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(71) Applicant: **Arçelik Anonim Sirketi**
34445 Istanbul (TR)

(72) Inventors:
- **YENER, Baris**
  34445 ISTANBUL (TR)
- **POLAT, Akif Hakki**
  34445 ISTANBUL (TR)
- **OKTAY, Ulas**
  34445 ISTANBUL (TR)
- **ASLAN, Sezer**
  34445 ISTANBUL (TR)

(54) **A CONTROL METHOD FOR INDUCTION HEATING COOKERS**

(57) The present invention relates to a control method which is suitable to be used in induction heating cookers comprising a first clock generator which works at high speed and which determines the main clock frequency; a second clock generator which works in real time; at least one amplifier module which enables the system to drive the signal from the first clock generator at higher frequencies; at least one modulation signal generator comprising at least one counter which separately counts the periods of the signal from the amplifier module and the signal from the second clock generator and a comparator which compares the counter values; at least one power switch which receives the signals passing through the modulation signal generator and which enables power switching; and a control unit which controls the clock generator, the amplifier module and the modulation signal generator, the control method being executed by the control unit.

EP 3 962 236 A1

Description

[0001] The present invention relates to a control method for reducing the noise generated at the base of the cooking vessel during the heating in the induction heating cookers.

[0002] In induction heating systems, which are widely used in cooking devices, by means of the magnetic field generated by the current passing through the induction coil, voltage is inducted at the base of the pot and current is passed through the base of the pot, thus the Eddy current begins to flow on the surface of the heated metal and heating is provided. Heating occurs on the surface where the current passing through the base of the pot passes. By means of the heating, a high temperature difference occurs between the heated area and the regions farther away, and minor expansions and contractions at high frequency are observed with the current flowing rapidly. Moreover, pushing and pulling movements occur due to the magnetic flux generated by the current passing through the base. Since the current passing through the base of the pot is at very high levels (400-600 A), the temperature at the penetration depth of the magnetic field at the base of the pot increases very rapidly, and due to these expansion-contraction movements between the lamellae on the base of the pan, sounds begin to be generated. The harder and more irregular these movements and the warming characteristics are, the more undesirable noise will be generated accordingly. The current passing through the induction coil is controlled by using the power switching element. Therefore, the variation of the fill factor and frequency of the signal applied to the switching element directly affects the sound emitted from the heated pot. In other words, the tolerance of the switching applied by the microprocessor in induction cookers using microprocessor and of the elements which form the clock frequency used in the switching directly affects said sound unwanted by the user. Especially when the modulation signals (pwm) are monitored, irregularities and flickers in the frequency become evident. It is observed that the current passing through the base of the pot provides heating at a very thin layer on the surface of the base of the pot and hence a high degree of temperature difference occurs between the heated surface and the cold intermediate layer. Minor expansions and contractions occur with the current flowing at high frequency, which cause push and pull movements with the effect of magnetic flux. This physical situation is reflected to the user as some unwanted sounds coming from the base of the pot. This type of unwanted sounds reduces user satisfaction and quality perception. The state of the art solutions often required very expensive hardware changes.

[0003] In the state of the art European Patent Application No. EP2339755A1, a balancing method is disclosed, which proposes a reverse feeding solution for calculating phase difference by sequential sampling from modulation signals and comparing and regulating frequency flicker.

[0004] In the state of the art USA Patent Application No. US2020003560A1, noise reduction by means of a digital circuit having a system comprising an analog to digital converter, demodulator, filter and phase-locked loop is disclosed.

[0005] The aim of the present invention is the realization of a control method which is suitable for use in induction cookers wherein two separate clock generators are periodically controlled so as to prevent frequency shifts and distortions.

