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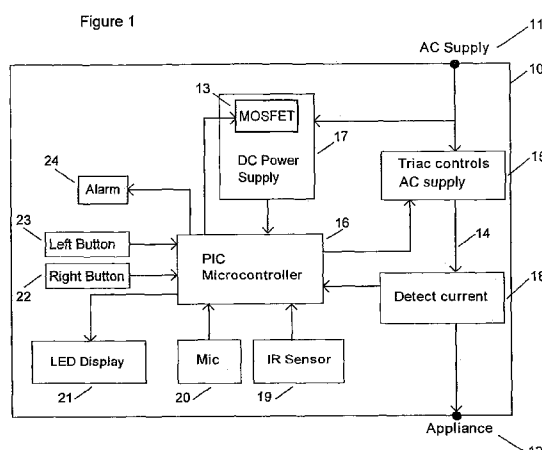
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(54) Title: ELECTRICAL POWER MANAGEMENT DEVICE



(57) Abstract: The present invention provides a device for managing power consumption of an electrical appliance connectable to an external power supply, comprising: an input connectable to the power supply; an output connectable to the electrical appliance; a switchable electrical connection between the input and the output to permit or prevent the supply of electrical power from the external power supply to the electrical appliance through the device; a sensor for providing an output signal indicative of the current supplied to the electrical appliance through the switchable electrical connection or indicative of an environmental condition; and a microcontroller connected to the sensor and to the switchable electrical connection that, in response to a predetermined output signal from the sensor, prevents the supply of electrical power to the electrical appliance and to the microcontroller. A device in accordance with the present invention is operable to reduce power consumption of electrical appliances and can enter a mode in which it consumes no power itself, leading to zero total power consumption.

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Electrical Power Management Device**Field of the Invention**

The present invention relates to the management of power consumption by electrical appliances connected to an external power supply, and in particular relates to a device for minimising unnecessary power consumption.

Background to the Invention

Many electrical appliances unnecessarily consume power when they are not in use, because they enter a standby mode. The standby mode is used to allow the appliance to be activated remotely or to re-start quickly, but very few consumers realise how much power appliances use when they are in a standby mode. It has been estimated that appliances left on standby use around 10% of total residential power consumption.

Offices are notoriously bad for the number of computer monitors unnecessarily left on standby overnight.

Many people leave appliances on standby when there is no need to do so, for example leaving their television sets on standby overnight or for extended periods during the day when they are out of the house, but it is difficult to change people's habits. It is therefore desirable to have a means to automatically reduce the consumption of energy by appliances left in standby. This is desirable both for economic and for environmental reasons.

A number of devices are available for connection between an appliance and its power supply in order to automatically shut off power to the appliance when a standby condition is detected. An example of such a device is the "energenie" product from www.nomorestandby.com.

However, these devices have limited functionality. It is an object of the present invention to provide an energy saving device with improved functionality that can be compact and inexpensive to produce.

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Summary of the Invention

The present invention is defined in the appended independent claims.

Preferred features are set out in the dependent claims.

Brief Description of the Drawings

Examples of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic illustration of an embodiment of the present invention;

Figure 2 illustrates a device in accordance with the present invention having a user interface;

Figure 3 illustrates another embodiment of the invention, suitable for connection to a plurality of appliances;

Figure 4 is a circuit diagram showing the components of a preferred embodiment of a DC power supply for use in a device according to the present invention; and

Figure 5 is a circuit diagram illustrating a preferred embodiment of a switch for breaking a power supply to an appliance in a device in accordance with the present invention.

Detailed Description

Figure 1 is a schematic illustration of a first embodiment of the present invention. The device 10 includes a housing having an input port 11 for connection to an AC power supply and an outlet port 12 for connection to an appliance.

The input port 11 may take the form of a plug suitable for mains supply sockets. The forms of such plugs vary from country to country, and any such plug may be used in the present invention. The plug may be formed integrally with the housing 10 or may be attached to the end of a cable extending from the

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housing. Alternatively the input port may take another form suitable for receiving AC power, such as an IEC socket.

The output port 12 may take the form of a socket matching a mains supply socket, so that appliances with suitable plugs may be inserted into the output port. Alternatively, the output port may be a plug, such as an IEC C13 or C14 plug typically used for household computers and computer monitors. In fact, any suitable connection port may be used and a convenient form may be chosen for use with specific types of appliance.

The input port 11 is connected to the outlet port 12 via a controllable electrical connection 14. Figure 1 shows a switch 15 operable to complete or break the connection 14, and hence control the supply of power to the connected appliance or appliances. The switch 15 is preferably implemented as a triac, but a pair of triacs or other forms of switch or relay may be used.

Figure 5 illustrates a preferred arrangement for implementing switch 15. The switch comprises a triac 50 that is activated by the microcontroller 16. To control the AC power supply to the device output 12, the microcontroller sends signals to transistor 51, which in turn cuts or supplies a voltage to the gate of the triac. If voltage to the gate of the triac is cut, at the end of the half cycle of the AC mains supply the current through the triac will drop below a predetermined threshold and the triac 50 will stop conducting, thus cutting power to the appliance. If a voltage is restored to the triac gate, the triac becomes conductive once again.

The switch 15 is connected to and controlled by a microcontroller 16. A preferred example microcontroller is the PIC16F690-I/P microcontroller available from www.microchip.com. The microcontroller is configured to control the switch in response to externally detected conditions and according to user set parameters. There are many alternative microcontrollers that could be used, such as the PIC16F88X microcontroller.

