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(54) Title: LIGHTING SYSTEMS

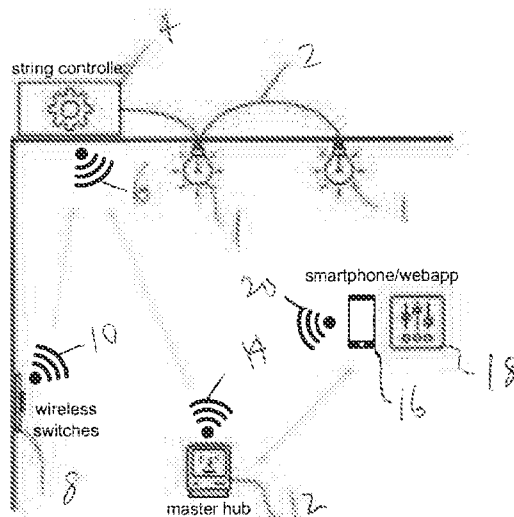


FIG 1

(57) Abstract: A controller for a lighting system comprising an input for receiving power, a wireless receiver configured to receive a wirelessly transmitted broadcast network command, an output for supplying output power to a light and a control circuit for controlling the output power dependent on the command, wherein the wirelessly transmitted broadcast command can be sent from a mobile device, a fixed panel or a computer.



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LIGHTING SYSTEMS

Field of the Invention

5 This invention relates to lighting systems, and is directed particularly toward remote control of lights such as LED string lights, but is not solely directed to that application. The invention also has application to systems that are controllable wirelessly.

Background

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Lighting systems that comprise a number of lights connected to a supply line in string i.e. "string lights" are known. The light emitting diode (LED) lights are often connected in a string which is supplied at a relatively low voltage, for example 12 volts. LED lights are sometimes individually connected to a power supply which is in turn supplied from a utility supply connection.

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Controllers for LED lights typically control the LED for dimming purposes at the low voltage, using a dimming circuit for example. One of the inefficiencies with a low voltage dimming circuit is that if a large number of lights are being supplied, then the dimming circuit needs to be designed to cope with relatively large current, and the cables that supply the lighting system
20 also need to use larger conductors in order to supply the required current. Both of these requirements can add significantly to cost of such systems.

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A number of users attempt to control LED lights by using dimming circuits which are intended for use with incandescent lights for example. A problem with this approach is that dimming circuits designed for incandescent lights tend not to be compatible with LED power supplies, resulting in flicker and other undesirable lighting effects including difficulty in controlling the dimming function.

30

Another difficulty with lighting systems in general is the cabling overhead involved with switches which control the lighting system. In a case of domestic buildings and offices for example there is a need to have an inline switch which completes the electrical circuit between the utility supply and the physical light. The switch is usually provided in a wall cavity, which means that wiring must be provided between the ceiling cavity and the wall cavity in order to complete the circuit. Moreover, there is significant additional wiring involved if multiple switches are used to
35 control the lighting system.

Object

It is an object of the invention to at least go some way toward overcoming one or more of the disadvantages of existing systems, such as one or more of the disadvantages referred to above.

Summary of Invention

In one aspect the invention provides a light control apparatus comprising:
an input for receiving power,
a wireless receiver configured to receive a wirelessly transmitted broadcast network command,
an output for supplying output power to a light, and
a control circuit for controlling the output power dependent on the command.

In one embodiment the command comprises an instruction and an address.

The output power is preferably controlled by the control circuit to change the illumination of the light.

In one embodiment the instruction results in the control circuit progressively dimming the light. The control circuit progressively dims the light pending receipt of a further command.

In one embodiment the output is connected to a light string.

In one embodiment the apparatus further comprises a remote switch having a wireless transmitter configured to wirelessly transmit a broadcast network command for receipt by the wireless receiver. A master controller may also be provided having a wireless transmitter configured to wirelessly transmit a broadcast network command for receipt by the wireless receiver.

In one embodiment the control circuit processes the instruction if the address is recognised.

In another aspect the invention provides a light control apparatus comprising:
a switch means configured to be responsive to an action of a user;
a wireless transmitter configured to wirelessly transmit a broadcast network command comprising an address unique to the switch and a lighting control instruction.

The apparatus may further comprise a switch controller configured to provide power to the apparatus for a selected time period following activation of the switch means. The switch controller comprises an additional switch means configured to connect the apparatus to a power supply for the selected time period.

In another aspect the invention broadly provides a lighting system comprising:
a plurality of lights operable at a first voltage and being supplied from a line at a second voltage,
a controller operable to control the line to thereby control a lighting characteristic of one or more
of the lights, and
a switch means adapted to provide a command to the controller.

In one embodiment the second voltage is higher than the first voltage, for example the second voltage may comprise utility supply voltage.

In another embodiment the controller receives a command wirelessly from the switch means.

In another embodiment the command which is received by the controller comprises a toggle command.

In yet another embodiment the total command is used by the controller to controllably dim one or more of the lights.

In another aspect the invention consists in a lighting system comprising a controller adapted to control a light unit or lighting means,
the controller including a wireless receiver to receive a command,
wherein the command comprises an instruction and an address.

In one embodiment the system further comprises a switch configured to send a wireless command to the controller.

In another aspect the invention broadly comprises a wireless controller, the controller comprising:

a first switch means which is manually actuated by a user,

a second switch means, and

a controller which is adapted to be energised upon actuation of the first switch and activate the second switch in order to maintain power to the controller for a predetermined time period.

5 In a further aspect the invention broadly consists in a lighting system including a controller for controlling a plurality of lights, and a plurality of wireless switches, each switch operable to be selectively paired with the controller.

10 In a further aspect the invention broadly consists in a lighting system including a plurality of controllers for controlling a plurality of lights, and a wireless switch, the switch operable to be selectively paired with one or more of the controllers.

In a further aspect the invention broadly provides a dimming circuit suitable for LED lights, the circuit comprising:
a controller adapted to provide an output to progressively dim one or more lights upon receipt of
15 a first command, and halt the progressive dimming on receipt of a second command.

In one embodiment the first command and the second command are the same.

20 In another aspect the invention consists in a lighting system comprising:
a controller adapted to control a light;
a switch adapted to send a wireless command to the controller.

In one embodiment the switch uses a broadcast communication system to send the command to the controller.

25 In one embodiment power for operation of the switch is unavailable after the switch has sent a command.

30 In another embodiment power is only made available for operation of the switch while a command is being sent.

In another embodiment the controller does not send an acknowledgement of receipt of a command to the switch.

35 In another aspect the invention provides a circuit board having a plurality of perpendicularly projecting pins, the pins being adapted for interconnection with screw terminals of a wall switch.

In one embodiment the circuit board comprises a wireless transmitter module.

