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(71) Applicant: **Balay S.A.**
50059 Zaragoza (ES)

(72) Inventors:
- **Garcia Martinez, Jose Andres**
  50059 Zaragozo (ES)
- **Garcia Gimenez, Jose Ramon**
  50059 Zaragozo (ES)
- **Martinez, Iturbe, Abelardo**
  50059 Zaragozo (ES)
- **Burdio Pinilla, Jose Miguel**
  50059 Zaragozo (ES)

(54) Flexible and re-configurable topology

(57) This invention concerns a flexible and re-configurable topology, wherein a three-phase bridge topology with non-symmetric legs including a single-pole two-positions switch yields a re-configurable structure consisting in a couple of single-phase full-bridge inverters. This variable structure has two topological stages associated with each of the two-positions switch. One of the switch positions allows an independent drive for each of the two coils used as induction cooking plates, with regulated power up to their nominal values. The other position allows the utilization of all the installed power and using it for driving one of them. This basic idea is extended by duplicating the number of switches, in this way, the installed power for both coils can be used for driving any of the two coils indistinctly.

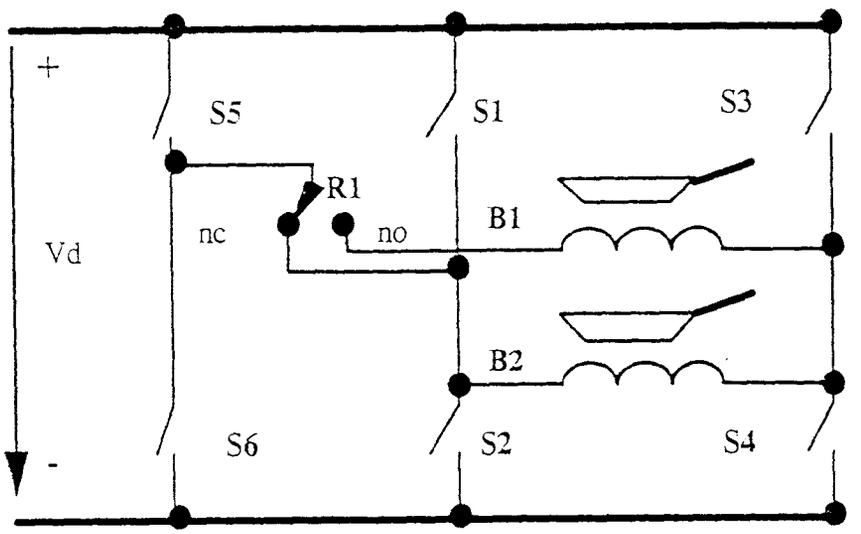


FIG 1

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Description

OBJECT OF THE INVENTION

The object of the present invention is a flexible and re-configurable topology based on the three-phase bridge with non-symmetric legs, which being used as a power source for two coils as those used in an induction cooking plates, it improves the cooking plate performances because it allows the utilization of all the installed power for both coils and using it for driving one of them. In this way it is obtained a heating element with a power boosted over nominal values, allowing an ultra fast heating of the pot or pan, shortening the rising time necessary to reach the stationary thermal state.

The initial basic idea is extended to get that all the installed power for both coils to be used for driving any of them.

The inherent flexibility of the topology allows to accomplish optimal control procedures in the management of the power losses in the semiconductor devices, oriented to reduce their operation temperature, leading to an improving in the system reliability and integrability, and reducing the heat sinking demands.

FIELD OF APPLICATION

This invention relates to induction heating and more specifically to a bridge inverter topology which has a variable structure suitable for use in induction heating apparatus having ultra-fast heating ability and optimised semiconductor switches power losses.

BACKGROUND OF THE INVENTION

The principle of induction cooking are the eddy current and hysteretic losses in the surface of a metallic object therein, it has several advantages over heating by conventional techniques as convection or conduction. Induction heating is usually faster than convection or conduction heating because lower thermal mass is associated with induction heating systems. In addition, the induction heating focuses the heat within the heated object yielding higher energy transfer efficiency in contrast to convection or conduction heating wherein the heat is produced outside the heated object.

The domestic induction heating hobs are driven by an alternative current of medium frequency (25-65 kHz) applied to a induction coil which heats by induction a pot or a pan placed on the coil. This current is generated by a power converter based on solid-state power devices. In what follows a new concept for the power converter used for induction heating hobs is presented.

The owner of this patent also owners the Patent of Invention n° 59.790 wherein an electronic system drives by a high frequency pulsed current a thermal plate as those used in an electric hob. This system uses a full-bridge inverter with MOS transistors which drives a flat coil housed inside a thermal plate by a serial of high frequency power pulses heating ferromagnetic pots or pans.