The microcontroller 16 is provided with power by a DC power supply 17. The DC power supply 17 is connected to the AC power supply via input 11 and

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converts the AC power into a DC power supply for the microcontroller and other elements of the device.

There are a large number of known circuits that can be used to convert AC power into DC power that may be used in a device in accordance with the present invention. A preferred embodiment of the DC power supply is shown in Figure 4. The circuit receives an input from the AC power supply and provides as an output a DC voltage. Figure 4 shows a circuit that receives an AC input voltage, rectifies the AC waveform and then smoothes and regulates the output to provide a DC voltage output.

The Zener diode 40 is the component that regulates the voltage to provide a uniform DC output. It does this by absorbing additional power so as to retain a fixed voltage. In order to reduce power wastage in the Zener diode 40, a metal-oxide-semiconductor field-effect transistor (MOSFET) 42 is provided within the rectifier circuit. The MOSFET 42 can cut or connect the DC power supply circuit and is connected to and controlled by the microcontroller 16. The microcontroller monitors the input AC voltage and controls the connect time of the MOSFET in order to reduce overcharging of capacitor 44 and hence reduce energy wastage in the Zener diode 40.

The MOSFET 42 can be used to cut the DC power supply circuit for extended periods, allowing for a zero power consumption mode of operation. A connection between the MOSFET 13 within the DC power supply circuit 17 and the microprocessor 16 is shown in Figure 1 to illustrate the ability of the microprocessor to cut power to the device completely, and thus consume no energy, as is described in more detail below. In order to switch the device back on again, the user presses the left button 46 for a short time, which renders the MOSFET conductive once again and allows DC power to be generated from the AC power supply.

A silicon-control rectifier (SCR) may be used in place of MOSFET 13.

The microcontroller 16 receives input signals from several sources. The first source of input signals is current sensor 18, which is positioned to detect the

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current being drawn through connection 14. The primary purpose of sensing the current in connection 14 is to determine when an appliance connected to the device has entered a stand-by mode. The current through connection 14 is sensed by sensor 18 and passed to the microcontroller 16. The sensed current is compared with a first threshold value stored in the microcontroller and, if the sensed current is less than the first threshold, an appliance is considered to be in stand-by. If the sensed current is above the first threshold the appliance or appliances are considered to be fully on. If an appliance is considered to be in stand-by, the microcontroller will break the electrical connection between the appliance and the power supply by switching switch 15, in accordance with a particular mode of operation, as will be described in detail below.

The current sensor 18 is preferably an inductive current sensor. The AC power supply is fed through a toroidal inductor, which induces a current in the inductor. The voltage across the inductor is indicative of the AC current. This voltage is amplified and fed to the microcontroller 16.

Alternatively, the current sensor may be implemented as another type of sensor, such as a Hall effect sensor or a sensor based on measurement of voltage across a resistor within connection 14.

A second source of input signals is an infrared (IR) radiation sensor 19. The IR sensor 19 is connected to the microcontroller 16. The microcontroller is configured to respond to detected IR signals in accordance with a particular mode of operation described below.

A third source of input signals is microphone 20. Again, the microcontroller is configured to respond to detected audio signals in a particular mode of operation described below.

A further source of input signals is buttons 22, 23 on the device housing, which allow the microcontroller to be configured by a user. A button or buttons may also be provided as a remote detachable device, connected to the housing by a cable.

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A display 21 is also provided on the device housing, preferably a simple LED display, which allows a user to view the operating parameters of the microcontroller. In a preferred embodiment, the display comprises two seven segment LED displays.

The device also includes an alarm 24, preferably in the form of a speaker, connected to the microprocessor.

The device may also include a thermal sensor (not shown) connected to the microcontroller that allows the microcontroller to shut down the device should it overheat.

Figure 2 illustrates the exterior of a device in accordance with the present invention having a single outlet i.e. a device to which a single device can connect. Figure 2 shows a device in which the outlet takes the form of a socket matching a mains socket. The inlet (not shown) takes the form of a matching plug and is on the opposite side of the device. Above the outlet is the LED display and two buttons, allowing a user to configure various operating parameters of the device, as explained below.

A device in accordance with the present invention may include a plurality of outlet ports, as shown in Figure 3. Figure 3 shows a device 30, having a plurality of output sockets 31, together with an LED display 32 and buttons 33, 34. The device includes a single input having a standard, mains plug connection 35 on the end of a flexible cable 36 attached to the body of the device. The device is essentially the same as a standard multiple socket extension lead in outward appearance, but with the addition of a display screen and two buttons. This embodiment is useful for a set of interrelated devices, such as a television, DVD player and surround-sound system, or a computer and a printer and scanner, where if the main device is switched off, the related devices should be switched off as well.

Modes of operation

The modes of operation of the exemplary embodiment described with reference to Figure 1 will now be described.

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In all modes of operation the microprocessor 16 is sensitive to current measurements from sensor 18. As previously described, the primary purpose of sensing the current in connection 14 is to determine when an appliance connected to the device has entered a stand-by mode. The current through connection 14 is sensed by sensor 18 and passed to the microcontroller 16. The sensed current is compared with a first threshold value stored in the microcontroller and, if the sensed current is less than the first threshold, an appliance is considered to be in stand-by. If the sensed current is above the first threshold the appliance or appliances are considered to be fully on. If an appliance is considered to be in stand-by, the microcontroller will break the electrical connection 14 between the appliance and the power supply by switching switch 15.

