



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.09.2019 Bulletin 2019/36

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

(21) Application number: **18159692.5**

(22) Date of filing: **02.03.2018**

(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
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

- **POSA, Paolo**
33080 Porcia (IT)
- **MARSON, Enrico**
33080 Porcia (IT)

(74) Representative: **Electrolux Group Patents**
AB Electrolux
S:t Göransgatan 143
10545 Stockholm (SE)

(71) Applicant: **ELECTROLUX APPLIANCES**
AKTIEBOLAG
105 45 Stockholm (SE)

(72) Inventors:
• **PIN, Gilberto**
33170 Pordenone (IT)

Remarks:

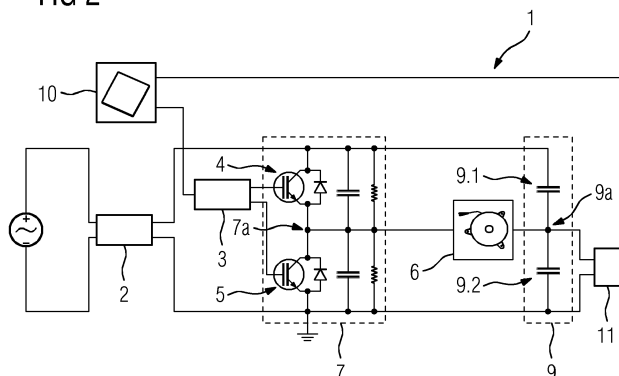
Amended claims in accordance with Rule 137(2) EPC.

(54) **INDUCTION HOB AND METHOD FOR OPERATING AN INDUCTION HOB**

(57) The invention relates to an induction hob comprising a circuitry (1a) for powering at least one induction coil (6), the circuitry (1a) comprising a power circuit portion (7) with at least one switching element (4, 5) adapted to provide pulsed electric power to said induction coil (6) and an oscillating circuit portion (9) comprising at least one resonance capacitor (9.1, 9.2) which is associated with a resonance capacitor voltage, said induction coil (6) being electrically coupled with said power circuit portion (7) and said oscillating circuit portion (9), wherein said induction hob comprises a control entity (10), said control entity (10) being configured to provide and/or receive resonance capacitor information, specifically, sam-

pled resonance capacitor voltage values, applying a discrete mathematical transformation to the resonance capacitor information thereby obtaining modified resonance capacitor information, said control entity (10) being further configured to calculate first and second electrical information related to the induction coil (6), specifically information regarding the amplitude of the electric current (I_c) provided through said induction coil (6) and information regarding the phase delay between the electric current (I_c) provided through said induction coil (6) and the voltage applied to the induction coil (6) based on said modified resonance capacitor information.

FIG 2



Description

[0001] The present invention relates generally to the field of induction hobs. More specifically, the present invention is related to an induction hob comprising a power circuit in which the functionality of a current transducer is replaced by arithmetic functionality provided by a control entity.

BACKGROUND OF THE INVENTION

[0002] Induction hobs for preparing food are well known in prior art. Induction hobs typically comprise at least one induction coil placed below a hob plate in order to heat a piece of cookware.

[0003] For controlling the induction hob, values regarding the peak current flowing through the induction coil and power factor indicating the load of the induction coil (dependent of the position of the piece of cookware, the material of the piece of cookware etc.) are required.

[0004] Common induction hobs comprise a current transducer based on which peak current flowing through the induction coil and a power factor can be determined. However, the usage of a current transducer is disadvantageous because the total costs and footprint of the power circuit board are increased.

SUMMARY OF THE INVENTION

[0005] It is an objective of the embodiments of the invention to provide an induction hob, which is improved with respect to costs and footprint of the power circuit board. The objective is solved by the features of the independent claims. Preferred embodiments are given in the dependent claims. If not explicitly indicated otherwise, embodiments of the invention can be freely combined with each other.

[0006] According to an aspect, the invention relates to an induction hob comprising a circuitry for powering at least one induction coil. The circuitry comprises a power circuit portion with at least one switching element adapted to provide pulsed electric power to said induction coil and an oscillating circuit portion comprising at least one resonance capacitor which is associated with a resonance capacitor voltage, said induction coil being electrically coupled with said power circuit portion and said oscillating circuit portion. Said induction hob comprises a control entity, said control entity being configured to provide and/or receive sampled resonance capacitor voltage values, applying a discrete mathematical transformation to the sampled resonance capacitor voltage values thereby obtaining modified resonance capacitor voltage information. Said control entity is further configured to calculate information regarding the amplitude of the electric current provided through said induction coil and information regarding the phase delay between the electric current provided through said induction coil and the voltage applied to the induction coil based on said modified resonance capacitor voltage information.

[0007] Said induction hob is advantageous because the functionality of the current transducer can be replaced by a mathematical approach, said mathematical approach taking available information of the power circuit of the induction hob. Said control entity is configured to calculate peak current value and phase delay based on said available information. Thereby, the total costs and footprint of the power circuit can be reduced, specifically when using existing resources (e.g. microprocessor etc.) for calculating said values.

[0008] According to embodiments, said resonance capacitor voltage is indicative for a voltage provided at a circuit node located between a pair of capacitors included in said oscillating circuit portion. Said circuit node may be used for electrically coupling the induction coil with the oscillating circuit portion. One capacitor of said pair of capacitors extends between said circuit node and supply voltage wherein the other capacitor of said pair of capacitors extends between said circuit node and ground.

[0009] According to embodiments, said resonance capacitor voltage is obtained using a sensing circuit portion comprising a voltage divider. Said voltage divider may be formed by two or more resistors which allow the measurement of resonance capacitor voltage.

[0010] According to embodiments, said information regarding the amplitude of the electric current provided through said induction coil and/or said information regarding the phase delay between the electric current provided through said induction coil and the voltage applied to the induction coil is calculated without considering information indicative for a voltage provided at a circuit node located between a pair of switching elements. In other words, only voltage information of a node included in the oscillating circuit portion but no voltage information of a node included in the power circuit portion is required. Thereby estimation inaccuracies can be reduced.

[0011] According to embodiments, said discrete mathematical transformation is a discrete cosine transformation. Based on the discrete cosine transformation, a sinusoidal wave is developed based on which the maximum and minimum values of resonance capacitor voltage are calculated. So, in other words, the maximum and minimum values are not directly established from the sampled resonance capacitor voltage but based on the sampled values of the resonance capacitor voltage, a sinusoidal wave is determined that fits to the acquired samples of resonance capacitor voltage.

Thereby, the influence of noise can be significantly reduced.

[0012] According to embodiments, said discrete mathematical transformation is based on sine and cosine reference convolution signals, said sine and cosine reference convolution signals being calculated based on information regarding the frequency of the electric current provided through said induction coil and the sampling frequency based on which the sampled resonance capacitor voltage is obtained. Said sine and cosine reference convolution signals form reference signals for establishing the sinusoidal wave based on the sampled values of the resonance capacitor voltage.