The transistorised full-bridge described in the aforementioned Patent is activated by a control circuit which achieves the regulation and the self adaptation of the firing time for each leg of the transistorised full-bridge, scheduled in relation with the inductive-energy time-recovering of the flat coil, and stopping the powering of the coil when there is non-ferromagnetic load. In that way, when a ferromagnetic pot or pan is placed on the thermal plate a thermal plate with self-firing ability is achieved.

Although the induction heating method is fast, the rising time necessary to reach the stationary thermal state can be shortened if the spare power drive capacity of an idle bridge which normally drives other induction heating plate are used to boost the bridge which drives the active induction plate. Another application of the idle bridge is to help in the reduction of the overall conduction losses of the power semiconductor switches of the active bridge.

To achieve these goals it is necessary a bridge inverter topology with a variable structure able to do these task. These topology is the core of this invention.

DESCRIPTION OF THE INVENTION

In this document a flexible and re-configurable topology is described. It is based on a non-symmetric three-phase bridge in which this topology is obtained by modifying another one which is well-known as the three-phase bridge. The later is frequently used as DC-AC converter to drive three-phase loads, but in this invention, it has been modified by adding a two positions one pole switch.

In this way, the three-phase bridge is non-symmetric because two of its legs are rated for the nominal ratings of the two loads, respectively. In this application the two loads are two coils which constitute the two heating plates of an induction cooking hob. Furthermore, the third leg, so called the common leg, is rated for the addition of the ratings of both loads.

So, when the switch is not activated, the obtained topology allows to drive both coils used as heating plates of an induction cooking hob, independently. Conversely, when the switch is activated, the obtained topology allows two legs to be connected in parallel. Consequently, the drive capacity is the addition of the drive capacity of both legs connected in parallel.

If the flexible and re-configurable topology is used as a power source for the two coils used as two heating plates of an induction cooking hob, it allows the improving of the performances of this induction hob because all the drive capacity available for the two coils can be used to apply it for driving one of the coils.

In addition, it allows to have a heating plate with a power higher than its nominal rate, therefore, having an

ultra-fast heating of a pot or a pan heated by the heating plate, shortening the rising-temperature time necessary to reach the stationary thermal state.

The inherent flexibility of the topology allows to accomplish optimal control procedures in the management of the power losses in the semiconductor switches, oriented to reduce their operation temperature, leading to an improving in the system reliability and integrability, and reducing the heat sinking demands.

In addition, it allows a modular design building up with it a induction module to drive two coils used as heating plates of an induction hob, and to incorporate this module in a mixed induction and non-induction hob.

Even so, this induction module allows to incorporate two of them to drive four coils used as a heating plates of an induction hob, two of them with a power higher than its nominal rate.

It has been foreseen that this topology, object of the invention, to be extended by adding two switches instead of one, yielding to an improved flexibility because in this case. it allows that all the installed power for both coils to be used for driving any of them, indistinctly.

When the topology with two switches is used as power source to drive two coils used as heating plates in an induction cooking hob, it allows an improving in performances because all the installed power for both coils can be used for driving any of them, in such a way that any of the heating plates can provide a heating power higher than its nominal rate. and thus, two ultra-fast heating plates are available for heating a pot or a pan, shortening the rising-temperature time necessary to reach the stationary thermal state of the pot or the pan.

So, the flexibility of the topology with two switches allows to accomplish optimal control procedures in the management of the power losses in the semiconductor devices. oriented to reduce their operation temperature, leading to an improving in the system reliability and integrability, and reducing the heat sinking demands.

In the same way, the two-switches topology allows a modular design building up with it a induction module suitable for driving two coils used as a heating plates of an induction cooking hob, and to incorporate this module in a mixed induction and non-induction cooking hob, even so, two modules can be incorporated to drive four coils used as heating plates in an induction cooking hob, all of them with power boost capacity.

