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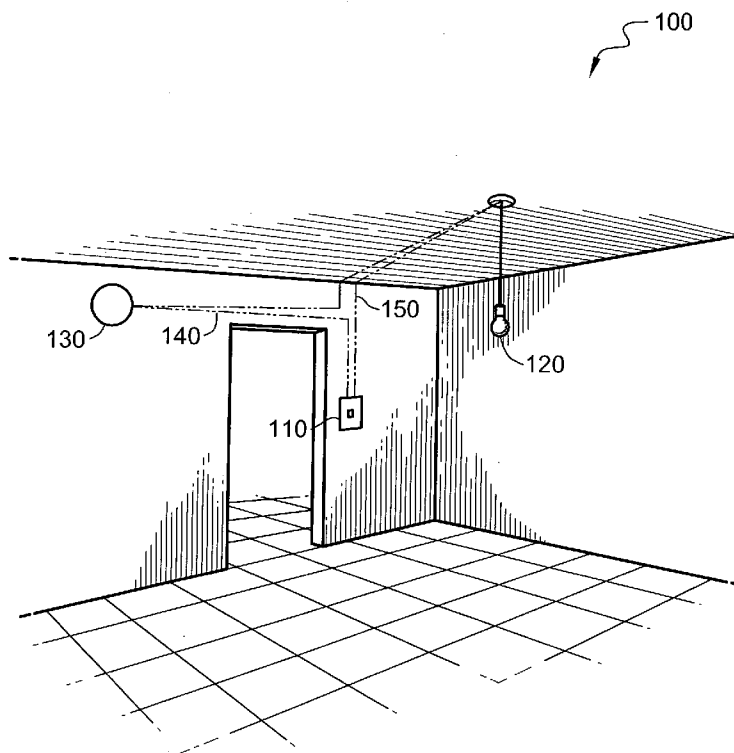
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(54) Title: REMOTE CONTROLLED ELECTRICAL SWITCH RETROFIT SYSTEM



(57) Abstract: A wall mounted power switch retrofit, including, a switch that connects to the existing wires of the retrofitted wall mounted power switch and allows power to be provided to a load when turned on and prevents power from being provided to the load when turned off, a control unit that controls the status of the switch, a circuit that draws power from the existing wires and provides it to the control unit; and wherein the control unit receives electrical power regardless of the status of the switch.

Fig. 1

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REMOTE CONTROLLED ELECTRICAL SWITCH RETROFIT SYSTEM

FIELD OF THE INVENTION

The present invention relates generally to retrofitting wall mounted electrical switches with switches that require electrical current to function and more specifically to a retrofit that does not require additional wiring.

BACKGROUND OF THE INVENTION

The operation of specific electrical devices by remote control is well known in the art, for example to control televisions, videos, and air-conditioners. In recent years house automation systems have been introduced, wherein remote controls are used to replace or supplement the standard wall mounted switches, for example to turn on/off or dim lights. Typically to implement such systems in an existing building requires a retrofit to replace or supplement the existing wall mounted switches so that the switches will receive commands from a remote control and respond accordingly. Generally, such a receiver needs electrical power to be able to receive instructions and act on them, regardless if the switch is on or off and without affecting the load. To overcome this problem most retrofit systems require the installation of additional wiring to provide power for the operation of the retrofit. This solution complicates the installation and generally requires installation by a skilled technician instead of simply replacing the switch by a layman. Alternatively, some retrofits are built to operate on batteries; however this limits their lifespan or requires the owner to periodically monitor the retrofits and replace batteries that have depleted.

Some retrofits only receive instructions to turn on and turn off the switch, whereas other provide more complicated functions, for example dimming the lights or providing varying electrical signals to control complex impedance devices.

In PCT publication no. WO 01/35181 from May 17, 2001 the disclosure of which is incorporated herein by reference, there is described a remote switching system and electrical device actuator.

SUMMARY OF THE INVENTION

An aspect of an embodiment of the invention, relates to a retrofit for a wall mounted electric switch that requires electrical power to function and controls the status of a load. The retrofit is connected to the existing two wires of the existing switch, instead of or in addition to the existing switch and it controls the status of the load without significantly affecting the load regardless of the state of the load (e.g. on or off).

Optionally, the retrofit is controlled through the use of a wireless remote control. Alternatively, the retrofit is pre-programmed to perform functions automatically, for example turning lights on and off at selected times. Further alternatively, the retrofit performs other functions that require power, for example turning on and off the load responsive to the lighting in the room or responsive to identifying the fingerprint of a specific person.

The power for the functionality of the retrofit is provided by drawing power from the main power source that powers the load. Optionally, the retrofit draws power from the main power source differently when the switch is turned off than when the switch is turned on. In some embodiments of the invention, the retrofit includes a rechargeable battery that is charged from the main power source to provide power for controlling the retrofit when the retrofit cannot draw power from the main power source. Optionally, the battery is charged only when the switch is turned off and the load is not powered. Alternatively, the battery is charged only when the switch is turned on or in all states.

In some embodiments of the invention, a single retrofit functions with all types of loads. Alternatively, different retrofits are used for different types of loads, for example a retrofit with one type of battery charging circuit for high impedance loads and a second type of battery charging circuit for low impedance loads. In some embodiments of the invention, a single retrofit can be programmed to function with different types of loads. Optionally, the retrofit can automatically detect the type of load connected and function accordingly. In some embodiments

of the invention, the retrofit allows certain actions only with specific types of loads, for example to dim the light only for pure impedance loads.