The microprocessor may be configured to break connection 14 only after a predetermined holding time. In this scheme, whenever a power off event is triggered, such as in response to a sensed current below the first threshold, the microprocessor waits a predetermined time before breaking connection 14 by starting a countdown. During the holding time, the device may be configured to issue an audible alarm signal from alarm 24, warning the user of an imminent power cut. During the holding time a user may also press one of the buttons 22, 23 to restart the countdown process.

In all modes, a power off event (i.e. a switching of switch 15 to break connection 14) may be triggered immediately by a sensed current above a second threshold value. This protects connected appliances from power surges. The device may also be configured to issue a warning signal from alarm 24 when the sensed current exceeds the second threshold value. A power off event may be also be triggered by a sensed temperature above a temperature threshold.

In a first mode, when the connection 14 is cut, the microcontroller 16 is responsive to signals from the microphone 20. Upon receiving an appropriate signal from the microphone, the microprocessor switches the switch 15 to complete the connection 14 and provide power to one or more connected

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devices. A particular pattern of signals may be required in order to activate the microprocessor, such as a signal resulting from two claps by a user. This ensures that spurious noise does not reconnect appliances that are not required for use. The minimum detected audio level required to trigger a power on event may also be configured by a user.

In this first mode, once the power has been reconnected, the current sensed by the sensor 18 is monitored to determine if the appliance is subsequently used. If the current remains below a predetermined threshold level for a predetermined period of time, for example 30 seconds, following reconnection, the connection 14 is broken by switching switch 15 and audio detection then resumes.

In a second mode, the infrared detector 19 is utilised. The second mode is particularly suited to entertainment systems comprising a number of related appliances, all connected to a single device of the type shown in Figure 3. Typically a television is associated with a number of other appliances such as a DVD player, video recorder, surround-sound and a computer games console. Each device may have its own IR remote control. Each device may also be placed in a stand-by state.

In the second mode, when the connection 14 between the inlet 11 and outlet 12 is broken, the microcontroller 16 is configured to be sensitive to signals from the IR sensor, such that in response to any detected IR signal the switch 15 is switched to complete connection 14, and thus establish a power supply to the connected appliances.

Typically, an IR remote control for consumer appliances emits a signal modulated on 36kHz. The modulation encodes a header sequence, specific to the particular device which the remote control is for, as well as a sequence encoding the specific instruction, such as "reduce volume". This means that multiple appliances, each with an IR remote control, can be used simultaneously and each appliance will only respond to the remote control with the matching header sequence.

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In preferred embodiments of the present invention, the device does not decode the modulated IR data streams from remote controls. The device simply responds to the existence of an IR signal (within a particular frequency range and above a threshold intensity level) regardless of the specific modulation or header sequence. In this way a device in accordance with the present invention is responsive to any IR remote control associated with a connected appliance.

As the microcontroller responds to any detected IR signal, it is not necessary to have a specifically configured remote control for the device. Thus when a user wishes to use the entertainment system he can use any single remote control to reconnect all the appliances.

In a preferred embodiment, the IR sensor 19 may be sensitive to radiation between 10kHz and 40kHz. The threshold intensity level for detected IR signals above which a power on event is triggered can be one of the configurable parameters of the microcontroller 16.

A particular number of discrete IR signals within a predetermined time period may be required to trigger a power on event. For example, the microcontroller may only switch switch 15 in response to three detected discrete IR signals within a two second period. This dramatically reduces the chance of stray IR signals from elsewhere triggering an unintended power on.

Once the connection 14 is completed and the appliances are receiving power, detected IR signals do not affect the operation of the microcontroller, so the user can continue to use remote control functionality for each of the devices. Thus the device reduces energy wastage by a number of appliances in stand-by and allows for convenient reconnection of all devices using a single press of any remote control.

In a third mode, the device can be fully switched off, such that it uses no power. One of the buttons on the device (in the embodiment of Figures 1 and 4 the left button) can be pressed to re-establish power to the DC power supply. Because the user is manually activating the device there is no need to supply power for

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any of the monitoring circuits, i.e. the current sensor, microphone and IR detector. A button for re-establishing power to the DC power supply may also be provided as a peripheral device, attached to the main device housing by a cable. This allows for convenient switch-on by a user if the main housing of the device is not easily accessible. For example, when the main device is plugged directly into the back of a computer monitor on a desk, the peripheral button can be placed on the desk for easy access.

In the third mode the monitoring devices can still be used to determine when to switch the device off. In particular, if the value detected by current sensor falls below a threshold value for a predetermined time, the microcontroller may break connection 14 by switching switch 15 and immediately thereafter switch the device itself off by cutting the signal to the MOSFET 42 within the DC power supply circuit.

When the button is pressed to switch the device back on, the microprocessor can be configured to immediately switch switch 15 to reconnect the appliances.

In a fourth mode of operation, the microcontroller is configured to automatically re-complete the connection 14 by switching switch 15 after a predetermined time. As with other parameters of the microcontroller 16, this predetermined time may be configured by a user using the screen and buttons.

