(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 360 989 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
05.04.2017 Bulletin 2017/14

(51) Int Cl.:
H05B 6/06 *(2006.01)*

(21) Application number: **11000712.7**

(22) Date of filing: **28.01.2011**

(54) Heating device having function of detecting location of foodstuff container

Wärmevorrichtung mit Funktion zur Erkennung der Position eines Lebensmittelbehälters

Dispositif de chauffage disposant d'une fonction de détection de l'emplacement d'un conteneur d'aliments

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **12.02.2010 TW 99104841**

(43) Date of publication of application:
24.08.2011 Bulletin 2011/34

(73) Proprietor: **Delta Electronics, Inc.**
Taoyuan Hsien 333 (TW)

(72) Inventors:
- **Yang, Yi-Lan**
  Taoyuan Hsien 320 (TW)
- **Cho, Cheng-Hsien**
  Taoyuan Hsien 320 (TW)
- **Chen, Yin-Yuan**
  Taoyuan Hsien 320 (TW)

(74) Representative: **Uexküll & Stolberg Partnerschaft von Patent- und Rechtsanwälten mbB**
Beselerstraße 4
22607 Hamburg (DE)

(56) References cited:
EP-A1- 2 034 801
GB-A- 2 183 941
JP-A- 2007 335 274
US-A1- 2009 321 425

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 2 360 989 B1

Printed by Jouve, 75001 PARIS (FR)

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a heating device, and more particularly to a heating device having a function of detecting a location of a foodstuff container.

BACKGROUND OF THE INVENTION

[0002] Nowadays, a variety of heating devices such as gas stoves, infrared oven, microwave oven and electric stove are widely used to cook food. Different heating devices have their advantages or disadvantages. Depending on the food to be cooked, a desired heating device is selected.

[0003] Take an induction cooking stove for example. When a current flows through the induction coil of the induction cooking stove, electromagnetic induction is performed to produce eddy current, thereby heating a foodstuff container. Depending on the location of the foodstuff container relative to the induction coil, the heat quantity for heating the foodstuff container by the induction coil and the current magnitude of the induction coil are varied. For example, in a case that the area of the foodstuff container overlying the induction coil with respect to the area of the induction coil is very high (e.g. 95%), the heat quantity for heating the foodstuff container by the induction coil is high. In this situation, the reactive power of operating the induction coil and the current magnitude are both reduced. On the other hand, in a case that the area of the foodstuff container overlying the induction coil with respect to the area of the induction coil is too low or the foodstuff container is largely deviated from the induction coil, the heat quantity for heating the foodstuff container by the induction coil become very low (or zero). In this situation, the reactive power of operating the induction coil and the current magnitude are both increased. As such, the induction cooking stove is possibly burnt out. For solving this problem, the induction cooking stove needs to have a function for accurately detecting the location of the foodstuff container.

[0004] The conventional induction cooking stove uses a micro-control unit (MCU) to calculate a ratio of a root-mean-square (rms) value of an input current to a root-mean-square (rms) value of an induction coil current, thereby determining the proper location of the foodstuff container. Since the frequency of the induction coil current is high (e.g. 20k~50kHz), the sampling rate should be high and the calculating amount and speed of the micro-control unit should be increased to calculate the root-mean-square value of the induction coil current. Since the calculating process is complicated, the fabricating cost of the induction cooking stove is increased.

[0005] In a case that the magnitudes of the induction coil current and the input current are both very high, a current transformer (CT) or a sense resistor is necessary for reducing the circuit magnitudes. After the circuit magnitudes are reduced, a current signal ratio is adjusted by an amplifying circuit, and then the reduced induction coil current and the reduced input current are sampled by a sampling circuit. Since the impedance matching of the amplifying circuit, the current transformer and the sampling circuit have respective tolerances and the current signals are readily interfered by noise, the current magnitude obtained by the micro-control unit has a large error, which is equal to the overall error resulted from the current transformer, the amplifying circuit and the sampling circuit. In this situation, the accuracy of determining the location of the foodstuff container is adversely affected by the noise. Moreover, when the location of the foodstuff container is changed, the ratio of the root-mean-square value of an input current to the root-mean-square value of the induction coil current is acquired with undue experiments. The accuracy of the ratio is usually unsatisfied.

[0006] UK patent application GB 2 183 941 A relates to an electromagnetic induction cooking apparatus capable of providing a substantially constant input power. The apparatus has a load detection circuit responsive to the current in a resonant circuit driven by an inverter in order to identify the material of the cooking utensil in use. If an iron or stainless steel load is sensed, the circuit causes a DC supply to produce a voltage E1 and a switch to close to contact so that the resonant circuit is formed by a capacitor and an inductor (N1 turns) and is driven at its resonant frequency f_1 by the inverter. If a copper or aluminium load is sensed, the supply produces a voltage E2, and the resonant circuit is formed by series-connected capacitors and series-connected inductors (N2 turns) driven at its resonant frequency f_2. The apparatus operates so that the following relationship holds: $N2/N1 = K \cdot (E2/E1) \cdot (f_2/f_1)$, wherein K is between 4 and 6, thereby ensuring a substantially constant input power for the different loads. The voltage produced by the DC supply may be changed by phase control of a thyristor, or by connection to different points in a voltage doubler, or by switching in different filter capacitors.

[0007] US 2009/0321425 A1 discloses a method for controlling an induction cooking appliance with at least one coil, wherein the power of the coil is adjusted as a function of a position of a cocking utensil on the coil. This document also relates to an induction cooking appliance for heating a cooking utensil, which has at least one coil and a drive unit for the coil, the induction cooking appliance being designed to implement the mentioned method.

SUMMARY OF THE INVENTION

[0008] It is an object of the present invention to provide a heating device having a function of detecting a location of a foodstuff container without complicated calculation and undue experiments. The function of detecting the location of the foodstuff container may be implemented by a micro controller with slower calculating amount and

speed.

[0009] Another object of the present invention provides a heating device having a function of detecting a location of a foodstuff container with high accuracy and reduced error.

[0010] A further object of the present invention provides a heating device capable of judging whether the components of the heating device is abnormal in order to overcome the problem of burning out the heating device.

[0011] In accordance with an aspect of the present invention, there is provided a heating device having a function of detecting a location of a foodstuff container. The heating device includes an induction coil, an inverter circuit, a first current-detecting circuit, a signal processing circuit and a controlling unit. The induction coil is used for heating the foodstuff container. The inverter circuit is used for receiving a rectified voltage and generating a driving voltage to drive the induction coil. The first current-detecting circuit is serially connected with the induction coil for detecting a first current flowing through the induction coil, thereby generating a first current-detecting signal. The signal processing circuit is connected to the first current-detecting circuit for generating a current phase signal according to the first current-detecting signal. The controlling unit is used for generating at least a first control signal according to a cooking option, thereby controlling the inverter circuit. According to a duration difference or a phase difference between the first control signal and the current phase signal, the controlling unit determines an area of the foodstuff container overlying the induction coil with respect to an area of the induction coil or a location of the foodstuff container relative to the induction coil, thereby adjusting an operation of the inverter circuit.