5 In another aspect the invention comprises a wireless switch mounted on a circuit board, the circuit board being flexible and resilient, and a switch cover having a lip adapted to contact an edge of the circuit board in use.

10 In one embodiment the circuit board, when mounted on a wall surface, contacts the lip to bias the cover against the wall surface.

In a further aspect the invention broadly comprises a method of installation for a lighting system, the method comprising the steps of:
installing a light string,
connecting a controller through the light string,
15 connecting a utility supply through the controller, and
pairing a wireless switch to the controller.

In one embodiment, pairing involves wirelessly connecting the switch to the controller.

20 In another embodiment, a plurality of switches are paired with a controller.

In another embodiment a master controller is paired with the controller.

25 The invention may also broadly comprise any novel feature or combination of features disclosed herein.

Further aspects of the invention will become apparent from the following description.

Drawing Description

30 One or more embodiments of the invention will be described below with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic illustration of a lighting system according to an embodiment of the invention.

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Figure 2 is a diagrammatic illustration of a controller for the lighting system of Figure 1.

Figure 3A is a diagrammatic illustration of a wireless switch circuit for use with the controller of Figure 2.

5 **Figure 3B** is a diagrammatic illustration of a circuit for use in adapting a wall switch (or similar) for use as a wireless switch for use with the controller of Figure 2.

Figure 4 is a diagrammatic illustration of a master controller for use with one or more controllers such as the controller shown and described with reference to Figure 2.

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Figure 5 is a diagram of an AC utility supply waveform at the output of the string controller of Figure 2.

Figure 6A is a rear elevation of a circuit board for use with a switch according to Figure 3A

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Figure 6B is a side elevation in cross section of a circuit board according to Figure 6A mounted on a wall together with a switch cover.

Figure 7A is a side elevation of a circuit board including componentry shown in Figure 3B;

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Figure 7B is a rear view of a standard wall switch.

Detailed Description

25 The invention relates primarily to residential and commercial lighting but does not exclude other controlled electrical loads, one example of which is fans.

Artificial lights are used in homes, offices and industrial settings to supplement or replace natural day lighting. There are many possible ways to control artificial lights but the most prevalent is via a mechanical switch attached to a wall which allows or disallows electricity to flow to the lighting system.

30

Some residential and commercial lighting set ups have dimmers integrated with the wall switches. These integrated dimmers usually consist of a switch for on/off function and a knob, dial or slider to control the dimming level. Typically the dimmer switch is wired in at a fixed position in the room and the dimming function is performed at the point of the dimmer switch.

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The invention outlined in this specification addresses drawbacks associated with a conventional wall mounted dimmer which includes but is not limited to;

- a. Installation requiring penetration of the wall lining for circuitry.
- b. Impracticalities in relocating the dimmer switch once installed.

The present invention in one aspect consists of a wireless wall switch to control the light level (dimness) for one or more luminaires 1 in a lighting circuit. The invention is designed to have similar look-and-feel to the conventional dimmer switch system above with additional benefits. The wireless wall switch has buttons that when pressed transmit signals wirelessly to a remote dimmer module enabling a change in light level (dimness) of the attached luminaires. The dimming levels may range from fully on to fully off in respect to the luminaire's normal operation.

The remote dimmer module consists primarily of a wireless receiver, microcontroller and semiconductor switched dimmer circuitry.

In one embodiment, the following features are provided:

- i. A single momentary press of the buttons on the wall switch toggles maximum (fully on) or minimum (fully off) dimness level. A press and hold of extended duration enables a stepped change in dimness level between maximum and minimum.
- ii. The wall switch may have one or more buttons with each button controlling one or more remote dimmer modules.
- iii. The remote dimmer may be of the phase controlled variant for AC (alternating current) powered loads or PWM (pulse width modulation) variant for DC (direct current) powered loads.
- iv. The remote dimmer accepts signals from multiple wall switches.

Referring to Figure 1, a schematic diagram of a first embodiment of a lighting system in accordance with the invention is shown. The system includes one or more lights 1 which may comprise a variety of different forms of lighting device. In one embodiment the lights 1 comprise light emitting diodes (LEDs), for example LEDs which are suitable for lighting in a domestic or commercial environment. The lights 1 are connected by a supply line or string 2 to a suitable light controller 4. The lights may be directly supplied with electrical energy from the string 2 as shown in Figure 1, however in other embodiments of the invention, the lights 1

(particularly if they are LEDs) may be connected to an LED power supply unit or circuit (which may supply one or more lights). Each of the power supplies may be present as part of each light unit, or may be a separate unit connected between the supply line 2 and one or more of the lights 1.

5

In one embodiment, the string controller 4 provides an output at a higher voltage than the voltage which lights 1 require. Therefore, for example the controller 4 may energise line 2 at a voltage which comprises a “mains” or utility supply voltage which in turn powers one or more individual power supplies that then supply the LEDs 1.

10

In a preferred embodiment the controller 4 controls the supply lines so as to control a characteristic of one or more of the lights 1. For example, in one embodiment the controller 4 makes lights 1 dimmable. In another embodiment the controller 4 may make lights 1 change colour for example. In a preferred embodiment the controller 4 provides an alternating current to line 2, and the waveform of the alternating current can be controlled to provide a dimming (or illumination) function, as will be described further below.

15

Controller 4 also includes means to receive a wireless command, demonstrated graphically in Figure 1 by signal 6. A switch, such as wall switch 8, is provided which can implement a switch command, and includes a wireless transmission function so as to wirelessly transmit the command to the controller 4. The wireless capability of the switch 8 is graphically illustrated in Figure 1 by wireless signal 10. As will be described further below, the switch 8, apart from providing a simple switch command, can also be used to command the controller 4 to provide other functions, such as the dimming function referred to above.

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In another embodiment, the system can include a master controller, referred to herein as a master hub 12, which has a wireless capability for receiving wireless commands and transmitting commands to one or more light controllers 4. Again, the command receipt and transmission function is performed wirelessly as illustrated by signal 14.

30

In a further embodiment, a computing device 16 may be used to communicate with the master hub 12. In the embodiment illustrated, the computing device comprises a mobile communications device such as a smart phone, which has a memory capable of storing an application 18 which can be run by the processor of the device. The device has a communication capability, for example WIFI and/or Bluetooth, as indicated by communication signal 20 which may be used to communicate with the master hub 12.

35

Referring to Figure 2, the string controller 4 is shown in more detail. Figure 2 comprises a circuit schematic which shows the inputs to the string controller 4, the operational modules within the string controller 4, and the output which is connected to the lights 1 supplied by the apparatus.

In use, the string controller 4 may be provided in a suitable housing (not shown) that can conveniently be located within a ceiling or wall cavity for example. The housing will typically be insulated to comply with electrical reticulation requirements.