In an exemplary embodiment of the invention, the wireless remote control uses RF signals or infrared signals to communicate with the retrofit. Alternatively, the wireless remote uses audio signals or other types of wireless signals, for example visible light waves (e.g. a LED pointer).

There is thus provided according to an exemplary embodiment of the invention, a wall mounted power switch retrofit, including:

- a switch that connects to the existing two wires of the retrofitted wall mounted power switch and allows power to be provided to a load when turned on and prevents power from being provided to the load when turned off;

- a control unit that controls the status of the switch;

- a circuit that draws power from the existing wires and provides it to the control unit; and

wherein the control unit receives electrical power regardless of the status of the switch. Optionally, the retrofit further comprises a rechargeable battery to provide power for the functionality of the control unit; and a battery charger to charge the battery. In an exemplary embodiment of the invention, the battery is charged when the switch is turned off; and the battery provides power for the functionality of the control unit when the switch is turned on. Optionally, the control turns off the switch periodically to allow the battery to recharge. In an exemplary embodiment of the invention, the control turns off the switch at specific times to allow the battery to recharge. Optionally, the retrofit draws a current of less than 2mA from the power lines to recharge the battery. In an exemplary embodiment of the invention, the retrofit draws a low current electrical signal from the power lines and provides the battery charger with a high current electrical signal with a lower potential. Optionally, the battery is charged regardless of the state of the switch.

In an exemplary embodiment of the invention, the retrofit includes a remote control to wirelessly transfer commands to the control of the retrofit. In an exemplary embodiment of the invention, the retrofit includes a motion sensor to

transfer commands to the control of said retrofit. Optionally, the retrofit includes a light sensor to transfer commands to the control of the retrofit. In an exemplary embodiment of the invention, the control unit is programmable. Optionally, the control unit comprises selector switches to select options. In an exemplary embodiment of the invention, the switch is turned off and turned on mechanically. Optionally, the switch is turned off and turned on electronically. In an exemplary embodiment of the invention, properties of the load are identified by said retrofit from the electrical signal on the power line. Optionally, the control manipulates the electrical signal on the power line by changing the status of the switch at a high rate. In an exemplary embodiment of the invention, the circuit stores power for powering the control. Optionally, the retrofit includes a capacitor to store power for powering the control. In an exemplary embodiment of the invention, if the power stored in said circuit goes below a threshold value, the control turns on the power to the load for a short period of time and shares the power with the circuit to replenish the power stored in the circuit. Optionally, the short period of time is negligible so that it is not noticeable that the load received power.

There is thus further provided according to an exemplary embodiment of the invention, a method of providing electrical power to a wall mounted power switch retrofit, including:

- connecting a switch between the existing wires of the wall mounted switch being retrofitted;

- connecting a bypass circuit in parallel to the switch;

- drawing electrical power from the existing wires to the bypass circuit when the switch is turned off;

- storing power in the bypass circuit for use when the switch is turned on;

- replenishing the stored power in the bypass circuit when it goes below a threshold value by sharing power with the load. Optionally, the bypass circuit stores power in a rechargeable battery. In an exemplary embodiment of the invention, the bypass circuit stores power in a capacitor. Optionally, the

replenishing is performed by turning off the switch for a pre-selected amount of time to replenish the power in the bypass circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and better appreciated from the following detailed description taken in conjunction with the drawings. Identical structures, elements or parts, which appear in more than one figure, are generally labeled with the same or similar number in all the figures in which they appear, wherein:

Fig. 1 is a schematic illustration of a perspective view of a room with a retrofitted wall mounted switch, according to an exemplary embodiment of the invention;

Fig. 2 is a schematic block diagram of a circuit for implementing a retrofit switch, according to an exemplary embodiment of the invention;

Fig. 3 is a state diagram illustrating various states of functionality of a retrofit, according to an exemplary embodiment of the invention;

Fig. 4 is a schematic illustration of a detailed circuit for implementing a retrofit switch, according to an exemplary embodiment of the invention; and

Fig. 5 is a schematic illustration of an alternative detailed circuit for implementing a retrofit switch, according to an exemplary embodiment of the invention.

DETAILED DESCRIPTION

Fig. 1 is a schematic illustration of a perspective view of a room 100 with a retrofitted wall mounted switch 110, according to an exemplary embodiment of the invention. In an exemplary embodiment of the invention, retrofit 110 is designed to replace a standard wall mounted switch that controls a load or to be attached to the wall and connected in parallel or in series to the standard wall mounted switch so that it can control the load in addition to the existing switch. Retrofit 110 is installed using the existing infrastructure of the previous switch, but it enhances the old switch by supporting functions, which require electrical power for the function to be provided, for example a wall mounted switch retrofit that senses motion and turns on the light for a specific time.

In an exemplary embodiment of the invention, the retrofit is connected by one wire 140 coming from a main power source 130 and a second wire 150 going to a load 120 (e.g. a incandescent light bulb).