[0012] In accordance with another aspect of the present invention, there is provided a heating device having a function of detecting a location of a foodstuff container. The heating device includes an induction coil, an inverter circuit, a first current-detecting circuit, a signal processing circuit and a controlling unit. The induction coil is used for heating the foodstuff container. The inverter circuit is used for receiving a rectified voltage, thereby generating a driving voltage to drive the induction coil. The first current-detecting circuit is serially connected with the induction coil for detecting a first current flowing through the induction coil, thereby generating a first current-detecting signal. The signal processing circuit is connected to the first current-detecting circuit for generating a current phase signal according to the first current-detecting signal. The controlling unit is used for generating at least a first control signal according to a cooking option, thereby controlling the inverter circuit. According to a duration difference or a phase difference between the first control signal and the current phase signal, the controlling unit determines an area of the foodstuff container overlying the induction coil with respect to an area of the induction coil or a location of the foodstuff container relative to the induction coil, thereby adjusting an operation of the inverter circuit. If the duration difference or the phase difference between the first control signal and the current phase signal exceeds a predetermined range, the controlling unit judges that the location of the foodstuff container is improper or abnormal and controls the inverter circuit to be operated in a pan detection mode. In the pan detection mode, the inverter circuit is operated at an increased switching frequency or a reduced duty cycle, or the inverter circuit is disabled.

[0013] The above contents of the present invention will become more readily apparent to those ordinarily skilled in the art after reviewing the following detailed description and accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

FIG 1 is a schematic circuit block diagram illustrating a heating device having a function of detecting a location of a foodstuff container according to an embodiment of the present invention;

FIG 2A is a schematic view illustrating the location of the foodstuff container relative to the induction coil in the heating device of the present invention;

FIG 2B is a schematic view illustrating another location of the foodstuff container relative to the induction coil in the heating device of the present invention; and

FIG 3 is a timing waveform diagram schematically illustrating the corresponding current signals and control signal processed in the heating device of FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] The present invention will now be described more specifically with reference to the following embodiments. It is to be noted that the following descriptions of preferred embodiments of this invention are presented herein for purpose of illustration and description only. It is not intended to be exhaustive or to be limited to the precise form disclosed.

[0016] FIG 1 is a schematic circuit block diagram illustrating a heating device having a function of detecting a location of a foodstuff container according to an embodiment of the present invention. As shown in FIG. 1, the heating device 1 includes a rectifier circuit 11, a filtering circuit 12, an inverter circuit 13, an induction coil 14, a first current-detecting circuit 15, a signal processing circuit 16, a controlling unit 17 and a user interface unit 18.

[0017] In this embodiment, the rectifier circuit 11 is a bridge rectifier circuit. An input voltage V_{in} is rectified into a rectified voltage V_r by the rectifier circuit 11. The filtering circuit 12 is connected to an output terminal of the rectifier circuit 11. The filtering circuit 12 is used for filtering off the high-frequency noise contained in the rectified volt-

age V_r. In this embodiment, the filtering circuit 12 includes a filter capacitor C_a. In some embodiments, the filtering circuit 12 may include plural inductors and plural capacitors (not shown). The induction coil 14 is disposed inside a heating panel 10 for heating a foodstuff container 2.

[0018] The power input terminal of the inverter circuit 13 is connected to the filtering circuit 12. The power output terminal of the inverter circuit 13, the induction coil 14 and the first current-detecting circuit 15 are connected with each other in series. In this embodiment, the inverter circuit 13 includes a first switch element Q_1, a second switch element Q_2, a first capacitor C_1 and a second capacitor C_2. The first switch element Q_1 and the second switch element Q_2 are connected with each other in series. A first connecting node between the first switch element Q_1 and the second switch element Q_2 is connected to the first current-detecting circuit 15. The first capacitor C_1 and the second capacitor C_2 are connected with each other in series. A second connecting node between the first capacitor C_1 and the second capacitor C_2 is connected to a first terminal of the induction coil 14. The first connecting node between the first switch element Q_1 and the second switch element Q_2 is served as a first power output terminal of the inverter circuit 13. The second connecting node between the first capacitor C_1 and the second capacitor C_2 is served as a second power output terminal of the inverter circuit 13. The control terminal of the first switch element Q_1 and the control terminal of the second switch element Q_2 are connected to the controlling unit 17. Under control of the controlling unit 17, the first switch element Q_1 and the second switch element Q_2 are conducted in an interleaved manner according to a first control signal S_1 and a second control signal S_2. As such, an AC driving voltage V_o is generated by the inverter circuit 13 to drive the induction coil 14.

[0019] In response to an enabling status of the first control signal S_1 and a disabling status of the second control signal S_2, the first switch element Q_1 is conducted but the second switch element Q_2 is shut off. As such, the electric energy of the rectified voltage V_r is transmitted to the induction coil 14 through the first switch element Q_1 and the second capacitor C_2. In this situation, the driving voltage V_o is equal to the positive component of the rectified voltage V_r, so that the positive component of the rectified voltage V_r is received by the induction coil 14. Whereas, in response to a disabling status of the first control signal S_1 and an enabling status of the second control signal S_2, the first switch element Q_1 is shut off but the second switch element Q_2 is conducted. As such, the electric energy of the rectified voltage V_r is transmitted to the induction coil 14 through the first capacitor C_1 and the second switch element Q_2. In this situation, the driving voltage V_o is equal to the negative component of the rectified voltage V_r, so that the negative component of the rectified voltage V_r is received by the induction coil 14.

[0020] In this embodiment, the first current-detecting circuit 15 is a current transformer. The primary side of the current transformer 15, the induction coil 14 and the power output terminal of the inverter circuit 13 are connected with each other in series. The secondary side of the current transformer 15 is connected to the signal processing circuit 16. The current transformer 15 is used for detecting the first current I_1 flowing through the induction coil 14. In addition, by the current transformer 15, the first current I_1 is reduced and a corresponding first current-detecting signal V_{s1} is generated. In other words, the waveform, time sequence and phase of the first current-detecting signal V_{s1} are identical to those of the first current I_1.

[0021] The signal processing circuit 16 is interconnected between the first current-detecting circuit 15 and the controlling unit 17. According to the first current-detecting signal V_{s1}, the signal processing circuit 16 issues a current phase signal Sp to the controlling unit 17. In this embodiment, the signal processing circuit 16 includes a comparing circuit. According to the first current-detecting signal V_{s1}, the comparing circuit outputs the current phase signal Sp. In a case that the first current I_1 is switched from a negative status to a positive status, the current phase signal S_p in an enabling status is issued from the comparing circuit to the controlling unit 17. Whereas, in a case that the first current I_1 is switched from the positive status to the negative status, the current phase signal S_p in a disabling status is issued from the comparing circuit to the controlling unit 17.

[0022] In some embodiment, the comparing circuit compares the first current-detecting signal V_{s1} with a reference voltage (not shown). If the first current-detecting signal V_{s1} is greater than the reference voltage, the current phase signal S_p in the enabling status is issued from the comparing circuit to the controlling unit 17. Whereas, if the first current-detecting signal V_{s1} is smaller than the reference voltage, the current phase signal S_p in the disabling status is issued from the comparing circuit to the controlling unit 17.