One input to the string controller comprises an input for receiving a power supply, being connectors 22 and 24 for the neutral and active, or phase, conductors respectively of the AC mains (i.e. utility) supply. Such a supply typically comprises a 110V 60Hz or 230V 50Hz single phase AC supply. As will become apparent from the following description, the string controller may be located in a ceiling or wall cavity where there is easy access to the utility supply without necessitating the creation of through holes in the wall or ceiling for switches or other access to the supply.

The string controller output comprises connectors 26 and 28 for the neutral and active conductors respectively for supply output power to the load i.e. the plurality of lights 1 that comprise the string. As indicated in Figure 2, the lighting loads 1 may consist of LEDs that include an appropriate power supply (also referred to as a driver which may comprise part of the light unit) to which the LEDs are each connected.

A semiconductor switch 30 is connected in series in the active line between input 24 and output 28. Switch 30 forms part of a control circuit may take a variety of different forms and may be controlled in various ways as will be apparent to those skilled in the art to which the invention relates. As indicated in Figure 2, in one embodiment the switch 30 may comprise one or more MOSFETs such as Dual Power MOSFETs which operate in parallel, having their source pins tied together. In use the switch 30 is controlled in order to control the power supplied to the load connected to the output 26 and 28. The power may be controlled in order to control one or more characteristics of the lights 1. In one embodiment the characteristic may comprise brightness or illumination i.e. the circuit may provide a dimming function to the lights 1. The manner in which the circuit is controlled according to at least one embodiment of the invention will be described below.

Still referring to Figure 2, a control circuit is shown generally referenced 32. A DC power supply 34 supplies power to the control circuit 32, the power supply in this embodiment is derived from the utility supply connected to inputs 22 and 24, however those skilled in the art will appreciate that other arrangements are possible. In one embodiment, supply 34 is isolated from the utility supply and provides a DC output at 3.3V which is a suitable supply for the microcontroller 36, the operation of which will be described further below.

The string controller 4 includes a wireless communication circuit 38. This allows the controller 4 to receive commands and perform other functions such as being paired with switches, as described further below. In one embodiment the communication circuit comprises a 2.4GHz radio receiver or transceiver module, for example based on the nRF24L01+ from Nordic Semiconductor. The functionality includes registers for setting addresses, configuration and for holding packets. These registers and integrated features make up the physical/data-link layer for communication. In one embodiment, circuit 38 may receive wireless communication signals 40 and 42 from lighting switches, and signals 44 and 46 from one or more controllers such as master controller 12 (Figure 1).

The information from the communication circuit is passed to the microcontroller 36, which in one embodiment comprises a PIC microcontroller that effectively constructs the network/application layer by forming packets and reading instructions. Thus the information in the registers of the communication module is provided to the microcontroller which assembles the information as packets which the microcontroller 36 parses so that the command information contained in each packet can be derived. The communication protocol will be described further below.

On receipt of a command to dim the light string for example, the microcontroller 36 provides a digital output to a gate driver circuit 48. In one embodiment the gate driver circuit 48 comprises a DC-DC converter circuit which may conveniently be provided as an integrated circuit and as such is easily provided on a PCB alongside the microcontroller in a relatively small footprint. Use of a DC-DC converter has the advantage that only one power supply output voltage is needed. The same low voltage power supply used to supply the microcontroller and radio transceiver module can be boosted to drive the MOSFET gate pins, thus reducing component count.

A zero-crossing detector circuit 50 provides voltage zero-crossing information regarding the utility supply. Again this can be derived from detecting the supply present at inputs 22 and 24.

In one embodiment the zero-crossing detection is performed using an optotransistor to provide an optoisolated detection circuit.

The zero-crossing information is used by the microcontroller so that it knows when switch 30 should be turned on or off to control the utility supply provided to lights 1 to control the performance of the lights 1 or the power supplies that drive them.

In one embodiment, a trailing edge phase cut dimming methodology is implemented. In using this approach, the microcontroller controls the switch 30 to implement a received instruction as follows. The microcontroller receives a signal from module 50 when a zero crossing occurs and commences timing a time period which is determined by the required degree of dimming selected by the user. At the end of the time period the microcontroller provides a signal to module 48 to switch switch 30 Off. This process is shown diagrammatically in Figure 5 in which the AC utility voltage waveform 90 is shown rising after zero crossing 92. After time period t (which may be a pre-determined time period as determined by the microcontroller based on the required degree of dimming) the microcontroller provides a signal to turn switch 30 Off. This is shown as a change in the voltage waveform at point 94, and it can be seen that the trailing edge of the half cycle sinusoidal waveform falls to zero. The remaining waveform that would otherwise be present is shown by broken line 96. The process repeats again in the next half cycle. As can be seen, reducing t reduces the time averaged utility voltage and current available to the drivers of lights 1. Thus reducing t reduces illumination or brightness (i.e. increases dimming) and increasing t increases illumination. If no dimming is required, then switch 30 can remain On and does not need to be switched Off, so that the drivers for lights 1 receive the complete voltage/current available from the utility supply. Similarly, keeping switch 30 Off will turn off the lights 1.

Although an example is provided above in respect of controlling the lights in order to achieve a selected level of dimming, the microcontroller may be used to control switch 30 (or other switches or components) in order to control other possible characteristics of the lights, including for example simply turning the lights on and off, controlling when the lights are turned on or off, and controlling the rate at which the lights increase or decrease light intensity while changing state.

As mentioned above, the string controller may receive commands wirelessly from one or more remotely located switches. Examples of switches according to one embodiment of the invention are shown in Figure 3A and 3B. Turning now to Figure 3A, an example of a circuit for use with

a wireless pushbutton switch is shown generally referenced 40. The pushbutton switch actuator which is responsive to a physical user action such as touching or pressing is referenced 42, and the power supply comprises a battery 44 which in this example comprises a 3V lithium battery.

The remaining circuitry for the switch may be provided in a small form factor, so that in one embodiment the switch and circuitry is essentially self-contained and can be easily relocated to a variety of positions within radio transceiver range of the relevant string controller(s) 4. The pushbutton switch 40 can even be provided as a completely mobile unit which may be used anywhere in range of the string controller(s) 4 with which it is paired. For example it may be left anywhere within the room illuminated by the lights it controls without having to remain at a fixed location. A touch pad may also be used as a switch in some embodiments.

Although a battery is used as the power source, other arrangements may additionally, or alternatively, be used. For example, a power generation device that is active when a user pushes the button, or apparatus that scavenges power from available electric fields in the vicinity of the apparatus may be used.

The pushbutton switch 40 includes a microcontroller 46 which may be an 8-bit microchip PIC, substantially as described above in connection with the string controller 4. Again, the microcontroller 46 provides a packet assembly function for provision of packets incorporating commands to a radio transceiver module 48. This may be substantially the same as, or similar to, the transceiver module described above in connection with the string controller 4, however the module 48 only needs to have transmission capability.

