Title: INDUCTION COOKER FAN PWM CONTROL FOR NOISE REDUCTION

Abstract: The present invention pertains to an induction cooker (1) comprising a plurality of hob rings for effecting heating of edible contents in a ferrous metal cookware being positioned on one of said rings, switching power components generating high frequency current in an induction coil, which in turn generates high frequency magnetic flux that induces eddy currents in said cookware, a cooling fan coupled to an electrical fan motor (3) for cooling down said switching power components, a driving circuit (2) for driving said cooling fan and a control circuit (4) for controlling said driving circuit (2). Said driving circuit (2) comprises a differential pair having a first and a second switching elements (Q1, Q2).
Description

INDUCTION COOKER FAN PWM CONTROL FOR NOISE REDUCTION

[0001] The present invention pertains to an electronic circuit for controlling and driving a cooling fan of an induction cooker.

[0002] Induction hobs and induction cookers have an induction coil located under ceramic cooking zones. When a hob ring is switched on with a ferrous metal bottomed pan being positioned on it, it completes an electric circuit between the hob and the pan and heat is transferred evenly to the pan and its edible contents. Induction hobs are energy efficient and are advantageous in that only the base of the pan heats up, so only the precise amount of energy is used; no wasted heat disappearing around the sides of the pan, and heating up the kitchen is in question.

[0003] The induction cooker is fed by an AC power source that is rectified to a DC voltage which is in turn connected to the induction coil. A high frequency current is generated in the coil by a switching power component such as IGBT. This current generates a high frequency magnetic flux which in turn induces eddy currents in the cookware that is placed above the induction coil. These eddy currents directly heat the cookware which in turn cooks the food.

[0004] Induction cookers or burners are static devices with a low noise profile. The only operational noise in those originates from the cooling fan of the burner. The cooling fan itself is responsible for maintaining the electronic circuit with switching power component that powers the copper wire coil placed underneath the cooking pot within an operational temperature range. The noise produced by the cooling fan may become an inconvenience especially when only one of the induction hob rings is on but the resulting noise is no different from the situation where all the rings are operational. Therefore providing effective cooling in situations where only one of the induction hob rings is on while at the same time having an improving noise performance is an object in the present technical field.

[0005] Among others, one of the prior art publications in the technical field of the present invention may be referred to as CN101 013326, which discloses a speed control method for induction cookers cooling fan. The method is
performed such that output voltage of the cooling fan drive circuit is changed in response to temperature feedback and the cooling fan speed is accordingly adjusted.

[0006] On the other hand, JP20041 11090 discloses an induction heating cooker with a heating coil, an inverter circuit to supply high frequency current to the heating coil, a controlling means to control output of the inverter circuit, a cooling fan and a speed controlling means to control the rotation speed of the cooling fan. The speed controlling means controls the speed of the cooling fan.

[0007] The present invention addresses the noise performance problem by dynamically changing the cooling fan’s speed and therefore operational noise performance according to an electronic driving circuit involving simplicity and sensitive speed control.

[0008] The present invention provides an induction cooker comprising a plurality of hob rings for effecting heating of edible contents in a ferrous metal cookware being positioned on one of said rings, switching power components generating high frequency current in an induction coil, which in turn generates high frequency magnetic flux that induces eddy currents in said cookware, a cooling fan coupled to an electrical motor for cooling down said switching power components, a driving circuit for driving said cooling fan and a control circuit for controlling said driving circuit. The control circuit is therefore responsible for dynamically regulating the power transferred to the cooling fan motor.

[0009] The driving circuit comprises a differential pair having a first and second switching element such that said second switching element is in series with a resistance and said second switching element and said resistance are in parallel with first switching element. This configuration provides selective triggering of the first or the second switching elements in response to different situations where demand for cooling effect may vary. To this end, the first or the second switching elements are selectively biased into conduction to alter the electrical potential applied to the terminals of the cooling fan motor. In this respect, said differential pair is disposed in series with said cooling fan motor, one terminal of motor
winding being connected to a DC voltage source generating Vcc feeding voltage for cooling fan motor.