Fig. 2 is a schematic block diagram of a circuit 200 for implementing retrofit switch 110, according to an exemplary embodiment of the invention. In an exemplary embodiment of the invention, circuit 200 of retrofit 110 includes two connection points (203, 204) to connect to wire 140 and wire 150. Optionally, circuit 200 includes a switch 210 that controls the power circuit, and turns on or turns off load 120. In an exemplary embodiment of the invention, circuit 200 additionally includes a battery charger 230 and a rechargeable battery 240. Optionally, when switch 210 is turned off power is drawn from the main power line via a bypass line 220 and used by battery charger 230 to recharge battery 240. In an exemplary embodiment of the invention, battery charger 230 is implemented by a step down switched regulator with a high efficiency (e.g. above 80%). Optionally, battery charger 230 draws a small amount of current from the main power line (e.g. less than 1mA) so that load 120 does not show any signs that current is being drawn from lines 140 and 150. In an exemplary embodiment of the invention, battery charger 230 exploits the fact that it is provided with a high

voltage (e.g. approximately 110V or 220V) and a low current (e.g. 2mA) to generate a high current and low voltage (e.g. 5V, 40mA) for quickly charging battery 240. Optionally, battery 240 is fully charged within an hour or less so that the load can be used most of the time.

In an exemplary embodiment of the invention, circuit 200 includes a control 250 that receives instruction from a remote control 260 or from other devices, for example a light sensor, a motion detector, a fingerprint sensor or a touch screen. Optionally, control 250 controls switch 210 responsive to the instructions provided to perform various actions such as to turn off switch 210, to turn on switch 210 or alternately turn on and off switch 210 so that load 120 (e.g. a light) will flash or be dimmed to various degrees. In an exemplary embodiment of the invention, remote control 260 uses RF communications, Infra-Red communications, visible light, audio signals or other methods.

In an exemplary embodiment of the invention, when switch 210 is in the on state; load 120 receives power from main power source 130 and is turned on. Optionally, when load 120 is powered on, bypass line 220 ceases to receive current since it is parallel to a short and the battery ceases to be charged. Optionally, control 250 also stops receiving power from main power source 130 and instead is provided power from battery 240, so that it can receive signals directing it to turn on or turn off switch 210 or take other actions.

Fig. 3 is a state diagram 300 illustrating the various states of functionality of retrofit 110, according to an exemplary embodiment of the invention. In an exemplary embodiment of the invention, circuit 200 determines (310) the status of switch 210. If switch 210 is turned on then battery charger 230 is off (320). Optionally, battery 240 provides (330) the power for control 250, so that it can receive automated instructions or wireless communications to turn on or turn off switch 210. If the power in battery 240 gets low (340), for example below a threshold value, for example an amount of power that is sufficient for less than 10 minutes. Then control 250 turns off (350) switch 210, causing load 120 to be turned off and battery charger 230 goes on (360). Likewise if the user turns off

switch 240 with remote control 260 or by physically moving switch 210, battery charger 230 goes on (360) and battery 240 is recharged (370). Optionally, when switch 210 is turned off, power for control 250 is provided (380) directly from main power source 130. In some embodiments of the invention, battery 240 can provide power for control 250 for at least two days or even a week, so that under normal use load 120 won't be turned off when needed by the user, for example a user may use remote control 260 to control a light while in bed and turn it off when going to sleep.

In some embodiments of the invention, control 250 includes a programmable microprocessor to allow implementation of complex rules. Optionally, control 250 may be set to turn off switch 210 after a specific amount of time or at a specific hour to charge battery 240, for example control 250 may turn on load 120 (e.g. a light or fan) between specific hours and turn off load 120 at other hours according to the requirements of the user, and to charge battery 240. In some embodiments of the invention, control 250 is programmed using remote control 260. Alternatively or additionally, circuit 200 may have selection switches 270 or a display 280 (e.g. LEDs or an LCD display) to select options for control 250 and provide indication to the user. As an example display 280 may give indication regarding the charge level in the battery or the time at which load 120 will be activated or deactivated.

In some embodiments of the invention, switch 210 is a mechanical relay. Alternatively, switch 210 is an electronic switch, for example a Triac, a FET, an IGBT or other type of electrical switch that can be turned on and off electronically. Optionally, control 250 can turn off and turn on switch 210 at a high rate (e.g. 50Hz, or 60Hz) to block parts of the sine wave of the electric current to produce a dimming effect, for example by transferring only part of the sine wave (blocking a percentage of the signal).

In an exemplary embodiment of the invention, when load 120 is activated, control 250 identifies if the load is a simple ohm impedance load or a reactive load (e.g. by detecting COS PHI). Optionally, control 250 prevents

actions, which are not appropriate for the type of load, for example performing dimming on a florescent light.