Configuration of the device

In order to allow a user to configure the microprocessor parameters, such as mode selection, time delay selection, threshold setting etc., the device is provided with a screen 21 and two buttons 22, 23. A button or buttons with the same functionality may be provided in a separate housing, attached to the device by a cable. In a preferred embodiment, the screen comprises two seven segment LED displays.

The following is one example of how the buttons may be used to control the operation of the device.

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When the left button 23 is pressed, the display displays the sensed value of the current by sensor 18, converted into a digital value by the microprocessor.

By checking the value of the current when the connected appliances are in standby and the value of the current when one or more is in use, a user can determine a suitable threshold value for standby detection.

When the right button is pressed it displays the value of one of the configurable parameters. If the right button is pressed twice within a predetermined time, the next configurable parameter is displayed.

When the user holds down both buttons for a predetermined time, such as two seconds, the device enters a configuration mode and the displayed parameter becomes configurable. In the configuration mode pressing the left button will decrease a parameter value and pressing the right button will increase a parameter value. To exit the configuration mode either both buttons must be pressed for a predetermined time, such as two seconds, or no buttons must be pressed for a longer time, say 15 seconds.

The following list illustrates available configurable parameters:

Configurable parameter	Logo	Value Limit
1. Current sensor level to trigger power off event.	C	0-99: real ADC value lower than preset value will trigger event.
2. Audio sensor trigger.	A	0-99: real ADC value higher than level preset value will trigger event Sounder is louder when ADC is higher.
3. IR remote controller.	Ir	0-99: real ADC value higher than sensitivity preset value will trigger event.
4. Holding time.	H	10-100 seconds: where power off event is triggered, hold power and alert the customer before cutting power. During this time, the customer may press any key to restart the counting process again, or enter to configure the mode/change setting.
5. Auto OFF timer.	O	0-99 minutes: the expiry of this time will trigger the power off event. 0: never power off based on this timer.

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Configurable parameter	Logo	Value Limit
6. Auto POWER on timer.	P	0-99 minutes: the expiry of this time will trigger the power on event. 0: never power on based on this timer.
7. Speaker volume level	S	0: mute. 1: low or "office" volume. 2: normal volume.

ADC in this context means the digitally converted value of the sensed analogue parameter.

It can be seen that the present invention provides enhanced functionality and energy savings when compared with prior power saving devices. Devices in accordance with the present invention can be produced simply and inexpensively in a compact and convenient form.

Further aspects of the Invention

In a further aspect, the invention provides a device for managing power consumption of an electrical appliance connectable to an external power supply comprising:

- an input connectable to the power supply;
- an output connectable to the electrical appliance;
- a switchable electrical connection between the input and the output to permit or prevent the supply of electrical power to the electrical appliance from the external power supply through the device;
- a sensor for providing an output signal indicative of the current being supplied to the electrical appliance through the switchable electrical connection;
- a microcontroller for controlling the switchable electrical connection in response to the output of the sensor, wherein operation of the microcontroller is dependent on at least one user configurable parameter; and
- a user interface allowing a user to set the at least one user configurable parameter.

The user configurable parameter may be a threshold level of current such that when the current being supplied to the appliance falls below the threshold level, the microcontroller prevents the supply of power to the electrical appliance.

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The user configurable parameter may be a time delay, wherein the microcontroller only prevents the supply of power to the appliance following an output signal from the sensor indicating that the current being supplied to the appliance has fallen below a threshold level after the time delay.

The input may be configured to be connectable to a mains socket.

The output may be configured to be an IEC plug.

The device may include an alarm connected to the microcontroller, and the microcontroller may activate the alarm in following an output signal from the sensor indicative of a current level below the threshold level.

The device may include an alarm connected to the microcontroller, and the microcontroller may activate the alarm in response to an output signal from the sensor indicative of a current level above a second threshold level.

A volume of an alarm signal generated by the alarm may be a user configurable parameter.

The user interface may comprise a button and a digital display.

The device may include a plurality of outputs each connectable to an electrical appliance and the sensor may provide an output signal indicative of the total current supplied to all of the appliances.

The device may further comprise an infrared detector connected to the microcontroller, wherein the microcontroller causes the switchable electrical connection to permit power to be supplied to the electrical appliance upon detection of one or more infrared signals.

The one or more infrared signals may be any infrared signals within a predetermined frequency range and above a threshold intensity level, irrespective of any modulation of the infrared signals.

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The threshold intensity level may be a user configurable parameter.

The user interface may allow the user to set a plurality of parameters that determine the operation of the microcontroller.

When the current being supplied to the appliance falls below the threshold level, the microcontroller may prevent the supply of power to the electrical appliance and to the device.

The switchable electrical connection may include a switch for permitting or preventing the supply of electrical power to the electrical appliance from the external power supply through the device, wherein the switch comprises at least one triac.

In another aspect, the invention provides a device for managing power consumption of an electrical appliance connectable to an external power supply, comprising:

- an input connectable to the power supply;
 - an output connectable to the electrical appliance;
 - a switchable electrical connection between the input and the output to permit or prevent the supply of electrical power from the external power supply to the electrical appliance through the device;
 - a sensor for detecting infrared signals; and
 - a control element connected to the sensor and to the switchable electrical connection,
- wherein when the switchable electrical connection is in a first state preventing the supply of electrical power to the electrical appliance, in response to the detection of one or more infrared signals by the sensor, the control element switches the switchable electrical connection to a second state permitting the supply of electrical power to the electrical appliance, irrespective of any modulation of the infrared signals.