[0013] According to embodiments, said sine and cosine reference convolution signals are based on the following formulas:

$$\omega = 2 \cdot \pi \cdot inFreq$$

$$\cos REF(k) = \cos((k-1) \cdot \omega \cdot \Delta t_{SAMPLE,S});$$

$$\cos REF ACC(k) = \sum_{i=1}^{i=k-1} \cos REF(i) + \cos REF(k);$$

$$\sin REF(k) = \sin((k-1) \cdot \omega \cdot \Delta t_{SAMPLE,S});$$

$$\sin REF ACC(k) = \sum_{i=1}^{i=k-1} \sin REF(i) + \sin REF(k);$$

wherein

infreq is the frequency of the current flowing through the induction coil;

k is an index indicating a certain sample value;

cosREF ACC and *sinREF ACC* are accumulators; and

$\Delta t_{SAMPLE,S}$ is the time span between two consecutive sampled values represented in seconds [s].

[0014] According to embodiments, said sine and cosine reference convolution signals are based on the following formulas:

$$averageCOS = \frac{\cos REF ACC}{bufferlength};$$

$$averageSIN = \frac{\sin REF ACC}{bufferlength};$$

$$\cos REF(k) = \cos REF(k-1) - averageCOS;$$

$$\sin REF(k) = \sin REF(k-1) - averageSIN;$$

wherein

bufferlength is calculated based on the following formula:

$$bufferlength = trunc(\frac{1}{inFreq \cdot \Delta t_{SAMPLE,S}});$$

wherein $inFreq$ is the frequency of the electric current provided through said induction coil.

[0015] According to embodiments, fitting signals are calculated as follows:

$$accCos(k) = \sum_{i=1}^{i=k-1} cos REF(i) \cdot inputSample(i) + cos REF(k) \cdot inputSample(k);$$

$$accSin(k) = \sum_{i=1}^{i=k-1} sin REF(i) \cdot inputSample(i) + sin REF(k) \cdot inputSample(k);$$

$$accAverageRec(k) = \sum_{i=1}^{i=k-1} inputSample(i) + inputSample(k).$$

[0016] According to embodiments, intermediate signal values are calculated as follows:

$$cos EST = 2 \cdot accCos \cdot inFreq \cdot \Delta t_{SAMPLE,S};$$

$$sin EST = 2 \cdot accSin \cdot inFreq \cdot \Delta t_{SAMPLE,S};$$

$$avgEst = \frac{accAverageRec}{bufferLength}.$$

[0017] The $avgEst$ value can be corrected considering the BIAS due to the leakage current that supply the resonance capacitor also in absence of power generation. This increases the precision of acquired data and at the end the estimated values.

[0018] According to embodiments, peak value, maximum and minimum values of resonance capacitor voltage and phase delay value are calculated as follows:

$$peakValue = \sqrt{cos Est^2 + sin Est^2};$$

$$VcMax = avgEst + peakValue;$$

$$VcMin = avgEst - peakValue;$$

$$phaseDelay Vc = \tan^{-1}\left(\frac{sinEst}{cosEst}\right).$$

[0019] According to embodiments, the peak value of the electric current provided through said induction coil is calculated based on the following formula:

$$Ic = 2\pi f(VcMax - VcMin) \cdot Cres;$$

wherein $Cres$ is the capacity value of the resonance capacitor and f is the switching frequency applied to the induction coil.

[0020] Consider that the following compensation could be added or not, depending on the desired reliability level or precision that would be reached in the estimation/reconstruction method.

This is an option and could be applied or not.

[0021] According to embodiments, a compensated phase delay between the electric current provided through said induction coil and the voltage applied to the induction coil is calculated based on the following compensation formulas:

$$\sin Comp = \frac{2\pi(\cos Est \cdot \cos(4\pi K) - \cos Est + \sin Est \cdot \sin(4\pi K) + 4\pi \cdot \sin Est \cdot K)}{\cos(4\pi K) + 8K^2\pi^2 - 1};$$

$$\cos Comp$$

$$= -\left(\frac{2\pi(\sin Est + \cos Est \cdot \sin(4\pi K) - \sin Est \cdot \cos(4\pi K) - 4\pi \cdot \cos Est \cdot K)}{\cos(4\pi K) + 8K^2\pi^2 - 1}\right);$$

wherein K is a compensation coefficient calculated as:

$$K = numSample \cdot \Delta t_{SAMPLE,S} \cdot inFreq.$$

[0022] According to embodiments, a new compensated phase delay and a new compensated peak value of the electric current provided through said induction coil could be computed based on the following formula:

$$peakValueComp = \sqrt{\cos Comp^2 + \sin Comp^2};$$

$$VcMaxComp = avgEst + peakValueComp;$$

$$VcMinComp = avgEst - peakValueComp;$$

$$phaseDelayVcVomp = \tan^{-1} \frac{\sin Comp}{\cos Comp}.$$

and

$$IcComp = 2\pi f(VcMaxComp - VcMinComp) \cdot Cres;$$

[0023] According to embodiments, an estimated average power value is calculated based on the following formula:

$$avgPowerEst = \frac{\sum_{k=1}^{nSamples} Vmain(k) \cdot Ic_{Est}(k) \cdot PhM_Est(k)}{2 * MainLineFreq};$$

wherein Vmain is the rectified value of main line voltage at sample k, I_{cEst} is the estimated value (compensated or not) of coil current obtained by the resonance capacitor analysis, PhM_Est is the phase delay (compensated or not) obtained by the resonance capacitor analysis and MainLineFreq is the frequency of AC main line voltage applied to the induction hob.

[0024] According to embodiments, the induction hob comprises no current transducer electrically coupled with the induction coil, wherein information regarding the amplitude of the electric current provided through said induction coil and information regarding the phase delay between the electric current provided through said induction coil and the voltage applied to the induction coil are provided by an algorithm calculating maximum and minimum peak values of resonance capacitor voltage by reconstructing a sinusoidal wave based on sampled values of said resonance capacitor voltage.

[0025] According to a further aspect, the invention relates to a method for operating an induction hob. The induction hob comprises a circuitry for powering at least one induction coil. The circuitry comprises a power circuit portion with at least one switching element adapted to provide pulsed electric power to said induction coil and an oscillating circuit portion comprising at least one resonance capacitor which is associated with a resonance capacitor voltage, said induction

coil being electrically coupled with said power circuit portion and said oscillating circuit portion. Said induction hob comprises a control entity performing the steps of:

- providing and/or receiving sampled resonance capacitor voltage values;
- applying a discrete mathematical transformation to the sampled resonance capacitor voltage values thereby obtaining modified resonance capacitor voltage information;
- calculating information regarding the amplitude of the electric current provided through said induction coil and information regarding the phase delay between the electric current provided through said induction coil and the voltage applied to the induction coil based on said modified resonance capacitor voltage information.

