S6. For example, the configuration module 26 may bypass step S6 and proceed straight to step S8 if it detects an override even, for example, a predetermined on/off sequence at the power input 36. This can be useful if, say, a neighbour has an operation master lamp that is outside of the control of the user 8, which the SHL would otherwise lock onto. Note this override is different from a factory re-set, and separate mechanisms may be incorporated for causing a factory reset and a default to the master role respectively.

That is, a mechanism is integrated in the illumination controller 20 such that, if it has already been configured as master or slave in a network, it can be reset to exhibit "fresh-out-of-the-box" behaviour again. For example, to correct a mistake of the user during configuring (e.g. wrong switch used first time, so wrong lamp becomes master); or, if the user wants to have more networks and for a given slave to now respond to a different master; or if the user has moved to a different home and wants to reconfigure his whole system etc. By switching the mains power on/off a specified number of times within a specified time window, the master or slave erases its binding parameters from non-volatile memory and act as "brand-new" lamp again.

To keep the system as simple as possible and to minimize the burden places on the user 8, a slave does not connect to another master. A slave already bound to a master doesn't bound to a new master if its master is not transmitting its beacon while another master is transmitting.

The SHL 5 (or the illumination controller 20) can be pre-fabricated and supplied in blisters, or it can be commissioned on the spot.

As the SHLs are all identical (one sku), commissioning is based on "first time to switch on" is particularly suitable.

As noted above, whilst in the examples described above, the master beacon messages themselves convey the current illumination state (simply by their presence in the simplest case, or additionally by including dimming levels), this is not essential. For example, as noted, two types of messages may be used – master beacon messages to convey presence, which drive the master/slave role assignments, and illumination control messages which convey the illumination state at the master and thereby control the operation of the slave lamps once they have been assigned the slave role, but which do not influence the master/slave assignments. For example, in this case, master beacon messages can be transmitted repeatedly for as long as the master lamp is on – such that a slave lamp can bind to it at any time – or for only a limited duration after power-up (e.g. two minutes), such that other lamps can only bind to it within this limited duration. In general, both message types (illumination and control) can be embodied in a single message (e.g. in a master beacon message), or in separately (in separate beacon and illumination control messages).

It will be appreciated that the above embodiments have been described by way of example only. 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 processor or other unit may fulfil 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. An illumination controller for an illumination source, the illumination controller comprising:

an interface for connecting to an illumination source;

a receiver;

a transmitter;

a configuration module configured to monitor the receiver in a configuration phase, and if an initial master beacon message is received at the receiver in the configuration phase, assign the illumination source a slave role, and if no initial master beacon message is received at the receiver in the configuration phase, assign the illumination source a master role;

a slave module configured to operate, if the illumination device has been assigned the slave role in the configuration phase, by controlling the illumination source according to at least one subsequent message which is received at the receiver and conveys an illumination state; and

a master module configured to operate, if the illumination source has been assigned the master role in the configuration phase, by controlling the transmitter to transmit messages, at least a first of which is a master beacon message, and at least a second of which conveys a current state of the illumination source;

wherein the slave module is configured to determine a composite dimming level by combining a dimming level conveyed by the at least one received message with a local dimming level, and apply the composite dimming level to the illumination source.

2. An illumination controller according to claim 1, wherein the illumination source is assigned the slave role by storing an identifier derived from the initial master beacon message in electronic storage;

wherein the slave module is configured to compare messages received at the receiver with the electronically stored identifier and select the at least one subsequent message therefrom based on the comparison; and wherein each of the messages transmitted by the master module comprises an identifier of the illumination controller.

3. An illumination controller according to claim 1 or 2, comprising a power input for receiving electrical power for powering the illumination source.

4. An illumination controller according to claim 3, wherein the configuration phase is instigated in response to an initial receipt of electrical power at the power input at a time when none of said roles has been assigned to the illumination source.