[0023] According to a user's cooking option, the operating frequencies and the durations of the first control signal S_1 and an enabling status of the second control signal S_2 are adjusted. The user's cooking option includes for example a powering off selective item, a powering on selective item, a heat quantity selective item, a heating time selective item, a fast heating selective item or a slow heating selective item. As the operating frequencies and the durations of the first control signal S_1 and an enabling status of the second control signal S_2 are adjusted, the power magnitude transmitted to the induction coil 14 from the inverter circuit 13, the magnitude of the first current I_1 and the heat quantity for heating the foodstuff container 2 by the induction coil 14 are changed. In addition, according to a duration difference or a phase difference between the first control signal S_1 and the current phase signal S_p, the controlling unit 17 determines an area of the foodstuff container 2 overlying the induction coil 14 with respect to an area of the induction coil 14 or a location of the foodstuff container 2 relative to the induction coil 14, thereby adjusting an operation of the

inverter circuit. In this embodiment, the duration difference or the phase difference between the second control signal S_2 and the current phase signal Sp is equal to the duration difference or the phase difference between the first control signal S_1 and the current phase signal S_p. In some embodiments, according to the duration difference or the phase difference between the second control signal S_2 and the current phase signal S_p, the controlling unit 17 determines an area of the foodstuff container 2 overlying the induction coil 14 with respect to an area of the induction coil 14 or a location of the foodstuff container 2 relative to the induction coil 14.

[0024] Hereinafter, the principle of determining an area of the foodstuff container 2 overlying the induction coil 14 with respect to an area of the induction coil 14 or a location of the foodstuff container 2 relative to the induction coil 14 according to the duration difference or the phase difference between the first control signal S_1 and the current phase signal Sp will be illustrated in more details.

[0025] The user interface unit 18 is connected to the controlling unit 17 for receiving the user's cooking option and indicating the operating message. The user's cooking option includes for example a powering off selective item, a powering on selective item, a heat quantity selective item, a heating time selective item, a fast heating selective item or a slow heating selective item. In this embodiment, the user interface unit 18 is a touch screen for implementing the user's cooking option. In addition, the operating message is also shown on the touch screen.

[0026] In this embodiment, the heating device 1 further includes a second current-detecting circuit 19. The second current-detecting circuit 19 includes a detecting resistor R_s. The detecting resistor R_s is interconnected between the filtering circuit 12 and the inverter circuit 13 for detecting a second current I_2 flowing through the inverter circuit 13, thereby generating a second current-detecting signal V_{s2} to the controlling unit 17. According to the second current-detecting signal V_{s2}, the controlling unit 17 calculates the second current I_2, which is relatively higher.

[0027] An example of the controlling unit 17 includes but is not limited to a pulse frequency modulation (PFM) controller, micro controller, a micro processor or a digital signal processor (DSP). Each of the first switch element and the second switch element is a metal oxide semiconductor field effect transistor (MOSFET), a bipolar junction transistor (BJT) or an insulated gate bipolar transistor (IGBT).

[0028] FIG 2A is a schematic view illustrating a location of the foodstuff container relative to the induction coil in the heating device of the present invention. As shown in FIG 2A, the foodstuff container 2 is placed over the middle portion of the induction coil 14. The area of the foodstuff container 2 overlying the induction coil 14 with respect to the area of the induction coil 14 is very high. For example, the area of the foodstuff container 2 overlying the induction coil 14 (A1) is 95% of the area of the induction coil 14. Since the heat quantity for heating the foodstuff container 2 by the induction coil 14 is high, both of the reactive power of operating the induction coil 14 and the first current I_1 are relatively lower. In this situation, the duration difference or the phase difference between the first control signal S_1 and the current phase signal S_p is within a predetermined range (e.g. 1μs~7μs). According to the duration difference or the phase difference, the controlling unit 17 will judge whether the area of the foodstuff container 2 overlying the induction coil 14 with respect to the area of the induction coil 14 or a location of the foodstuff container 2 relative to the induction coil 14 is suitable. In addition, according to the duration difference or the phase difference, the controlling unit 17 controls the inverter circuit 13 to output the heat power or heat quantity set by the cooking option. Meanwhile, the maximum heat power or heat quantity outputted from the inverter circuit 13 is equal to the rated value.

[0029] FIG 2B is a schematic view illustrating another location of the foodstuff container relative to the induction coil in the heating device of the present invention. As shown in FIG 2B, the foodstuff container 2 is not completely placed over the middle portion of the induction coil 14. The area of the foodstuff container 2 overlying the induction coil 14 with respect to the area of the induction coil 14 is very low. For example, the area of the foodstuff container 2 overlying the induction coil 14 (A2) is 15% of the area of the induction coil 14. Since the heat quantity for heating the foodstuff container 2 by the induction coil 14 is low, both of the reactive power of operating the induction coil 14 and the first current I_1 are increased in comparison with FIG. 2A. In this situation, the duration difference or the phase difference between the first control signal S_1 (or the second control signal S_2) and the current phase signal S_p exceeds the predetermined range (e.g. > 7μs). According to the duration difference or the phase difference, the controlling unit 17 will judge that the location of the foodstuff container 2 is improper or abnormal. Meanwhile, the controlling unit 17 controls the inverter circuit 13 to be operated in a pan detection mode. In the pan detection mode, the first switch element Q_1 and the second switch element Q_2 of the inverter circuit 13 are operated at a higher switching frequency or a lower duty cycle. Alternatively, the induction coil 14 is disabled in order to prevent from burning out the heating device 1 because the foodstuff container 2 is improperly or abnormally positioned or no foodstuff container 2 is placed on the induction coil 14.

[0030] In another case that the foodstuff container 2 is placed over the middle portion of the induction coil 14 but the area of the foodstuff container 2 is very small (for example area of the foodstuff container 2 overlying the induction coil 14 (A1) is 30% of the area of the induction coil 14), the duration difference or the phase difference between the first control signal S_1 (or the second control signal S_2) and the current phase signal Sp is within the predetermined range. In comparison with the case of FIG

2A, both of the reactive power of operating the induction coil 14 and the first current I_1 are increased. In addition, the root-mean-square (rms) value of the second current I_2 or the second current-detecting signal V_{s2} will be smaller than a first current threshold value (e.g. 1A). For preventing from burning out the heating device 1, the heat power or heat quantity outputted by the inverter circuit 13 is reduced under control of the controlling unit 17. Meanwhile, the maximum heat power or heat quantity outputted from the inverter circuit 13 is lower than the rated value. That is, for complying with different sizes of foodstuff containers, the duration difference or the phase difference between the first control signal S1 (or the second control signal S2) and the relation between the second current I_2 and the first current threshold value should be taken into consideration.

[0031] If the controlling unit 17 judges that the duration difference or the phase difference between the first control signal S_1 (or the second control signal S2) and the current phase signal Sp is within the predetermined range and the second current I_2 is smaller than the first current threshold value, it is meant that a relatively smaller foodstuff container 2 is placed over the middle portion of the induction coil 14. In this situation, the heat power or heat quantity outputted by the inverter circuit 13 is reduced under control of the controlling unit 17, so that the maximum heat power or heat quantity outputted from the inverter circuit 13 is lower than the rated value. Whereas, if the controlling unit 17 judges that the duration difference or the phase difference between the first control signal S_1 (or the second control signal S_2) and the current phase signal Sp is within the predetermined range and the second current I_2 is greater than the first current threshold value, it is meant that a normal-sized foodstuff container 2 is placed over the middle portion of the induction coil 14. In this situation, the controlling unit 17 controls the inverter circuit 13 to output the heat power or heat quantity set by the cooking option, so that the maximum heat power or heat quantity outputted from the inverter circuit 13 is equal to the rated value.