When the device is configured to permit the supply of electrical power from the external power supply to the electrical appliance through the device, the control element may be configured not to respond to any signals from the sensor.

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The control element may switch the switchable electrical connection to a second state permitting the supply of electrical power to the electrical appliance only if the infrared signals have a received intensity greater than a threshold intensity level. The threshold intensity level may be adjustable by a user.

The control element may switch the switchable electrical connection to a second state permitting the supply of electrical power to the electrical appliance only in response to a predetermined number of discrete infrared signals detected by the sensor within a predetermined time period.

CLAIMS

1. A device for managing power consumption of an electrical appliance connectable to an external power supply, comprising:
 - an input connectable to the power supply;
 - an output connectable to the electrical appliance;
 - a switchable electrical connection between the input and the output to permit or prevent the supply of electrical power from the external power supply to the electrical appliance through the device;
 - a sensor for providing an output signal indicative of the current supplied to the electrical appliance through the switchable electrical connection or indicative of an environmental condition; and
 - a microcontroller connected to the sensor and to the switchable electrical connection that, in response to a predetermined output signal from the sensor, prevents the supply of electrical power to the electrical appliance and to the microcontroller.
2. A device according to claim 1, wherein the predetermined output signal is indicative of a current supplied by the external power supply below a predetermined threshold level.
3. A device according to claim 1 or 2, wherein the microcontroller is configured to prevent the supply of electrical power to the electrical appliance and to the microcontroller after a predetermined time following receipt of the predetermined output signal from the sensor.
4. A device according to any one of claims 1 to 3, further comprising a user actuable switch wherein actuation of the switch following prevention of the supply of power to the microcontroller permits the supply of power to the control element.
5. A device according to any one of the preceding claims, wherein the microcontroller controls a MOSFET or an SCR within a DC power supply circuit connected to the microcontroller to prevent the supply of power to the microcontroller.

6. A device according to any one of the preceding claims, wherein operation of the microcontroller is dependent on at least one user configurable parameter; and wherein the device further comprises a user interface allowing a user to set the at least one user configurable parameter.
7. A device according to claim 6, wherein the user configurable parameter is a threshold level of current such that when the current being supplied to the appliance falls below the threshold level, the microcontroller prevents the supply of power to the electrical appliance.
8. A device according to claim 6, wherein the user configurable parameter is a time delay, wherein the microcontroller only prevents the supply of power to the appliance following an output signal from the sensor indicating that the current being supplied to the appliance has fallen below a threshold level after the time delay.
9. A device according to any one of claims 6, 7 or 8, wherein the user interface comprises a button and a digital display.
10. A device according to any one of claims 6 to 9, wherein the user interface allows the user to set a plurality of parameters that determine the operation of the microcontroller.
11. A device according to any one of the preceding claims, wherein the input is configured to be connectable to a mains socket.
12. A device according to any one of claims 1 to 10, wherein the output is configured to be an IEC plug.
13. A device according to any one of the preceding claims, wherein the device includes an alarm connected to the microcontroller, and wherein the microcontroller activates the alarm in following an output signal from the sensor indicative of a current level below the threshold level.

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14. A device according to any one of the preceding claims, wherein the device includes an alarm connected to the microcontroller, and wherein the microcontroller activates the alarm in response to an output signal from the sensor indicative of a current level above a second threshold level.

15. A device according to claim 13 or 14, wherein a volume of an alarm signal generated by the alarm is a user configurable parameter.

16. A device according to any one of the preceding claims, wherein the device includes a plurality of outputs each connectable to an electrical appliance and wherein the sensor provides an output signal indicative of the total current supplied to all of the appliances.

17. A device according to any one of the preceding claims, further comprising an infrared detector connected to the microcontroller, wherein the microcontroller causes the switchable electrical connection to permit power to be supplied to the electrical appliance upon detection of one or more infrared signals.

18. A device according to claim 17, wherein the one or more infrared signals are any infrared signals within a predetermined frequency range and above a threshold intensity level, irrespective of any modulation of the infrared signals.

19. A device according to claim 18, wherein the threshold intensity level is a user configurable parameter.

20. A device according to any one of the preceding claims wherein the switchable electrical connection includes a switch for permitting or preventing the supply of electrical power to the electrical appliance from the external power supply through the device, wherein the switch comprises at least one triac.