5. An illumination controller according to claim 1, 2, 3 or 4, wherein the master module is configured to constantly transmit a sequence of messages, each conveying a current state of the illumination source, once the illumination source has been assigned the master role for as long as the illumination source remains in an emitting state, those messages ceasing upon the illumination source transitioning to a non-emitting state; and

wherein the slave module is configured to control the illumination source to operate in an emitting state for as long as a sequence of subsequent messages, each conveying an illumination state, is being received at the receiver, and in a non-emitting state upon cessation of thereof.

6. An illumination controller according to claim 5, wherein the slave module is configured to constantly transmit the sequence of messages once the illumination source has been assigned the master role for as long as electrical power is being received at the power input, those messages ceasing when electrical power stops being received at the power input.

7. An illumination controller according to any preceding claim, wherein the second message conveys a current local dimming level.

8. An illumination controller according to any preceding claim, wherein the composite dimming level is no greater than the local dimming level.

9. An illumination controller according to claim 3 or claim 7 or 8 when dependent on claim 3, comprising a dimming module configured to derive the local dimming level from the received electrical power.

10. An illumination controller according to any preceding claim, wherein the slave module is configured to control the transmitter to re-transmit a copy of the at least one received subsequent message.

11. An illumination device comprising:

an illumination controller according to any preceding claim; and

an illumination source connected to the interface of the illumination controller.

12. A method of controlling an illumination source, the method comprising implementing by an illumination controller the following steps:

monitoring a receiver of the illumination controller in a configuration phase, and if an initial master beacon message is received at the receiver in the configuration phase, assigning the illumination source a slave role, and if no initial master beacon message is received at the receiver in the configuration phase, assigning the illumination source a master role;

if the illumination device has been assigned the slave role in the configuration phase, controlling the illumination source according to at least one subsequent message which is received at the receiver and conveys an illumination state; and

if the illumination source has been assigned the master role in the configuration phase, controlling the transmitter to transmit messages, at least a first of which is a master beacon message, and at least a second of which conveys a current state of the illumination source;

wherein the step of controlling the illumination source according to at least one subsequent message which is received at the receiver and conveys an illumination state comprises:

determining a composite dimming level by combining a dimming level conveyed by the at least one received message with a local dimming level, and

appling the composite dimming level to the illumination source.

13. A computer program product comprising code stored on a computer readable storage medium and configured when executed on an illumination controller to implement the method of claim 13.

14. A method of commissioning a lighting system comprising at least two illumination devices, each of which is configured according to claim 11, the method comprising:

instigating the configuration phase at a first of the illumination devices, thereby causing it to be assigned the master role; and

once the first lighting device has been assigned the master role, instigating the configuration phase at a second of the illumination devices, thereby causing it be assigned the slave role in response to a master beacon message received from the first illumination device.