[0006] The control method realized in order to attain the aim of the present invention, explicated in the claims, is suitable to be used in induction heating cookers comprising a first clock generator which works at high speed and which determines the main clock frequency; a second clock generator which works in real time; at least one amplifier module which enables the system to drive the signal from the first clock generator at higher frequencies; at least one modulation signal generator comprising at least one counter which separately counts the periods of the signal from the amplifier module and the signal from the second clock generator and a comparator which compares the counter values; at least one power switch which receives the signals passing through the modulation signal generator and which enables power switching; and a control unit which controls the clock generator, the amplifier module and the modulation signal generator, the control method being executed by the control unit. It is known that the sensitivity of the period of the high-speed first clock generator is low while the period of the second clock generator working in real time is high. The control method first realizes the step of generating an electrical signal at the first clock generator at the main clock frequency and transmitting the same to the amplifier module. Afterwards, an electrical signal at a frequency lower than the main clock frequency is generated at the second clock generator and transmitted to the modulation signal generator. The frequency of the incoming signal at the main clock frequency is increased in the amplifier module and transmitted to the modulation signal generator. A database is created for the differences in the period by increasing the value of the counter in each period of the signal coming from both the amplifier module and the second clock generator up to a value determined by the producer. At the same time, the signal from the amplifier module is transmitted to the power switch. Afterwards, the counter values of the low and high frequency signals entering the modulation signal generator during the time the counter performs the counting process are compared by the comparator, and thus, high and low sensitivity clock generators are compared in a way. By means of the step of entering the period difference calculated as a result of the comparison of the counters to the modulation signal generator by feedback, and driving the modulation signal with the corrected frequency, the drift and deviations in the frequency related to the first clock generator can be minimized. Since, as the last step, the ir-

regular movements in the frequency are eliminated by transferring the modulation signals corrected as a result of the feedback from the modulation signal generator to the power switch, undesirable noises coming from the pots on the induction cookers are also greatly reduced.

[0007] In another embodiment of the present invention, the control method comprises the step of connecting the first and second clock generators to the system internally or externally. Thus, a clock generator in the microcontroller can be used and an addition can be made from outside the microprocessor by means of an external connection. Consequently, this feature can be provided by inner or outer hardware.

[0008] In an embodiment of the present invention, the control method comprises the step of connecting at least two comparators to at least one counter. By sending the counter values to different comparators, the period control can be made in a more sensitive manner as a result of different combinations, and frequency deviations are better improved.

[0009] Another embodiment of the present invention is an induction heating cooker suitable to be used with the above-described control method. Especially by means of transmitting the corrected signal to the power switch, the performance of the induction heating cooker system can be improved.

[0010] By means of the control method of the present invention, two separate clock generators in the induction heating cookers are periodically controlled, and frequency shifts in the induction heating cookers are prevented.

[0011] The control method is suitable to be used in induction heating cookers comprising a first clock generator which works at high speed and which determines the main clock frequency; a second clock generator which works in real time; at least one amplifier module which enables the system to drive the signal from the first clock generator at higher frequencies; at least one modulation signal generator comprising at least one counter which separately counts the periods of the signal from the amplifier module and the signal from the second clock generator and a comparator which compares the counter values; at least one power switch which receives the signals passing through the modulation signal generator and which enables power switching; and a control unit which controls the clock generator, the amplifier module and the modulation signal generator, the control method being executed by the control unit. It is known that the sensitivity of the period of the high-speed first clock generator is low while the period of the second clock generator working in real time is high. In general, the clock generators can be a crystal resonator or an internal generator. As the amplifier module, a low cost digital component (FLL: frequency locked loop) with low sensitivity or a high cost analog component (PLL: phase locked loop) with high sensitivity can be used. By using the digital amplifier module in the microprocessor considered as the control unit, a better cost advantage is provided. The modulation signal generator is considered as a unit which generates the signal to which the pulse width modulation (PWM) technique is applied. The modulation (PWM) signals generated by the modulation signal generator are directly supplied to the power switch, thus providing a type of power control. The control method first realizes the step of generating an electrical signal at the first clock generator at the main clock frequency and transmitting the same to the amplifier module. Afterwards, an electrical signal at a frequency lower than the main clock frequency is generated at the second clock generator and transmitted to the modulation signal generator. The frequency of the incoming signal at the main clock frequency is increased in the amplifier module and transmitted to the modulation signal generator.