[0026] The term "essentially" or "approximately" as used in the invention means deviations from the exact value by +/- 10%, preferably by +/- 5% and/or deviations in the form of changes that are insignificant for the function.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The various aspects of the invention, including its particular features and advantages, will be readily understood from the following detailed description and the accompanying drawings, in which:

Fig. 1 shows an example embodiment of a schematic power circuit of a state-of-the-art induction hob;

Fig. 2 shows an example embodiment of a schematic power circuit of an induction hob according to the present invention;

Fig. 3 shows sampling values of resonance capacitor voltage V_c over a whole period; and

Fig. 4 shows an equivalent circuit of a power circuit according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0028] The present invention will now be described more fully with reference to the accompanying drawings, in which example embodiments are shown. However, this invention should not be construed as limited to the embodiments set forth herein. Throughout the following description similar reference numerals have been used to denote similar elements, parts, items or features, when applicable.

[0029] Fig. 1 shows a schematic diagram of a power circuit 1 of a state-of-the-art induction hob. The power circuit 1 comprises an input stage 2. Said input stage 2 may be coupled with AC mains, e.g. 230V AC mains. Said input stage 2 may be adapted to rectify and/or filter the AC mains voltage. Specifically, the input stage 2 may comprise a rectification bridge. In addition, the power circuit 1 may comprise a coil driver entity 3. The coil driver entity 3 may be adapted to control one or more switching elements 4, 5. Said switching elements 4, 5 may be electrically coupled with said input stage 2 in order to receive rectified AC voltage. In addition, said coil driver entity 3 may be electrically coupled with control inputs of said switching elements 4, 5 in order to be able to provide pulsed electrical power to an induction coil 6. Said switching elements 4, 5 may be, for example, IGBTs. The IGBTs may be integrated in a power circuit portion 7, said power circuit portion 7 being configured as a half-bridge converter.

[0030] Between said power circuit portion 7 and said induction coil 6, a current transducer 8 is provided. Said current transducer 8 may be adapted to provide information regarding the peak value of the electric current provided through the induction coil 6 (in the following also referred to as coil current) and the power factor. More in detail, the coil current I_c may flow through the current transducer 8. Thereby, the current transducer 8 is able to measure/determine the peak value of the coil current I_c and the power factor. The current transducer 8 may be electrically coupled with a circuit node 7a of the power circuit portion 7 which is arranged between the pair of switching elements 4, 5.

[0031] At the opposite side of the current transducer 8, the induction coil 6 is coupled with an oscillating circuit portion. Said oscillating circuit portion 9 may comprise a pair of capacitors 9.1, 9.2, said capacitors 9.1, 9.2 forming together with the inductivity of the induction coil 6 an electrical resonant or quasi-resonant circuit which enables an oscillating excitation of the induction coil 6. The induction coil 6 may be coupled with a circuit node 9a being arranged between said pair of capacitors 9.1, 9.2. Said capacitors 9.1, 9.2 are in the following referred to as resonance capacitors.

[0032] Said current transducer 8 may be electrically coupled with a control entity 10 for providing information regarding the peak value of the coil current and the power factor to said control entity 10. Based on said information, the control entity 10 controls the switching elements 4, 5 of the power circuit portion 7.

[0033] Fig. 2 shows a schematic diagram of a power circuit 1a of an induction hob according to the present invention. The basic structure of the power circuit 1a is similar to the structure of the power circuit 1. Therefore, in the following

only differences of the power circuit 1a with respect to power circuit 1 are explained. Apart from that, the features described before do also apply to the embodiment of Fig. 2.

[0034] The first main difference to the power circuit 1 is that the power circuit 1a does not comprise a current transducer 8. More in detail, the induction coil 6 is directly coupled with the circuit node 7.1 provided between the pair of switching elements 4, 5. A further difference is the voltage divider 11 which is electrically coupled with the circuit node 9a of the oscillating circuit portion 9. In order to be able to replace the functionality of the current transducer 8, the control entity 10 is configured to gather information regarding the peak value of the coil current and the power factor/phase delay based on a mathematical algorithm. More in detail, the control entity 10 may receive certain information available at the power circuit 1a, e.g. information correlated/associated with the voltage of the circuit node 9a. The wording "information correlated/associated with a voltage" may refer to the case that a voltage is tapped at a certain node (e.g. node 9a) thereby said information being the voltage value at said node. However, the wording "information correlated/associated with a voltage" may alternatively be indicative for said voltage at said node, but may be derived by an arithmetic operation based on other parameters or, for example, derived by the voltage divider 11.

[0035] In the following, the implementation of calculating information regarding the peak value of the coil current and an estimated power value is described in detail.

[0036] The inventor(s) found out that an estimation of coil current I_c , phase delay between the electric current and the voltage applied to the induction coil and the electric power applied to the induction coil can be obtained from an analysis of resonance capacitor voltage, i.e. without considering an equivalent local coil/pot model including an estimation of an equivalent load series resistance and an equivalent load series inductance.

[0037] The algorithmic implementation (and not based on a current transducer) of providing information regarding the peak value of the coil current and the estimated power value can be obtained based on several information available at the power circuit 1a or derivable from information available at the power circuit 1a.

[0038] In the arithmetic implementation, information regarding the resonance capacitor voltage V_c is gathered. Preferably, said information is obtained by the voltage divider 11. Usually, the resonance capacitor voltage V_c is quite close to a sinusoid. However, in order to reduce the impact of noise, the maximum and minimum values of resonance capacitor voltage V_c are, preferably, not obtained directly by a peak determination entity or peak determination function but resonance capacitor voltage V_c is sampled and a best fitting method is applied on said samples in order to obtain a "best fitted" sinusoidal wave that fits the acquired samples of resonance capacitor voltage V_c .

[0039] Fig. 3 shows an example of sampled values of V_c related to a switching frequency of switching elements 4, 5 of 40kHz.

[0040] In order to increase noise immunity and thereby obtain a high reliability level, a discrete mathematical transformation is applied to the sampled values of V_c . For example, said discrete mathematical transformation is a discrete cosine transformation (DCT). However, also other discrete mathematical transformations can be used. Considering that DCT is derived from the Fourier Transformation, other methodologies are for instance the Wavelet filtering, the Fourier Transform (Regular, Fast or other typologies) and related mathematical variations.

[0041] The resonance capacitor voltage V_c is sampled, for example, with a frequency of 1MHz or more. Also lower frequencies may be possible, for instance in the range of 100kHz to 1MHz, specifically 500kHz or 250kHz. Said sampling may be obtained periodically, for example with a frequency of 10kHz. As a result of said sampling, a complete period of resonance capacitor voltage V_c is stored in a storage entity, e.g. RAM. Said stored samples of resonance capacitor voltage V_c are elaborated in order to obtain upper-mentioned estimated values of coil current I_c , phase delay between the electric current and the voltage applied to the induction coil and the electrical power applied to the induction coil 6.