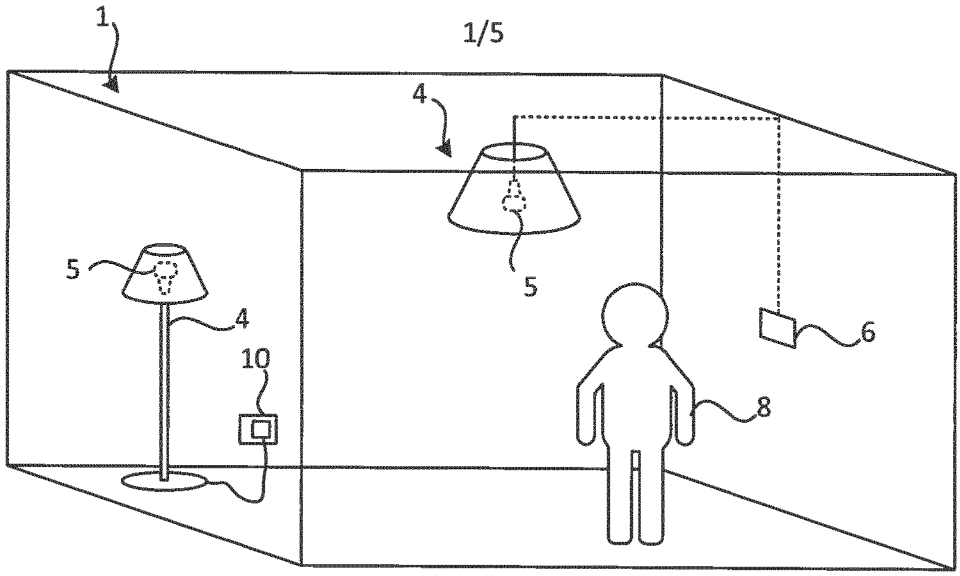

FIG. 1

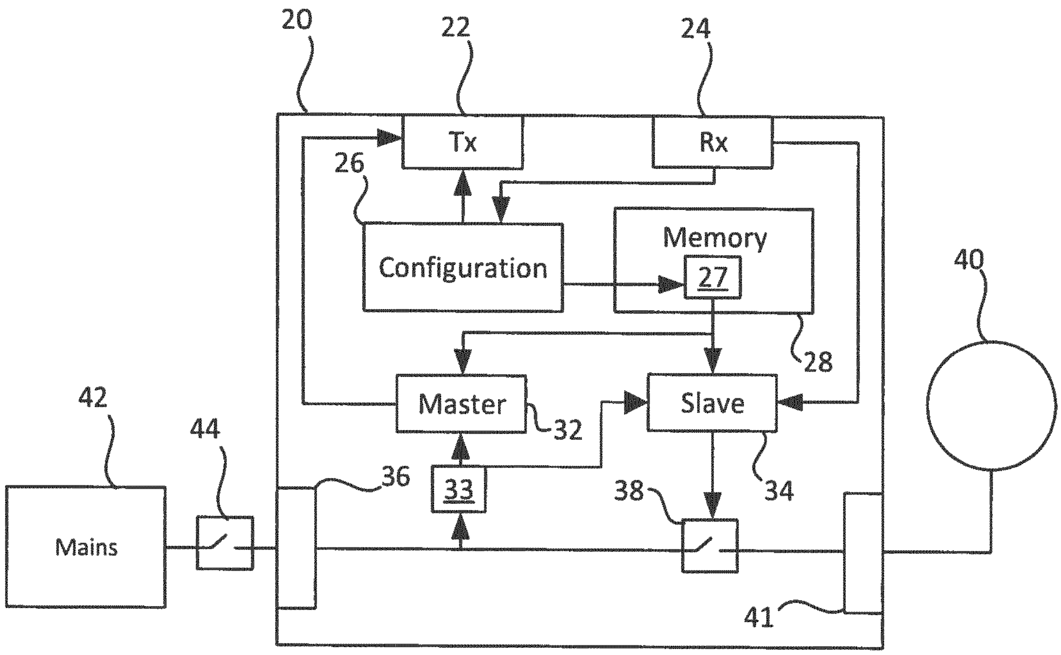

FIG. 2

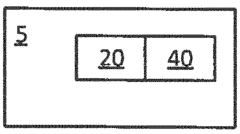

FIG. 2A

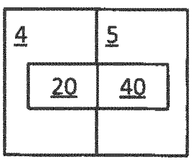

FIG. 2B

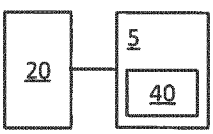

FIG. 2C

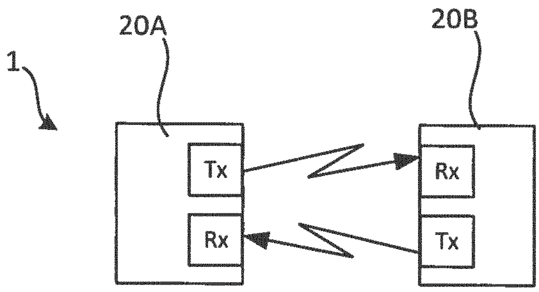

FIG. 2D

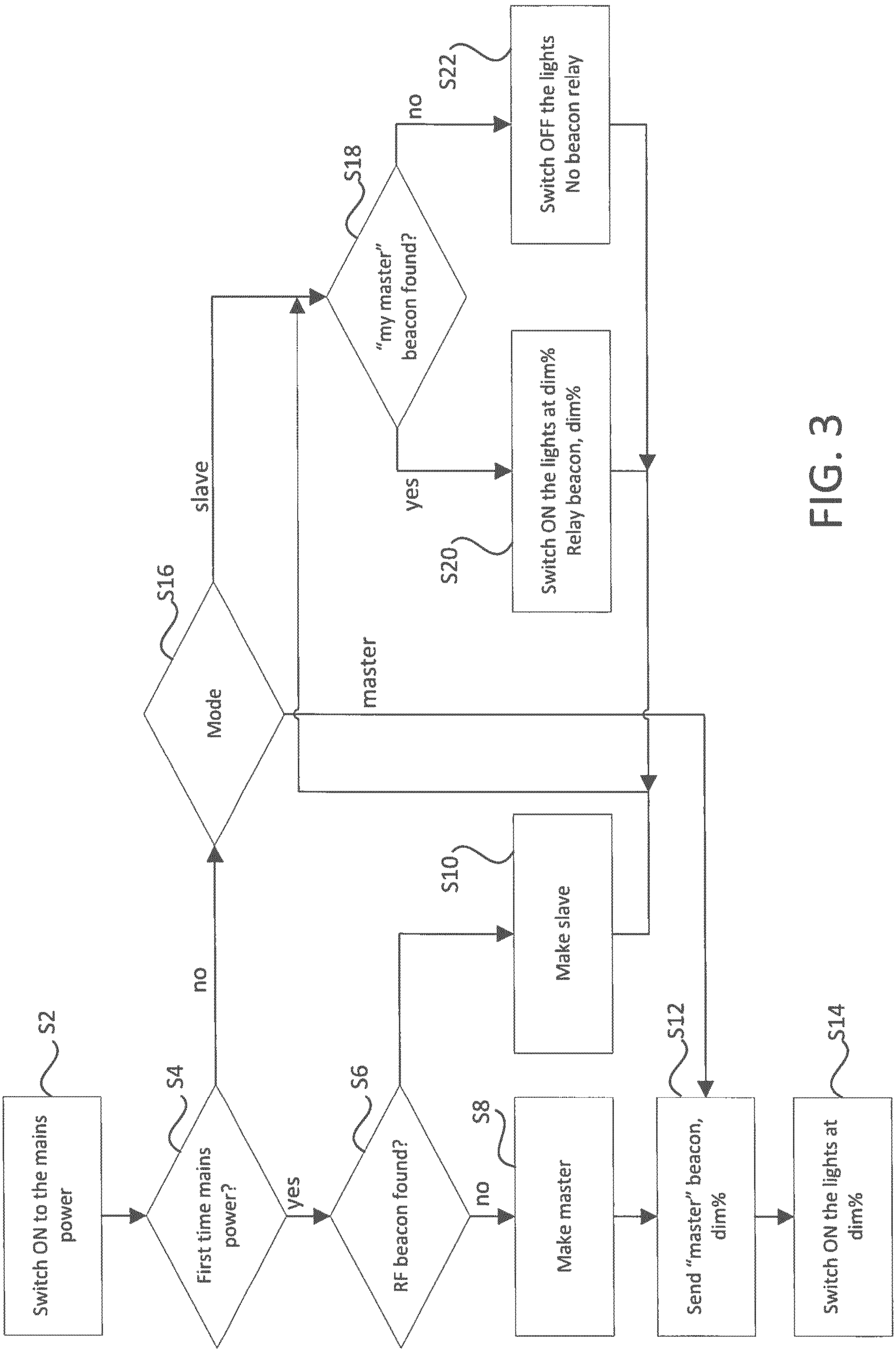
S2
Switch ON to the mains power
S4
First time mains power?
yes
no
S6
RF beacon found?
no
S8
Make master
S10
Make slave
S12
Send "master" beacon, dim%
S14
Switch ON the lights at dim%
S16
Mode
slave
master
S18
"my master" beacon found?
yes
no
S20
Switch ON the lights at dim% Relay beacon, dim%
S22
Switch OFF the lights No beacon relay