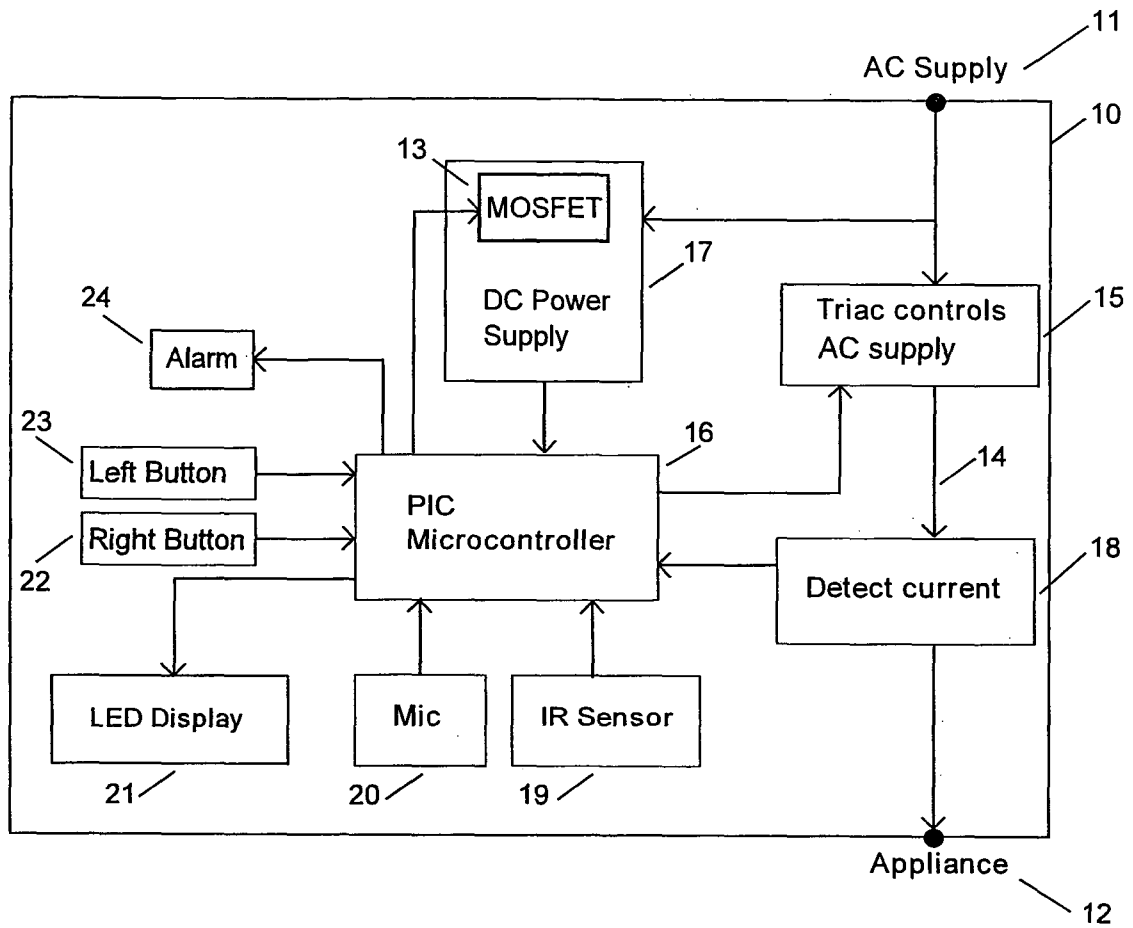


Figure 1

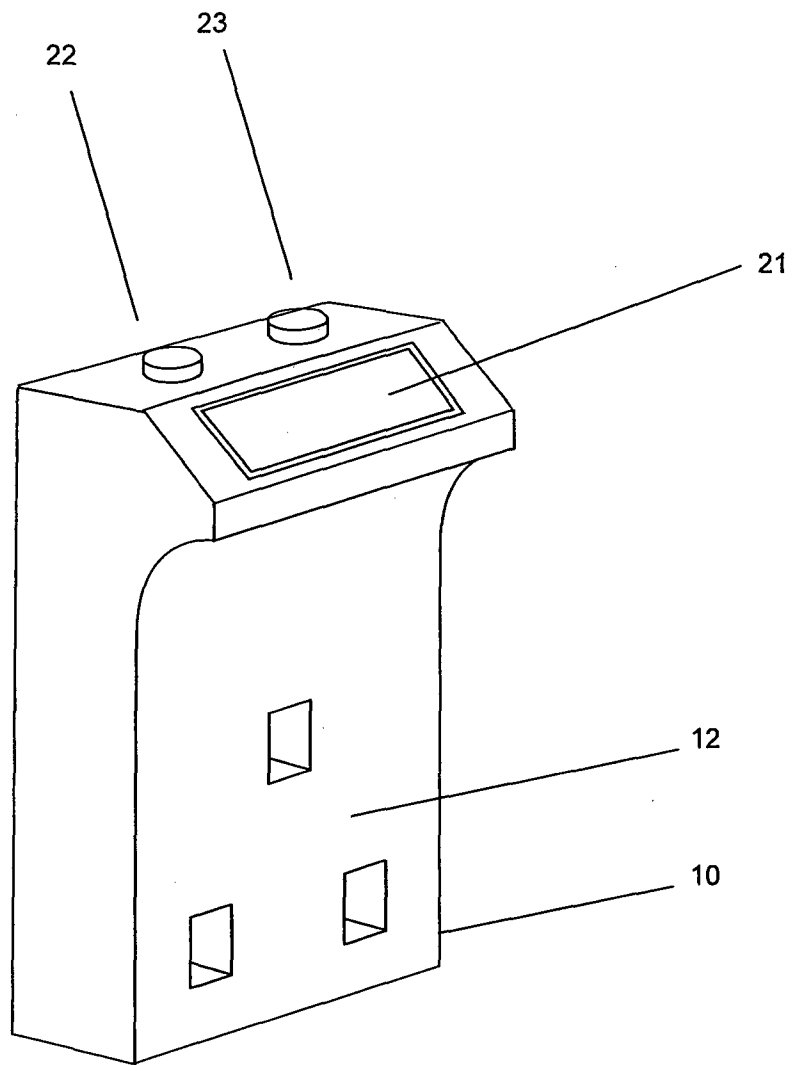