[0010] The time duration of the first switching element is in conduction is adjustable in response to received temperature, power level or speed feedback by said control circuit such that the effective voltage applied to the fan motor by said driving circuit is regulated.

[0011] The present invention provides an induction cooker having a cooling fan driving circuit as defined in the characterizing portion of Claim 1.

[0012] Primary object of the present invention is to provide an induction cooker having a cooling fan driving circuit involving simplicity and sensitive speed control.

[0013] Accompanying drawings are given solely for the purpose of exemplifying the technical approach of the present invention whose advantages were outlined above and will be explained hereinafter in brief.

[0014] The drawings are not meant to delimit the scope of protection as identified in the claims nor should they be referred to alone in an effort to interpret the scope identified in said claims without recourse to the technical disclosure in the description of the present invention.

[0015] Fig. 1 demonstrates a schematic view of the electronic circuit for driving the cooling fan of the induction cooker according to the present invention.

[0016] Fig. 2 demonstrates voltage-time graph indicating minimum and maximum voltage values applied to the cooling fan of the induction cooker according to the present invention.

[0017] Fig. 3 demonstrates voltage-time graph in which the first switching element is in conduction mode and the second switching element is in non-conduction mode according to the present invention.

[0018] Fig. 4 demonstrates voltage-time graph in which the first and the second switching elements are in conduction mode and the first switching element is operated with a duty cycle of %50.

[0019] Fig. 5 demonstrates voltage-time graph in which the first switching element is operated with a duty cycle of %50.

[0020] The following numerals are used in this detailed description:

[0021] Induction cooker (1)
[0022] Driving circuit (2)
[0023] Fan motor (3)
[0024] Control circuit (4)

[0025] Referring now to the figures outlined above, the present invention proposes an induction cooker (1) comprising a cooling fan driving circuit (2) as defined in Claim 1.

[0026] The present invention proposes an induction cooker (1) having a cooling fan driving circuit (2). The cooling fan is coupled to an electrical DC cooling fan motor (3) whose speed can conventionally be controlled by way of varying the DC voltage applied to the motor windings.

[0027] The present invention features a cooling fan driving circuit (2) having a differential pair, i.e. a circuit having two sides symmetric to each other with two switching elements in parallel. Each side of the differential pair comprises a switching element (Q1, Q2) in the form of bipolar junction transistors (BJT). The skilled person would appreciate that the specific requirements, i.e. power range and switching frequency of the circuit for driving a small power cooling fan as in the present household appliance allows use of a regular specification switching element and as such BJTs are readily replaceable by other switching elements. Appropriate gate signals are applied through the resistances R3 and R4 to drive the switching elements such that they are biased into conduction as explained below.

[0028] The differential pair of the driving circuit (2) is disposed in series with the cooling fan motor (3); one terminal of the winding thereof is connected to a DC voltage source generating cooling fan motor (3) feeding voltage Vcc. In this configuration, the differential pair acts as a voltage regulator such that in the event that Q2 is in conduction mode, the cooling fan motor (3) shares Vcc with a resistance R1. In other words, voltage drop across the terminals of R1 causes active power dissipation and the cooling fan is driven at an offset voltage. Since Q2 is in series with R1 and the latter two in parallel with Q1, when Q1 is triggered into conduction by a proper gate signal, Vcc is directly supplied to the load, i.e. to the cooling fan motor (3).

[0029] Due to the fact that, by adjusting the time duration Q1 remains in
conduction, one can regulate the effective voltage applied to the fan motor. Q2 is operated in continuous conduction mode and Vcc-VR1 is fed to the load in the event Q1 is not conducting. Therefore the duty cycle of Q1 determines the effective DC voltage and therefore the speed of the cooling fan.