[0042] For applying said discrete mathematical transformation to the sampled values of V_c , sine and cosine reference convolution signals are computed based on the following formulas:

$$\omega = 2 \cdot \pi \cdot \text{inFreq}; \quad (\text{Formula 1})$$

$$\cos REF(k) = \cos\left((k-1) \cdot \omega \cdot \Delta t_{SAMPLE,S}\right); \quad (\text{Formula 2})$$

$$\cos REF ACC(k) = \sum_{i=1}^{i=k-1} \cos REF(i) + \cos REF(k); \quad (\text{Formula 3})$$

$$\sin REF(k) = \sin\left((k-1) \cdot \omega \cdot \Delta t_{SAMPLE,S}\right); \quad (\text{Formula 4})$$

$$\sin REF\ ACC(k) = \sum_{i=1}^{i=k-1} \sin REF(i) + \sin REF(k); \quad (\text{Formula } 5)$$

wherein

$infreq$ is the frequency of the current flowing through the induction coil;

$\Delta t_{SAMPLE,s}$ is the time span between two consecutive sampling values represented in seconds [s];

k is an index indicating a certain sample value; and $\cos REF\ ACC$ and $\sin REF\ ACC$ are accumulators.

[0043] The total number of samples referring to one period of resonance capacitor voltage V_c can be calculated as follows:

$$bufferlength = trunc(\frac{1}{infreq \cdot \Delta t_{SAMPLE,s}}); \quad (\text{Formula } 6)$$

[0044] Thereby, the "trunc"-function provides the integer part of the division result.

[0045] The final reference convolution signals with the compensation of the average are:

$$averageCOS = \frac{\cos REF\ ACC}{bufferlength}; \quad (\text{Formula } 7)$$

$$averageSIN = \frac{\sin REF\ ACC}{bufferlength}; \quad (\text{Formula } 8)$$

$$\cos REF(k) = \cos REF(k-1) - averageCOS \quad (\text{Formula } 9)$$

$$\sin REF(k) = \sin REF(k-1) - averageSIN \quad (\text{Formula } 10)$$

[0046] Said reference convolution signals could be computed every half of main line voltage period. For example, if the main line period is 50 Hz, the half main line voltage period is 10ms. The reference convolution signals can be computed every half of main line voltage period because the switching frequency usually changes every half of main line voltage period.

[0047] Inside the half of main line voltage period (e.g. 10ms), the interesting signals are updated every 100 μ s, for example.

[0048] Based on the acquired samples of resonance capacitor voltage V_c , in the following referred to as $inputSample$, and based on the convolution signals described before, fitting signals are computed based on the following formulas:

$$accCos(k) = \sum_{i=1}^{i=k-1} \cos REF(i) \cdot inputSample(i) + \cos REF(k) \cdot inputSample(k); \quad (\text{Formula } 11)$$

$$accSin(k) = \sum_{i=1}^{i=k-1} \sin REF(i) \cdot inputSample(i) + \sin REF(k) \cdot inputSample(k); \quad (\text{Formula } 12)$$

$$accAverageRec(k) = \sum_{i=1}^{i=k-1} inputSample(i) + inputSample(k); \quad (\text{Formula } 13)$$

[0049] Based on the results of formulas 11 to 13, intermediate signal values are calculated as follows:

$$\cos EST = 2 \cdot accCos \cdot inFreq \cdot \Delta t_{SAMPLE,S}; \quad (\text{Formula 14})$$

$$\sin EST = 2 \cdot accSin \cdot inFreq \cdot \Delta t_{SAMPLE,S}; \quad (\text{Formula 15})$$

$$avgEst = \frac{accAverageRec}{bufferLength}; \quad (\text{Formula 16})$$

[0050] The average estimation (*avgEst*) value can be corrected considering the BIAS due to the leakage current that supply the resonance capacitor also in absence of power generation. This increases the precision of acquired data and at the end the estimated values. According to a test case, at a line voltage of 230V, this value is around 18.5V.

[0051] The peak, maximum and minimum values of resonance capacitor voltage *V_c* and the phase delay of *V_c* can be calculated based on the following formulas:

$$peakValue = \sqrt{\cos Est^2 + \sin Est^2}; \quad (\text{Formula 17})$$

$$VcMax = avgEst + peakValue; \quad (\text{Formula 18})$$

$$VcMin = avgEst - peakValue; \quad (\text{Formula 19})$$

$$phaseDelay Vc = \tan^{-1}\left(\frac{\sin Est}{\cos Est}\right); \quad (\text{Formula 20})$$

[0052] Said phase delay value *phaseDelay V_c* is the delay between the generated voltage to the coil and the envelop of resonance capacitor voltage reconstructed with the fast sampling acquisition procedure.

[0053] Fig. 4 shows an equivalent circuit covering the power circuit portion 7, the induction coil 6 and the oscillating circuit 9 of the power circuit 1a according to Fig. 2. The induction coil 6 is replaced by a load representation modelled by *R_s* and *L_s*. The values of *R_s* and *L_s* depend on the applied frequency, the temperature, the material of the piece of cookware placed on the induction coil and the position of the piece of cookware with respect to the induction coil 6. Based on said equivalent circuit, the coil current *I_c* can be reconstructed using the following model equations:

$$I_1 = I_{cL} + I_{cH}; \quad (\text{Formula 21})$$

$$\frac{dV_c}{dt} = \frac{I_1}{2C_{res,2}}; \quad (\text{Formula 22})$$

$$I_c = I_1 = 2C_{res,2} \cdot \frac{dV_c}{dt}; \quad (\text{Formula 23})$$

[0054] Based on the last formula, coil current *I_c* can be reconstructed as follows:

$$I_c = 2\pi f(V_{c,max} - V_{c,min})C_{res,2}; \quad (\text{Formula 24})$$

wherein

f is the frequency of the AC-current provided to the induction coil;

V_{C,max} is the maximum value of the voltage provided at circuit node 9a;

$V_{C,min}$ is the minimum value of the voltage provided at circuit node 9a; and
 $C_{res,2}$ is the capacitor value of a resonance capacitor included in said oscillating circuit.

[0055] Similar to the coil current estimation process, it is possible to define a procedure for estimating the phase delay.

[0056] The estimation of phase delay can be performed based on the following facts:

- the resonance capacitor voltage has a phase delay of 90° with respect to the current through the resonance capacitor;
- the current through the resonance capacitor is a portion of the total coil current, specifically one half of the total coil current in case of identical values of $C_{res,1}$ and $C_{res,2}$;
- the knowledge of phase delay between the pulse width modulated (PWM) signal (which is present at circuit node 7a between the switching elements 4 as indicated in Figure 1) and maximum of V_{cRes} is linked to the value of phase delay between V_c and I_c .

[0057] In order to obtain an improved phase delay estimation, based on formula 20, a compensation procedure is introduced considering that the number of samples stored in the storage entity is an integer number and for this reason, the information stored in the storage entity does not reflect an entire period of resonance capacitor voltage V_c .

[0058] Consider that the following compensation could be added or not, depending on the desired reliability level or precision that would be reached in the estimation/reconstruction method.

So, in other words, this option and could be applied or not.

