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(54) **COMPACT CONVERTER PLUG FOR LED LIGHT STRINGS**

**Publication Classification**

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CPC ..... *H05B 33/0815* (2013.01)

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(57) **ABSTRACT**

(21) Appl. No.: **14/486,933**

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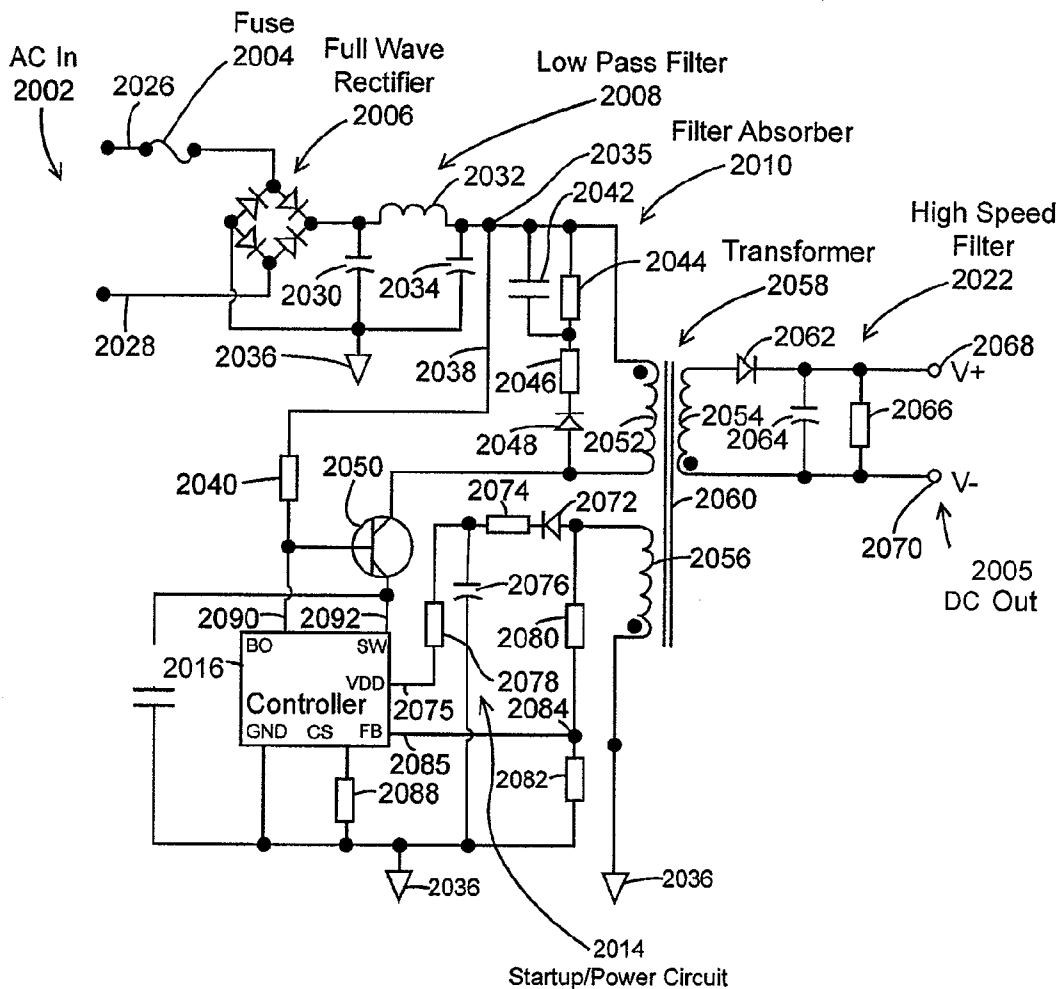
**Related U.S. Application Data**

(63) Continuation of application No. 12/834,949, filed on Jul. 13, 2010, now Pat. No. 8,836,224.

**Foreign Application Priority Data**

Aug. 26, 2009 (CN) ..... 200920230903.3  
Aug. 27, 2009 (CN) ..... 200920231361.1

Disclosed is a compact converter plug that can be used with LED lighting strings. The converter plug has a size and shape that is comparable to a standard wall plug and is capable of plugging into a standard wall socket. The converter plug is waterproof and can be easily assembled. A unique converter circuit is utilized that is compact and highly efficient. Monitoring is performed by a transformer coil that generates a monitoring signal. The converter is controlled by controlling the modulation frequency of a direct current signal using a controller.



