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(54) **Title:** MODULAR DEVICE FOR WIRELESS TRANSMISSION OF ELECTRICAL POWER

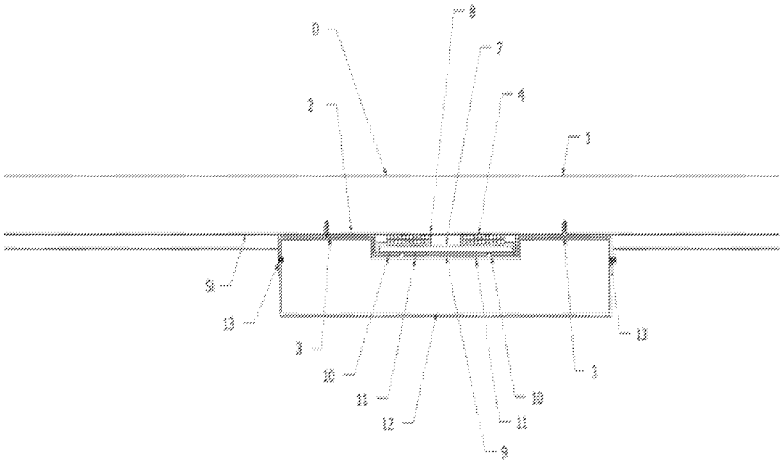

FIG. i

(57) **Abstract:** A modular device (D) for transmitting electrical power in wireless mode, comprises a plane element (1) of the tile type, the bottom surface (Si) of which is adapted for an inductor group **(4)** to be fitted; said inductor group **(4)** comprising electrical board means and contact connector means (10).

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MODULAR DEVICE FOR WIRELESS TRANSMISSION OF ELECTRICAL POWER.

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The present invention relates to a modular device for wireless transmission of electrical power.

In particular, the invention in question is advantageously employed to perform the transmission of electrical power from a power source to an electrical load without the use of a solid conductor or a direct connection between the two, through surfaces of buildings and constructions in general, e.g., brickwork flooring or walls, which the following description will make explicit reference to without thereby losing generality.

In general, "wireless power supply" or "wireless electrical power transmission" refer to the transmission of electrical power from a power source to an electrical load without the use of a solid conductor or a direct connection between the two.

Wireless transmission is useful in cases where interconnection cables are inconvenient, dangerous, unsightly or where operating conditions prevent their use.

Presently, the prior art for wireless power transfer involves the use of electromagnetic radiation.

In general terms, the problems relating to the transmission of electrical power by means of electromagnetic waves are similar to those of telecommunications, to which, however, the problem of power attenuation of the transmitted signal must be added, which, in the case of wireless electrical power transmission, has consequences in terms of transmission efficiency.

Transmission efficiency is defined as the ratio between the electrical power

produced by the receiver in a given time frame divided by power absorbed by the emitter during the same time interval.

At present, commercially available devices allow power transmissions generally lower than 10W at a distance of 5-17 mm with operating frequencies of the magnetic field produced by the emitter exceeding 100 kHz .

The safety regulations for variable magnetic fields in household define a 100 kHz threshold after which such fields may begin to be harmful to the human body. In terms of safety, therefore, it is critical produce a technology capable of maintaining transmission efficiency levels between emitter and receiver inductors over 80% with fields at a frequency of less than 100 kHz.

Moreover, in terms of power, a threshold of 10 Watts is insufficient to create emitting flooring capable, for example, of feeding lighting bodies.

In terms of transmission distance, all equipment produced according to the state of the art allows efficient transmissions (over eighty per cent) in a distance range between 5 and 17 mm. Today, only some known equipment allows transmissions in a range over 15 cm, but such devices employ pulsed magnetic fields with frequencies greater than 3 MHz.

Therefore, in terms of distance, the production of new technologies capable of transmitting powers over 10 Watts at distances in the range between 20 and 50 mm is required. In terms of cost and applicability, all technologies presently available on the market and made according to the state of the art do not allow a widespread application of electrical power transmission technology; in fact, they require to be installed directly into the load of a receiving device. Having to be installed directly into the load, the receiving device cannot exceed certain size limits set by the manufacturer of the device itself.