FIG. 3

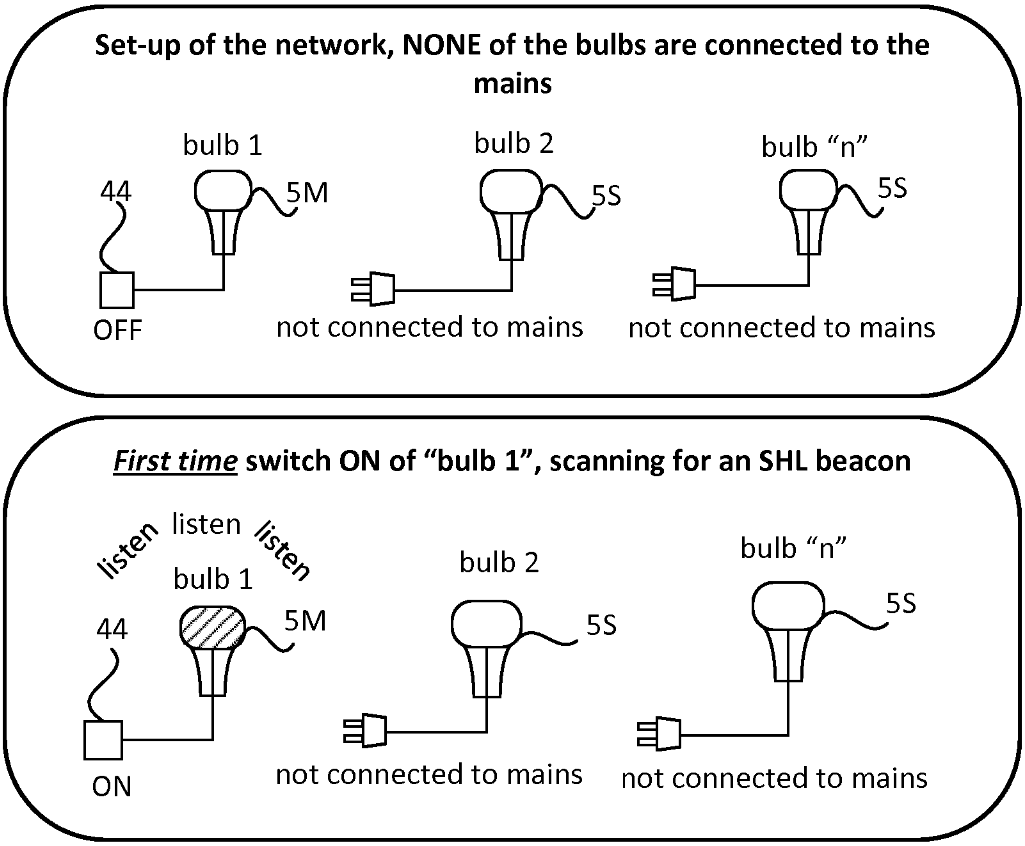
Set-up of the network, NONE of the bulbs are connected to the mains
bulb 1
bulb 2
bulb "n"
44
5M
5S
5S
OFF
not connected to mains
not connected to mains
First time switch ON of "bulb 1", scanning for an SHL beacon
listen
listen
listen
bulb 1
bulb 2
bulb "n"
44
5M
5S
5S
ON
not connected to mains
not connected to mains