Pushbutton switch actuator 42 is normally open and closes only momentarily when actuated (i.e. when pushed). When switch actuator 42 is pressed, the power source 44 is connected to switch microcontroller 46 which then commences using power. Until actuator 42 closes, the microcontroller 46 does not consume power. The connection of the supply 44 to the microcontroller 46 via switch actuator 42 is illustrated by broken line 50. The microcontroller also monitors the state of the switch actuator 42 using state monitoring line 52. In some embodiments there may be multiple gang actuators, and the state monitoring line 52 allows the microcontroller to know which gang is being pressed.

Once the supply 44 is connected to the microcontroller 46, the microcontroller activates an optocoupler 54 via a control line 56 to connect the supply 44 to the microcontroller via a supply connection illustrated by broken line 58. The purpose of this is to maintain a power supply to the microcontroller after the momentary closure of actuator 42 has expired. The microcontroller

uses control line 56 to maintain a power supply to itself for as long as necessary in order to complete processing and transmission of the required command to the one or more string controllers 4.

5 In use, the wireless switch 40 in this example is used to transmit two types of command: Toggle, and; Invoke Pairing. A simple press of the actuator 42 will result in the Toggle command being transmitted. If the actuator is held closed for a selected period of time i.e. press-and-hold, then the Invoke Pairing command is transmitted. These commands will be described further below.

10 Another embodiment of a switch arrangement that may be used is wireless switch 60 shown in Figure 3B. Features or modules of the circuitry for switch 60 which have the same function as those of switch 40 have the same reference numerals. In this embodiment the switch actuator 62 comprises a toggle type switch in which the switch contacts may toggle between an open and a closed state. As indicated in Figure 3, the actuator may comprise a typical wall switch
15 such as that normally connected in series in a utility supply line to switch a light on or off. Therefore, this circuit described in connection with this embodiment may be used in conjunction with a standard wall switch, and may be supplied as an adapter kit for retrofitting to an existing wall switch so that the existing wall switch can be used to provide commands to one or more string controllers 4.

20 As shown in Figure 3B, the switch actuator 62 is connected in series with the interrupt line 64 and ground 66. When the switch 62 is opened or closed the microcontroller interrupts and transmits. When the circuitry is first powered and if the switch actuator is in the closed state, then the Invoke Pairing command is performed. Therefore, removing and reinserting the battery
25 while the switch is in the conducting mode will invoke pairing. The microcontroller runs this check on power-up.

The electronic components (including in one embodiment the battery) for the switch of Figure 3A for example may be mounted on a circuit board such as PCB 100 as shown in Figure 6A.
30 PCB 100 has a wall or surface mounting means such as holes 102 through which fastening means such as mounting screws can be located in use. PCB 100 is adapted to have a required degree of flexibility. In some embodiments this can be achieved by selection of the material and/or thickness of the circuit board substrate. For example, a circuit board comprising a standard substrate which has an overall thickness of 0.8mm has been found to perform
35 satisfactorily according to one embodiment.

In Figure 6B the circuit board 100 is shown mounted on a wall surface 104. Switch cover 106 has one or more mounting projections or lips 108 against which edges of board 100 abut in use. The flexible yet resilient nature of board 100, which is mounted on the wall 104, biases the cover against the wall surface so that the switch cover body 106 is substantially maintained flush against the wall surface.

In Figure 7A a circuit board 110 is mounted with circuitry 112 which may comprise circuitry 46 and 48 of switch 60 for example of Figure 3B, and battery 44 of switch 60. Two conductive pins 114 and 116 are provided extending from board 110. In Figure 7B, a rear view of a typical SPST wall switch 122 is shown. This includes screw terminals 118 and 120 intended for receiving wires carrying mains power which the switch actuator (62 in Figure 3B) acts to bridge (i.e. electrically connect) when the switch is operated. The location and extent of projection of pins 114 and 116 is adapted such that these pins may be located in screw terminals 118 and 120 respectively. In this manner an existing wall switch is easily adapted so as to be operable as a wireless switch as shown in Figure 3B. The circuitry of Figure 7A can be easily accommodated in the wall cavity behind typical domestic and commercial switch installations.

Turning now to Figure 4, operation of the master hub 12 (as also shown in Figure 1) is shown in more detail. The master hub acts as a master controller that is a bridge between smart devices, such as WIFI enabled devices, and the lower level wireless communication protocol used by the string controllers.

The hub 12 includes a transceiver module 70 that is substantially the same as, or similar to, the modules 38 and 48 described above. In one embodiment the master hub takes the form of a small UNIX based computer with a hardware connection to the transceiver module 70. Those skilled in the art to which the invention relates will appreciate that, apart from module 70, the master hub could in some embodiments be provided in software via a WIFI enabled machine or access point. In the embodiment shown, a WIFI access point 72 may comprise a part of the hub unit, or be provided separately, such that another WIFI enabled device such as a smart phone or tablet for example may communicate with the hub 12. If access point 72 is provided separately, for example as an adapter as shown in Figure 4, then the hub may comprise unit 74.

A Web App 78 provides the interface for allowing a WIFI enabled communication device which supports a Web Browser to control the hub 12. Traffic addressed to the WIFI access point 72 is redirected via the captive portal 76 to the Web App 78. A database or another suitable memory

records the current state of the control environment, and data values from the database or memory are converted by an appropriate module such as python script module 82 into appropriate inputs for transmission by module 70.

- 5 In another embodiment, a GPRS or GSM module may additionally or alternatively be provided to allow another communication option through which the master hub 12 may receive instructions from a user. Embodiments which incorporate a GPRS/GSM communication module may have additional functionality, for example being able to receive and implement commands by SMS.

10 As shown graphically by diagram 84 in Figure 4, the interface visible to a user of a WIFI enabled device may be presented as a series of sliders or bars, each slider corresponding to a different controller 4, and the extent of each slider being representative of the state of the light string controlled by that controller. For example the extent of each bar may represent illumination (or
15 “dimness”), so that if a user manipulates the device to extend a slider, then the light string relating to that slider increases in illumination. Conversely, reducing the extent or length of a slider can result in the amount of dimming increasing (i.e. illumination decreases). The state of each string of lights can be stored in a database or other suitable memory. When the user makes a change to a slider then the mast hub transmits a signal to the corresponding string
20 controller, and the new status is stored in the memory or database.

As mentioned above, the wireless communication is based on use of a 2.4GHz transceiver module. In one embodiment the transceiver modules include registers for setting
25 addresses, configuration and for holding packets. These features make up the physical/data-link layer for the system. The PIC microcontroller used in conjunction with each transceiver module effectively constructs the network/application layer by forming packets and/or reading instructions. Those skilled in the art will appreciate that this architecture comprises one example, and that other arrangements or chipsets can be used.