This represents the main issue for the diffusion of a universal wireless electrical transmission technology intended as a technology capable of feeding different types of devices without requiring any type of design or construction modification to the manufacturer of the device in question. Furthermore, limited and peculiar possibility of different sizes for each device allows the production of receivers capable of generating at most a DC current, being provided solely with an AC/DC converter. Therefore, all devices requiring alternating current power supply at 220/1 10 volts/ 50/60Hz and all devices that do not allow a post-production installation of a receiver inside the case or that do not allow the the wiring to a power supply circuit are presently excluded.

Also excluded are the possible uses on brickwork structures and constructions, because the distance between emitter and receiver (20 mm) exceeds any ability of commercially available devices to efficiently transmit electrical power.

The user devices which may be used fail to exceed the 5-10 watt power, thus being limited to battery chargers and low-power lighting devices.

Furthermore, in terms of reliability, all equipment presently available on the market comes with integrated logic systems or even software adapted to control the surrounding environment and decide whether to turn on or not the emitting apparatus.

This approach is unacceptable in case the user wants to insert disposable emitting equipment including it in construction materials, both for economic reasons, related to high production costs of such equipment, and for the long-term reliability of the employed electronic components. In terms of reliability and cost, it is therefore necessary to provide a very simple and reliable emission circuit with low-cost hardware control systems.

Finally, it is necessary to make special flooring allowing the installation of the electrical equipment and its maintenance without compromising the aesthetic result of the brickwork and without causing any weakening of the wall structure itself.

The object of the present invention is therefore to realize a modular wireless electrical power transmission device, capable of overcoming the drawbacks and problems of the prior art, highlighted above.

In particular, the object of the present invention is to provide an emitter/transmitter provided with an emission inductor not dependent on the emitting board and provided with a bracket structure adequate for the installation on modular elements such as tiles or flooring in general.

A further object of the present invention is to provide an emitter/transmitter based on inductive coupling technology and mountable on modular elements (e.g. tiles) for flooring or walls in order to supply power to light sources in wireless mode or with electrical load or the like.

A further object is to provide an emitter/transmitter that is activated only in presence of a suitable user device nearby, in order to reduce electrical consumption and prevent accidental couplings with other objects, and able to transfer at least 100 watts of power at a given distance (preferably 20 mm) and with an 80% higher efficiency.

A further object of the present invention is to provide an emitter/transmitter that does not exceed the 100kHz safety threshold for humans in terms of transmission frequency.

A further object is to provide an emitter/transmitter only consisting of *hardware* to avoid any human mistake and error (bug) in *software* implementations and accommodating a quick-release coupling system in order to facilitate the replacement of the component in case of *hardware* failures.

The structural and functional characteristics of the present invention and its

advantages over the known art will become even more apparent and more evident from the claims below, and in particular from an examination of the description that follows, referring to the attached drawings, which show the schematic representations of a preferred but non-limiting embodiment of a modular device for wireless transmission of electrical power, wherein:

- Figure 1 shows a side, central section view of the inductor/emitter with the modular bracket structure in question;
- Figure 2 is a bottom plan view of the inductor/emitter with the modular bracket structure of Figure 1;
- Figure 3 is a top plan view of the inductor/emitter with the modular bracket structure of Figure 1;
- Figure 4 represents the wiring diagram and components for the construction of an emitting board of the modular device in question;
- Figure 5 represents the wiring diagram and components for the construction of a receiving board of the modular device in question for lighting applications; and
- Figure 6 shows the wiring diagram and components for the construction of the receiving board of the modular device to supply loads at 220/1 10 volts/ 50/60Hz.

With reference to the annexed Figure 1, D globally indicates a modular device for wireless electrical power transmission, particularly installable in building floorings or walls in general, in order to perform the electrical power transmission from a power source to an electrical load in general, for example a lighting lamp or an equivalent lighting source, without the use of a solid conductor or a direct connection between the two.

The device D comprises a flat element 1 of the tile type, which is adapted to be installed on a flooring, and a bottom surface Si of the same, adapted for mounting

an inductor-emitter group 4 supported by a bracket 2 attached to the same surface Si with screw coupling means 3.