FIG. 4A

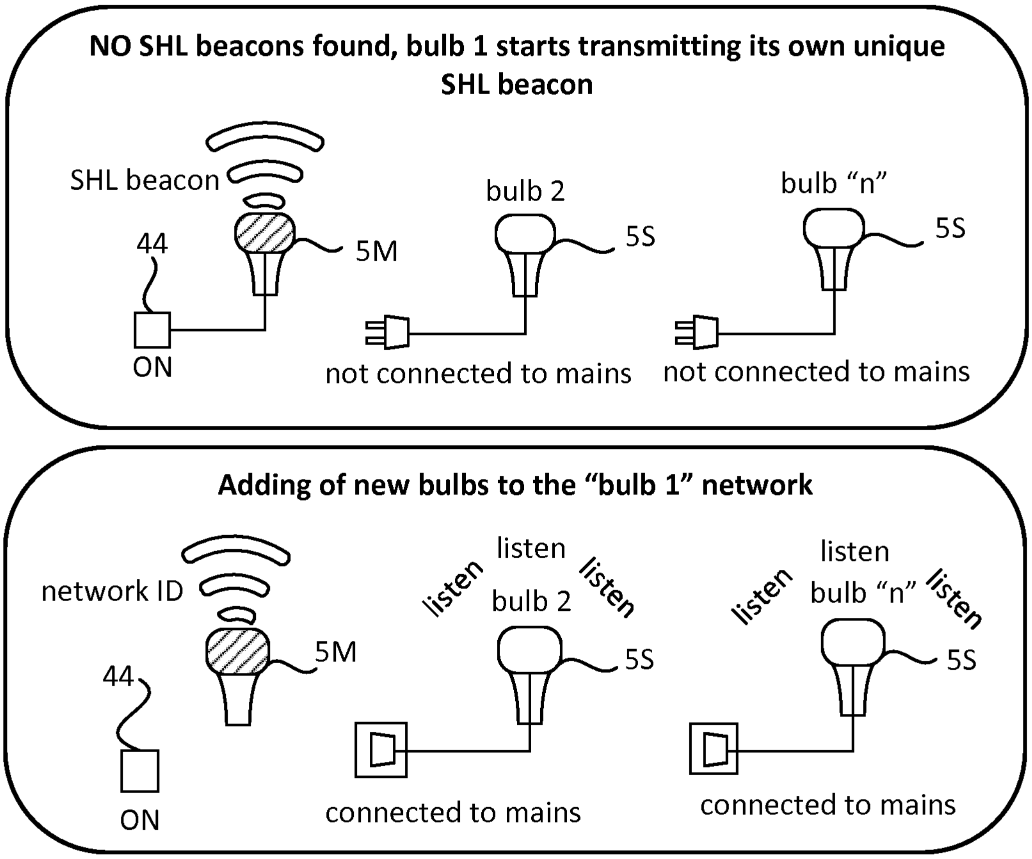
NO SHL beacons found, bulb 1 starts transmitting its own unique SHL beacon
SHL beacon
bulb 2
bulb "n"
44
5M
5S
5S
ON
not connected to mains
not connected to mains
Adding of new bulbs to the "bulb 1" network
network ID
listen
listen
listen
bulb 2
listen
listen
listen
bulb "n"
44
5M
5S
5S
ON
connected to mains
connected to mains