To complete this description and with the aim to help in the understanding of the characteristics of the invention, it has been is included a set of drawings in this descriptive document, as a part of it, which have as illustrative but non-limited character. It has been represented what follows:

BRIEF DESCRIPTIONS OF THE DESIGNS

The features of the invention believed to be novel are set forth with particularity in the appended claims. The invention itself, however, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings in which:

FIG. 1.- Shows the re-configurable and multi-bridge topology with a single switch and the B2 coil with reinforced power. In this figure it is named:

- S1 to S6 as the power semiconductor switches.
- The leg formed by S3 and S4 are the so called common leg of the three-phase bridge.
- The leg formed by S1 and S2 are the so called the booster leg of the three-phase bridge.
- The leg formed by S5 and S6 are the so called the fixed leg of the three-phase bridge.
- B1 is the coil without power boost.
- B2 is the coil with power boost.
- R1 is the single-pole two-positions switch.
- Vd is a generic DC current or voltage power source, obtained by rectifying an AC power source, either filtered or not, being the filter active or passive whether applicable, without any limitation introduced by the nature of the power source.

FIG. 2.- Shows the re-configurable and multi-bridge topology with two switches and the coils B1 and B2 with reinforced power. This figure uses the same names as in figure 1. but in addition:

- R2 is the second single-pole two-positions switch incorporated to the topology.

FIG. 3.- This is a table which shows the power availability for each of the B1 and B2 coils versus the switches R1 and R2 activation state represented by "1", or the non-activation state represented by "0".

DESCRIPTION OF A PREFERRED EMBODIMENT

The invention provides a flexible topology which allows the power supplying for two coils independently which are used as heating plates of an induction cooking hob.

The basic flexible topology depicted in Figure 1, and so claimed, is obtained by modifying another one which is well-known as the three-phase bridge. The later is frequently used as DC-AC converter to drive three-phase loads, but in this invention, it has been modified by adding a two positions one pole switch.

The basic flexible topology depicted in Figure 1 is used to explain the basic idea. Subsequently, the topology is expanded by doubling the number of switches included to it as depicted in Figure 2, achieving in this way, the improving in flexibility and performances.

The three-phase bridge in Figure 1 is constituted by three identical legs (legs S1-S2, S3-S4 and S5-S6) connected in parallel which draws power from a common power source with voltage Vd. Each leg is constituted by a series connection of two power semiconductor

switches (the power semiconductor switches are depicted as plain switches and named as S1, S2, S3, S4, S5 and S6) which activation or non-activation states are externally controlled.

The functionality of the stage is not affected by the power semiconductor switches used or their technology state.

The common point between the semiconductor switches of a leg constitutes an output terminal or one of the output phase of the bridge. If the bridge has three phases as in our case, it is named three-phase bridge.

A bridge is not symmetric if all their legs are not identical concerning the controllability of the power semiconductor switches, the working zone of the voltage/current quadrant or the handled power.

The modification introduced in the bridge consists in rating individually two of the legs (S1-S2 and S5-S6) with a power handling capacity fitted to the respective coils rating B1 and B2. These coils constitute two independent heating plates of an induction cooking hob. The third leg, formerly named as the common leg, is rated with a power handling capacity equal to the added ratings of the other two legs. The legs different from the common leg are distinguished themselves by naming them as the fixed leg (S5-S6) and the booster leg (S1-S2), respectively.

Between the booster leg output (S1-S2) and the common leg output (S3-S4) it is permanently connected one of the coil which constitutes one of the heating plate of the induction cooking hob, which can receive in its case, a power boost. This coil B2 is distinguished because it is named the power boost coil. In the same way, the other coil B1 is distinguished because it is named the coil without power boost.

The fixed leg output (S5-S6) is connected to the common pole of the two positions switch. When the switch is in its activated state (no position), it connects the coil without power boost B1 between the fixed leg output (S5-S6) and the common leg output (S3-S4).

When the switch is not in its activated state (nc position), it connects in parallel the booster leg output (S1-S2) to the fixed leg output (S5-S6). In this way, the coil without power boost B1 is in open circuit and the coil with power boost B2 has available all the installed power being able to draw a power higher than its nominal rate, that is the reason because it is named power boost coil B2.

This idea of the basic flexible and re-configurable topology depicted in Figure 1 is extended to allow both coils to draw power higher than their nominal rate. For this purpose, the number of switches has been duplicated, yielding the topology depicted in Figure 2. In this way, the second switch R2 is placed with its common pole connected to the formerly named booster leg (S1-S2). When the second switch R2 is in its activated state, it connects the formerly named power boost coil B2 between the booster leg output (S1-52) and the common leg output (S3-S4).

Figure 3 shows as a table, the power availability for each of the coils B1 and B2 versus the activation state represented as (1) or the non-activation state represented as (0) for both switches R1 and R2.

With the second switch R2 non-activated (nc position), it connects in parallel the booster leg output (S1-S2) with the fixed leg output (S5-S6). In this way, both switches together with the connected legs and the powered coils shows a symmetric position each other. This symmetry yields in an improved flexibility which allows any coil B1 or B2 to draw all the installed power, indistinctly. The role of the booster leg and the fixed leg in Figure 1 are both interchangeable for the topology in Figure 2 with two switches.