Fig. 4 is a schematic illustration of a detailed circuit 400 for implementing a retrofit switch 110, according to an exemplary embodiment of the invention. In an exemplary embodiment of the invention, circuit 400 is connected in serial to load 120 and main power source 130 at connection points 203, 204. Optionally, circuit 400 includes 4 main segments, namely: 410, 420, 430 and 440. Optionally, segment 410 serves as a voltage source for segment 420. Segment 410 has a high voltage (e.g. 110V, 220V) on its inputs and it consumes a low current (e.g. 0.1mA or less) from the positive cycle of main power source 130. In an exemplary embodiment of the invention, the output from segment 410 is provided to segment 420 that serves as a step down controlled power supply. Segment 420 has a high voltage (e.g. 110V, 220V) on its inputs that was regulated by segment 410. Segment 420 extracts a low current (e.g. 0.1mA or less) from main power source 130 via segment 410, and converts it to a low voltage (e.g. about 5V) and high current source (e.g. 40mA) over its output. Optionally, segment 420 includes a FET switch that is held in saturated mode as long as the current is below 50mA. When the current reaches 50mA the FET is placed in cut off mode for about 10 microseconds to regulate the current that is passed on from segment 420. In an exemplary embodiment of the invention, the regulated current is passed onto segment 430, and is provided to charger 230 to charge battery 240. Optionally, when segment 420 is in saturation mode the current from segment 420 charges inductor L1. Inductor L1 charges capacitor C3, which provides voltage to charge battery 240. Optionally, in cutoff mode inductor L1 continues to provide current so that charger 230 will function continuously. In an exemplary embodiment of the invention, segment 4 serves to control switch 210 and detect load 120. Optionally, segment 4 includes control 250 to control switch 210. In an exemplary embodiment of the invention, control 250 includes a microprocessor, a communication interface (e.g. an RF receiver) and algorithmic software to determine the actions to be taken in dealing with switch 210, for example if to

turn on or turn off switch 210. Optionally switch 210 is implemented by a Triac or Relay so that it can be turned on or turned off rapidly responsive to a signal from control 250. In an exemplary embodiment of the invention, control 250 may turn on and turn off switch 210 rapidly (e.g. 50-120 times a second), to block parts of the power signal and form a dimming effect.

In an exemplary embodiment of the invention, segment 4 implements a zero cross detector for the sine wave of the electrical power. Optionally, when switch 210 is turned off segment 4 samples the voltage over the Triac. The measured voltage allows segment 4 to determine the phase difference (COS PHI) between the voltage and the current when the triac is turned off (switch 210 is turned off). Optionally, the phase difference gives indication if load 120 is a simple ohm impedance load (e.g. a light bulb) or is a reactive device (e.g. with capacitors and/or inductors). Optionally, control 250 can take actions that match the type of load 120.

In some embodiments of the invention, retrofit 110 draws power from main power source 130 also when switch 210 is turned on and load 120 is functional. Optionally, circuit 200 is connected in parallel to switch 210 as described above and additionally in series with load 120 to draw a small current from main power source 130 (e.g. 1mA) that does not significantly affect the load. Optionally, circuit 200 may be implemented with or without a battery. In some embodiments of the invention circuit 200 does not require a battery since it draws power from main power source 130, when switch 210 is turned off and when it is turned on. Alternatively, circuit 200 is implemented with a battery to make it more robust and not influenced by the characteristics of load 120. In some embodiments of the invention, the characteristics of load 120 are detected automatically by circuit 200 so that circuit 200 can adjust itself accordingly, for example to adjust the resistance of the part of circuit 200 that is connected in series with load 120. Alternatively, the characteristics of load 120 are preprogrammed to retrofit 200 or selected by inputs of circuit 200, for example selector switches 270.

Fig. 5 is a schematic illustration of an alternative detailed circuit 500 for implementing a retrofit switch, according to an exemplary embodiment of the invention. Circuit 500 is designed to power control 250 regardless of the status of switch 210 without the use of a battery. In an exemplary embodiment of the invention, circuit 500 maintains a capacitor (C1) in a constantly loaded state to provide electrical current to power retrofit 110. Optionally, circuit 500 is designed to extract a small amount of current from each cycle or from a specific number of cycles of the electrical power sine wave, when needed to keep capacitor C1 loaded. In an exemplary embodiment of the invention, when the positive part of the electrical current sine wave starts and/or ends, if the charge on capacitor C1 is below a desired value, circuit 500 enables capacitor C1 to draw a negligible amount of power from the main power source in series to load 120. Optionally, charging capacitor C1 is performed while the voltage on diode D1 is positive (or negative) and below a specific voltage (e.g. 5V, 10V), which occurs for less than a tenth of the positive part of each cycle. Thus for an electrical current of 220V at 50Hz the positive part of the cycle takes about 10ms, so that charging capacitor C1 is performed during less than 1ms, for example 0.01 ms. Optionally, when load 120 is on the power used to charge capacitor C1 is negligible so it is unnoticeable, when load 120 is off the circuit 500 closes a circuit with it for a negligible amount of time, so that it is not noticeable either.

In an exemplary embodiment of the invention, circuit 500 comprises two main segments (510, 520). Segment 510 serves as a power supply for control 250. Segment 510 is connected to main power source 130 and keeps capacitor C1 charged at all times.

In an exemplary embodiment of the invention, the power drawn from main power supply 130 is low (e.g. below 300mW), so that the power consumption of retrofit 110 is negligible relative to the consumption of load 120, which may typically be between 25W to 1200W. Optionally, capacitor C1 provides power to segment 520, which is similar to segment 440 from Fig. 4. Segment 520 includes control 250 that controls switch 210.