30 The communication protocol which is used does not require any handshaking between the communication modules. The protocol broadly resembles a broadcast network. In one embodiment all the string controllers 4 have the same receive address and therefore all receive the same packets of data. In a preferred embodiment, the packets are each 5 bytes, comprising a 1-byte command and a 4-byte address. The command execution is validated by the
35 microcontroller by reading the 4-byte address contained in the same packet.

All the switches 40, 60 and the master controller 12 have unique addresses. Thus when a switch for example is activated it transmits a broadcast network command (for example a toggle command) with its unique address. The packet is received by all of the string controllers 4
5 within range (in one embodiment the range is at least 30 meters). Any string controller 4 that has stored the unique address of that particular switch will then process and respond to the command, or otherwise discard the packet.

10 A summary of the commands (with hex notation where relevant in brackets) that may be sent and received by the various components of the system is set out below:

The **string controller receives** the following commands:

SET LEVEL (0x01 to 0x64)

TOGGLE (0x65)

15 INVOKE PAIRING (0xDD)

DISCOVERY REQUEST

EXIT DISCOVERY MODE

The **string controller transmits** the following commands:

20 DISCOVERY RESPONSE

The **switch transmits** the following commands (switch does not receive):

TOGGLE (0x65)

INVOKE PAIRING (0xDD)

25

The **master controller receives** the following commands:

DISCOVERY RESPONSE

The **master controller transmits** the following commands:

30 SET LEVEL (0x01 to 0x64)

DISCOVERY REQUEST

EXIT DISCOVERY MODE

Packets are 5 bytes long constructed as (0x00, 0x00000000)

35 CMD, ADDRESS

In use, a string controller 4 will operate as follows:

On first receive of a toggle command the lights controlled by the particular string controller will
5 be switched on to full brightness. A subsequent receive of a toggle command will start the lights
dimming (i.e. reverse phase dimming) by gradually reducing the time for which switch 30 is On
in each half cycle as described with reference to Figure 5. The lights will continue to
progressively dim over a required time period, for example a period of approximately 5-6
seconds unless another toggle command is received in which event the progressive dimming
10 will be halted at the dimness level at the time the subsequent toggle command was received.
Once halted at a dimness level another toggle command will switch the lights off.

In use, switches such as switches 40 and 60 operate as follows:

15 When the switch actuator 42 or 62 is closed the power from the battery is connected to the
relevant electronic circuits including the microcontroller, as described above. The
microcontroller then transmits a packet with the toggle command for receipt by string controllers 4
with which the particular switch is paired. Subsequent actuation of the switch will send further
toggle commands to control the operation of the relevant string controllers as described above.
20 For switch 40, if the switch actuator is held closed for a required period of time e.g. 1 second,
then the microcontroller sends a packet that includes the invoke pairing command. String
controllers that are operational and in range can then store that address for the switch so as to
be responsive to that address upon receipt of toggle commands. Similarly, and as described
above, for switch 60 insertion of the battery while the actuator is closed will cause an invoke
25 pairing command to be sent so that applicable string controllers 4 can store the switch address
for receipt of future commands from the switch.

The master controller 12 can send a discovery request to which each operable string controller
within range will respond with a discovery response. The address of the master controller can
30 then be stored by each string controller. After the master controller sends an exit discovery
mode command the string controllers with the noted master controller address will then be
operable to process set level commands (to set the level of illumination or dimness as described
above) sent from the master controller address.

35 The communication protocol and the system components have the following features:

1. There is no handshaking required, nor any acknowledgement of receipt of instructions, commands or other data that are sent. This means that devices such as switches do not need to remain active to await a response. As such, there is a considerable power saving. This means that battery life in the switches for example is considerably enhanced, to the extent that a typical 3V lithium battery in a switch may last years rather than months if another protocol such as BLUETOOTH for example were to be used.
2. The short packet length, or small packet size, means that minimal data is transmitted, which again leads to power saving and processing speed. In particular, the system can accomplish all required tasks using a one byte command, while still having many available variations (up to the total of 256).
3. The processor (microcontroller) in the switches is only operable when the switch is sending a command. This again saves considerable power, contributing to the greatly enhanced battery life referred to above.

From the foregoing it will be appreciated that the present invention provides a wirelessly controlled lighting system which uses a broadcast communication system and low power consumption switches to achieve considerable power saving and thus enhance battery life. The system conveniently allows switches to be located anywhere within range, and enables existing wall switches to be adapted for use with the system.

Unless the context clearly requires otherwise, throughout the description, the words "comprise", "comprising", and the like, are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense, that is to say, in the sense of "including, but not limited to".

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

Claims:

1. Light control apparatus comprising:
5 an input for receiving power,
 a wireless receiver configured to receive a wirelessly transmitted broadcast network command,
 an output for supplying output power to a light, and
 a control circuit for controlling the output power dependent on the command.
10
2. Light control apparatus as claimed in claim 1 wherein the command comprises an instruction and an address.
3. Light control apparatus as claimed in claim 1 wherein the output power is controlled by
15 the control circuit to change the illumination of the light.
4. Light control apparatus as claimed in any one of the preceding claims wherein the instruction results in the control circuit progressively dimming the light.
- 20 5. Light control apparatus as claimed in claim 4 wherein the control circuit progressively dims the light pending receipt of a further command.
6. Light control apparatus as claimed in any one of the preceding claims wherein the output is connected to a light string.
25
7. Light control apparatus as claimed in any one of the preceding claims further comprising a remote switch having a wireless transmitter configured to wirelessly transmit a broadcast network command for receipt by the wireless receiver.
- 30 8. Light control apparatus as claimed in any one of the preceding claims further comprising a master controller having a wireless transmitter configured to wirelessly transmit a broadcast network command for receipt by the wireless receiver.
- 35 9. Light control apparatus as claimed in claim 7 or claim 8 wherein the wireless transmitter command comprises an instruction and an address.

10. Light control apparatus as claimed in claim 9 wherein the control circuit processes the instruction if the address is recognised.

5 11. Light control apparatus comprising:
a switch means configured to be responsive to an action of a user;
a wireless transmitter configured to wirelessly transmit a broadcast network command comprising an address unique to the switch and a lighting control instruction.