The two-switches topology allows a modular design building up with it an induction module suitable for driving two coils used as a heating plates of an induction hob, and to incorporate this module in a mixed induction and non-induction cooking hob, even so, two modules can be incorporated to drive four coils used as heating plates in an induction cooking hob, all of them with power boost capacity.

The inherent flexibility of both topologies allows to accomplish optimal control procedures in the management of the power losses in the power semiconductor switches, oriented to reduce their working temperature, leading to an improving in the system reliability and integrability, and reducing the heat sinking demands.

Given the arrangement selected for both switches in non-activated position, as depicted in Figure 2, when only one coil is powered, it has available all the installed power because both the fixed coil and the booster leg are parallel connected. In this way the overall conduction losses and the temperature of the power semiconductor switches are lowered.

The switch position depicted in Figure 1 corresponds to its non-activated state. In this state the common pole of the switch is electrically connected to its normally-close pole (nc), thus, paralleling the fixed leg and the booster leg. In this way all the installed power is available for the coil with power boost B2. If the switch is in its activated state, the common pole of the switch is electrically connected to its normally-open pole (no), thus, the fixed leg powers the coil B1 and the booster leg powers the coil B2.

The switches positions depicted in Figure 2 correspond to their non-activated state. If R1 is exclusively activated, all the installed power is available for the coil B1. If R2 is exclusively activated, all the installed power is available for the coil B2. If both switches are activated each coil draws its own rated power.

While the invention has been particularly shown and described with reference to several preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the true spirit and scope of the invention as defined by the appended claims.

Claims

1. Flexible and re-configurable topology, preferentially used to be incorporated in household appliances as induction cooking hobs or in induction cooking surface units. characterised by being based on a non-symmetric three-phase bridge wherein said topology is obtained by modifying another one which is well-known as the three-phase bridge and is frequently used as DC-AC converter to drive three-phase loads, wherein said modification is achieved by adding a two positions one-pole switch.

2. The invention according to claim 1 wherein said flexible and re-configurable topology is characterised by a non-symmetric three-phase bridge wherein said bridge has two legs rated for the nominal ratings of their loads, wherein said loads are two coils which constitute the two heating plates of an induction cooking hob, and where the third leg, so called the common leg, is rated for the addition of the ratings of both loads.

3. The invention according to claim 1 wherein said flexible and re-configurable topology is characterised by allowing, when the switch is non-activated, to drive both coils used as heating plates of an induction cooking hob, independently.

4. The invention according to claim 1 wherein said flexible and re-configurable topology is characterised by allowing, when the switch is activated, two legs to be connected in parallel therefore, the drive capacity is the addition of the drive capacity of both said legs connected in parallel.

5. The invention according to claim 1 wherein said flexible and re-configurable topology is characterised by allowing the improvement in performances of this induction hob, when used as a power source for the two coils used as two heating plates of an induction cooking hob, because all the drive capacity available for the two coils can be used to apply it for driving one of the coils.

6. The invention according to claim 1 wherein said flexible and re-configurable topology is characterised by allowing a heating plate with a power higher than its nominal rate, therefore, having an ultra-fast heating of a pot or a pan heated by the heating plate, shortening the rising-temperature time necessary to reach the stationary thermal state in said pot or pan.

7. The invention according to claim 1 wherein said flexible and re-configurable topology is characterised by allowing to accomplish optimal control procedures in the management of the power losses in the semiconductor devices, oriented to reduce their operating temperature, yielding an improving in the system reliability and integrability, and reducing the heat sinking demands of the said semiconductor switches

8. The invention according to claim 1 wherein said flexible and re-configurable topology is characterised by allowing modular design building up with it a induction module to drive two coils used as a heating plates of an induction hob. Having power boost one of said induction coils.

9. The invention according to claim 8 wherein said flexible and re-configurable topology is characterised by allowing this module to be incorporated in a mixed induction an non-induction hob with two induction heating plates. Having power boost one of said induction coils.

10. The invention according to claim 8 wherein said flexible and re-configurable topology is characterised by allowing two of these modules to be incorporated in a four heating plates induction cooking hob. Two of them with power boost.

11. The invention according to claim 1 wherein said flexible and re-configurable topology idea is extended by adding two switches instead of one, yielding to an improved flexibility because in this case, it allows that all the installed power for both coils to be used for driving any of them, indistinctly.