[0032] FIG 3 is a timing waveform diagram schematically illustrating the corresponding current signals and control signal processed in the heating device of FIG 1. As shown in FIG 3, the waveform and time sequence of the first current-detecting signal V_{s1} are identical to those of the first current I_1. Since the current phase signal S_p is obtained by the signal processing circuit 16 according to the first current-detecting signal V_{s1}, the time sequence of the current phase signal S_p is substantially identical to that of the first current I_1. In other words, the duration difference (d) or the phase difference (d) between the control signal (S_1 or S_2) and the current phase signal S_p is equal to the duration difference (d) or the phase difference (d) between the control signal (S_1 or S_2) and the first current I_1. As such, the controlling unit 17 may calculate the duration difference (d) or the phase difference (d) between the control signal (S_1 or S_2) and the first current I_1 according to the current phase signal S_p. The process of calculating the duration difference (d) or the phase difference (d) between the control signal (S_1 or S_2) and the current phase signal S_p is simplified because huge amount of sampling data is no loner needed. In this circumstance, even if the frequency of the first current I_1 flowing the induction coil 14 is high (e.g. > 20 kHz), the controlling unit 17 may be implemented by a micro controller with slower calculating amount and speed. For example, at a first time spot t_1, a timer (not shown) of the controlling unit 17 is activated to count time in response to the first control signal S_1 in the enabling status; and at a second time spot t_2, the timer of the controlling unit 17 stops counting time in response to the current phase signal S_p in the enabling status. As a consequence, the duration difference (d) or the phase difference (d) between the first control signal S_1 and the current phase signal S_p will be calculated without difficulty.

[0033] In this embodiment, the first switch element Q_1 and the second switch element Q_2 are operated in a zero voltage switching (ZVS) manner. In a case that the first switch element Q_1, the second switch element Q_2, the first capacitor C_1, the second capacitor C_2, the induction coil 14 or any other software or hardware component has a failure or is abnormal, the first switch element Q_1 and the second switch element Q_2 fail to be operated in the zero voltage switching (ZVS) manner. In this situation, the switching current is too large or the first current I_1 is largely increased. Meanwhile, the duration difference or the phase difference between the first control signal S_1 (or the second control signal S_2) and the current phase signal S_p is below the predetermined range (e.g. < 1μs). If the duration difference or the phase difference between the first control signal S_1 (or the second control signal S_2) and the current phase signal S_p is below the predetermined range, it is meant that one or more components of the heating device 1 has a failure or is abnormal. For preventing from burning out the heating device 1, the heat power or heat quantity outputted by the inverter circuit 13 is reduced under control of the controlling unit 17. Meanwhile, the maximum heat power or heat quantity outputted from the inverter circuit 13 is lower than the rated value. Alternatively, the heating device 1 is disabled.

[0034] In the above embodiments, the heating device 1 determines the location of the foodstuff container 2 according to the duration difference (d) or the phase difference (d) between the control signal (S_1 or S_2) and the current phase signal S_p. The process of calculating the duration difference (d) or the phase difference (d) is simplified because huge amount of sampling data is no loner needed. In this circumstance, the controlling unit 17 may be implemented by a micro controller with slower calculating amount and speed. As such, the heating device 1 is cost-effective. In a case that the foodstuff container 2 is not completely placed over the middle portion of the induction coil 14 and the area of the foodstuff container 2 overlying the induction coil 14 with respect to the area of the induction coil 14 is reduced, the duration difference

(d) or the phase difference (d) between the control signal (S_1 or S_2) and the current phase signal S_p is increased. Whereas, in a case that the area of the foodstuff container 2 overlying the induction coil 14 with respect to the area of the induction coil 14 is increased, the duration difference (d) or the phase difference (d) between the control signal (S_1 or S_2) and the current phase signal S_p is reduced. Since the duration difference (d) or the phase difference (d) between the control signal (S_1 or S_2) and the current phase signal S_p is detectable by an instrument (e.g. an oscilloscope) without undue experiments.

[0035] Moreover, after the signal processing circuit 16 generates the current phase signal S_p according to the first current-detecting signal V_{s1}, the controlling unit 17 will calculate the duration difference (d) or the phase difference (d) between the control signal (S_1 or S_2) and the current phase signal S_p according to the current phase signal S_p. As such, the error of detecting the foodstuff container 2 is reduced, the possibility of being interfered by noise is reduced and the accuracy of detecting the foodstuff container 2 is enhanced. Moreover, since the duration difference (d) or the phase difference (d) can be used to judge whether the components of the heating device is abnormal, the problem of burning out the heating device 1 is overcome.

Claims

1. A heating device (1) having a function of detecting a location of a foodstuff container (2), said heating device (1) comprising:

   an induction coil (14) for heating said foodstuff container (2);
   an inverter circuit (13) for receiving a rectified voltage (V_r) and generating a driving voltage (V_o) to drive said induction coil (14);
   a first current-detecting circuit (15) serially connected with said induction coil (14) for detecting a first current (I_1) flowing through said induction coil (14), thereby generating a first current-detecting signal (V_{s1});
   a signal processing circuit (16) connected to said first current-detecting circuit (15) for generating a current phase signal (S_p) according to said first current-detecting signal (V_{s1}); and
   a controlling unit (17) for generating at least a first control signal (S_1) according to a cooking option, thereby controlling said inverter circuit (13),
   characterized in that according to a duration difference or a phase difference between said first control signal (S_1) and said current phase signal (S_p), said controlling unit (17) determines an area of said foodstuff container (2) overlying said induction coil (14) with respect to an area of said induction coil (14) or a location of said foodstuff container (2) relative to said induction coil (14), thereby adjusting an operation of said inverter circuit (13).

2. The heating device according to claim 1 **characterized in that** said signal processing circuit (16) comprises a comparing circuit for generating said current phase signal (S_p) in an enabling status or a disabling status according to said first current-detecting signal (V_{s1}).

3. The heating device according to claim 2 **characterized in that** if said first current-detecting signal (V_{s1}) is greater than a reference voltage, said current phase signal (S_p) in said enabling status is issued from said comparing circuit to said controlling unit (17), wherein if said first current-detecting signal (V_{s1}) is smaller than said reference voltage, said current phase signal (S_p) in said disabling status is issued from said comparing circuit to said controlling unit (17).

4. The heating device according to claim 1 **characterized in that** if said duration difference or said phase difference between said first control signal (S_1) and the current phase signal (S_p) exceeds a predetermined range, said controlling unit (17) judges that said location of said foodstuff container (2) is improper or abnormal and controls said inverter circuit (13) to be operated in a pan detection mode, wherein in said pan detection mode, said inverter circuit (13) is operated at an increased switching frequency or a reduced duty cycle, or said inverter circuit (13) is disabled.

5. The heating device according to claim 1 **characterized in that** further comprising:

   a rectifier circuit (11) for rectifying an input voltage (V_{in}) into said rectified voltage (V_r); and
   a filtering circuit (12) connected to said inverter circuit (13) and said rectifier circuit (11).