[0059] Preferably, said compensation is done every time, the coil current I_c and phase delay are computed, i.e. according to the upper-mentioned timing regime, every $100\mu s$ (or more). Said compensation is made based on the following set of formulas:

$$\sin Comp = \frac{2\pi(\cos Est \cdot \cos(4\pi K) - \cos Est + \sin Est \cdot \sin(4\pi K) + 4\pi \cdot \sin Est \cdot K)}{\cos(4\pi K) + 8K^2\pi^2 - 1}; \text{ (Formula 25)}$$

$$\cos Comp = - \left(\frac{2\pi(\sin Est + \cos Est \cdot \sin(4\pi K) - \sin Est \cdot \cos(4\pi K) - 4\pi \cdot \cos Est \cdot K)}{\cos(4\pi K) + 8K^2\pi^2 - 1} \right); \text{ (Formula 26)}$$

[0060] Thereby, $\sin Comp$ is the estimated sine value, $\cos Comp$ is the estimated cosine value and K is a compensation coefficient calculated as follows:

$$K = numSample \cdot \Delta t_{SAMPLE,S} \cdot inFreq; \text{ (Formula 27)}$$

[0061] Said compensation coefficient is always lower than zero.

[0062] Based on formulas 25 and 26, a new compensated phase delay and a new compensated peak value of the electric current provided through said induction coil can be calculated as follows:

$$peakValueComp = \sqrt{\cos Comp^2 + \sin Comp^2}; \text{ (Formula 28)}$$

$$VcMaxComp = avgEst + peakValueComp; \text{ (Formula 29)}$$

$$VcMinComp = avgEst - peakValueComp; \text{ (Formula 30)}$$

$$phaseDelayVcVomp = \tan^{-1} \frac{\sin Comp}{\cos Comp}. \text{ (Formula 31)}$$

and

$$I_{cComp} = 2\pi f(V_{cMaxComp} - V_{cMinComp}) \cdot C_{res}; \quad (\text{Formula } 32)$$

[0063] The electric power provided through the induction coil is estimated considering the already estimated values of coil current I_c and phase delay. Said estimated power value is calculated as an average based on the entire half of main line voltage and can be calculated considering a sum of instantaneous values based on the following formula:

$$avgPowerEst = \frac{\sum_{k=1}^{nSamples} V_{main}(k) \cdot I_{cEst}(k) \cdot PhM_Est(k)}{2 * MainLineFreq}; \quad (\text{Formula } 33)$$

wherein V_{main} is the rectified value of main line voltage at sample k , I_{cEst} is the estimated value (compensated or not) of coil current obtained by the resonance capacitor analysis at sample k , PhM_Est is the phase delay (compensated or not) obtained by the resonance capacitor analysis and $MainLineFreq$ is the frequency of AC main line voltage applied to the induction hob.

[0064] The estimated power value could be calculated considering, for instance, only a portion of the half of main line voltage period. For instance, the portion of period near the zero crossing of main line rectified voltage value could be skipped in the calculation of the average power value.

[0065] It should be noted that the description and drawings merely illustrate the principles of the proposed induction hob. Those skilled in the art will be able to implement various arrangements that, although not explicitly described or shown herein, embody the principles of the invention.

List of reference numerals

[0066]

- 1, 1a power circuit
 - 2 input stage
 - 3 coil driver entity
 - 4 switching element
 - 5 switching element
 - 6 induction coil
 - 7 power circuit portion
 - 7a circuit node
 - 8 current transducer
 - 9 oscillating circuit portion
 - 9a circuit node
 - 9.1 capacitor
 - 9.2 capacitor
 - 10 control entity
 - 11 voltage divider
-
- I_c coil current
 - V_c resonance capacitor voltage

Claims

1. Induction hob comprising a circuitry (1a) for powering at least one induction coil (6), the circuitry (1a) comprising a power circuit portion (7) with at least one switching element (4, 5) adapted to provide pulsed electric power to said induction coil (6) and an oscillating circuit portion (9) comprising at least one resonance capacitor (9.1, 9.2) which is associated with a resonance capacitor voltage, said induction coil (6) being electrically coupled with said power circuit portion (7) and said oscillating circuit portion (9), wherein said induction hob comprises a control entity (10), said control entity (10) being configured to provide and/or receive resonance capacitor information, specifically, sampled resonance capacitor voltage values, applying a discrete mathematical transformation to the resonance capacitor information thereby obtaining modified resonance capacitor information, said control entity (10) being further configured to calculate first and second electrical information related to the induction coil (6), specifically

information regarding the amplitude of the electric current (Ic) provided through said induction coil (6) and information regarding the phase delay between the electric current (Ic) provided through said induction coil (6) and the voltage applied to the induction coil (6) based on said modified resonance capacitor information.

2. Induction hob according to claim 1, wherein said first and/or second electrical information related to the induction coil (6) is calculated without considering information indicative for a voltage provided at a circuit node located between a pair of switching elements (4, 5).
3. Induction hob according to claim 1 or 2, wherein said discrete mathematical transformation is a discrete cosine transformation.
4. Induction hob according to anyone of the preceding claims, wherein said discrete mathematical transformation is based on sine and cosine reference convolution signals, said sine and cosine reference convolution signals being calculated based on information regarding the frequency of the electric current (Ic) provided through said induction coil (6) and the sampling frequency based on which the sampled resonance capacitor voltage is obtained.
5. Induction hob according to claim 4, wherein said sine and cosine reference convolution signals are based on the following formulas:

$$\omega = 2 \cdot \pi \cdot inFreq$$

$$\cos REF(k) = \cos((k-1) \cdot \omega \cdot \Delta t_{SAMPLE,S});$$

$$\cos REF ACC(k) = \sum_{i=1}^{i=k-1} \cos REF(i) + \cos REF(k);$$

$$\sin REF(k) = \sin((k-1) \cdot \omega \cdot \Delta t_{SAMPLE,S});$$

$$\sin REF ACC(k) = \sum_{i=1}^{i=k-1} \sin REF(i) + \sin REF(k);$$

wherein

inFreq is the frequency of the current flowing through the induction coil;
k is an index indicating a certain sample value;
cosREF ACC and sinREF ACC are accumulators; and
 $\Delta t_{SAMPLE,S}$ is the time span between two consecutive sampling values.

6. Induction hob according to anyone of the preceding claims, said sine and cosine reference convolution signals are based on the following formulas:

$$averageCOS = \frac{\cos REF ACC}{bufferlength};$$

$$averageSIN = \frac{\sin REF ACC}{bufferlength};$$

$$\cos REF(k) = \cos REF(k-1) - averageCOS;$$

$$\sin REF(k) = \sin REF(k-1) - average SIN;$$

wherein

bufferlength is calculated based on the following formula:

$$bufferlength = trunc(\frac{1}{inFreq \cdot \Delta t_{SAMPLE,S}});$$

wherein *inFreq* is the frequency of the electric current (*Ic*) provided through said induction coil (6).