The group 4 comprises an inductor/emitter 4 disposed and fixed on a graphite plate or sheet 7, bearing a centering magnet 8 at its centre, also attached to the graphite plate or sheet, in turn arranged on a central support 9 of bracket 2, and electrically connected to two contact connectors, both marked with 10, also attached to the graphite plate or sheet.

Figure 1 also shows the housing 12 of an emitting board, hooked to the bracket screw coupling means 13 and provided with two contact connectors 11, to which the emitting board is wired. Once in contact, the two connectors 10 and 11 form the closing of the circuit shown in Figure 4.

Figures 2 and 3 show in detail the bracket 2 and the inductor/emitter therefrom supported in top and bottom view.

According to the wiring diagram shown in Figure 4, an emitting circuit is employed, fed by an AC/DC transformer that transforms the network current into a direct current up to 19 Volts and 4 amps.

The emitting circuit consists of a DC/AC transformer or oscillating, Royer-type circuit transforming the 19-volt direct current in an alternating current with a rate of less than 100 Hz by means of an LC oscillator.

The emitting circuit, the layout and sizing of the main components of which is shown in Figure 4, constitutes an oscillating, self-amplified LC circuit supplied in direct voltage with maximum yield frequency of the amplifier peaked on the oscillation frequency of the LC circuit, consisting of an inductor L5 and the capacitor C5.

The emitter circuit supplied by the AC/DC transformer constitutes the primary circuit transforming the network current in an alternating current with a frequency of less

than 100 kHz. The use of a planar inductor with an air gap as the inductor L5 finally allows to transform the alternating current with a frequency of less than 100 kHz into a pulsed magnetic field with a frequency of less than 100 kHz.

It must be emphasised that the calibration of the capacitors and inductances of receiving circuits and the transmitter are critical to obtain transmission (at 20 mm) with a less than 100 kHz frequency and an efficiency greater than 80%.

In use, the emitting circuit and the AC/DC power supply are inserted into the housing 12, hooked to the bracket 2 which in turn is coupled to tile 1 and connected to the network at 220/1 10V. The tile 1 is then installed on the floor or wall of a building.

Therefore, a LED lighting body is realized with two LEDs (boards 5) of equal power but wired with reverse polarization, so that one is off when the other is on and vice versa, as shown in the diagram of Figure 5.

The lighting body may be installed in the preferred support provided that the receiving circuit is maintained, defined by an LC circuit with inductance l_2 and capacitor C and resonance frequency corresponding to the resonance frequency of the emitting circuit and thus coupled therewith, close to the floor or wall.

At this time, by closing the switch T1, the battery-powered starter circuit is fed, which turns the electromagnet E1 on. The electromagnet E1 is calibrated to activate the reed switch A1 of the emitter only if the receiver is within a radius of 50 mm from the receiver. If this condition is satisfied, the magnetic field generated by the electromagnet E1 activates the reed switch of the emitter, closing its supply circuit and turning the pulsed electromagnetic field on. The portion concatenated to the receiving inductor will be converted to an alternate current of equal frequency of the produced magnetic field that will power the two LEDs alternately.

On the other hand, signal amplitude, and then the secondary circuit current voltage, will depend on the portion of the field concatenated to the inductor 12 of the receiver; thus, moving the receiver within a radius of 50 mm from the emitter, a *dimmer* effect of the lighting body is obtained.

A variant of the invention illustrated in Figure 6 involves providing the receiving circuit with a power driver or secondary circuit. The two circuits are separated by a unit transformer decoupling the two circuits without changing the voltage and signal current features.

The secondary circuit has an AC/DC transformer that rectifies the alternating current with a frequency of less than 100 kHz and produces a direct current with voltage between 5 and 60 Volts, a DC/DC transformer that transforms the direct current voltage between 5 and 60 Volts in a direct current with a 24-Volts voltage and a DC/AC inverter or transformer to transform 24V direct current in 220/1 10 volt/-50/60Hz alternating current.

In this case, the secondary circuit acts as a wireless multiple socket, i.e. a wireless device capable of supplying electrical loads requiring 220/1 10 volt/ 50/60Hz alternating voltages.