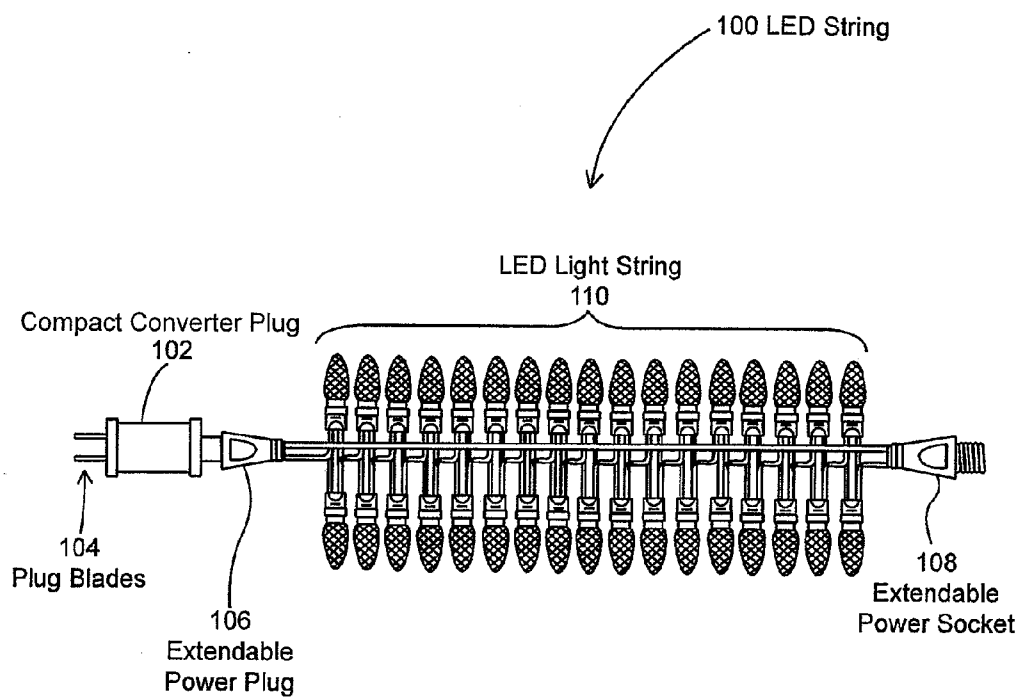


FIG. 1

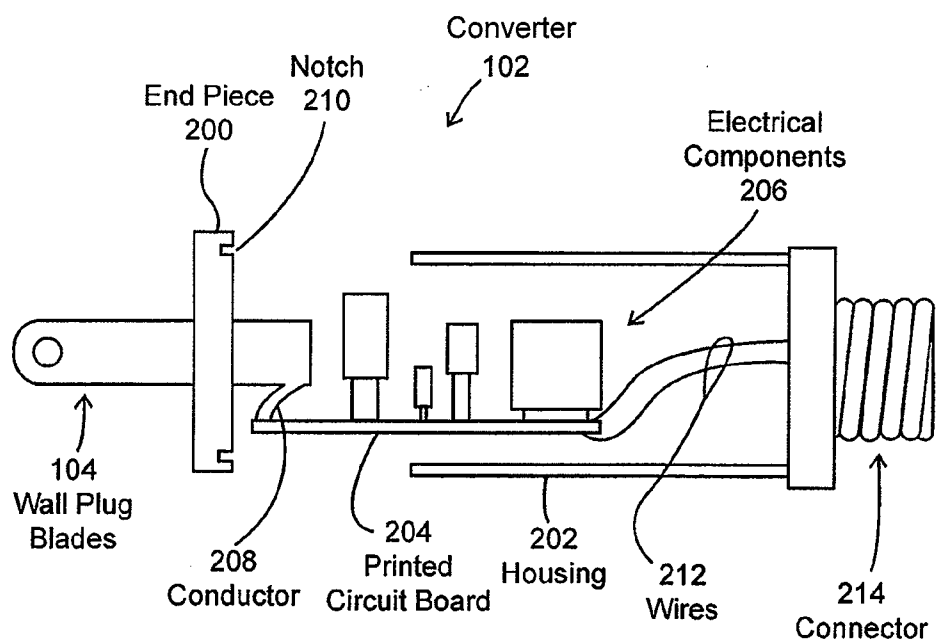


FIG. 2

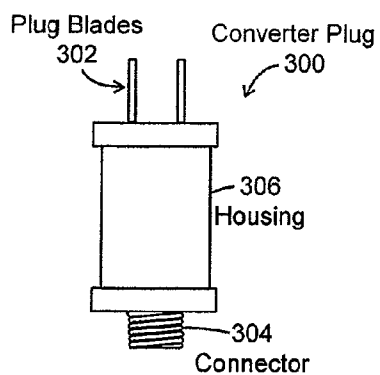


FIG. 3

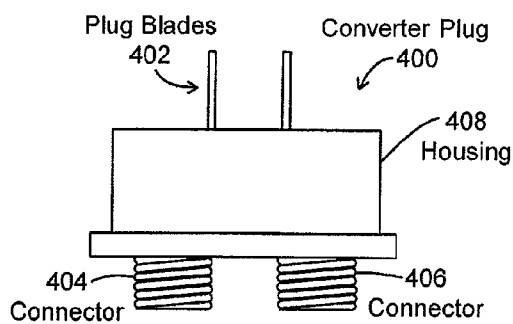


FIG. 4

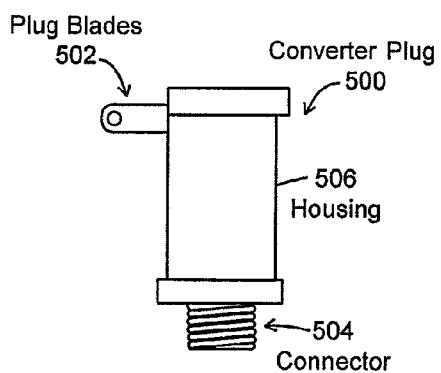


FIG. 5

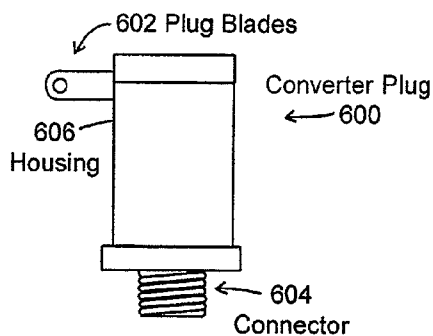


FIG. 6