6. The heating device according to claim 5 **characterized in that** further comprising a second current-detecting circuit (19), which is interconnected between said filtering circuit (12) and said inverter circuit (13) for detecting a second current (I_2) flowing through said inverter circuit (13), thereby generating a second current-detecting signal (V_{s2}).

7. The heating device according to claim 6 **characterized in that** if said duration difference or said phase difference between said first control signal (S_1) and said current phase signal (S_p) is within a predetermined range and said second current (I_2) is smaller than a first current threshold value, said controlling unit (17) controls said inverter circuit (13) to output

reduced heat power or heat quantity such that the maximum heat power or heat quantity outputted from said inverter circuit is (13) lower than a rated value.

8. The heating device according to claim 7 **characterized in that** if said duration difference or said phase difference between said first control signal (S_1) and said current phase signal (S_p) is within said predetermined range and said second current (I_2) is greater than said first current threshold value, said controlling unit (17) controls said inverter circuit (13) to output the heat power or heat quantity set by said cooking option, so that the maximum heat power or heat quantity outputted from said inverter circuit is equal to said rated value.

9. The heating device according to claim 1 **characterized in that** if said duration difference or said phase difference between said first control signal (S_1) and said current phase signal (S_p) is below a predetermined range, said controlling unit (17) judges that one or more components of said heating device (1) has a failure or is abnormal, and said controlling unit (17) controls said inverter circuit (13) to output reduced heat power or heat quantity such that the maximum heat power or heat quantity outputted from said inverter circuit (13) is lower than a rated value, or said heating device (1) is disabled.

10. The heating device according to claim 1 **characterized in that** according to said first control signal (S_1) and said current phase signal (S_p), a timer of said controlling unit (17) is activated to count time or stops counting time, thereby calculating said duration difference or said phase difference between said first control signal (S_1) and said current phase signal (S_p).

11. The heating device according to claim 1 **characterized in that** said inverter circuit (13) comprises:

a first switch element (Q_1) having a control terminal connected to said controlling unit (17);
a second switch element (Q_2) connected to said first switch element (Q_1), wherein a first connecting node between said first switch element (Q_1) and said second switch element (Q_2) is served as a first power output terminal of said inverter circuit (13);
a first capacitor (C_1); and
a second capacitor (C_2) connected with said first capacitor (C_1) in series, wherein a second connecting node between said first capacitor (C_1) and said second capacitor (C_2) is served as a second power output terminal of said inverter circuit (13),
wherein under control of said controlling unit (17), said first switch element (Q_1) and said second switch element (Q_2) are conducted in an interleaved manner according to said first control signal (S_1) and a second control signal (S_2), so that said driving voltage (V_o) is generated by said inverter circuit (13) to drive said induction coil (14).

12. The heating device according to claim 1, further comprising a user interface unit (18), which is connected to said controlling unit (17) for receiving said cooking option and indicating an operating message.

Patentansprüche

1. Heizvorrichtung (1) mit einer Funktion zum Erfassen einer Position eines Nahrungsmittelbehälters (2), wobei die Heizvorrichtung (1) aufweist:

eine Induktionsspule (14) zum Erhitzen des Nahrungsmittelbehälters (2);
eine Inverterschaltung (13) zum Empfangen einer gleichgerichteten Spannung (V_r) und zum Erzeugen einer Speisespannung (V_o), um die Induktionsspule (14) zu speisen;
eine erste Stromerfassungsschaltung (15), die in Reihe mit der Induktionsspule (14) verbunden ist, um einen ersten Strom (I_1) zu erfassen, der durch die Induktionsspule (14) fließt, um dadurch ein erstes Stromerfassungssignal (V_{s1}) zu erzeugen;
eine Signalverarbeitungsschaltung (16), die mit der ersten Stromerfassungsschaltung (15) verbunden ist, um basierend auf dem ersten Stromerfassungssignal (V_{s1}) ein Stromphasensignal (S_p) zu erzeugen; und
eine Steuereinheit (17), um basierend auf einer Koch-Option mindestens ein erstes Steuersignal (S_1) zu erzeugen, um dadurch die Inverterschaltung (13) zu steuern,
dadurch gekennzeichnet, dass, basierend auf einer Zeitdauerdifferenz oder einer Phasendifferenz zwischen dem ersten Steuersignal (S_1) und dem Stromphasensignal (S_p), die Steuereinheit (17)ein Gebiet des Nahrungsmittelbehälters (2), das sich über der Induktionsspule (14) befindet, und zwar bezüglich eines Gebiets der Induktionsspule (14), oder eine Position des Nahrungsmittelbehälters (2) relativ zur Induktionsspule (14) bestimmt, wodurch ein Betrieb der Inverterschaltung (17) eingestellt wird.

2. Heizvorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Signalverarbeitungsschaltung (16) eine Vergleichsschaltung aufweist, um in einem Freigabe-Zustand oder in einem Sperr-Zustand das Stromphasensignal (S_p) zu erzeugen, und zwar basierend auf dem ersten Stromerfassungssignal (V_{s1}).

3. Heizvorrichtung nach Anspruch 2, **dadurch gekennzeichnet, dass,** wenn das erste Stromerfassungssignal (V_{s1}) größer als eine Referenzspannung ist, das Stromphasensignal (S_p) im Freigabe-Zustand von der Vergleichsschaltung an die Steuereinheit (17) ausgegeben wird, wobei, wenn das erste Stromerfassungssignal (V_{s1}) kleiner als die Referenzspannung ist, das Stromphasensignal (S_p) im Sperr-Zustand von der Vergleichsschaltung zur Steuereinheit (17) ausgegeben wird.

4. Heizvorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass,** wenn die Zeitdauerdifferenz oder die Phasendifferenz zwischen dem ersten Steuersignal (S_1) und dem Stromphasensignal (S_p) einen vorbestimmten Bereich überschreitet, die Steuereinheit (17) beurteilt, dass die Position des Nahrungsmittelbehälters (2) unsachgemäß oder unnormal ist, und die Inverterschaltung (13) steuert, um in einem Topf-Erfassungsmodus betrieben zu werden, wobei die Inverterschaltung (13) in dem Topf-Erfassungsmodus mit einer erhöhten Schaltfrequenz oder einer reduzierten Einschaltdauer (Duty Cycle) betrieben wird, oder die Inverterschaltung (13) deaktiviert wird.

5. Heizvorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** diese außerdem aufweist:

eine Gleichrichterschaltung (11) zum Gleichrichten eine Eingangsspannung (V_{in}) in die gleichgerichtete Spannung (V_r); und
eine Filterschaltung (12), die mit der Inverterschaltung (13) und der Gleichrichterschaltung (11) verbunden ist.

6. Heizvorrichtung nach Anspruch 5, **dadurch gekennzeichnet, dass** diese außerdem eine zweite Stromerfassungsschaltung (19) aufweist, die zwischen der Filterschaltung (12) und der Inverterschaltung (13) geschaltet ist, um einen zweiten Strom (I_2) zu erfassen, der durch die Inverterschaltung (13) fließt, um dadurch ein zweites Stromerfassungssignal (V_{s2}) zu erzeugen.