7. Induction hob according to claim 6, wherein fitting signals are calculated as follows:

$$accCos(k) = \sum_{i=1}^{i=k-1} \cos REF(i) \cdot inputSample(i) + \cos REF(k) \cdot inputSample(k);$$

$$accSin(k) = \sum_{i=1}^{i=k-1} \sin REF(i) \cdot inputSample(i) + \sin REF(k) \cdot inputSample(k);$$

$$accAverageRec(k) = \sum_{i=1}^{i=k-1} inputSample(i) + inputSample(k);$$

8. Induction hob according to claim 7, wherein intermediate signal values are calculated as follows:

$$\cos EST = 2 \cdot accCos \cdot inFreq \cdot \Delta t_{SAMPLE,S};$$

$$\sin EST = 2 \cdot accSin \cdot inFreq \cdot \Delta t_{SAMPLE,S};$$

$$avgEst = \frac{accAverageRec}{bufferLength};$$

9. Induction hob according to anyone of the preceding claims, wherein maximum and minimum values of resonance capacitor voltage and phase delay value are calculated as follows:

$$peakValue = \sqrt{\cos Est^2 + \sin Est^2};$$

$$VcMax = avgEst + peakValue;$$

$$VcMin = avgEst - peakValue;$$

$$phaseDelay Vc = \tan^{-1}(\frac{\sin Est}{\cos Est}).$$

10. Induction hob according to claim 9, wherein the peak value of the electric current (*Ic*) provided through said induction coil (6) is calculated based on the following formula:

$$Ic = 2\pi f(VcMax - VcMin) \cdot Cres;$$

wherein C_{res} is the capacity value of the resonance capacitor (9.1, 9.2) and f is the switching frequency applied to the induction coil (6).

11. Induction hob according to anyone of claims 8 to 10, wherein a compensated phase delay between the electric current (I_c) provided through said induction coil (6) and the voltage applied to the induction coil (6) is calculated based on the following compensation formulas:

$$\sin Comp = \frac{2\pi(\cos Est \cdot \cos(4\pi K) - \cos Est + \sin Est \cdot \sin(4\pi K) + 4\pi \cdot \sin Est \cdot K)}{\cos(4\pi K) + 8K^2\pi^2 - 1};$$

$$\cos Comp = -\left(\frac{2\pi(\sin Est + \cos Est \cdot \sin(4\pi K) - \sin Est \cdot \cos(4\pi K) - 4\pi \cdot \cos Est \cdot K)}{\cos(4\pi K) + 8K^2\pi^2 - 1}\right);$$

wherein K is a compensation coefficient calculated as:

$$K = numSample \cdot \Delta t_{SAMPLE,S} \cdot inFreq;$$

12. Induction hob according to claim 11, wherein a compensated phase delay is computed based on the following formula:

$$peakValueComp = \sqrt{\cos Comp^2 + \sin Comp^2};$$

$$VcMaxComp = avgEst + peakValueComp;$$

$$VcMinComp = avgEst - peakValueComp;$$

$$phaseDelayVcVomp = \tan^{-1} \frac{\sin Comp}{\cos Comp};$$

$$IcComp = 2\pi f(VcMaxComp - VcMinComp) \cdot Cres;$$

13. Induction hob according to claim 12, wherein an estimated average power value is calculated based on the following formula:

$$avgPowerEst = \frac{\sum_{k=1}^{nSamples} Vmain(k) \cdot Ic_{Est}(k) \cdot PhM_Est(k)}{2 * MainLineFreq};$$

wherein $Vmain$ is the rectified value of main line voltage at sample k , I_{cEst} is the estimated value of compensated or uncompensated coil current obtained by the resonance capacitor analysis and PhM_Est is the compensated or uncompensated phase delay obtained by the resonance capacitor analysis.

14. Induction hob according to anyone of the preceding claims, comprising no current transducer (8) electrically coupled with the induction coil (6), wherein said first and second electrical information related to the induction coil (6) are provided by an algorithm calculating maximum and minimum peak values of resonance capacitor voltage by reconstructing a sinusoidal wave based on sampled values of said resonance capacitor voltage.

15. Method for operating an induction hob, the induction hob comprising a circuitry (1a) for powering at least one induction coil (6), the circuitry (1a) comprising a power circuit portion (7) with at least one switching element (4, 5) adapted to provide pulsed electric power to said induction coil (6) and an oscillating circuit portion (9) comprising at least one resonance capacitor (9.1, 9.2) which is associated with a resonance capacitor voltage, said induction coil (6) being electrically coupled with said power circuit portion (7) and said oscillating circuit portion (9), wherein said induction hob comprises a control entity (10) performing the steps of:

- providing and/or receiving resonance capacitor information, for example resonance capacitor voltage information, specifically sampled resonance capacitor voltage values;
- applying a discrete mathematical transformation to the resonance capacitor information thereby obtaining modified resonance capacitor information, specifically modified resonance capacitor voltage information;
- calculating first and second electrical information related to the induction coil (6), specifically information regarding the amplitude of the electric current (Ic) provided through said induction coil (6) and information regarding the phase delay between the electric current (Ic) provided through said induction coil (6) and the voltage applied to the induction coil (6) based on said modified resonance capacitor information.

Amended claims in accordance with Rule 137(2) EPC.

1. Induction hob comprising a circuitry (1a) for powering at least one induction coil (6), the circuitry (1a) comprising a power circuit portion (7) with at least one switching element (4, 5) adapted to provide pulsed electric power to said induction coil (6) and an oscillating circuit portion (9) comprising at least one resonance capacitor (9.1, 9.2) which is associated with a resonance capacitor voltage, said induction coil (6) being electrically coupled with said power circuit portion (7) and said oscillating circuit portion (9), wherein said induction hob comprises a control entity (10), said control entity (10) being configured to provide and/or receive resonance capacitor information, the information being sampled resonance capacitor voltage values, applying a discrete mathematical transformation to the resonance capacitor information thereby obtaining modified resonance capacitor information, said control entity (10) being further configured to calculate first and second electrical information related to the induction coil (6), the information being information regarding the amplitude of the electric current (Ic) provided through said induction coil (6) and information regarding the phase delay between the electric current (Ic) provided through said induction coil (6) and the voltage applied to the induction coil (6) based on said modified resonance capacitor information.
2. Induction hob according to claim 1, wherein said first and/or second electrical information related to the induction coil (6) is calculated without considering information indicative for a voltage provided at a circuit node located between a pair of switching elements (4, 5).
3. Induction hob according to claim 1 or 2, wherein said discrete mathematical transformation is a discrete cosine transformation.
4. Induction hob according to anyone of the preceding claims, wherein said discrete mathematical transformation is based on sine and cosine reference convolution signals, said sine and cosine reference convolution signals being calculated based on information regarding the frequency of the electric current (Ic) provided through said induction coil (6) and the sampling frequency based on which the sampled resonance capacitor voltage is obtained.
5. Induction hob according to claim 4, wherein said sine and cosine reference convolution signals are based on the following formulas:

$$\omega = 2 \cdot \pi \cdot inFreq$$

$$\cos REF(k) = \cos\left((k-1) \cdot \omega \cdot \Delta t_{SAMPLE,S}\right);$$

$$\cos REF ACC(k) = \sum_{i=1}^{i=k-1} \cos REF(i) + \cos REF(k);$$

$$\sin REF(k) = \sin((k-1) \cdot \omega \cdot \Delta t_{SAMPLE,S});$$

5

$$\sin REF ACC(k) = \sum_{i=1}^{i=k-1} \sin REF(i) + \sin REF(k);$$

wherein

10

infreq is the frequency of the current flowing through the induction coil;

k is an index indicating a certain sample value;

cosREF ACC and sinREF ACC are accumulators; and

$\Delta t_{SAMPLE,S}$ is the time span between two consecutive sampling values.