[0012] A database is created for the differences in the period by increasing the value of the counter in each period of the signal coming from both the amplifier module and the second clock generator up to a value determined by the producer. At the same time, the signal from the amplifier module is transmitted to the power switch. Afterwards, the counter values of the low and high frequency signals entering the modulation signal generator during the time the counter performs the counting process are compared by the comparator, and thus, high and low sensitivity clock generators are compared in a way. As the clock generator working at low frequency generates signals with high sensitivity, the period difference is lower related to the other clock generator. By means of the step of entering the period difference calculated as a result of the comparison of the counters to the modulation signal generator by feedback, and driving the modulation signal with the corrected frequency, the drift and deviations in the frequency related to the first clock generator can be minimized. For example, if one counter value is 500 and the other is 450, the value which drives the power switch according to the counter connected to the low frequency clock generator is normalized to eliminate the frequency shifts of the high-speed clock generator. The resulting difference is corrected by being supplied as input to the modulation signal generator by the comparator. Since, as the last step, the irregular movements in the frequency are eliminated by transferring the modulation signals corrected as a result of the feedback from the modulation signal generator to the power switch, undesirable noises coming from the pots on the induction cookers are also greatly reduced. Thus, without requiring an additional component for frequency shifts and flickers occurring at the bases of the pots, a cost-effective feedback solution is offered.

[0013] In another embodiment of the present invention, the control method comprises the step of connecting the first and second clock generators to the system internally or externally. Thus, a clock generator in the microcontroller can be used and an addition can be made from outside the microprocessor by means of an external connection. Consequently, this feature can be provided by inner or outer hardware.

[0014] In an embodiment of the present invention, the

control method comprises the step of connecting at least two comparators to at least one counter. By sending the counter values to different comparators, the period control can be made in a more sensitive manner as a result of different combinations, and frequency deviations are better improved.

[0015] Another embodiment of the present invention is an induction heating cooker suitable to be used with the above-described control method. Especially in the induction heating cooker system, where smooth frequency transfer to the power switch is critical, a great improvement is achieved.

[0016] By means of the control method of the present invention, as a result of the periodic control of the separate clock generators operating at high and low speed in the induction heating cookers, the drifts and deviations in frequency are significantly prevented.

Claims

1. A control method which is suitable to be used in induction heating cookers comprising a first clock generator which works at high speed and which determines the main clock frequency; a second clock generator which works in real time; at least one amplifier module which enables the system to drive the signal from the first clock generator at higher frequencies; at least one modulation signal generator comprising at least one counter which separately counts the periods of the signal from the amplifier module and the signal from the second clock generator and a comparator which compares the counter values; at least one power switch which receives the signals passing through the modulation signal generator and which enables power switching; and a control unit which controls the clock generator, the amplifier module and the modulation signal generator, the control method being executed by the control unit, **characterized by** the steps, executed by the control unit, of

    - Generating an electrical signal at the first clock generator at the main clock frequency and transmitting the same to the amplifier module,
    - Generating an electrical signal at a frequency lower than the main clock frequency at the second clock generator and transmitting the same to the modulation signal generator,
    - Amplifying the frequency of the incoming signal in the amplifier module and transmitting the same to the modulation signal generator,
    - Increasing the value of the counter in each period of the signal coming from both the amplifier module and the second clock generator up to a value determined by the producer,
    - Transmitting simultaneously the signal from the amplifier module to the power switch,
    - Comparing the counter values of the low and high frequency signals entering the modulation signal generator during the time the counter performs the counting process by the comparator,
    - Entering the period difference calculated as a result of the comparison to the modulation signal generator by feedback, and driving the modulation signal with the corrected frequency,
    - Transferring the modulation signals corrected as a result of the feedback from the modulation signal generator to the power switch.

2. A control method as in Claim 1, **characterized by** the step of connecting the first and second clock generators to the system internally or externally.

3. A control method as in Claim 1 or 2, **characterized by** the steps of connecting at least two comparators to at least one counter.

4. An induction heating cooker suitable to be used with the methods described above.

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EUROPEAN SEARCH REPORT

Application Number
EP 21 18 7855

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	WO 82/02466 A1 (MATSUSHITA ELECTRIC IND CO LTD [JP]; OGINO YOSHIO [JP] ET AL.) 22 July 1982 (1982-07-22) * abstract; figures 1-7 *	1-4	
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2 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 January 2022	Garcia, Jesus

CATEGORY OF CITED DOCUMENTS

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REFERENCES CITED IN THE DESCRIPTION

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- US 2020003560 A1 **[0004]**