Figure 2

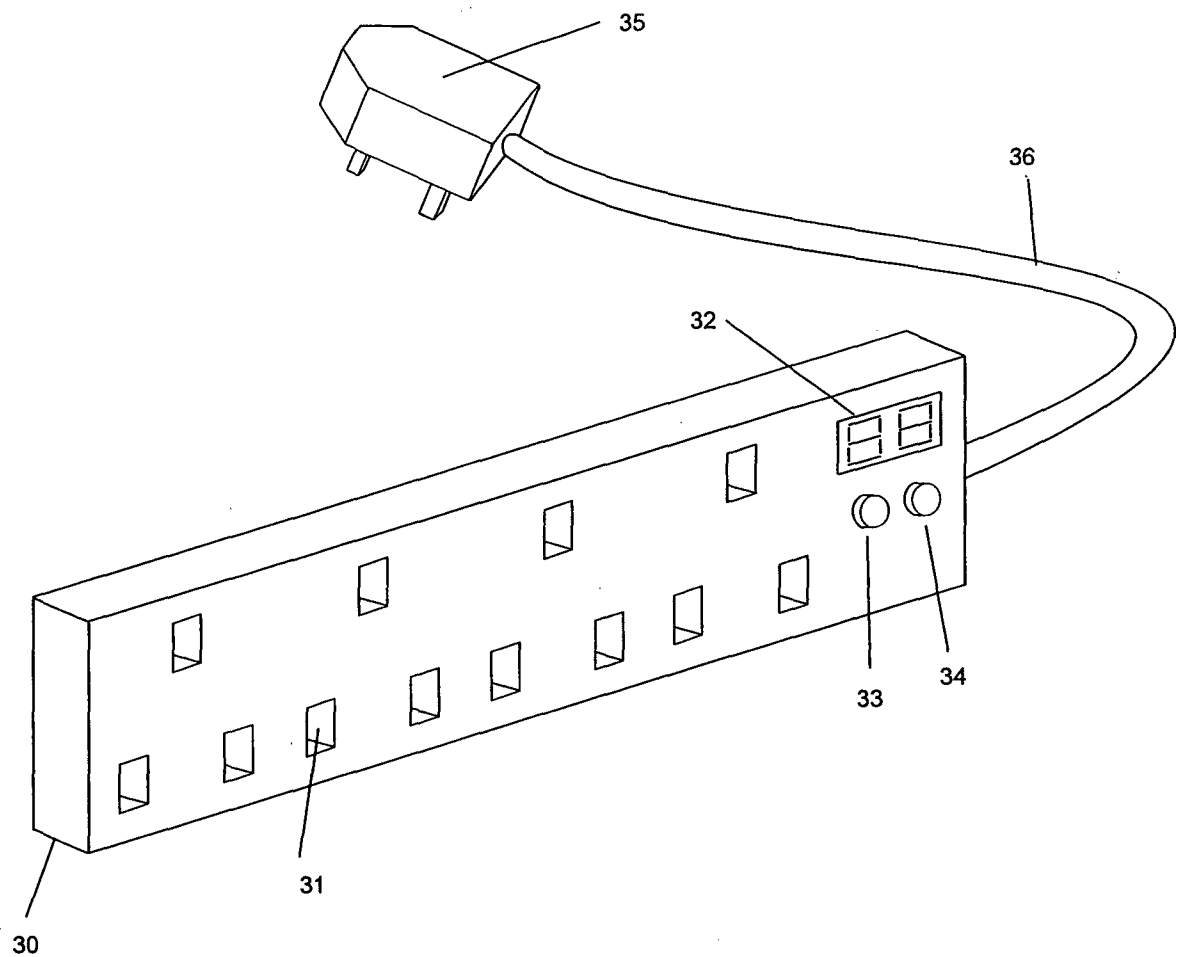


Figure 3