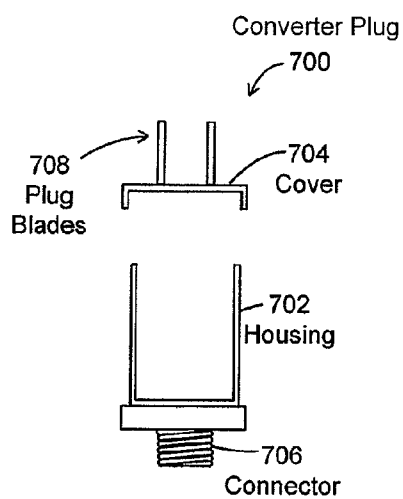


FIG. 7

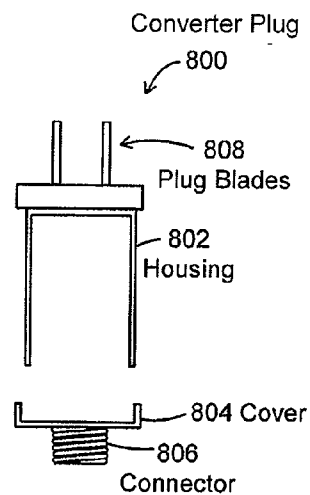


FIG. 8

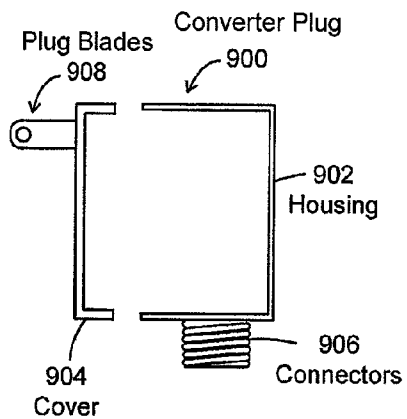


FIG. 9

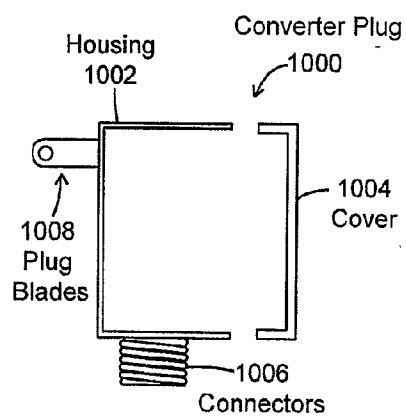


FIG. 10

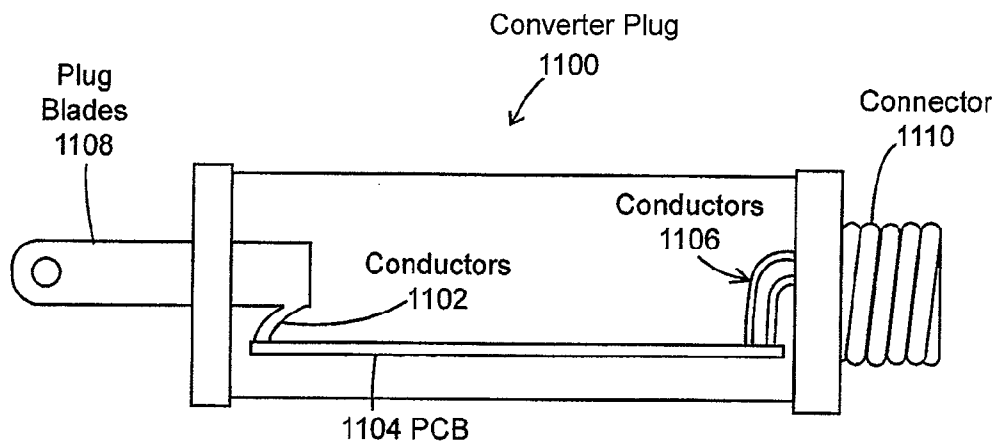


FIG. 11

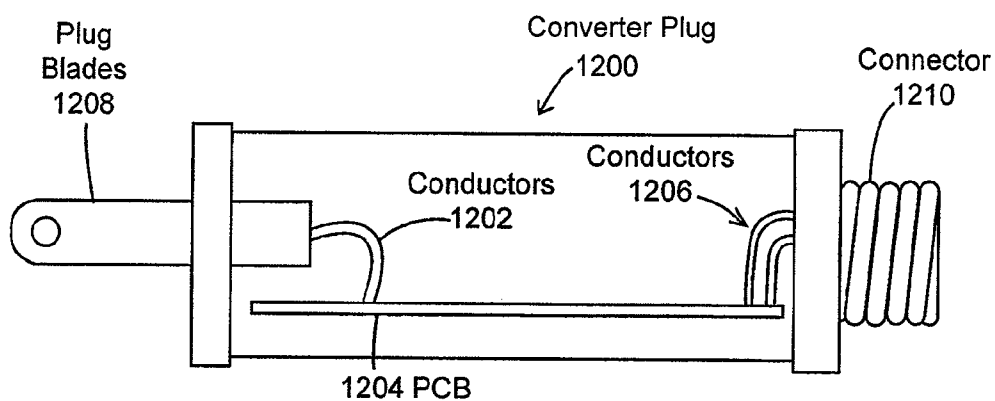


FIG. 12

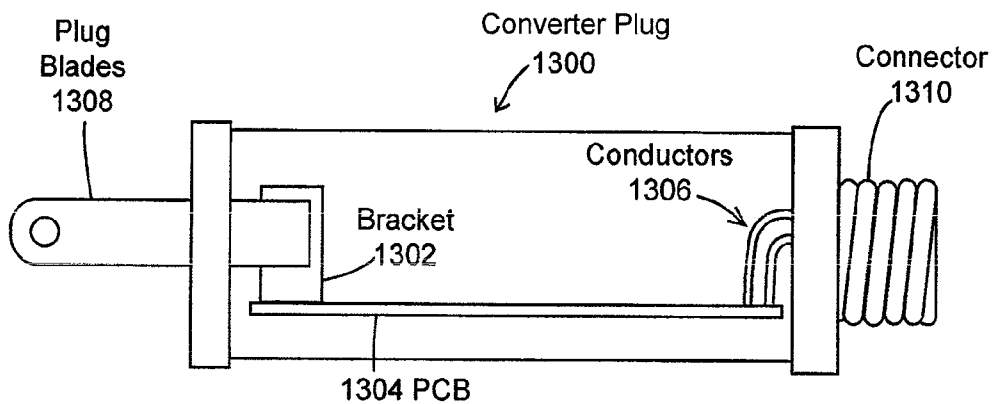