In an exemplary embodiment of the invention, segment 510 includes a switch regulator controller 530 and a FET 540 to regulate the charge on capacitor C1 in series to load 120 whether the load is in the on state or off state. In an exemplary embodiment of the invention, a Triac serves as switch 210. Optionally, after every zero crossing of the sine wave of the electrical current the Triac is automatically turned off and needs to be retriggered if it should be on to allow current to power load 120. In an exemplary embodiment of the invention, when switch 210 is set to be off, control 250 notifies switch regulator controller 530 on a trigger request line (line 5 of switch regulator controller 530) that switch 210 is off and switch regulator controller 530 should not retrigger the Triac. If switch 210 is set on, control 250 notifies switch regulator controller 530 that it may retrigger the Triac. Optionally, when switch 210 is on, at the beginning of every negative cycle of the electrical current sine wave, switch regulator controller 530 sends a signal on a trigger out line (line 4 of switch regulator controller 530) to retrigger the Triac. At the beginning and during the positive cycle of the electrical current sine wave the conditions described below will determine the status of the Triac.

In an exemplary embodiment of the invention, during the positive cycle with the Triac initially off, power from main power source 130 arrives at FET 540 and charges capacitor C1. Optionally, FET 540 remains on if the following conditions exist:

1. The voltage over the switch terminals (connection points 203, 204) is less than 5V.
2. The voltage over capacitor C1 is less than 3V.
3. The current through the current sense ports (lines 1, 7 of switch regulator controller 530) is less than a predetermined value, to prevent circuit 500 from being burnt out.

Optionally, if any of the three conditions is violated, switch regulator controller 530 will instruct FET 540 to block the charging process, to prevent the supply of excessive charge to segment 520. When switch 210 is in the turned on

state, switch regulator controller 530 retriggers the Triac as soon as FET 540 is turned off. Thus when switch 210 is set to be on circuit 500 may share a small amount of power with load 120 (when FET 540 is on), from the beginning of the positive part of the sine wave until the voltage exceeds 5V (from the 110 or 220 provided), or until C1 is fully charged.

In an exemplary embodiment of the invention, a dimming affect is achieved by having control 250 delay the retriggering of the Triac or by actually turning off the Triac for a specific percentage of each cycle or a specific percentage of cycles per second.

In some embodiments of the invention, a similar method is used to keep a battery charged instead of a capacitor whether switch 210 is turned on or turned off.

It should be appreciated that the above described methods and apparatus may be varied in many ways, including omitting or adding steps, changing the order of steps and the type of devices used. It should be appreciated that different features may be combined in different ways. In particular, not all the features shown above in a particular embodiment are necessary in every embodiment of the invention. Further combinations of the above features are also considered to be within the scope of some embodiments of the invention.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims, which follow.

CLAIMS

1. A wall mounted power switch retrofit, comprising:
 - a switch that connects to the existing two wires of the retrofitted wall mounted power switch and allows power to be provided to a load when turned on and prevents power from being provided to the load when turned off;
 - a control unit that controls the status of said switch;
 - a circuit that draws power from the existing wires and provides it to the control unit; and
 - wherein said control unit receives electrical power regardless of the status of said switch.
2. A retrofit according to claim 1, further comprising:
 - a rechargeable battery to provide power for the functionality of said control unit; and
 - a battery charger to charge said battery.
3. A retrofit according to claim 2, wherein said battery is charged when the switch is turned off; and
 - wherein said battery provides power for the functionality of said control unit when the switch is turned on .
4. A retrofit according to claim 3, wherein said control turns off said switch periodically to allow said battery to recharge.
5. A retrofit according to claim 3, wherein said control turns off said switch at specific times to allow said battery to recharge.
6. A retrofit according to claim 3, wherein said retrofit draws a current of less than 2mA from said power lines to recharge said battery.

7. A retrofit according to claim 3, wherein said retrofit draws a low current electrical signal from said power lines and provides said battery charger with a high current electrical signal with a lower potential.
8. A retrofit according to claim 2, wherein said battery is charged regardless of the state of the switch.
9. A retrofit according to claim 1, comprising a remote control to wirelessly transfer commands to the control of said retrofit.
10. A retrofit according to claim 1, comprising a motion sensor to transfer commands to the control of said retrofit.
11. A retrofit according to claim 1, comprising a light sensor to transfer commands to the control of said retrofit.
12. A retrofit according to claim 1, wherein said control unit is programmable.
13. A retrofit according to claim 1, wherein said control unit comprises selector switches to select options.
14. A retrofit according to claim 1, wherein said switch is turned off and turned on mechanically.
15. A retrofit according to claim 1, wherein said switch is turned off and turned on electronically.
16. A retrofit according to claim 1, wherein properties of the load are identified by said retrofit from the electrical signal on the power line.

17. A retrofit according to claim 1, wherein said control manipulates the electrical signal on the power line by changing the status of the switch at a high rate.
18. A retrofit according to claim 1, wherein said circuit stores power for powering said control.
19. A retrofit according to claim 18, comprising a capacitor to store power for powering said control.
20. A retrofit according to claim 18, wherein if the power stored in said circuit goes below a threshold value, said control turns on the power to the load for a short period of time and shares the power with the circuit to replenish the power stored in said circuit.
21. A retrofit according to claim 20, wherein said short period of time is negligible so that it is not noticeable that the load received power.
22. A method of providing electrical power to a wall mounted power switch retrofit, comprising:
 - connecting a switch between the existing wires of the wall mounted switch being retrofitted;
 - connecting a bypass circuit in parallel to the switch;
 - drawing electrical power from the existing wires to the bypass circuit when the switch is turned off;
 - storing power in the bypass circuit for use when the switch is turned on;
 - replenishing the stored power in the bypass circuit when it goes below a threshold value by sharing power with the load.