7. Heizvorrichtung nach Anspruch 6, **dadurch gekennzeichnet, dass,** wenn die Zeitdauerdifferenz oder die Phasendifferenz zwischen dem ersten Steuersignal (S_1) und dem Stromphasensignal (S_p) innerhalb eines vorbestimmten Bereichs liegt, und wenn der zweite Strom (I_2) kleiner ist als ein erster Stromgrenzwert, die Steuereinheit (17) die Inverterschaltung (13) steuert, um eine reduzierte Wärmeleistung oder Wärmemenge auszugeben, so dass die maximale Wärmeleistung oder Wärmemenge, die von der Inverterschaltung (13) ausgegeben wird, kleiner ist als ein Nennwert.

8. Heizvorrichtung nach Anspruch 7, **dadurch gekennzeichnet, dass,** wenn die Zeitdauerdifferenz oder die Phasendifferenz zwischen dem ersten Steuersignal (S_1) und dem Stromphasensignal (S_p) innerhalb des vorbestimmten Bereichs liegt, und wenn der zweite Strom (I_2) größer ist als der erste Stromgrenzwert, die Steuereinheit (17) die Inverterschaltung (13) steuert, um die Wärmeleistung oder Wärmemenge auszugeben, wie sie durch die Koch-Option eingestellt ist, so dass die maximale Wärmeleistung oder Wärmemenge, die von der Inverterschaltung ausgegeben wird, gleich dem Nennwert ist.

9. Heizvorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass,** wenn die Zeitdauerdifferenz oder die Phasendifferenz zwischen dem ersten Steuersignal (S_1) und dem Stromphasensignal (S_p) unterhalb eines vorbestimmten Bereichs liegt, die Steuereinheit (17) beurteilt, dass eine oder mehrere Komponenten der Heizvorrichtung (1) einen Fehler aufweisen oder unnormal sind, und die Steuereinheit (17) die Inverterschaltung (13) steuert, um eine reduzierte Wärmeleistung oder Wärmemenge auszugeben, so dass die maximale Wärmeleistung oder Wärmemenge, die von der Inverterschaltung (13) ausgegeben wird, kleiner ist als ein Nennwert, oder die Heizvorrichtung (1) deaktiviert wird.

10. Heizvorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass,** basierend auf dem ersten Steuersignal (S_1) und dem Stromphasensignal (S_p), ein Zeitgeber der Steuereinheit (17) aktiviert wird, um eine Zeit zu zählen oder eine Zählzeit zu stoppen, um dadurch die Zeitdauerdifferenz oder die Phasendifferenz zwischen dem ersten Steuersignal (S_1) und dem Stromphasensignal (S_p) zu berechnen.

11. Heizvorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Inverterschaltung (13) aufweist:

ein erstes Schaltelement (Q_1) mit einem Steueranschluss, der mit der Steuereinheit (17) verbunden ist;
ein zweites Schaltelement (Q_2), das mit dem ersten Schaltelement (Q_1) verbunden ist, wobei ein erster Verbindungsknoten zwischen dem ersten Schaltelement (Q_1) und dem zweiten Schaltelement (Q_2) als ein erster Leistungsausgangsanschluss der Inverterschaltung (13) dient;
einen ersten Kondensator (C_1); und
einen zweiten Kondensator (C_2), der mit dem ersten Kondensator (C_1) in Reihe verbunden ist, wobei ein zweiter Verbindungsknoten zwischen dem ersten Kondensator (C_1) und dem zweiten Kondensator (C_2) als ein zweiter Leistungsaus-

gangsanschluss der Inverterschaltung (13) dient,
wobei das erste Schaltelement (Q_1) und das zweite Schaltelement (Q_2) unter Steuerung der Steuereinheit in einer verschachtelten Weise basierend auf dem ersten Steuersignal (S_1) und einem zweiten Steuersignal (S_2) leitend werden, so dass die Speisespannung (V_o) durch die Inverterschaltung (13) erzeugt wird, um die Induktionsspule (14) zu speisen.

12. Heizvorrichtung nach Anspruch 1, außerdem mit einer Benutzerschnittstelleneinheit (18), die mit der Steuereinheit (17) verbunden ist, um die Koch-Option zu empfangen und um eine Betriebsmeldung anzugeben.

Revendications

1. Dispositif de chauffage (1) ayant une fonction de détection d'un emplacement d'un récipient de nourriture (2), ledit dispositif de chauffage (1) comprenant :

une bobine d'induction (14) pour chauffer ledit récipient de nourriture (2) ;
un circuit inverseur (13) pour recevoir une tension rectifiée (V_r) et générant une tension pilote (V_o) pour piloter ladite bobine d'induction (14) ;
un premier circuit de détection de courant (15) connecté en série avec ladite bobine d'induction (14) pour détecter un premier courant (I_1) s'écoulant à travers ladite bobine d'induction (14), générant ainsi un premier signal de détection de courant (V_{s1}) ;
un circuit de traitement de signal (16) connecté audit premier circuit de détection de courant (15) pour générer un signal de phase de courant (S_p) selon ledit premier signal de détection de courant (V_{s1}) ; et
une unité de commande (17) pour générer au moins un premier signal de commande (S_1) selon une option de cuisson, commandant ainsi ledit circuit inverseur (13),
caractérisé en ce que selon une différence de durée ou une différence de phase entre ledit premier signal de commande (S_1) et ledit signal de phase de courant (S_p), ladite unité de commande (17) détermine une aire dudit récipient de nourriture (2) recouvrant ladite bobine d'induction (14) par rapport à une aire de ladite bobine d'induction (14) ou un emplacement dudit récipient de nourriture (2) relativement à ladite bobine d'induction (14), réglant ainsi un fonctionnement dudit circuit inverseur (13).

2. Dispositif de chauffage selon la revendication 1 **caractérisé en ce que** ledit circuit de traitement de signal (16) comprend un circuit comparateur pour générer ledit signal de phase de courant (S_p) dans un statut de permission ou un statut d'interdiction selon ledit premier signal de détection de courant (V_{s1}).

3. Dispositif de chauffage selon la revendication 2 **caractérisé en ce que** si ledit premier signal de détection de courant (V_{s1}) est supérieur à une tension de référence, ledit signal de phase de courant (S_p) dans ledit statut de permission est sorti dudit circuit comparateur vers ladite unité de commande (17), dans lequel si ledit premier signal de détection de courant (V_{s1}) est inférieur à ladite tension de référence, ledit signal de phase de courant (S_p) dans ledit statut d'interdiction est sorti dudit circuit comparateur vers ladite unité de commande (17).

4. Dispositif de chauffage selon la revendication 1 **caractérisé en ce que** si ladite différence de durée ou ladite différence de phase entre ledit premier signal de commande (S_1) et le signal de phase de courant (S_p) dépasse une plage prédéterminée, ladite unité de commande (17) juge que ledit emplacement dudit récipient de nourriture (2) est impropre ou anormal et commande audit circuit inverseur (13) d'être actionné dans un mode de détection de plat, dans lequel dans ledit mode de détection de plat, ledit circuit inverseur (13) est actionné à une fréquence de commutation augmentée ou un facteur d'utilisation réduit, ou ledit circuit inverseur (13) est désactivé.