FIG. 13

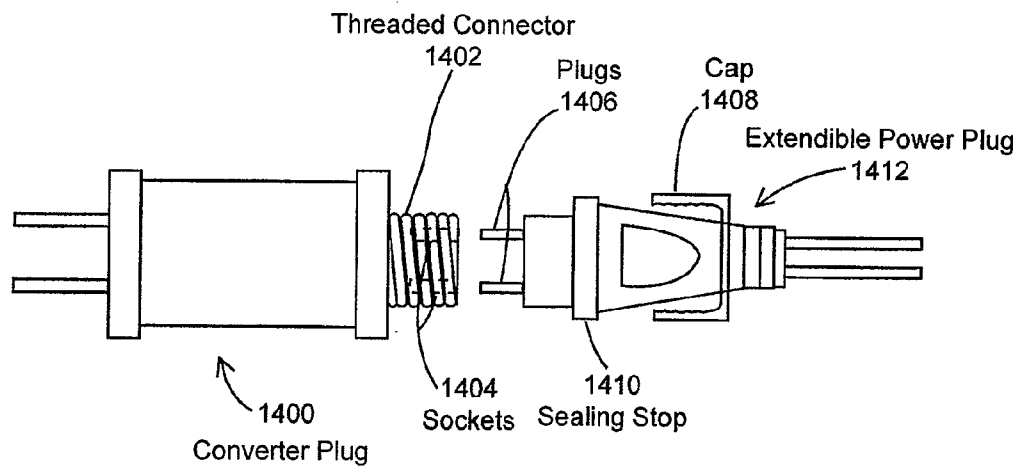


FIG. 14

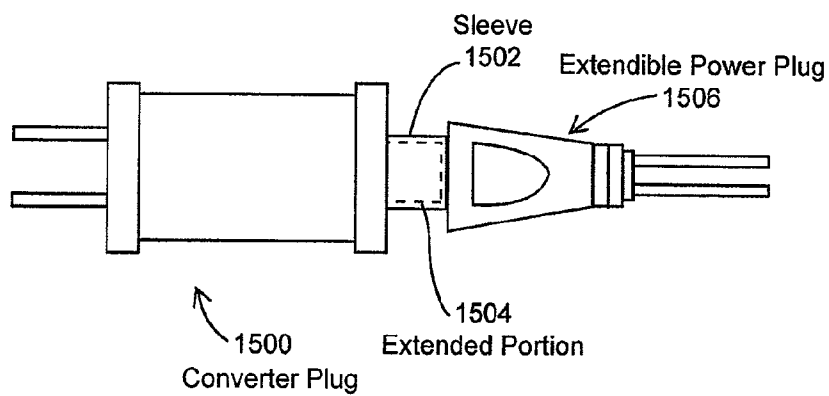


FIG. 15

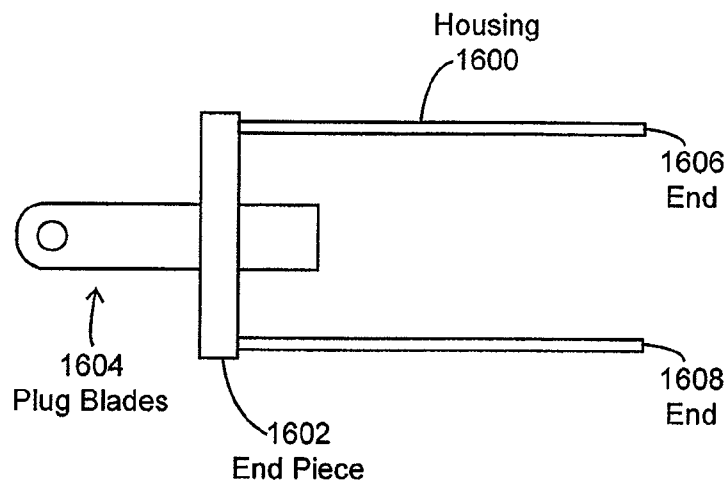


FIG. 16

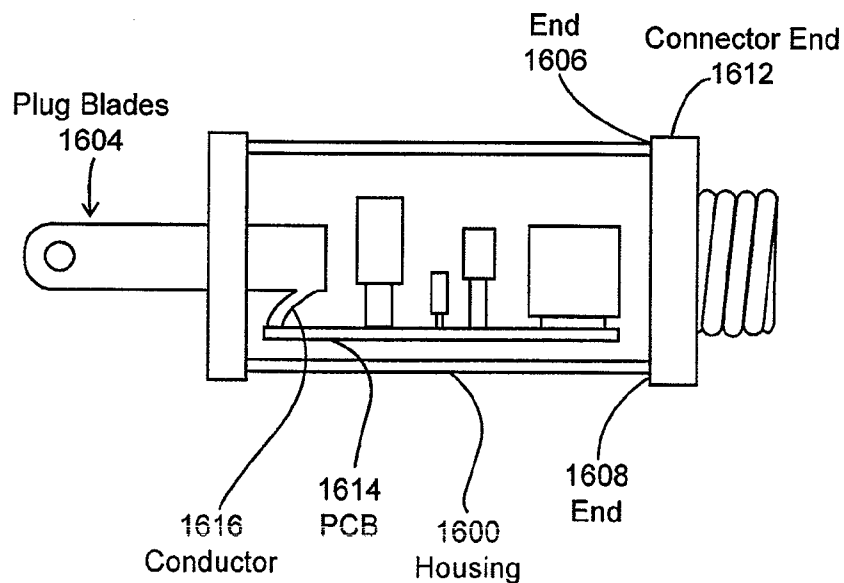


FIG. 17



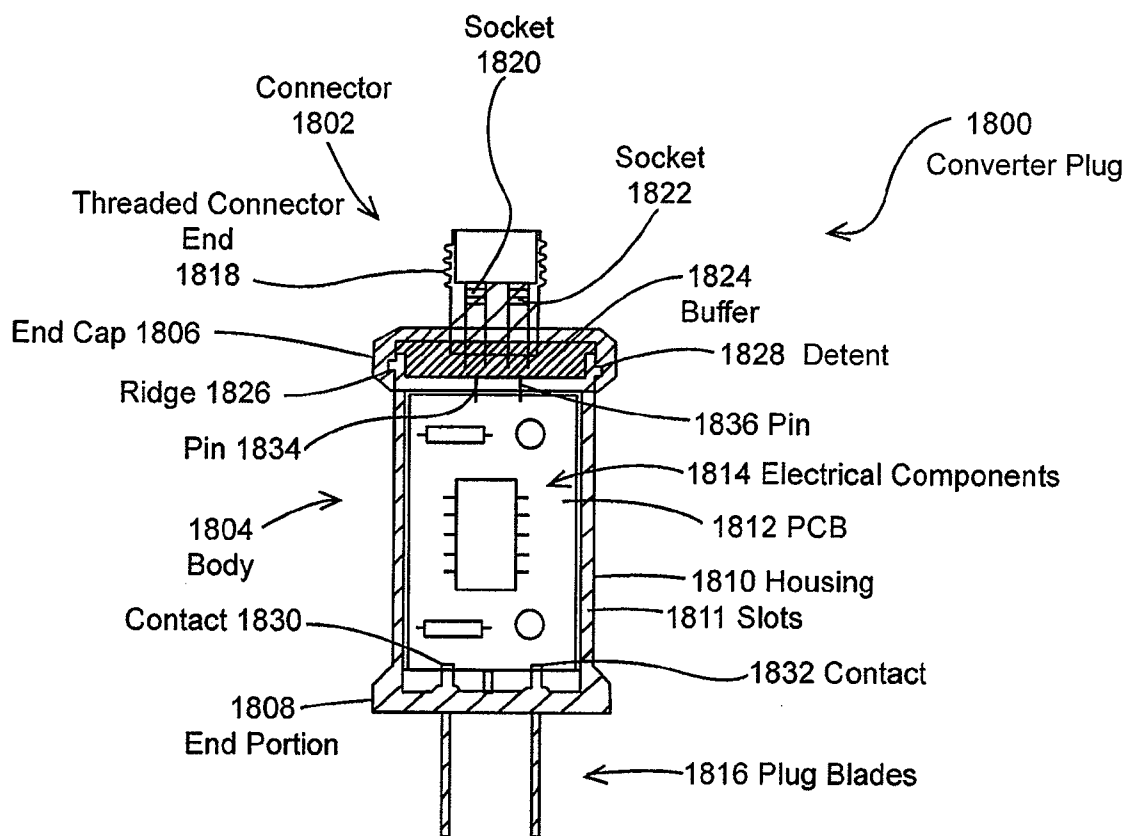
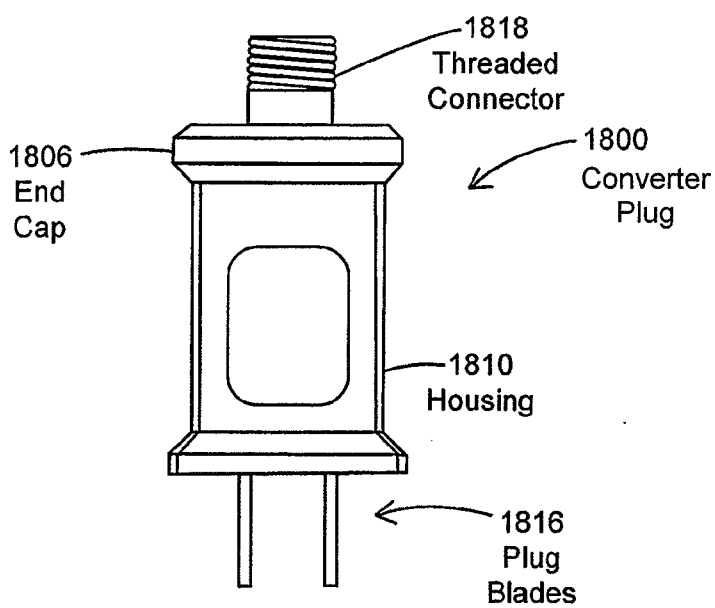