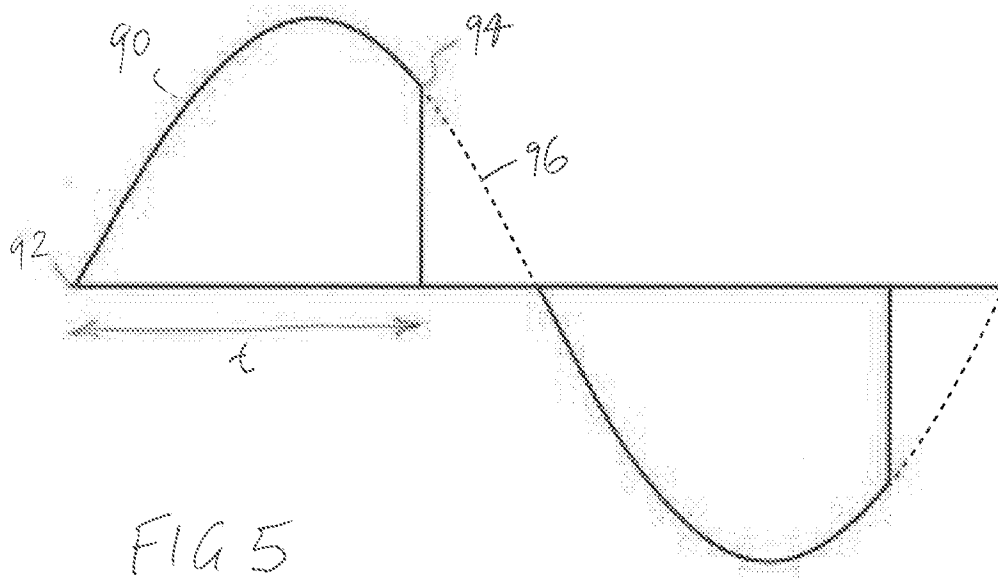
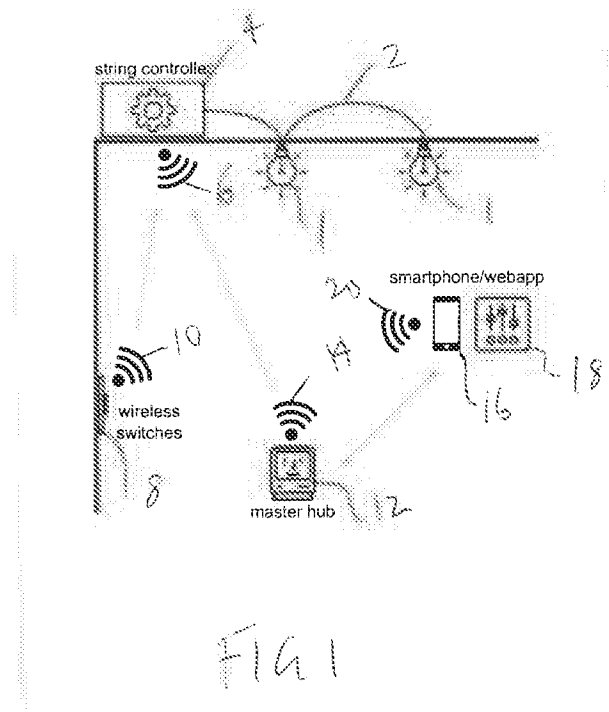
10 12. Light control apparatus as claimed in claim 11 further comprising a switch controller configured to provide power to the apparatus for a selected time period following activation of the switch means.

15 13. Light control apparatus as claimed in claim 12 wherein the switch controller comprises an additional switch means configured to connect the apparatus to a power supply for the selected time period.

20 14. Light control apparatus as claimed in any one of claims 11 to 13 wherein actuation of the switch means results in an instruction to dim a light.

15. Light control apparatus as claimed in claim 14 wherein further actuation of the switch means halts dimming of the light.

25 16. Apparatus substantially as herein described with reference to the drawings.