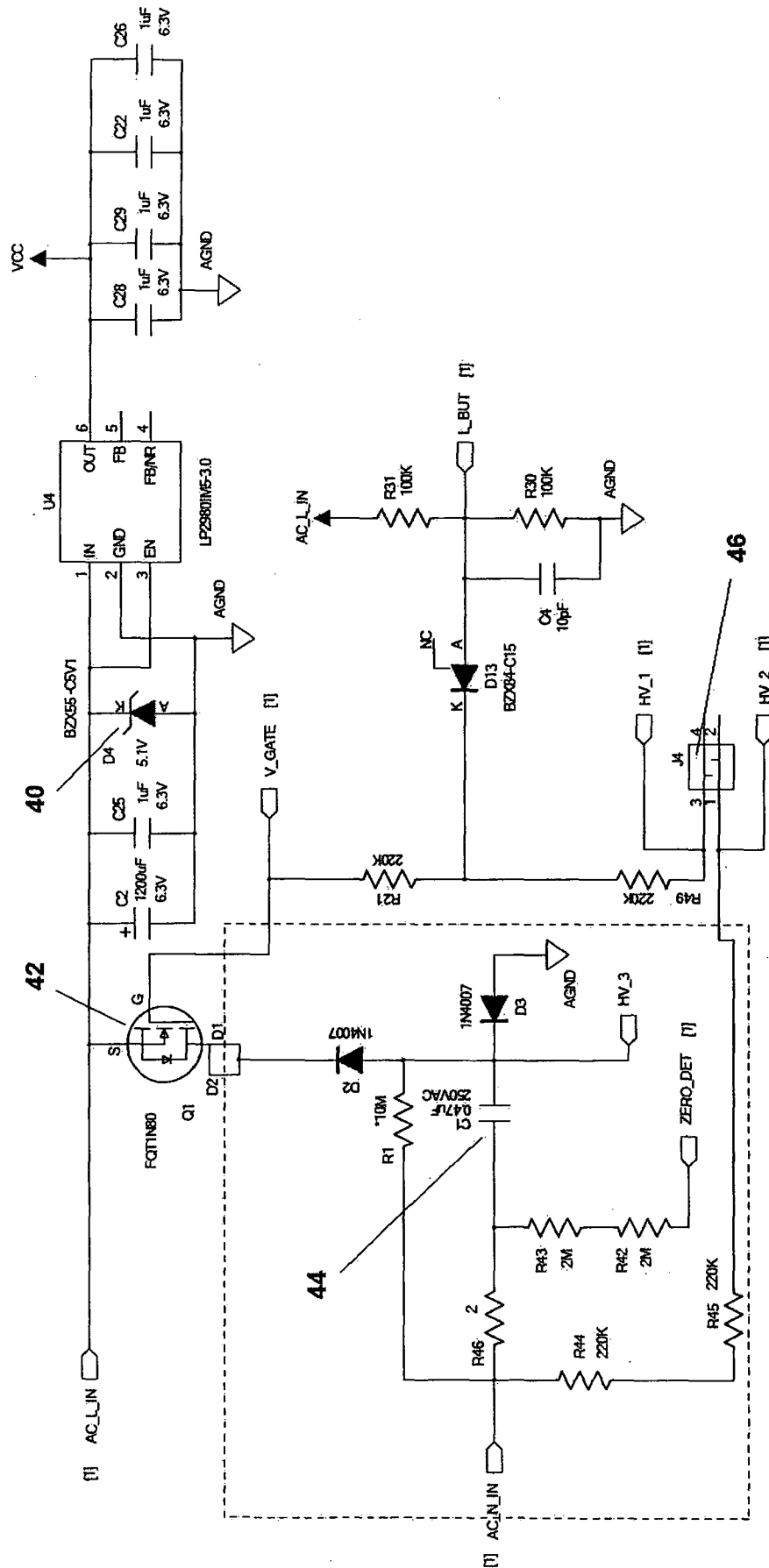


Figure 4

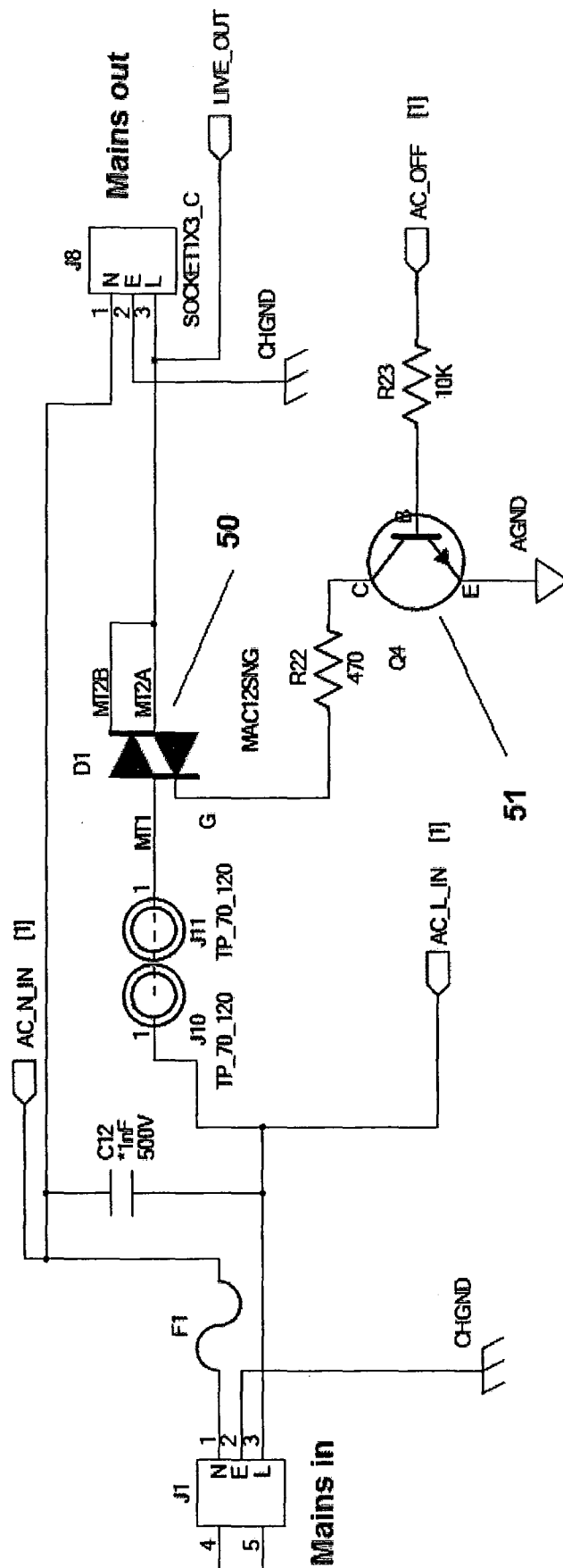


Figure 5