FIG. 18



**FIG. 19**

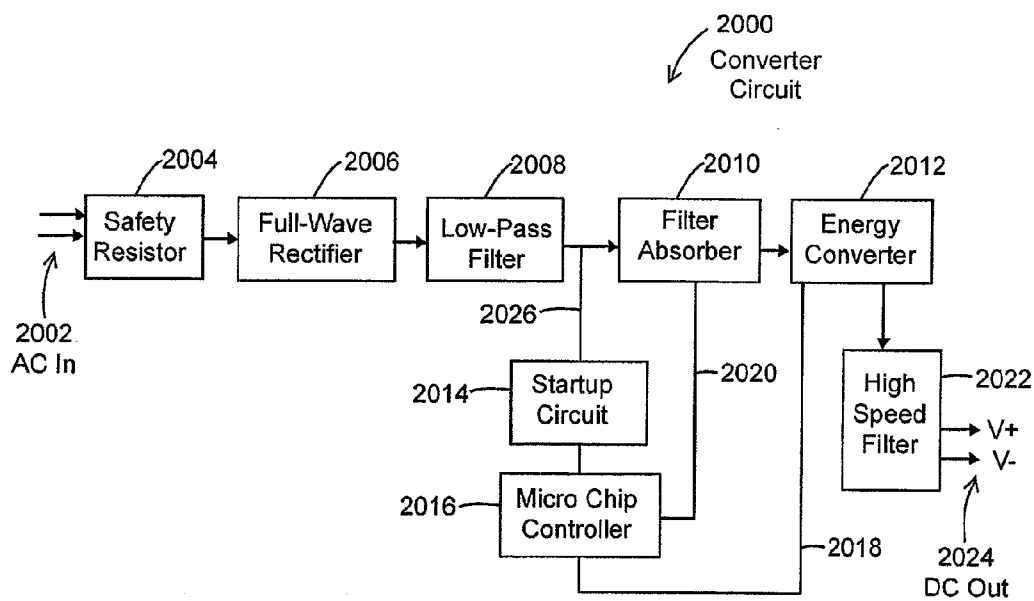


FIG. 20

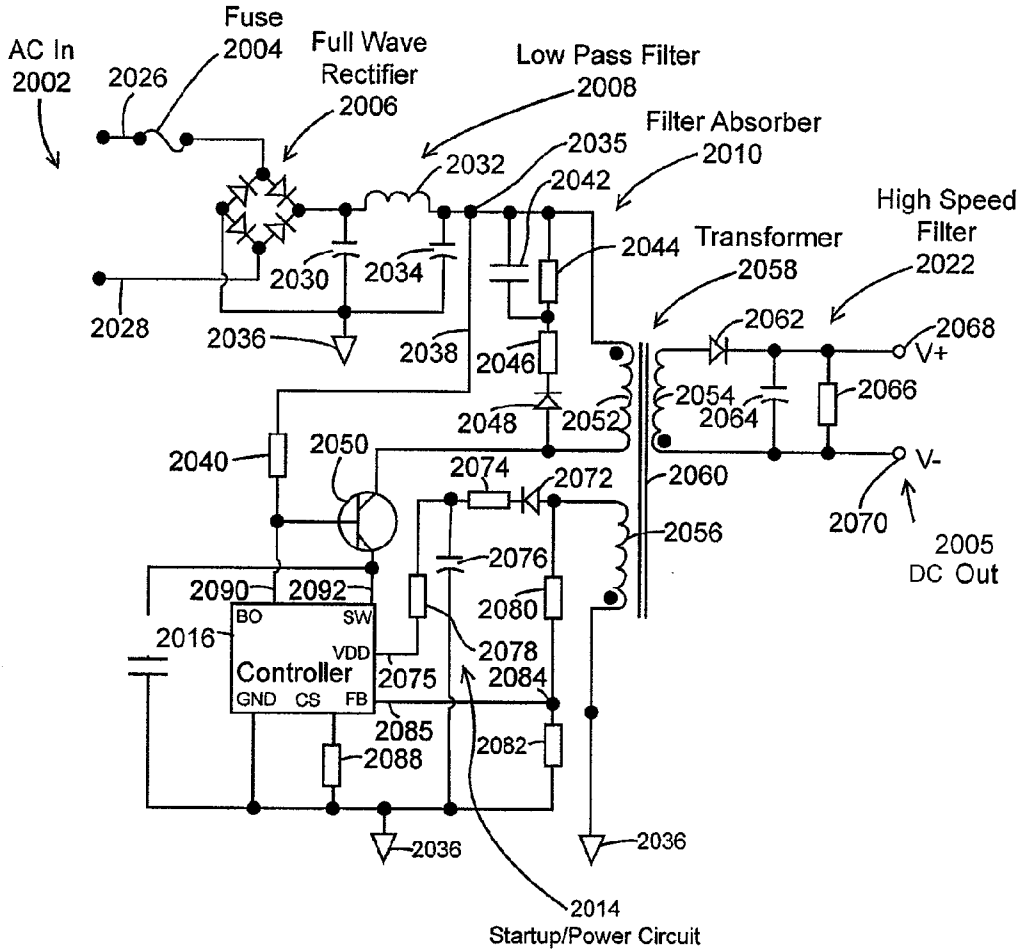


FIG. 21

**COMPACT CONVERTER PLUG FOR LED LIGHT STRINGS**

**CROSS-REFERENCE TO RELATED APPLICATION**

[0001] This application is a continuation of U.S. application Ser. No. 12/834,949, filed Jul. 13, 2010, which application claims benefit of and priority to Chinese Application Serial No. 200920230903.3, filed Aug. 26, 2009, by Long Chen and Beijing Yu, and Chinese Application Serial No. 200920231361.1, filed Aug. 27, 2009, by Long Chen and Beijing Yu, the entire contents of which are specifically incorporated herein by reference for all that they disclose and teach.

**BACKGROUND**

[0002] Lighting using light emitting diodes is a practical and inexpensive way to provide illumination for various purposes. The advantages of LED lighting are that LEDs operate effectively at low direct current voltages and currents. Further, LED lights produce a large number of lumens for the energy that the LEDs consume. Moreover, LEDs do not generate a significant amount of heat, which renders LED lights a safer alternative to other forms of lighting.

**SUMMARY**

[0003] An embodiment of the present invention may therefore comprise a converter plug for an LED light string that plugs into a household alternating current socket that converts alternating current household power to a low voltage direct current output comprising: an enclosure that is watertight and has a shape and size similar to a wall plug; plug blades that have a watertight seal with the enclosure; a printed circuit board having converter circuitry mounted on at least one surface of the printed circuit board, the printed circuit board mounted in the enclosure, the converter circuitry comprising: a rectifier that rectifies a source of alternating current from a household socket to produce a rectified alternating current signal at an output of the rectifier; a low pass filter, connected to the output of the rectifier, that filters the rectified alternating current signal to provide a filtered, rectified, alternating current signal; a high speed switching transistor that modulates the filtered, rectified, alternating signal to produce a modulated, rectified signal having a selected modulation frequency; a first coil, in a transformer, coupled to the modulated, rectified signal that induces voltage changes in a second transformer coil to produce a second induced voltage and induces voltage changes in a third transformer coil to produce a third induced voltage; a voltage detection circuit connected to the third transformer coil that produces a monitoring signal, without an optical coupler, from the third induced voltage on the third transformer coil that is proportional to the second induced voltage on the second transformer coil; a controller that controls the selected modulation frequency of the modulated, rectified signal in response to the monitoring signal.

[0004] An embodiment of the present invention may further comprise a converter plug for use with an LED light string comprising: plug blades that fit in an alternating current wall socket; a housing having an end portion that is molded around the plug blades that provides a watertight seal between the housing and the plug blades; a printed circuit board having converter circuitry mounted thereon, the printed circuit board having pins that provide direct current power from the printed

circuit board; an end cap that attaches to the housing so that a watertight seal is created between the end cap and the housing; a connector molded to the end cap having sockets that are electrically connected to the pins on the printed circuit board, the connector having a watertight coupling for coupling the converter plug to the LED light string.

**BRIEF DESCRIPTION OF THE DRAWINGS**

- [0005] FIG. 1 is schematic view of a circuit layout employing embodiments of the present invention.
- [0006] FIG. 2 is an embodiment illustrating an assembly procedure for an converter employed as a plug.
- [0007] FIGS. 3-6 illustrate various configurations of an converter plug.
- [0008] FIGS. 7-10 illustrate various assembly configurations for converter plugs.
- [0009] FIGS. 11-13 illustrate various techniques for connecting conductors to a printed circuit board.
- [0010] FIGS. 14 and 15 illustrate two embodiments of connectors for connecting a light string to an converter plug.
- [0011] FIGS. 16 and 17 illustrate an assembly process for an converter plug.
- [0012] FIG. 18 is a cross-sectional view of an another embodiment of an converter plug
- [0013] FIG. 19 is a side view of an assembled converter plug of the embodiment of FIG. 18.
- [0014] FIG. 20 is a schematic block diagram of an embodiment of an converter circuit.
- [0015] FIG. 21 is a schematic circuit diagram of the embodiment of the converter circuit of FIG. 20.

**DETAILED DESCRIPTION OF THE EMBODIMENTS**

[0016] FIG. 1 is a schematic diagram of one embodiment of an LED string 100 utilizing a compact converter plug 102. The compact converter plug 102 has plug blades 104 for plugging the compact converter plug 112 into a wall socket, such as a standard 117 volt rms alternating current power source. The miniature converter plug 102 has a small size which is similar to the size of a standard wall plug with a slightly extended length. The LED light string 110 is connected to the compact converter plug 102 using an extendable power plug 106. The extendable power plug 106 can be easily inserted and removed from the compact converter plug 102, while maintaining a watertight seal. Alternatively, the LED light string 110 can be permanently connected to the miniature converter plug 102. At the other end of the LED light string 110, an extendable power socket can be employed, which allows the LED light string 110 to be connected to additional light strings with extendable power plugs, such as extendable power plug 106. In accordance with the embodiments in which the extendable power plug 106 can be disconnected from the miniature converter plug 102, the compact converter plug 102 can be sold separately from the LED light strings 110, which allows the consumer greater options and greater savings in employing multiple or single light strings, such as LED light string 110 in various applications, as desired.