5. Dispositif de chauffage selon la revendication 1 **caractérisé en ce qu'**il comprend en outre :

un circuit rectificateur (11) pour rectifier une tension d'entrée (V_{in}) en ladite tension rectifiée (V_r) ; et
un circuit filtrant (12) connecté audit circuit inverseur (13) et audit circuit rectificateur (11).

6. Dispositif de chauffage selon la revendication 5 **caractérisé en ce qu'**il comprend en outre un second circuit de détection de courant (19), qui est interconnecté entre ledit circuit filtrant (12) et ledit circuit inverseur (13) pour détecter un second courant (I_2) s'écoulant à travers ledit circuit inverseur (13), générant ainsi un second signal de détection de courant (V_{s2}).

7. Dispositif de chauffage selon la revendication 6 **caractérisé en ce que** si ladite différence de durée ou ladite différence de phase entre ledit premier signal de commande (S_1) et ledit signal de phase de courant (S_p) est dans une plage prédéterminée et ledit second courant (I_2) est inférieur à une première valeur de seuil de courant, ladite unité de commande (17) commande ledit circuit inverseur (13) pour sortir

une puissance thermique ou une quantité de chaleur réduite de telle manière que la puissance thermique ou la quantité de chaleur sortie dudit circuit inverseur (13) est inférieure à une valeur nominale.

8. Dispositif de chauffage selon la revendication 7 **caractérisé en ce que** si ladite différence de durée ou ladite différence de phase entre ledit premier signal de commande (S_1) et ledit signal de phase de courant (S_p) est dans ladite plage prédéterminée et ledit second courant (I_2) est supérieur à ladite première valeur de seuil de courant, ladite unité de commande (17) commande ledit circuit inverseur (13) pour sortir la puissance thermique ou la quantité de chaleur réglée par l'option de cuisson, de telle manière que la puissance thermique ou la quantité de chaleur maximum sortie du circuit inverseur est égale à ladite valeur nominale.

9. Dispositif de chauffage selon la revendication 1 **caractérisé en ce que** si ladite différence de durée ou ladite différence de phase entre ledit premier signal de commande (S_1) et ledit signal de phase de courant (S_p) est sous une plage prédéterminée, ladite unité de commande (17) juge si un ou plusieurs composants dudit dispositif de chauffage (1) a une panne ou est anormal, et ladite unité de commande (17) commande ledit circuit inverseur (13) pour sortir une puissance thermique ou une quantité de chaleur réduite de telle manière que la puissance thermique ou la quantité de chaleur maximum sortie dudit circuit inverseur (13) est inférieure à une valeur nominale, ou ledit dispositif de chauffage (1) est désactivé.

10. Dispositif de chauffage selon la revendication 1 **caractérisé en ce que** selon ledit premier signal de commande (S_1) et ledit signal de phase de courant (S_p), un chronomètre de ladite unité de commande (17) est activé pour compter le temps ou arrête de compter le temps, calculant ainsi ladite différence de durée ou ladite différence de phase entre ledit premier signal de commande (S_1) et ledit signal de phase de courant (S_p).

11. Dispositif de chauffage selon la revendication 1 **caractérisé en ce que** ledit circuit inverseur (13) comprend :

un premier élément de commutation (Q_1) ayant une borne de commande connectée à ladite unité de commande (17) ;
un second élément de commutation (Q_2) connecté audit premier élément de commutation (Q_1), dans lequel un premier noeud de connexion entre ledit premier élément de commutation (Q_1) et ledit second élément de commutation (Q_2) sert de première borne de sortie de puissance dudit circuit inverseur (13) ;
un premier condensateur (C_1) ; et
un second condensateur (C_2) connecté avec ledit premier condensateur (C_1) en série, dans lequel un second noeud de connexion entre ledit premier condensateur (C_1) et ledit second condensateur (C_2) sert de seconde borne de sortie de puissance dudit circuit inverseur (13),
dans lequel sous la commande de ladite unité de commande (17), ledit premier élément de commutation (Q_1) et ledit second élément de commutation (Q_2) sont conduit d'une manière imbriquée selon ledit premier signal de commande (S_1) et un second signal de commande (S_2), de telle manière que ladite tension pilote (V_o) est générée par ledit circuit inverseur (13) pour piloter ladite bobine d'induction (14).

12. Dispositif de chauffage selon la revendication 1, comprenant en outre une unité d'interface utilisateur (18), qui est connectée à ladite unité de commande (17) pour recevoir ladite option de cuisson et indiquer un message de fonctionnement.

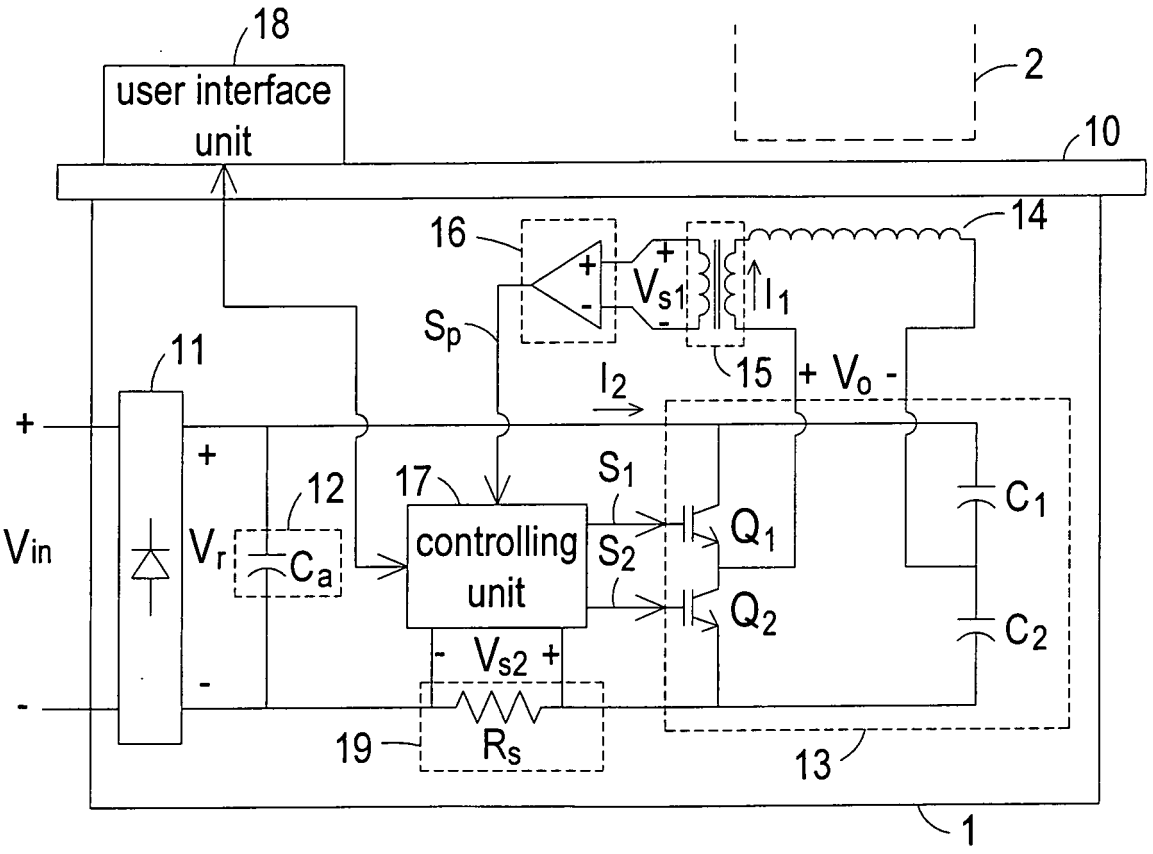

18
user interface unit
2
10
16
14
Sp
Vs1
I1
11
15
+ Vo -
I2
+
Vin
-
Vr
12
Ca
17
controlling unit
S1
S2
Q1
Q2
C1
C2
- Vs2 +
19
Rs
13
1