23. A method according to claim 22, wherein said bypass circuit stores power in a rechargeable battery.

24. A method according to claim 22, wherein said bypass circuit stores power in a capacitor.

25. A method according to claim 22, wherein said replenishing is performed by turning off the switch for a pre-selected amount of time to replenish the power in the bypass circuit.

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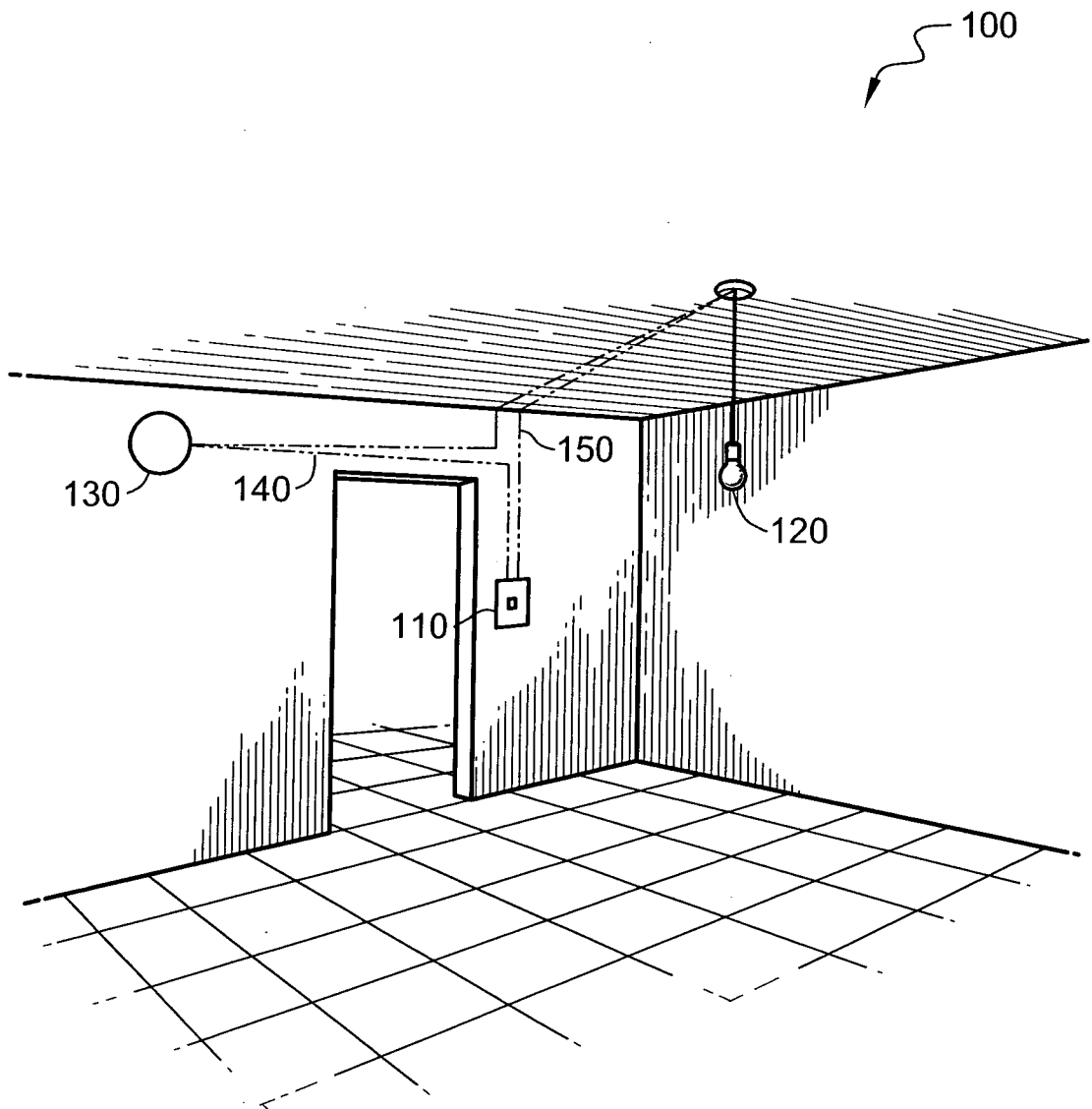