[0017] FIG. 2 illustrates the manner in which the converter plug 102 can be assembled. As illustrated in FIG. 2, wall plug blades 104 are mounted in an end piece 200. This process can be achieved by molding the end piece 200 around the wall plug blades 104, using injection molding, such that the wall

plug blades **104** are securely mounted and sealed in the front cover **200**. Front cover **200** also includes a notch **210**, which engages with housing **202** to provide a secure, watertight seal between the front cover **200** and housing **202**. A conductor **208** connects the wall plug blades **104** to the printed circuit board **204**. Wires **212** connect the printed circuit board **204** to the connector **214**. The mating of the housing **202** with the front cover **200** can be by way of a friction fit, ultrasonic welding, or other standard processes for creating a watertight fit. In this manner, the converter plug **102** can be used in outdoor environments while maintaining a watertight seal for the electrical components **206** mounted on the printed circuit board **204** inside housing **202**.

[0018] FIG. 3 is a side view of one embodiment of an converter plug **300**. As shown in FIG. 3, plug blades **302** extend from a first end of the converter plug **300** while connector **304** extends from an opposite end of the converter plug **300**. Housing **306** can provide watertight encapsulation of the electrical components within the converter plug **300**.

[0019] FIG. 4 is a side view of another embodiment of an converter plug **400**. As illustrated in FIG. 4, housing **408** encloses the electronic components. Plug blades **402** extend from one end of the housing **408** while connectors **404**, **406** extend from the opposite end of the housing **408**. In the embodiment illustrated in FIG. 4, two connectors **404**, **406** are provided, which are capable of supplying direct current power to two separate LED light strings. Circuitry can be provided for producing direct current outputs to each of the connectors **404**, **406**.

[0020] FIG. 5 discloses another embodiment of an converter plug **500**. As illustrated in FIG. 5, plug blades **502** extend laterally from the housing **506** at one end of the converter plug **500**. Connector **504** extends in a longitudinal direction at the other end of the housing **506**. The configuration illustrated in the embodiment of FIG. 5 is useful in situations where there is limited space adjacent the wall socket.

[0021] FIG. 6 illustrates another embodiment of an converter plug **600**. As disclosed in FIG. 6, plug blades **602** extend laterally from the housing **606**. Multiple connectors **604** are provided at an opposite end of the housing **606**.

[0022] FIGS. 7-10 illustrate four different ways of assembling converter plugs. As illustrated in FIG. 7, a cover **704**, which has plug blades **708** mounted therein, can be assembled in housing **702** during initial fabrication. Connector **706** is mounted to the housing **702** during initial fabrication of the plug blade **700**.

[0023] FIG. 8 illustrates an alternative method of assembling an converter plug **800**. As illustrated in FIG. 8, plug blades **808** are connected to the housing **802** during initial fabrication. Similarly, connector **806** is connected to cover **804** during initial fabrication. Then, after the electronic circuits are inserted into the housing **802**, the cover **804** can be assembled with the housing **802** in accordance with any of the methods described above.

[0024] FIG. 9 illustrates another embodiment of a process for assembling an converter plug **900**. As shown in FIG. 9, the housing **902** and connectors **906** are assembled in the initial fabrication process. Similarly, plug blades **908** and cover **904** are assembled in the initial fabrication process. After a circuit board is inserted in housing **902**, the cover **904** can be assembled and sealed to the housing **902** in accordance with any of the desired methods disclosed above, including ultra-

sonic welding, heat curing, friction fit assembly and other methods, to create a watertight seal between the cover **904** and housing **902**.

[0025] FIG. 10 illustrates another embodiment of a process for assembling an converter plug **1000**. As shown in FIG. 10, both the plug blades **1008** and connectors **1006** are initially fabricated and secured to the housing **1002**. A printed circuit board and accompanying circuitry is then mounted in the housing **1002**, and the electrical connections are made to the plug blades **1008** and connectors **1006**. Cover **1004** is then sealed to the housing **1002** using any of the methods disclosed above.

[0026] FIGS. 11-13 disclose various processes for connecting a printed circuit board to the plug blades. As disclosed in FIG. 11, a bent metal conductor **1102** is used to connect the printed circuit board **1104** to the plug blades **1108**. In addition, conductors **1106** are used to connect the printed circuit board **1104** to the connector **1110**.

[0027] As illustrated in FIG. 12, wire conductors **1202** are used to connect the printed circuit board **1204** to the plug blades **1208**. Conductors **1206**, such as wires, are used to connect the printed circuit board **1204** to the connector **1210**.

[0028] As illustrated in FIG. 13, a socket bracket **1302** is used to connect the plug blades **1308** to the printed circuit board **1304**. Conductors **1306** are used to connect the printed circuit board **1304** to the connector **1310**.

[0029] FIGS. 14 and 15 disclose two different embodiments for connecting an extendable power plug to an converter plug. As illustrated in FIG. 14, converter plug **1400** has a pair of sockets **1404** disposed in a threaded connector **1402**. Plugs **1406** disposed in an extendable power plug **1412** can be inserted in the sockets **1404** and electrically connected to the sockets **1404**. A cap **1408** is threaded on the threaded connector **1402** and seals the extendable power plug **1412** against the sealing stop **1410**.

[0030] FIG. 15 is an illustration of another embodiment of an converter plug **1500** and an extendable power plug **1506**. The extendable power plug **1506** has a sleeve **1502** that slides over an extended portion **1504** of the converter plug **1500**, as illustrated by the dotted lines in FIG. 15. Sleeve **1502** creates a friction fit with the extended portion **1504** to create a watertight seal between the sleeve **1502** and the extended portion **1504**. Also, a tight slide fit can be created between sleeve **1502** and extended portion **1504** and a locking mechanism provided. Alternatively, sleeve **1502** can be permanently attached to the extended portion **1504**, using ultrasonic welding, adhesives, or other methods. The disadvantage in permanently attaching the sleeve **1502** to the extended portion **1504** is that the converter plug **1500** cannot be used with other light strings. For example, the LED light string attached to the extendable power plug **1506** may be damaged and unrepairable. In that case, the converter plug **1500** will have to be discarded with the light string. Of course, the removable extended power plug **1412**, illustrated in FIG. 14, allows the converter plug **1400** of FIG. 14 to be used with other light strings.

[0031] FIGS. 16 and 17 illustrate one method of assembling an converter plug. As illustrated in FIG. 16, plug blades **1604** are molded into an end piece **1602** that encapsulates and surrounds the plug blades **1604**. A watertight seal is created between the plug blades **1604** and the end piece **1602**. End piece **1602** can be part of the housing **1600** or can be attached to the housing **1600** by various means, including ultrasonic

welding, etc. Housing 1600 has ends 1606, 1608 that extend on the open end of housing 1600.