15

6. Induction hob according to anyone of the preceding claims, said sine and cosine reference convolution signals are based on the following formulas:

20

$$averageCOS = \frac{\cos REF ACC}{bufferlength};$$

$$averageSIN = \frac{\sin REF ACC}{bufferlength};$$

25

$$\cos REF(k) = \cos REF(k-1) - averageCOS;$$

30

$$\sin REF(k) = \sin REF(k-1) - averageSIN;$$

wherein

bufferlength is calculated based on the following formula:

35

$$bufferlength = trunc(\frac{1}{inFreq \cdot \Delta t_{SAMPLE,S}});$$

40

wherein inFreq is the frequency of the electric current (Ic) provided through said induction coil (6).

7. Induction hob according to claim 6, wherein fitting signals are calculated as follows:

45

$$accCos(k) = \sum_{i=1}^{i=k-1} \cos REF(i) \cdot inputSample(i) + \cos REF(k) \cdot inputSample(k);$$

50

$$accSin(k) = \sum_{i=1}^{i=k-1} \sin REF(i) \cdot inputSample(i) + \sin REF(k) \cdot inputSample(k);$$

$$accAverageRec(k) = \sum_{i=1}^{i=k-1} inputSample(i) + inputSample(k);$$

55

8. Induction hob according to claim 7, wherein intermediate signal values are calculated as follows:

$$\cos EST = 2 \cdot accCos \cdot inFreq \cdot \Delta t_{SAMPLE,S};$$

$$\sin EST = 2 \cdot accSin \cdot inFreq \cdot \Delta t_{SAMPLE,S};$$

$$avgEst = \frac{accAverageRec}{bufferLength};$$

9. Induction hob according to anyone of the preceding claims, wherein maximum and minimum values of resonance capacitor voltage and phase delay value are calculated as follows:

$$peakValue = \sqrt{\cos Est^2 + \sin Est^2};$$

$$VcMax = avgEst + peakValue;$$

$$VcMin = avgEst - peakValue;$$

$$phaseDelay Vc = \tan^{-1}\left(\frac{\sin Est}{\cos Est}\right).$$

10. Induction hob according to claim 9, wherein the peak value of the electric current (Ic) provided through said induction coil (6) is calculated based on the following formula:

$$Ic = 2\pi f(VcMax - VcMin) \cdot Cres;$$

wherein Cres is the capacity value of the resonance capacitor (9.1, 9.2) and f is the switching frequency applied to the induction coil (6).

11. Induction hob according to anyone of claims 8 to 10, wherein a compensated phase delay between the electric current (Ic) provided through said induction coil (6) and the voltage applied to the induction coil (6) is calculated based on the following compensation formulas:

$$\sin Comp = \frac{2\pi(\cos Est \cdot \cos(4\pi K) - \cos Est + \sin Est \cdot \sin(4\pi K) + 4\pi \cdot \sin Est \cdot K)}{\cos(4\pi K) + 8K^2\pi^2 - 1};$$

$$\cos Comp$$

$$= -\left(\frac{2\pi(\sin Est + \cos Est \cdot \sin(4\pi K) - \sin Est \cdot \cos(4\pi K) - 4\pi \cdot \cos Est \cdot K)}{\cos(4\pi K) + 8K^2\pi^2 - 1}\right);$$

wherein K is a compensation coefficient calculated as:

$$K = numSample \cdot \Delta t_{SAMPLE,S} \cdot inFreq;$$

12. Induction hob according to claim 11, wherein a compensated phase delay is computed based on the following formula:

$$peakValueComp = \sqrt{\cos Comp^2 + \sin Comp^2};$$

$$VcMaxComp = avgEst + peakValueComp;$$

$$VcMinComp = avgEst - peakValueComp;$$

$$phaseDelayVcVomp = \tan^{-1} \frac{\sin Comp}{\cos Comp};$$

$$IcComp = 2\pi f(VcMaxComp - VcMinComp) \cdot Cres;$$

13. Induction hob according to claim 12, wherein an estimated average power value is calculated based on the following formula:

$$avgPowerEst = \frac{\sum_{k=1}^{nSamples} Vmain(k) \cdot Ic_{Est}(k) \cdot PhM_Est(k)}{2 * MainLineFreq};$$

wherein Vmain is the rectified value of main line voltage at sample k, I_{cEst} is the estimated value of compensated or uncompensated coil current obtained by the resonance capacitor analysis and PhM_Est is the compensated or uncompensated phase delay obtained by the resonance capacitor analysis.

14. Induction hob according to anyone of the preceding claims, comprising no current transducer (8) electrically coupled with the induction coil (6), wherein said first and second electrical information related to the induction coil (6) are provided by an algorithm calculating maximum and minimum peak values of resonance capacitor voltage by reconstructing a sinusoidal wave based on sampled values of said resonance capacitor voltage.

15. Method for operating an induction hob, the induction hob comprising a circuitry (1a) for powering at least one induction coil (6), the circuitry (1a) comprising a power circuit portion (7) with at least one switching element (4, 5) adapted to provide pulsed electric power to said induction coil (6) and an oscillating circuit portion (9) comprising at least one resonance capacitor (9.1, 9.2) which is associated with a resonance capacitor voltage, said induction coil (6) being electrically coupled with said power circuit portion (7) and said oscillating circuit portion (9), wherein said induction hob comprises a control entity (10) performing the steps of:

- providing and/or receiving resonance capacitor information, for example resonance capacitor voltage values;
- applying a discrete mathematical transformation to the resonance capacitor information thereby obtaining modified resonance capacitor information,;
- calculating first and second electrical information related to the induction coil (6), the first and second electrical information being information regarding the amplitude of the electric current (Ic) provided through said induction coil (6) and information regarding the phase delay between the electric current (Ic) provided through said induction coil (6) and the voltage applied to the induction coil (6) based on said modified resonance capacitor information.