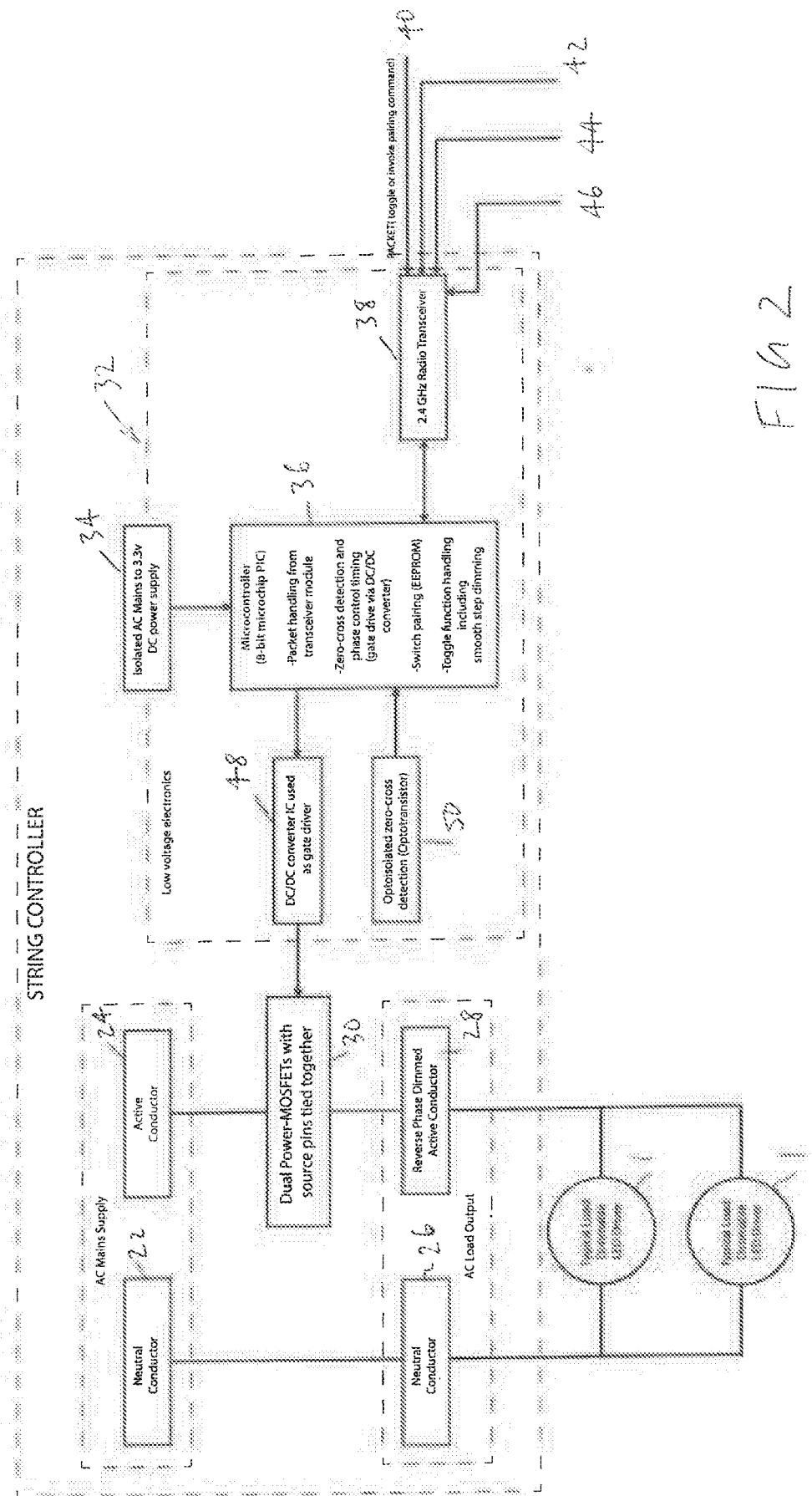


FIG 3A

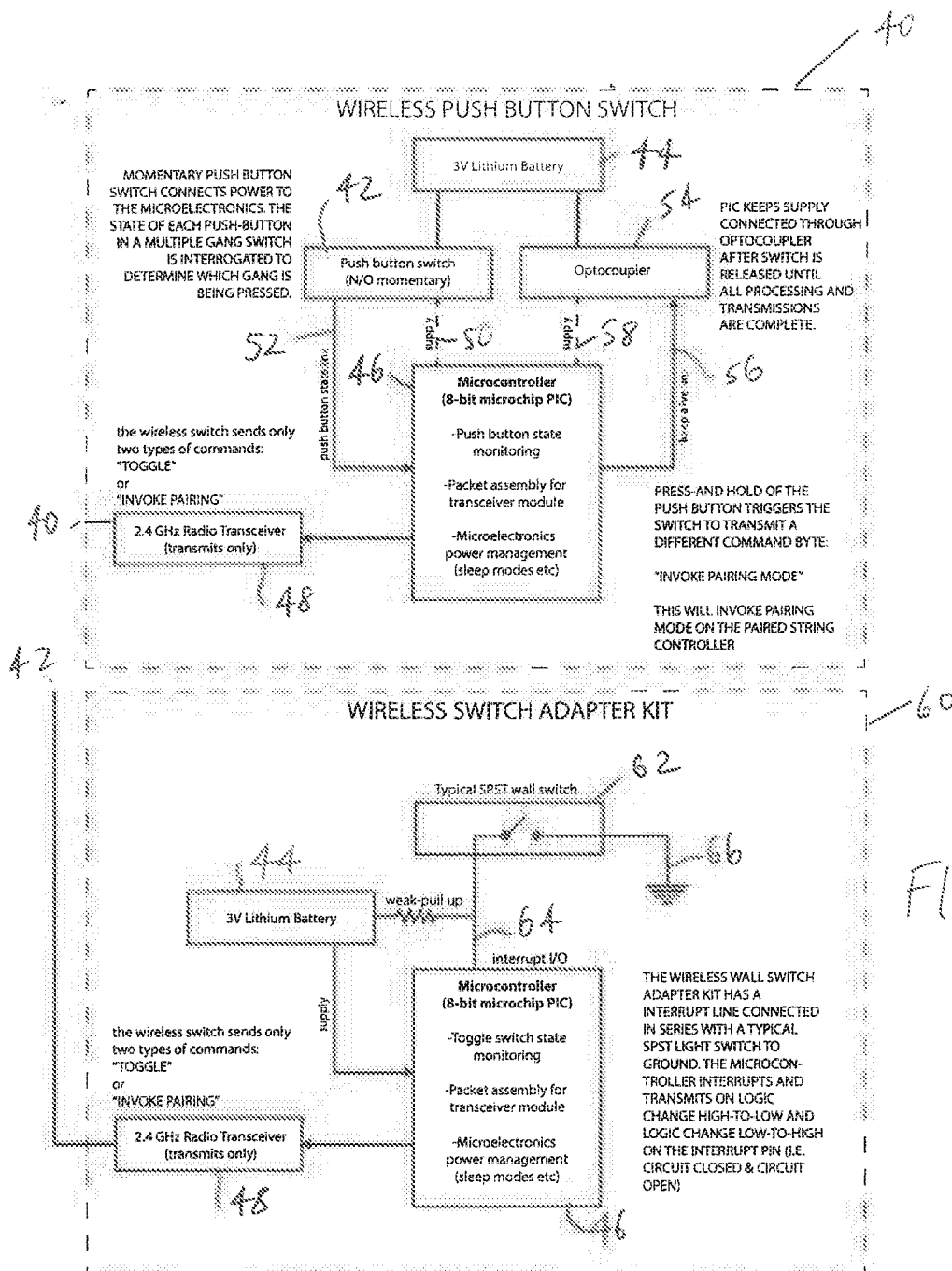


FIG 3B

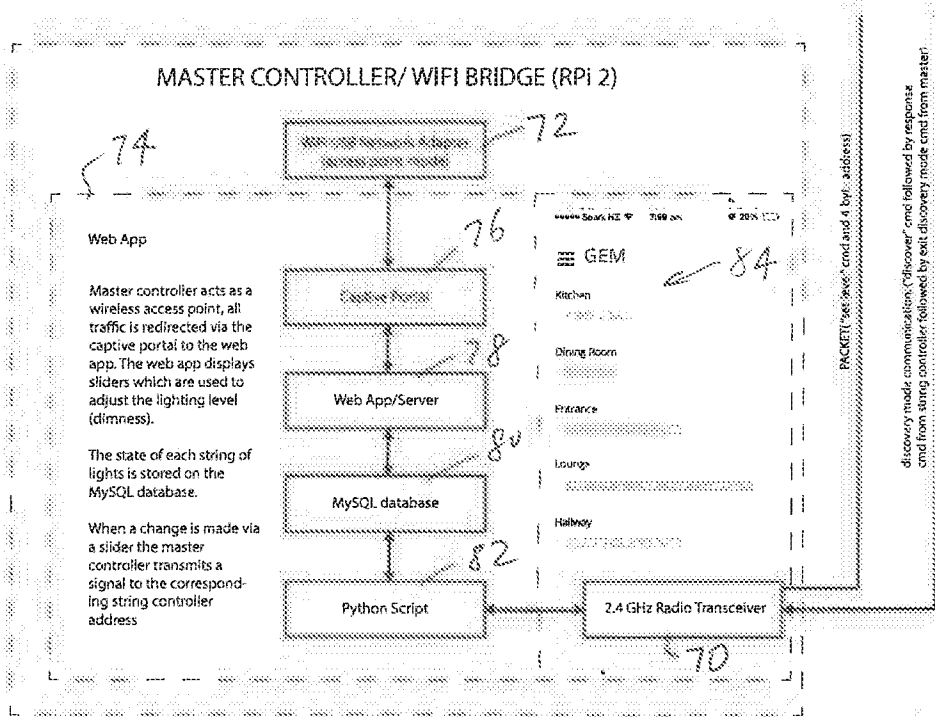


FIG 4

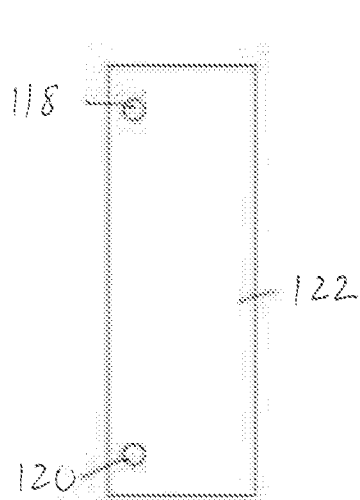


FIG 7B

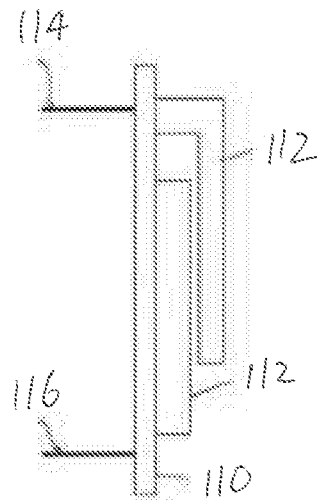


FIG 7A

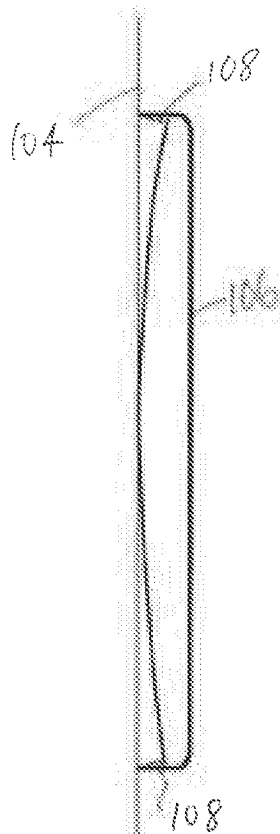


FIG 6B

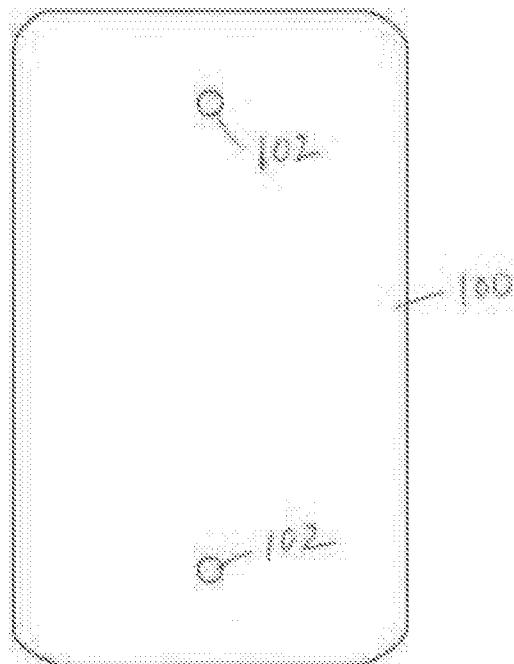


FIG 6A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2016/050004

A. CLASSIFICATION OF SUBJECT MATTER

H05B 37/02 (2006.01) H05B 41/36 (2006.01) H04L 29/08 (2006.01)

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)

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)

Database: EPODOC, WPI and WPIAP

IPC: H05B and Y02B /low

Keywords: lighting, wireless, address, location, position, dimming, level and similar terms

Database: Google, Google Patents, Espacenet, Auspat and Patentscope.

Keywords: light, dimming, wireless, transmitter, receiver, address, IP, control, monitor and similar terms.

Applicant and Inventor Search: Auspat: ELLIS, Tomas Espacenet: ELLIS, Tomas Patentscope: ELLIS, Tomas Google Patents: ELLIS, Tomas; Internal databases provided by IP Australia.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 10 June 2016		Date of mailing of the international search report 10 June 2016	
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustalia.gov.au		Authorised officer Leo Lai AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832769	

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including
2. ☒ Claims Nos.: 16
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
See Supplemental Box
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/NZ2016/050004
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 203387715 U (ZHONGYU ELECTRICAL APPLIANCE CO. LTD.) 08 January 2014 abstract, figure 1, [0019], [0025] and [0040]	1-15
X	US 2003/020999 A1 (HUI et al.) 13 November 2003 abstract, figure 2a, 4b, [0023]-[0025], [0028]	1-5, 7-11, 14 and 15