CLAIMS

1. Modular device (D) for transmitting electrical power in wireless mode, characterized in that it comprises a flat element (1) of the tile type, a bottom surface (Si) of which is adapted for an inductor group (4) to be fitted; said inductor group (4) comprising electrical board means and contact connector means (10).

2. Modular device according to claim 1, characterized in that the said inductor-emitter group (4) is supported by bracket means (2) attached to said surface (Si) by screw coupling means (3).

3. Modular device according to claim 2, characterized in that the said electrical board means are arranged and fixed on a graphite plate or sheet 7 bearing magnet means (8); said magnet means (8) being arranged on a central support (9) of said bracket means (2).

4. Wall or flooring of buildings, comprising the modular device according to one or more of claims 1 to 3.

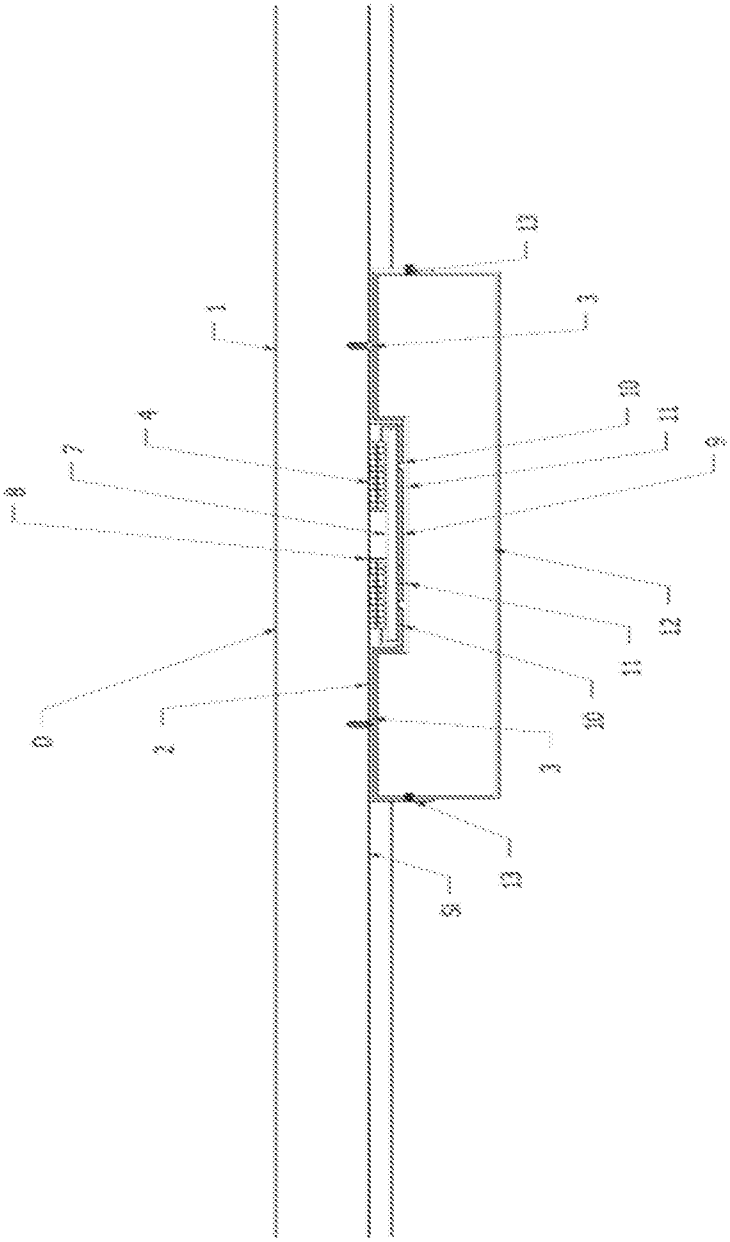


FIG. 1

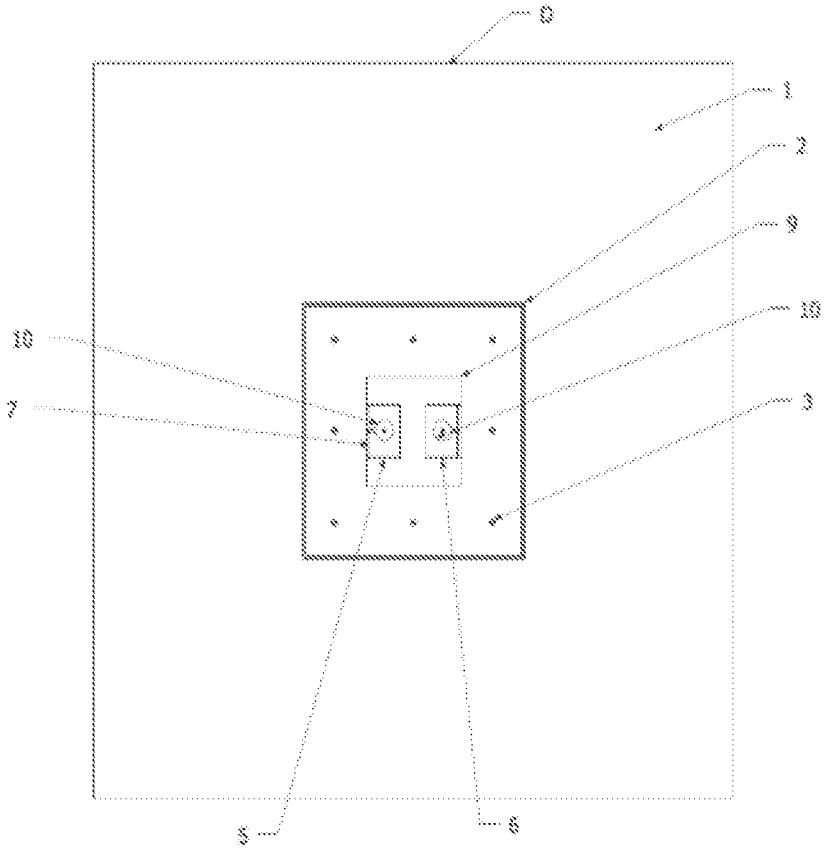


FIG. 2

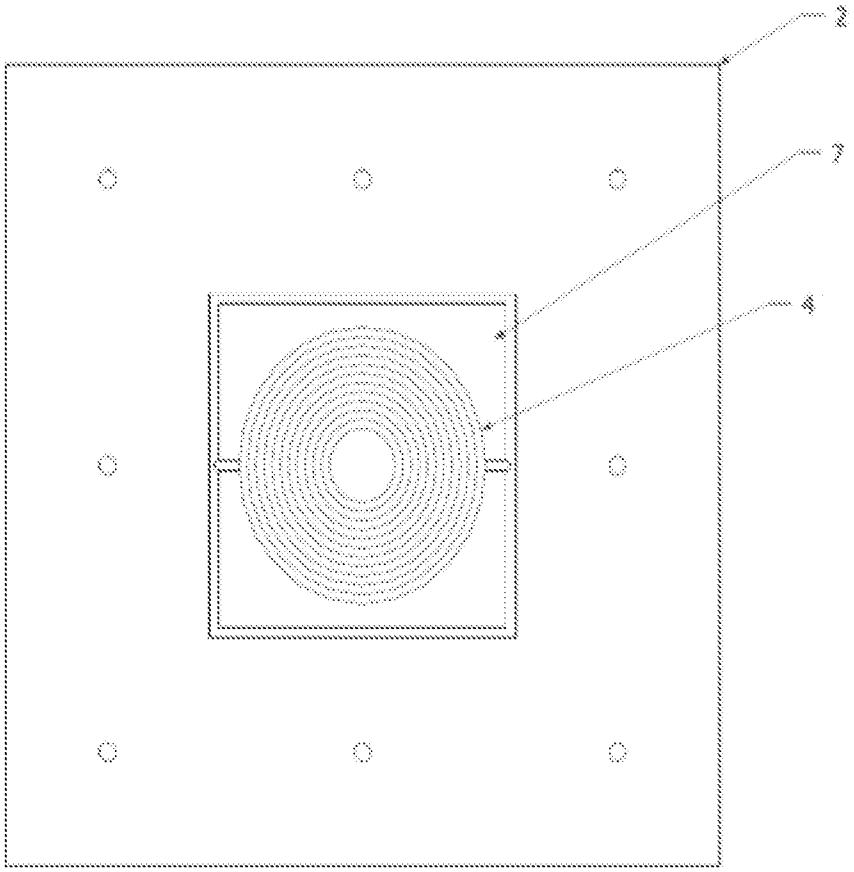


FIG. 3

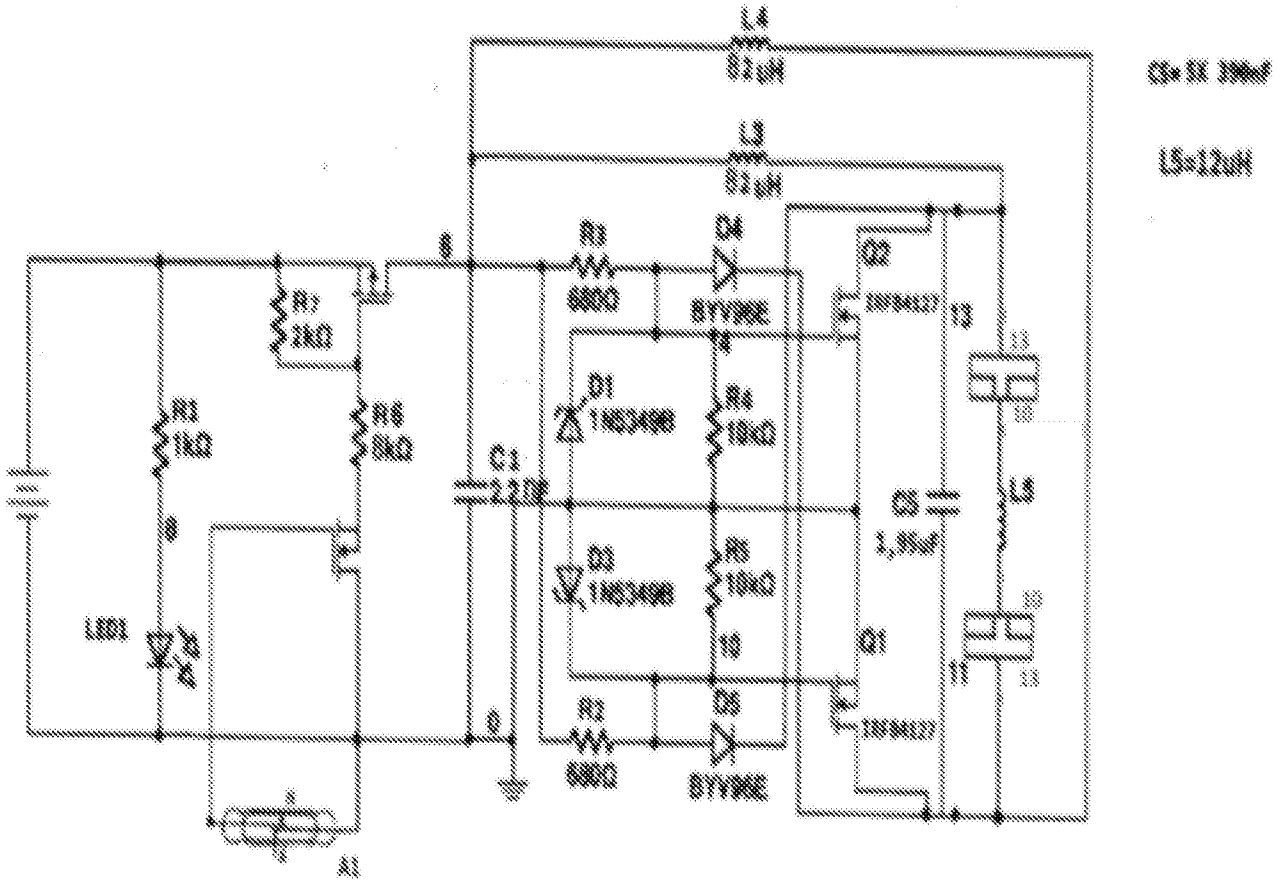
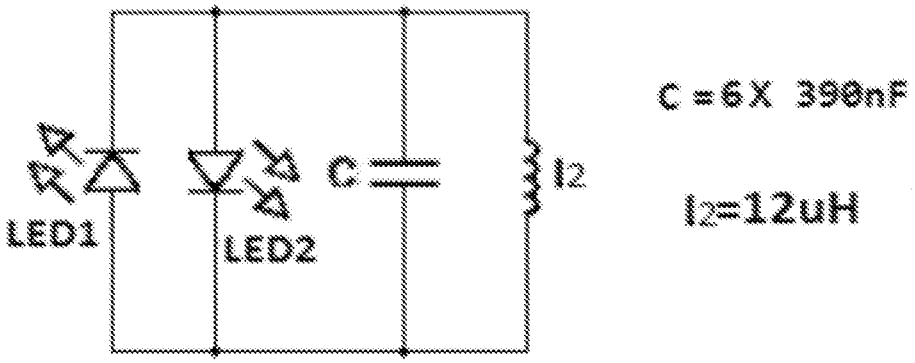