[0030] The present invention addresses the noise performance problem by dynamically changing the cooling fan's speed and therefore operational noise performance according to the electronic driving circuit (2) involving simplicity and sensitive control as explained above. The electronic control circuit (4) according to the invention conventionally receives temperature feedback (TEMP), power level feedback (P) or speed feedback (S) in order for regulating the power transferred to the cooling fan. For example, in the event that only one hob ring is turned on, the switching power component generating the high frequency current in the induction coil must still be cooled down but a reduced cooling fan speed could be adequate for obtaining the desired effect. To this end, Q1 in the fan driving circuit (2) is not biased into conduction by the control circuit (4) and the offset voltage, i.e. the minimum voltage obtained when Q2 is operated in continuous conduction mode is read between input terminals of the cooling fan motor (3) winding.

[0031] The latter situation may also be the case where the control circuit (4) establishes that the actual temperature is far from exceeding reference boundary values and a reduced cooling fan speed is adequate for sound operation, despite the fact that all hob rings are switched on. In this case Vavg or Vmin in Fig. 3 is equal to the offset voltage Vcc-VR1.

[0032] Cooling fan speed can be increased by using a duty cycle of %50 for Q1, that is, by adjusting on and off times of Q1 in conduction mode in the switching period (Ts). The conduction time T1 over the switching period (Ts), hence the duty cycle is dynamically modified by the control circuit (4). In case where a reduced cooling fan speed is not adequate for keeping operational temperature within the reference boundaries, the control circuit (4) will increase the duty cycle. For instance Fig. 4 demonstrates the situation where the duty cycle is 0,5. There can be cases where full power
must be transferred to the fan despite the resulting fan noise. In this case, Q1 is conduction and Q2 is in non-conduction mode. Vcc is read between input terminals of the cooling fan motor (3) winding and there is no power dissipation across the terminals of R1.

[0033] According to the present invention, the square wave obtained by the on and off times of Q1 is independent of the switching frequency. A frequency value above 20 Hz. is suitable for changing cooling fan speed in an unnoticeable manner, i.e. with smooth noise level transitions.

[0034] The driving circuit (2) according to the present invention also provides the advantageous effect of extending operational life of the fan motor. The fact that the cooling fan motor is started only for a single time for a single cooking session or duration, the cooling fan motor’s (3) lifetime is not shortened by repetitive starting.
Claims

1. An induction cooker (1) comprising a plurality of hob rings for effecting heating of edible contents in a ferrous metal cookware being positioned on one of said rings, switching power components generating high frequency current in an induction coil, which in turn generates high frequency magnetic flux that induces eddy currents in said cookware, a cooling fan coupled to a cooling fan motor (3) for cooling down said switching power components, a driving circuit (2) for driving said cooling fan motor (3) and a control circuit (4) for controlling said driving circuit (2) characterized in that;

   said driving circuit (2) comprises a differential pair having a first and a second switching elements (Q1, Q2) such that said second switching element (Q2) is in series with a resistance (R1) and said second switching element (Q2) and said resistance (R1) are in parallel with first switching element (Q1),

   said differential pair is disposed in series with the cooling fan motor (3), one terminal of fan motor (3) winding being connected to a DC voltage source (Vcc),

   time duration of the first switching element (Q1) is in conduction is adjustable in response to received temperature feedback (TEMP), power level feedback (P) or speed feedback (S) by the control circuit (4) such that the effective voltage applied to the fan motor (3) by the driving circuit (2) is regulated.

2. An induction cooker (1) as in Claim 1, characterized in that the first and second switching elements (Q1, Q2) are bipolar junction transistors.

3. An induction cooker (1) as in Claim 1 or 2, characterized in that the switching frequency of the first switching element (Q1) is above 20 Hz.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. F04D27/00 H02P7/29 H05B6/12
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)
F04D H02P H05B

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

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.      See patent family annex.

* Special categories of cited documents:
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