12. The invention according to claim 11 wherein said flexible and re-configurable topology is characterised by allowing this module to be incorporated in an induction hob with two induction heating plates. Allowing said module that all the installed power for both coils to be used for driving any of them, indistinctly.

13. The invention according to claim 11 wherein said flexible and re-configurable topology is characterised by having this module two heating plates with power boost capacity. Thereof, having two plates with fast-heating ability, shortening the rising-temperature time necessary to reach the stationary thermal state of the pot or the pan.

14. The invention according to claim 11 wherein said flexible and re-configurable topology is characterised by allowing to accomplish optimal control procedures in the management of the power losses in the power semiconductor switches, oriented to reduce their operating temperature, leading to an improving in the system reliability and integrability, and reducing the heat sinking demands.

15. The invention according to claim 11 wherein said flexible and re-configurable topology is characterised by allowing modular design building up with it a induction module to drive two coils used as a heating plates of an induction hob. Having both heating plates power boost capacity.

16. The invention according to claim 11 wherein said flexible and re-configurable topology is characterised by allowing this module to be incorporated in a mixed induction an non-induction hob with two induction heating plates. Having both induction heating plates power boost capacity.

17. The invention according to claim 11 wherein said flexible and re-configurable topology is characterised by allowing two of these modules to be incorporated in a four heating plates induction cooking hob. Having all heating plates power boost capacity.

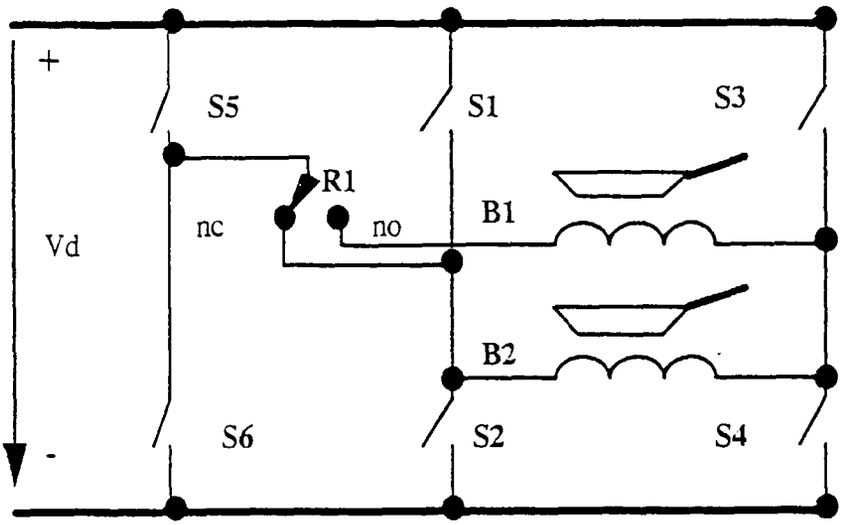

+
S5
S1
S3
R1
nc
no
B1
Vd
B2
S6
S2
S4
-

FIG 1

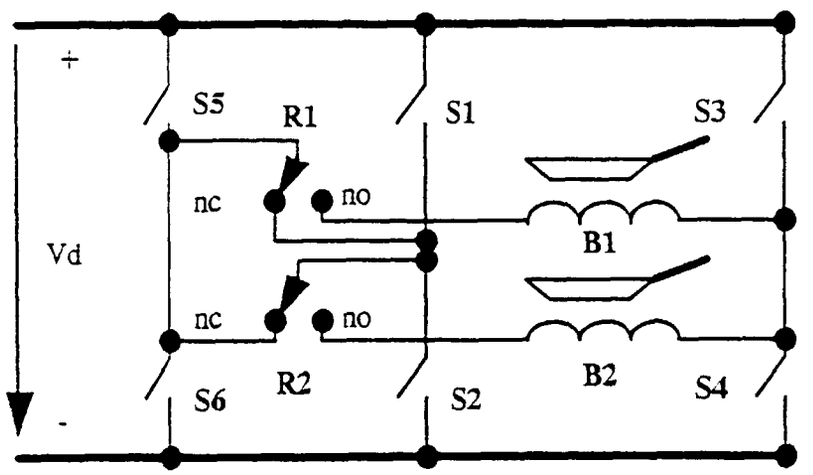

+
S5
R1
S1
S3
nc
no
B1
Vd
nc
no
B2
S6
R2
S2
S4
-

FIG 2

R1, R2 / % Pot	0, 0	0, 1	1, 0	1, 1
B1	0%	0%	>100%	100%
B2	0%	>100%	0%	100%

FIG. 3