FIG. 4


LED1
LED2
C
I2
C = 6X 390nF
I2=12uH

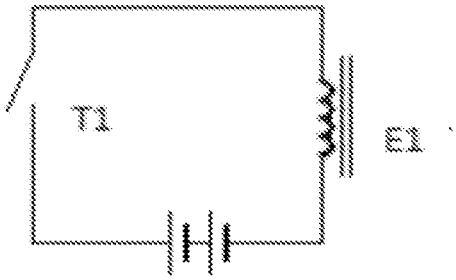

T1
E1

FIG. 5

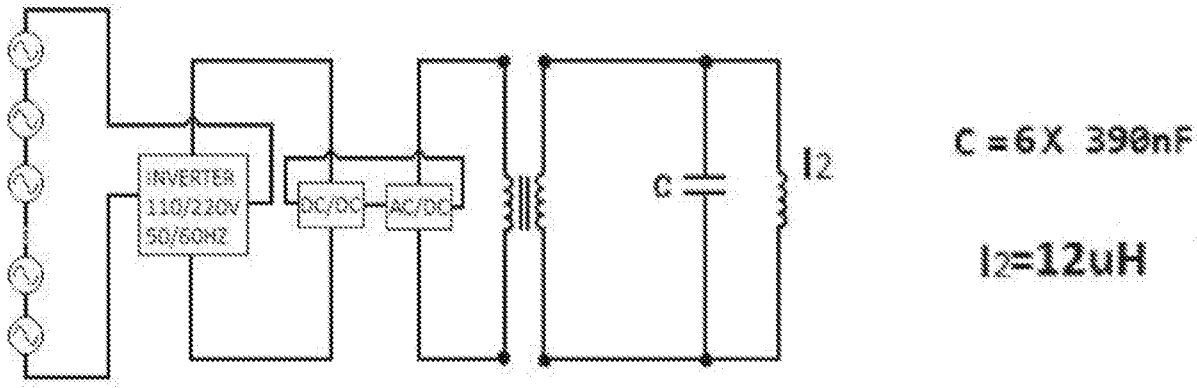
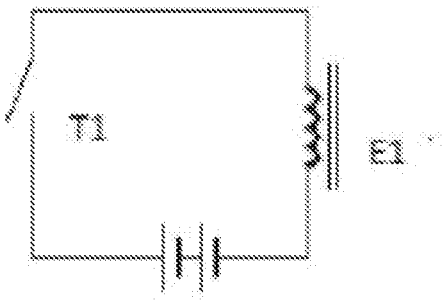

INVERTER
110/230V
50/60HZ
DC/DC
AC/DC
C
I2
C = 6X 390nF
I2=12uH

FIG. 6


T1
E1

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2O16/05GO07

A. CLASSIFICATION OF SUBJECT MATTER
INV. H02J50/10
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H02J

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/219183 Al (AZANCOT YOSSI [I L] ET AL) 2 September 201Q (2010-09-02) the whole document	1-4
X	US 2012/248981 Al (KARALIS ARISTEIDIS [US] ET AL) 4 October 2012 (2012-10-04) paragraph [0162] - paragraph [0167] ; f i gures 129, 131	1-4

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 March 2016	14/03/2016

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INTERNATIONAL SEARCH REPORT

Information on patent Tamlly members

International application No
PCT/IB2O16/05GO07

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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