[0032] FIG. 17 is a schematic illustration of an assembled converter plug. As illustrated in FIG. 17, plug blades 1604 are secured in the end piece 1602. The printed circuit board 1614 is connected to the plug blades 1604 by conductor 1616. Conductor 1616 may be a bent piece of metal that has a sufficient amount of elasticity so that, when the printed circuit board 1614 is mounted in the housing 1600, an electrical contact is made between the plug blades 1064 and the printed circuit board 1614. In that regard, housing 1600 may include various mounting devices for mounting the printed circuit board 1614 in the housing 1600. As also illustrated in FIG. 17, connector end piece 1612 is attached at ends 1606, 1608 to housing 1600. Attachment can be performed by various methods, including ultrasonic welding and other techniques disclosed herein.

[0033] FIG. 18 is a schematic cutaway view of another embodiment of an converter plug 1800. As illustrated in FIG. 18, the converter plug 1800 includes a connector 1802 and a body 1804. Plug blades 1816 are molded into the end portion 1808 and extend into an interior portion of the converter plug 1800. Printed circuit board 1812 is mounted in housing 1810 by sliding the printed circuit board 1812 into slots 1811, along the sides of housing 1810. Plug blades 1816 abut against contacts 1830, 1832 to make electrical contact with the printed circuit board 1812. Alternatively, wires can be used to connect PCB 1812 to plug blades 1816. Electrical components 1814 are mounted on the printed circuit board 1812 and comprise the converter circuitry necessary to invert the alternating current from a standard household plug, such as a 117 volt RMS alternating current signal, to a low voltage direct current signal that is less than 10 volts.

[0034] As further shown in FIG. 18, the printed circuit board has a pair of pins 1834, 1836 that provide the output direct current voltage from the printed circuit board 1812. Pins 1834, 1836 are connected to sockets 1820, 1822, which interface with plugs, such as plugs 1406, illustrated in FIG. 14. End cap 1806, as illustrated in FIG. 18, attaches to housing 1810. As illustrated in the embodiment of FIG. 18, a ridge on the housing 1810 interfaces with a detent 1828 on the end cap 1806 to provide a watertight seal between housing 1810 and end cap 1806. Of course, other methods of attaching the end cap 1806 to the housing 1810 can be used. For example, end cap 1806 may be permanently attached to housing 1810 using ultrasonic welding, melting or other techniques. Buffer 1824 is disposed between the end cap 1806 and the printed circuit board 1812. Buffer 1824 assists in holding the printed circuit board 1812 in place and urging contacts 1830, 1832 against the ends of plug blades 1816 to make an electrical connection between the printed circuit board 1812 and plug blades 1816. The buffer 1824 can be constructed of acrylonitrile butadiene styrene (ABS) or other type of suitable thermoplastic material. Pins 1834, 1836 can be pressed against sockets 1820, 1822, respectively, or otherwise electrically connected using wires (not shown). Connector 1802 also includes a threaded connector end 1818 that allows a watertight connection between an LED string and the converter plug 1800.

[0035] FIG. 19 is a side view of the assembled converter plug 1800. As illustrated in FIG. 19, the converter plug 1800 has a general shape and size that corresponds to a standard electric plug to be inserted into an electrical wall socket. As such, the converter plug 1800 is a convenient device for

providing direct current power to an LED array because of its size and high efficiency. Threaded connector 1818 allows light strings to be attached and detached from the converter plug 1800, while providing a watertight seal between the converter plug 1800 and an LED light string. End cap 1806 provides a convenient device for attaching the threaded connector 1818 to the housing 1810. As illustrated in various embodiments disclosed above, plug blades 1816 can extend from the end or sides of the converter plug 1800.

[0036] FIG. 20 is a schematic block diagram of an embodiment of a converter circuit 2000 that can be utilized with any of the embodiments of the converter plug disclosed herein. As illustrated in FIG. 20, an alternating current input 2002 is applied to a safety resistor 2004. Safety resistor 2004 may be a resistive fuse that blows when an excessive amount of current is applied to the converter circuit 2000. The alternating current signal is then applied to a full wave rectifier 2006, which rectifies the alternating current input into a fully rectified signal. Low pass filter 2008 filters out higher frequencies, so that a direct current signal is produced at the input to filter absorber 2010. Filter absorber 2010 absorbs current spikes that protects the microchip controller 2016, energy converter 2012 and other components in the converter circuit 2000. The direct current signal is then applied via connector 2020 to microchip controller 2016. Startup circuit 2014 assists in starting the microchip controller 2016 and providing a source of direct current power to operate the microchip controller 2016. Energy converter 2012 includes a high speed switching circuit and a transformer that reduces the voltage level of the direct current voltage signal. High speed filter 2022 creates the direct current output 2024. This circuit is more fully disclosed in FIG. 21.

[0037] FIG. 21 illustrates the converter circuit 2000, shown in the block diagram of FIG. 20. As illustrated in FIG. 21, an alternating current signal 2002 is applied to leads 2026, 2028. Fuse (safety resistor) 2004 is a 10 ohm winding resistor installed in the alternating current power input on lead 2026. If a short circuit, or other abnormal condition occurs, fuse 2004 produces an open circuit and prevents the application of the alternating current input power to the converter circuit 2000. Fuse 2004 also limits the current fluctuation during on and off transitions. Full wave rectifier 2006 rectifies the alternating current input 2002 to produce a pulsed direct current voltage. Low pass filter 2008, which comprises capacitors 2030, 2034 and inductor 2032, generates a direct current voltage at node 2035. Lead 2038 applies the direct current voltage to resistor 2040 and to the base of switching transistor 2050. Direct current voltage at node 2035 is also applied to a filter absorber 2010, which comprises capacitor 2042, resistor 2044, resistor 2046, and diode 2048. Filter absorber 2010 protects the switching transistor 2050 from voltage spikes that may occur during operation of the transformer 2058.

[0038] The switching transistor 2050, of FIG. 21, is controlled by controller 2016. A suitable controller for use as controller 216 for low power converters, comprises part #FT831B, FT881 from Fremont Micro Devices (SZ) Ltd., #5-8, 10-F, Changhong Science and Technology Building, Ke-Ji Nan 12 Road, Nanshan District, Shenzhen, Guangdong. For higher power converters, part #ACT361, ACT355 is available from Active-Semi, Inc., 2728 Orchard Parkway, San Jose, Calif., 95134, or from iWatt, Inc., 101 Albright Way, Los Gatos, Calif., 95032. Switching transistor 2050 is turned on and off by pins 2090, 2092 of controller 2086, which modulates the direct current voltage at node 2035. Since the

direct current voltage at node **2035** is modulated, the voltage transitions are transmitted from the primary coil **2052** of transformer **2058** to secondary coils **2054**, **2056** via transformer core **2060**. The transitioning voltage across coil **2052** induces a voltage in secondary coil **2054**. The voltage transitions occur in both a positive and negative direction on coil **2052**. This causes both positive going and negative going voltage transitions to be induced in secondary coils **2054**, **2056**.

[0039] Diode **2062** only allows the current to pass in the direction of the diode **2062**. The high speed filter **2022**, which comprises capacitor **2064** and resistor **2066** filters and stores the positive direct current voltage on node **2068** and the negative output direct current voltage on node **2070** of direct current output voltage **2004**.