X	US 7623042 B2 (HUIZENGGA) 24 November 2009 abstract, figure 1, column 2 lines 19-41, column 2 line 52- column 3 line 3, column 3 lines 35-40, column 4 line 8-column 5 line 22	1-5, 9-11, 14 and 15
X A	US 2009/0278472 A1 (MILLS et al.) 12 November 2009 abstract, figure 1, [0005], [0016], [0018], [0026], [0029] Whole Document	1-4, 7-11, 14 and 15 1-15
X A	US 7167777 B2 (BUDIKE, Jr.) 23 January 2007 abstract, figure 9, column 4 lines 45-63 Whole Document	1-5, 7, 9-11, 14 and 15 1-15
X	CN 103731961 U (CHEN YUN et al.) 16 April 2014 abstract, [0019], [0023], [0024]	1-5, 7, 9-11, 14 and 15
P,X	US 2015/0038165 A1 (TUO et al.) 05 February 2015 abstract, figure 1, 3 and 4, [0012]-[0023], [0030]-[0041] and [0048]-[0065]	1-11, 14 and 15

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NZ2016/050004**Supplemental Box****Continuation of Box II**

Claim 16 does not comply with Rule 6.2(a) because it/they rely on references to the description and/or drawings.

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/NZ2016/050004	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
CN 203387715 U	08 January 2014		
US 2003/020999 A1	13 November 2003	US 2003020999 A1	30 Jan 2003
		US 6661564 B2	09 Dec 2003
		JP 2002312104 A	25 Oct 2002
US 7623042 B2	24 November 2009	US 2006215345 A1	28 Sep 2006
		US 7623042 B2	24 Nov 2009
		US 2010191388 A1	29 Jul 2010
		US 7884732 B2	08 Feb 2011
US 2009/0278472 A1	12 November 2009	US 2009278472 A1	12 Nov 2009
US 7167777 B2	23 January 2007	US 2005097162 A1	05 May 2005
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		CA 2544959 A1	26 May 2005
		EP 1685497 A2	02 Aug 2006
		JP 2007511058 A	26 Apr 2007
		JP 4749337 B2	17 Aug 2011
		US 2006025891 A1	02 Feb 2006
		US 7346433 B2	18 Mar 2008
		WO 2005048654 A2	26 May 2005
CN 103731961 U	16 April 2014	None	
US 2015/0038165 A1	05 February 2015	US 2015038165 A1	05 Feb 2015
		US 9279686 B2	08 Mar 2016
		CN 103476169 A	25 Dec 2013
		EP 2959752 A1	30 Dec 2015
		WO 2015007189 A1	22 Jan 2015
End of Annex			
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001. Form PCT/ISA/210 (Family Annex)(July 2009)			