Fig. 1

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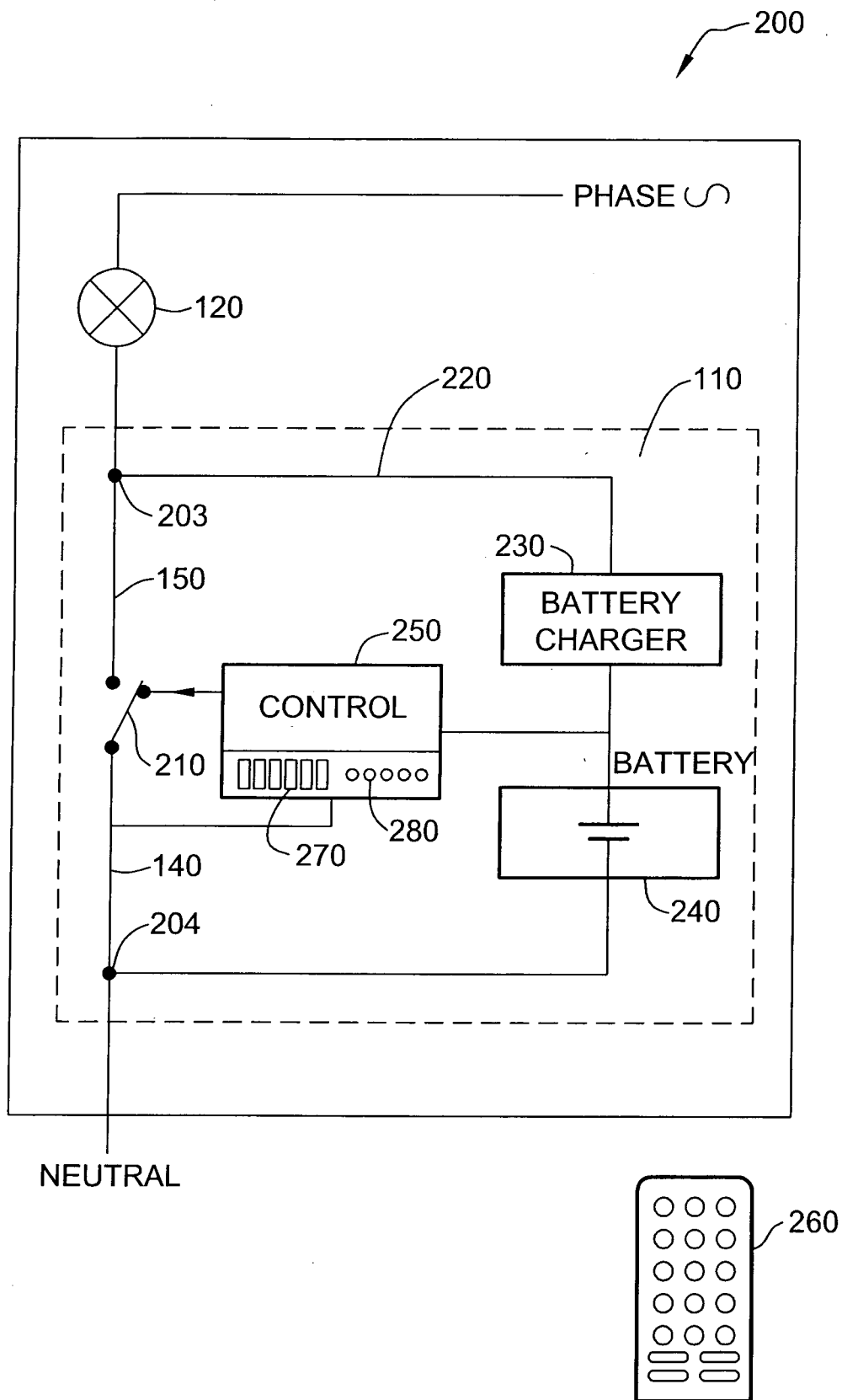


Fig. 2

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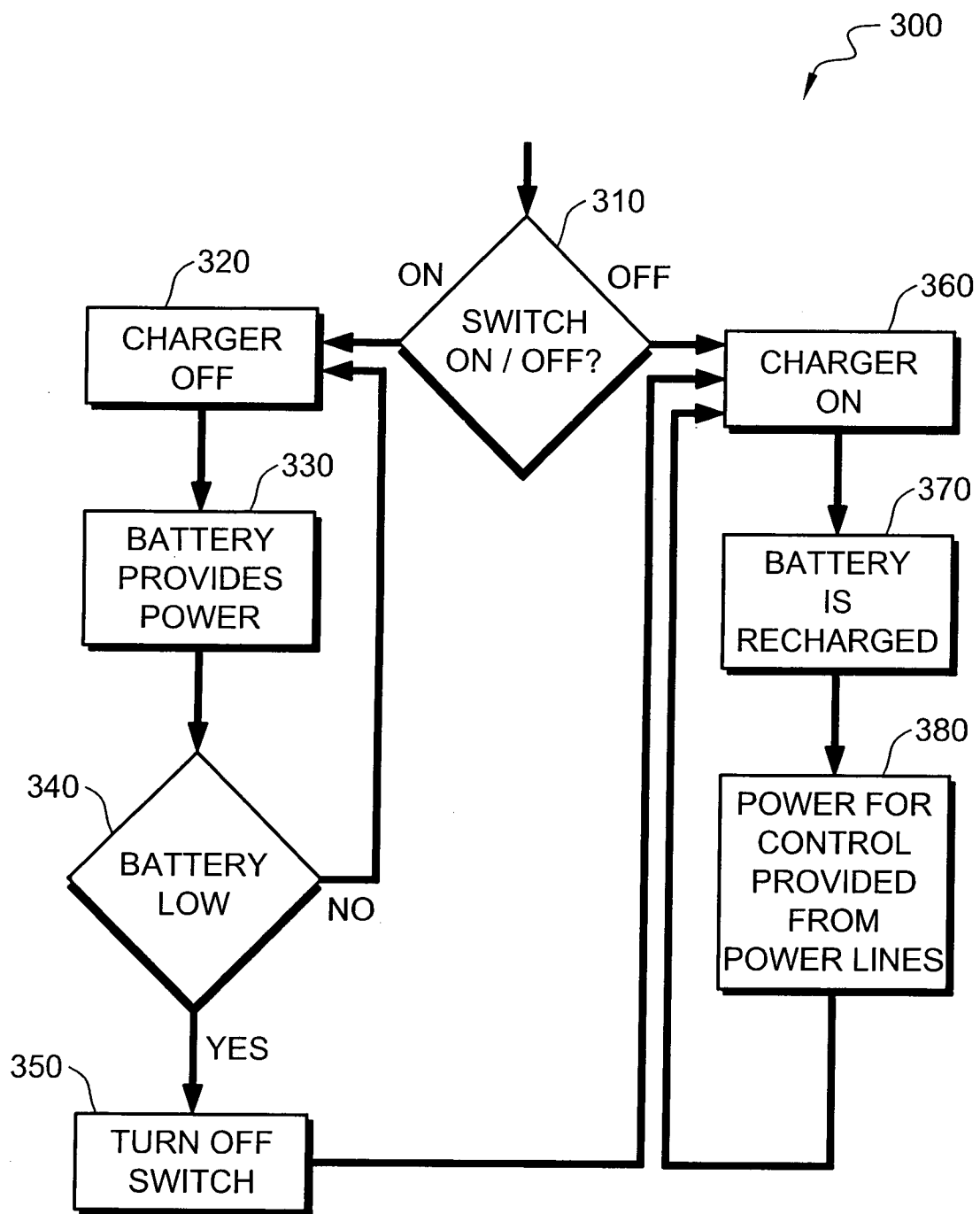