[0040] As also illustrated in FIG. 21, the transitioning voltages on primary coil **2052** also create transitioning voltages on secondary coil **2056** that are applied to the startup circuit **2014** and the voltage dividing circuit comprising resistors **2080**, **2082**. With regard to the startup circuit **2014**, diode **2072** only allows passage of current in the direction of the diode **2072**. Resistors **2074**, **2078** and capacitor **2076** provide a voltage at pin **2075**, which is the VDD voltage that operates the controller **2086**. The voltage dividing circuit that comprises **2080**, **2082** provides a voltage at node **2084**, which is the induced voltage on secondary coil **2056** divided between resistors **2080**, **2082**. The voltage on node **2084** is applied to the feedback pin **2085** of controller **2086**. The voltage at feedback pin **2085** of controller **2086** controls the frequency of switching on nodes **2090**, **2092** of controller **2086**. When there is no load at the direct current output **2004**, the frequency is reduced to achieve energy savings. When a load is present at the direct current output **2004**, the frequency of the switching transistor **2050** is increased, which delivers more energy across the transformer **2058** from primary coil **2052** to secondary coil **2056** to support the energy requirements of the load at the direct current output **2004**. Secondary coil **2056** has a proportional amount of energy transferred from the primary coil **2052** as the secondary coil **2054**, depending upon the number of windings in secondary coil **2054** and secondary coil **2056**. Hence, secondary coil **2056** has the same, or a proportional, amount of energy delivered to the secondary coil **2056** as the secondary coil **2054**. In other words, the secondary coil **2054** has a certain amount of energy delivered across the transformer **2058** and secondary coil **2056** has the same, or a proportional, amount of energy delivered to it. Hence, the voltage at node **2084**, which is applied to the feedback pin **2085**, is proportional to the voltage produced at the direct current output **2004**. In this manner, the controller **2086** can monitor the voltage that is produced at the direct current output **2004** without any feedback from the direct current output **2004**. Optic couplers have been used to provide a feedback loop from an output voltage, such as the direct current output voltage **2004**, which provides isolation between a direct current output and a controller, such as direct current output **2004** and controller **2086**. Opto-couplers are expensive and bulky. In order to maintain a small package that has a size that is consistent with a wall plug, opto-couplers provide an inconvenient solution that does not meet the size requirements for the miniature converter **102**, illustrated in FIG. 1.

[0041] The foregoing description of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the

precise form disclosed, and other modifications and variations may be possible in light of the above teachings. The embodiment was chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and various modifications as are suited to the particular use contemplated. It is intended that the appended claims be construed to include other alternative embodiments of the invention except insofar as limited by the prior art.

What is claimed is:

1. A converter plug for an LED light string that plugs into a household alternating current socket that converts alternating current household power to a low voltage direct current output comprising:

an enclosure that is watertight and has a shape and size similar to a wall plug;

plug blades that have a watertight seal with said enclosure; a printed circuit board having converter circuitry mounted on at least one surface of said printed circuit board, said printed circuit board mounted in said enclosure, said converter circuitry comprising;

a rectifier that rectifies a source of alternating current from a household socket to produce a rectified alternating current signal at an output of said rectifier;

a low pass filter, connected to said output of said rectifier, that filters said rectified alternating current signal to provide a filtered, rectified, alternating current signal;

a high speed switching transistor that modulates said filtered, rectified, alternating signal to produce a modulated, rectified signal having a selected modulation frequency;

a first coil, in a transformer, coupled to said modulated, rectified signal that induces voltage changes in a second transformer coil to produce a second induced voltage and induces voltage changes in a third transformer coil to produce a third induced voltage;

a voltage detection circuit connected to said third transformer coil that produces a monitoring signal, without an optical coupler, from said third induced voltage on said third transformer coil that is proportional to said second induced voltage on said second transformer coil;

a controller that controls said selected modulation frequency of said modulated, rectified signal in response to said monitoring signal.

2. The converter plug of claim 1 further comprising:

a connector disposed on said enclosure having sockets that are adapted to connect to plugs on said LED light string, said connector being watertight and having a watertight coupler that mates with said LED light string to provide a watertight connection between said connector and said light string, said connector being mounted on, and sealed to, said enclosure so that said enclosure and said watertight connector are watertight, said watertight coupler allowing said converter plug to be disconnected from and directly connected to said LED light string.

3. The converter plug of claim 2 wherein said watertight coupler comprises a cylindrical threaded extension connected to said enclosure that is adapted to mate with a threaded cap disposed on an extendable power plug that forms a portion of said LED light string.

4. The converter plug of claim 3 wherein said watertight coupler comprises an extension that is connected to said



enclosure having a surface that creates a watertight friction fit with an extendable power plug of said LED light string.

5. The converter plug of claim 1 wherein said rectifier is a full wave rectifier.

6. The converter plug of claim 1 further comprising:  
a power circuit coupled to said third transformer coil that produces a power signal that powers said controller.

7. A converter plug for use with an LED light string comprising:

plug blades that fit in an alternating current wall socket;  
a housing having an end portion that is molded around said plug blades that provides a watertight seal between said housing and said plug blades;

a printed circuit board having converter circuitry mounted thereon, said printed circuit board having pins that provide direct current power from said printed circuit board;  
an end cap that attaches to said housing so that a watertight seal is created between said end cap and said housing;

a connector molded to said end cap having sockets that are electrically connected to said pins on said printed circuit board, said connector having a watertight coupling for coupling said converter plug to said LED light string.

8. The converter plug of claim 7 wherein said end cap and said housing have ridges and detents that allow said end cap to snap fit on said housing to provide said watertight seal.

9. The converter plug of claim 7 wherein said end cap is friction fit to said housing.

10. The converter plug of claim 7 wherein said end cap is ultrasonically welded to said housing.

11. The converter plug of claim 7 wherein said converter circuitry comprises:

a rectifier that rectifies a source of alternating current from a household socket to produce a rectified alternating current signal at an output of said rectifier;

a low pass filter, connected to said output of said rectifier, that filters said rectified alternating current signal to provide a filtered, rectified signal;

a high speed switching transistor that modulates said filtered, rectified signal to produce a modulated, rectified signal having a selected modulation frequency;

a first coil, in a transformer, coupled to said modulated, rectified signal that induces voltage changes in a second transformer coil to produce a second induced voltage and induces voltage changes in a third transformer coil to produce a third induced voltage;

a voltage detection circuit connected to said third transformer coil that produces a monitoring signal, without

an optical coupler, from said third induced voltage on said third transformer coil that is proportional to said second induced voltage on said second transformer coil;  
a controller that controls said selected modulation frequency of said modulated direct current signal in response to said monitoring signal.

12. The converter plug of claim 11 further comprising:  
a power circuit coupled to said third transformer coil that produces a power signal that powers said controller.

13. The converter plug of claim 11 wherein said rectifier is a full wave rectifier.

14. A converter circuit for use in a converter plug for producing a direct current output for an LED light string comprising:

a rectifier that rectifies a source of alternating current from a household socket to produce a rectified alternating current signal at an output of said rectifier;

a low pass filter, connected to said output of said rectifier, that filters said rectified alternating current signal to provide a filtered, rectified, alternating signal;

a filter absorber that protects said converter circuit from voltage spikes;

a high speed switching transistor that modulates said filtered, rectified, alternating signal to produce a modulated, rectified signal having a selected modulation frequency;

a first coil, in a transformer, coupled to said modulated, rectified signal that induces voltage changes in a second transformer coil to produce a second induced voltage and induces voltage changes in a third transformer coil to produce a third induced voltage;

a voltage detection circuit connected to said third transformer coil that produces a monitoring signal, without an optical coupler, from said third induced voltage on said third transformer coil that is proportional to said second induced voltage on said second transformer coil;  
a controller that controls said modulation frequency of said modulated direct current signal in response to said monitoring signal.

15. The converter circuit of claim 14 further comprising:  
a power circuit coupled to said third transformer coil that produces a power signal that powers said controller.

16. The converter circuit of claim 14 wherein said rectifier is a full wave rectifier.

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