FIG. 1

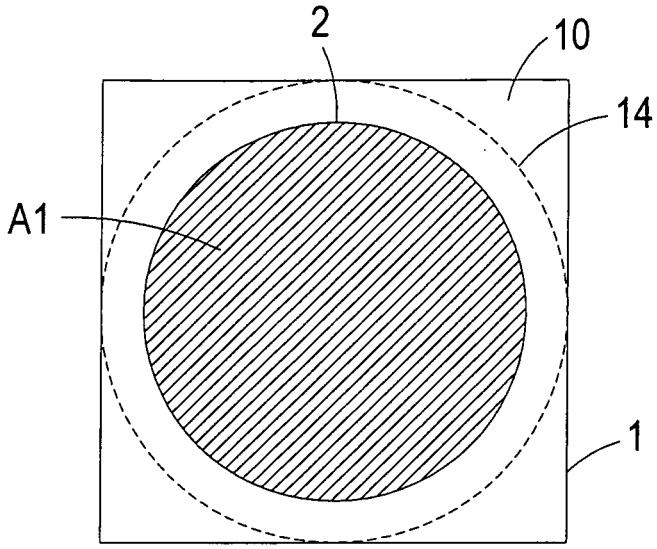


FIG. 2A

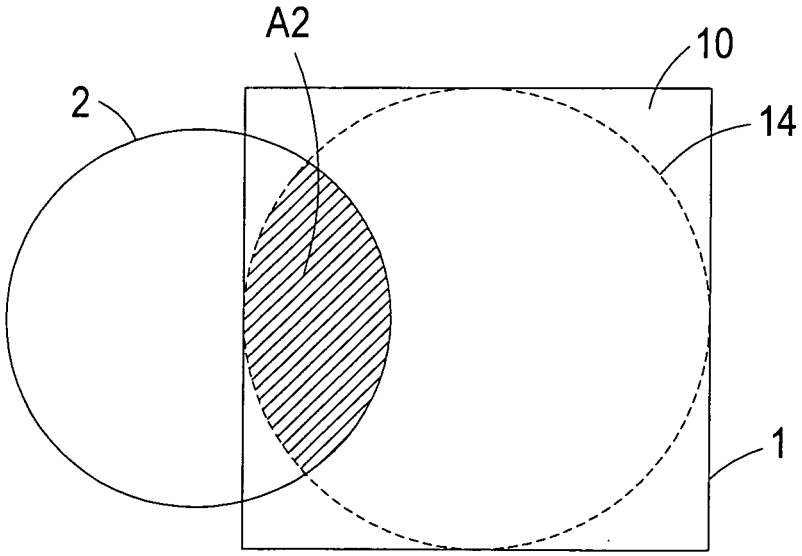


FIG. 2B

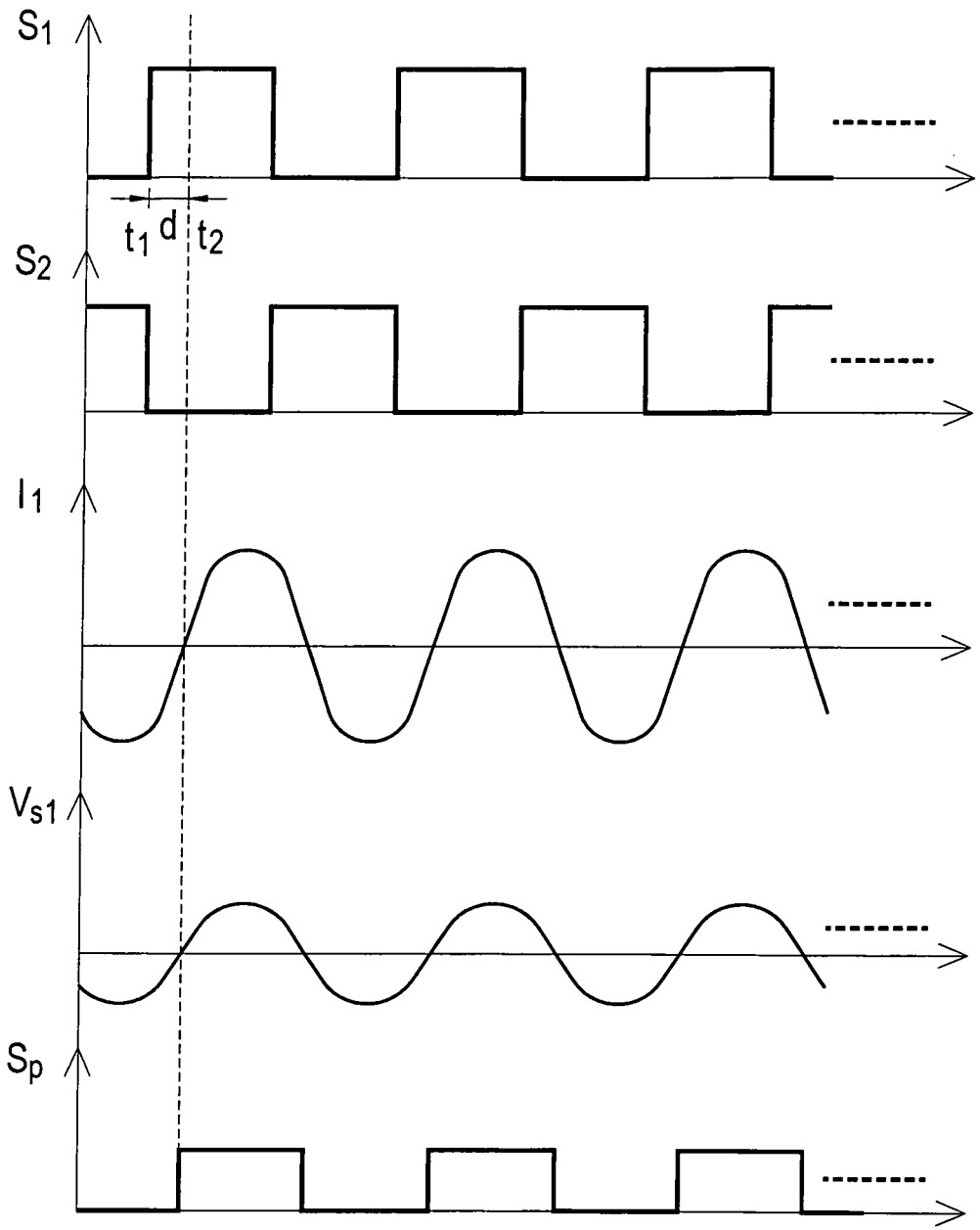


FIG. 3

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- GB 2183941 A **[0006]**
- US 20090321425 A1 **[0007]**