Fig. 3

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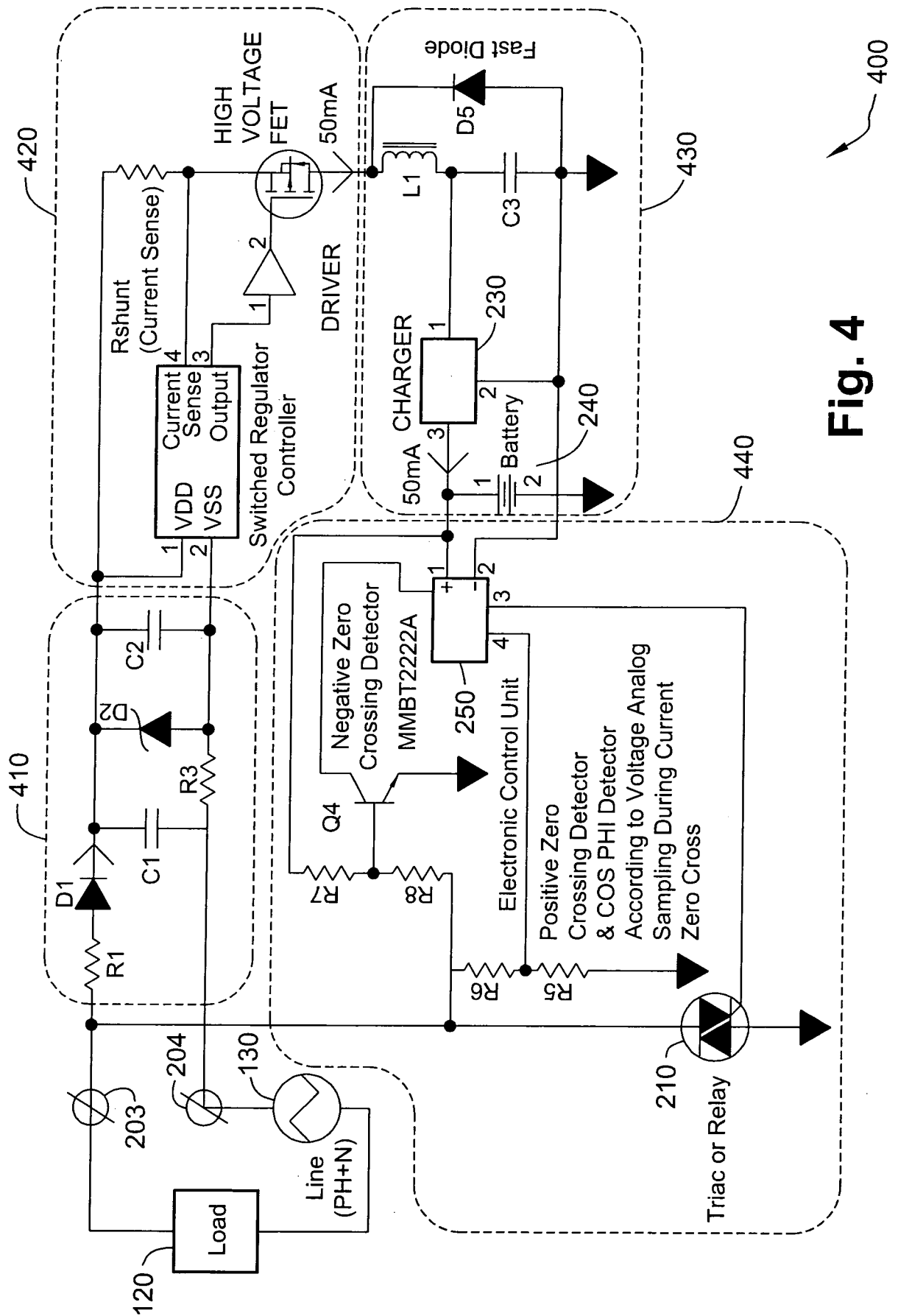


Fig. 4