FIG. 4B

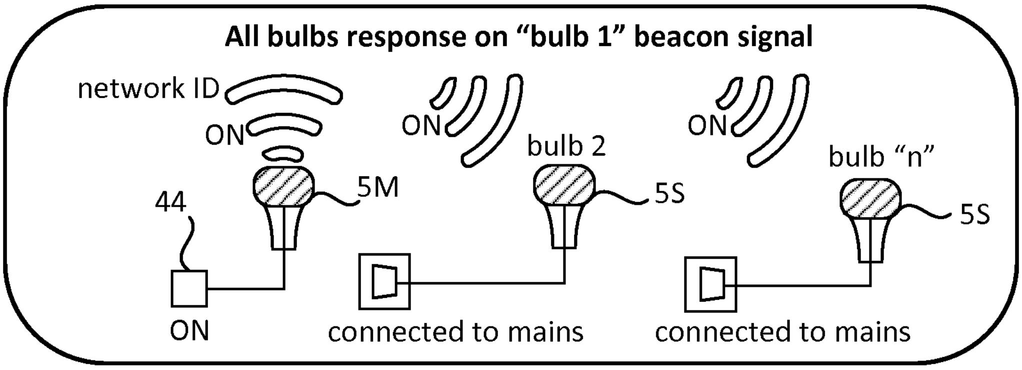

FIG. 4C

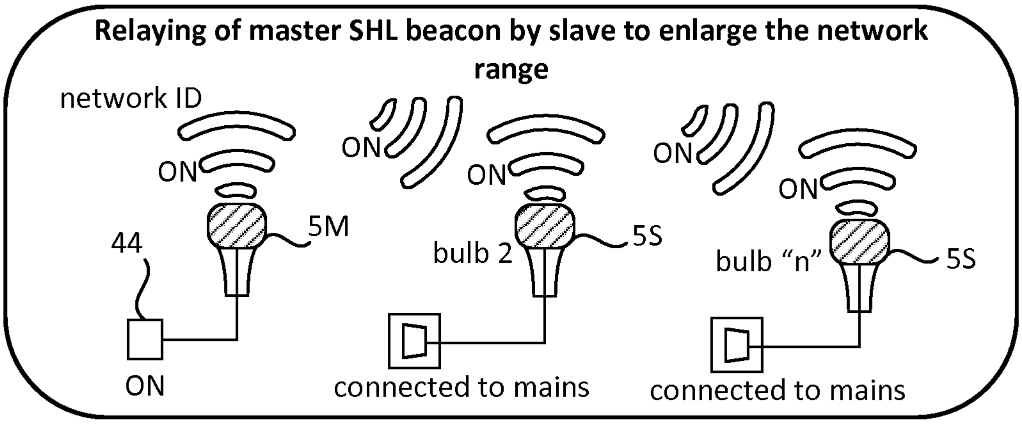

FIG. 5

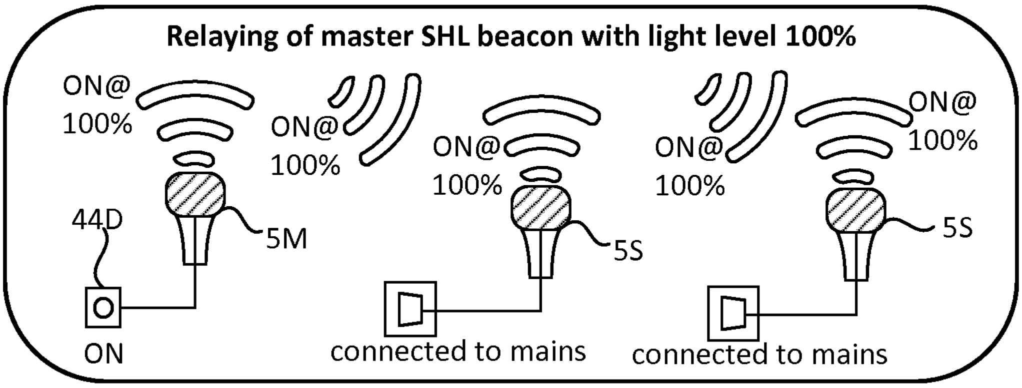

FIG. 6A

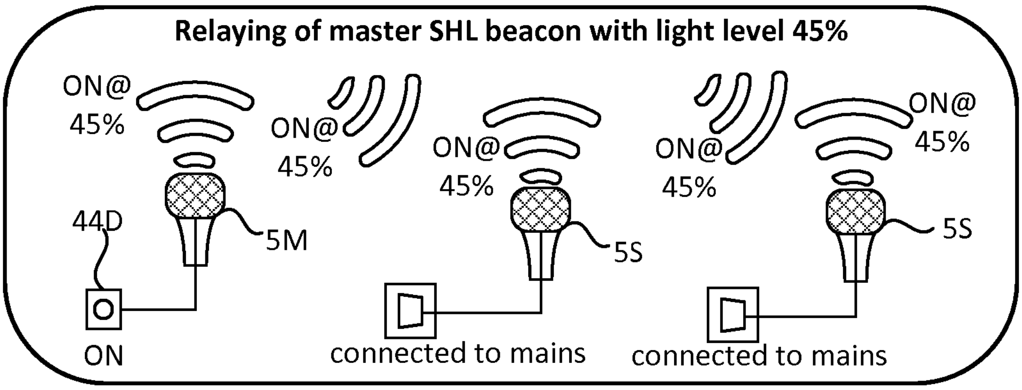

FIG. 6B

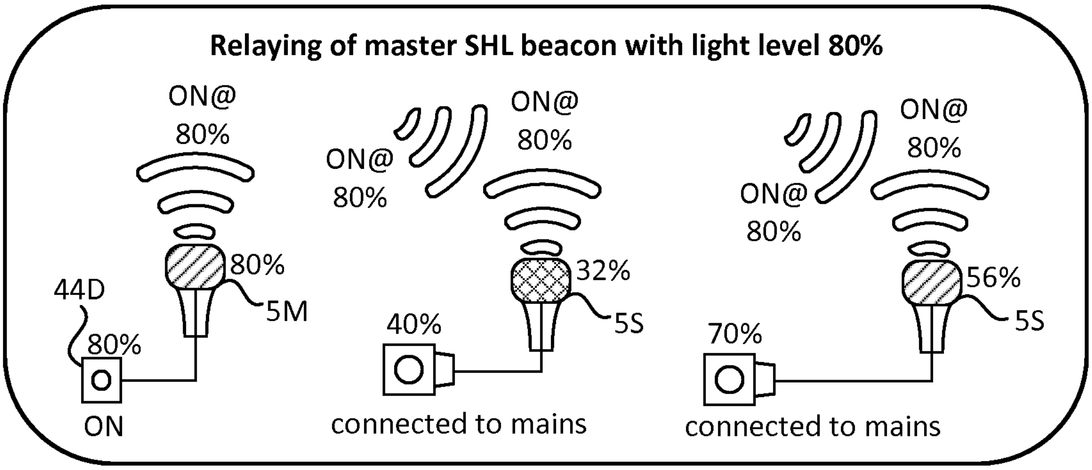
Relaying of master SHL beacon with light level 80%
ON@
80%
80%
44D
5M
80%
ON
ON@
80%
ON@
80%
32%
40%
5S
connected to mains
ON@
80%
ON@
80%
56%
70%
5S
connected to mains

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/066427

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B37/02
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2015/189725 A1 (KARC JEFFREY [US] ET AL) 2 July 2015 (2015-07-02) pages 2-4; figure 2 -----	1-14
A	US 2013/027176 A1 (STOCKER R PAUL [US]) 31 January 2013 (2013-01-31) paragraph [0069]; figure 7 -----	1-14
A	US 2006/244624 A1 (WANG LING [US] ET AL) 2 November 2006 (2006-11-02) the whole document -----	1-14

☐ 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	Date of mailing of the international search report
26 September 2017	04/10/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Morrish, Ian

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/066427

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015189725 A1	02-07-2015	NONE	
US 2013027176 A1	31-01-2013	CA 2676739 A1	14-08-2008
		CN 101919312 A	15-12-2010
		EP 2119322 A2	18-11-2009
		US 2008191837 A1	14-08-2008
		US 2013027176 A1	31-01-2013
		WO 2008097434 A2	14-08-2008
US 2006244624 A1	02-11-2006	AT 458379 T	15-03-2010
		AU 2003303008 A1	09-07-2004
		CN 1726742 A	25-01-2006
		EP 1579737 A1	28-09-2005
		JP 2006510181 A	23-03-2006
		US 2006244624 A1	02-11-2006
		WO 2004056157 A1	01-07-2004