FIG 1

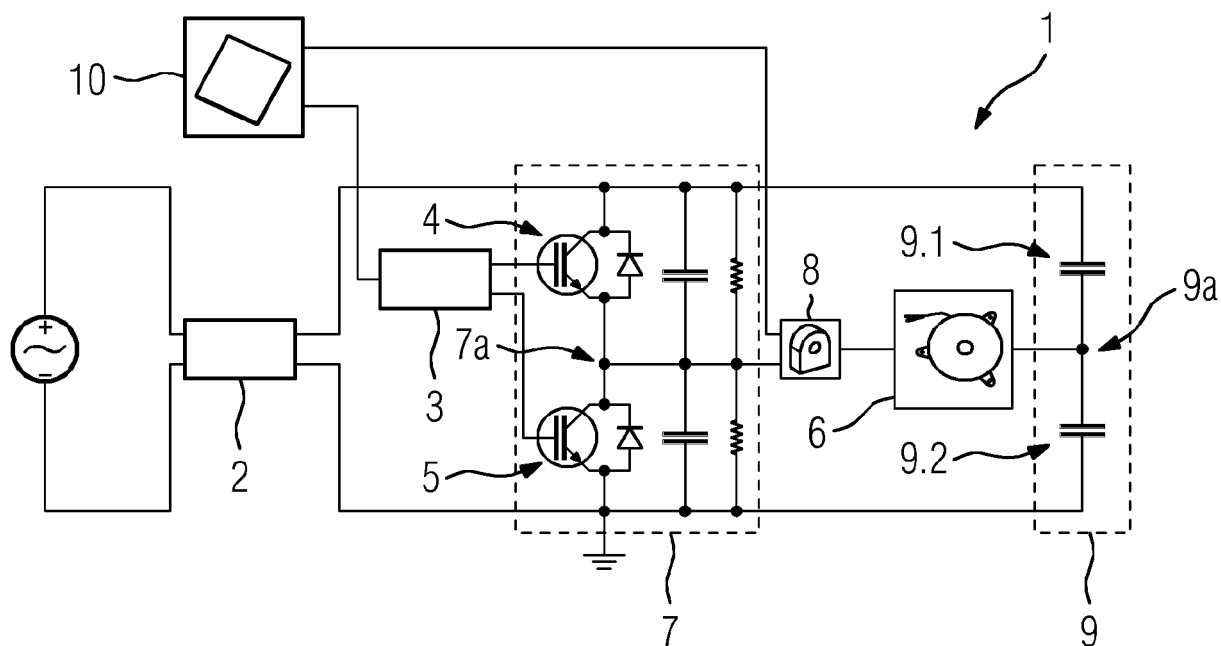


FIG 2

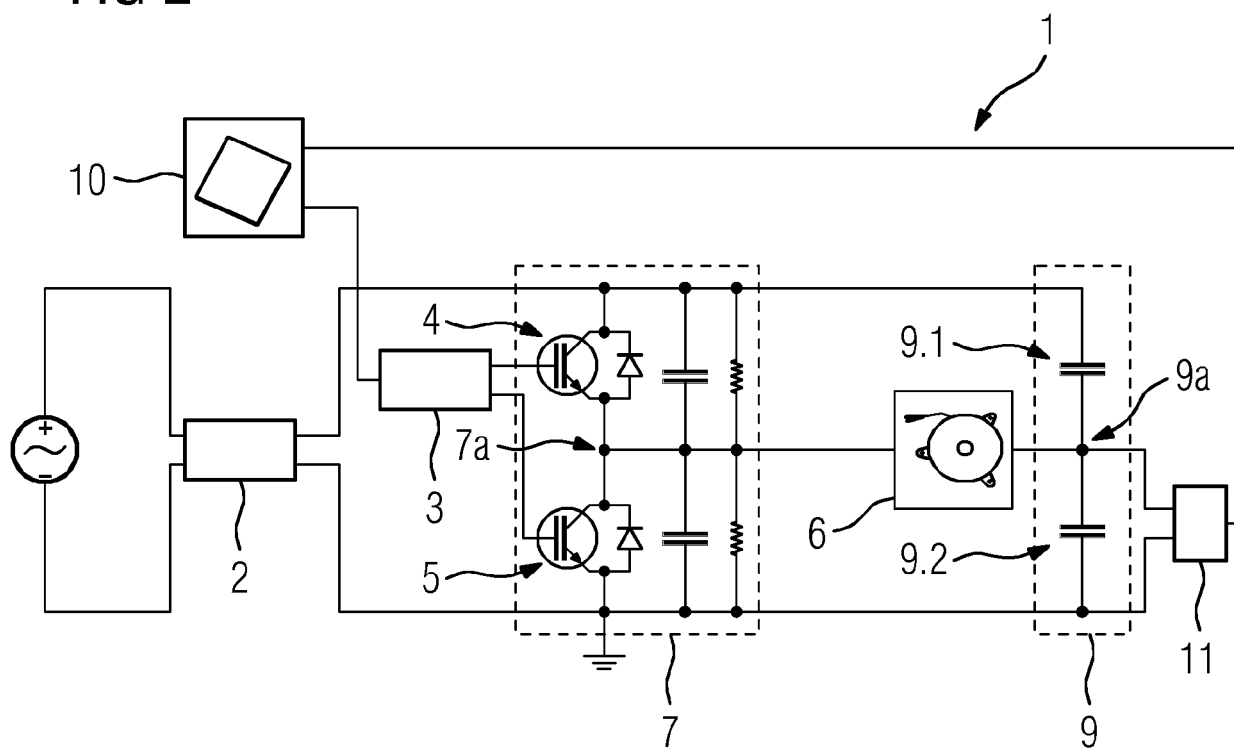


FIG 3

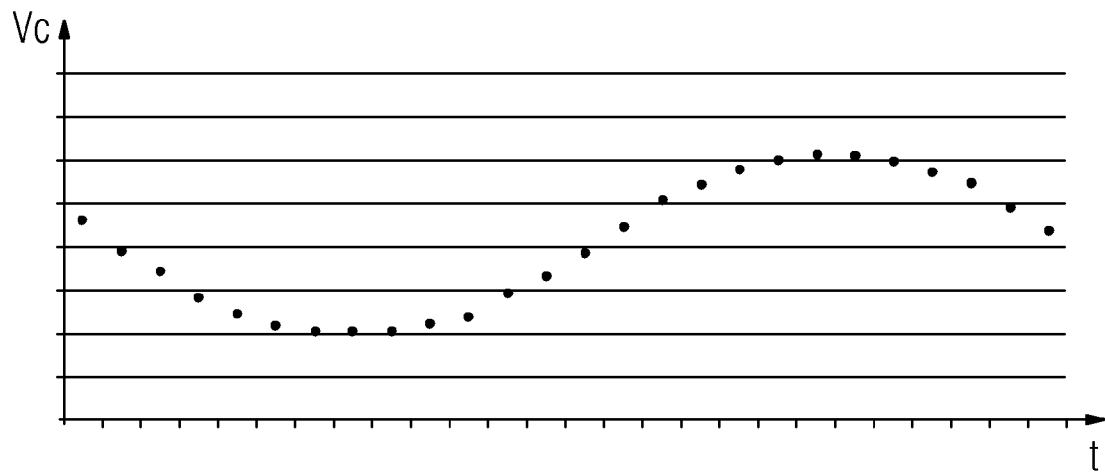
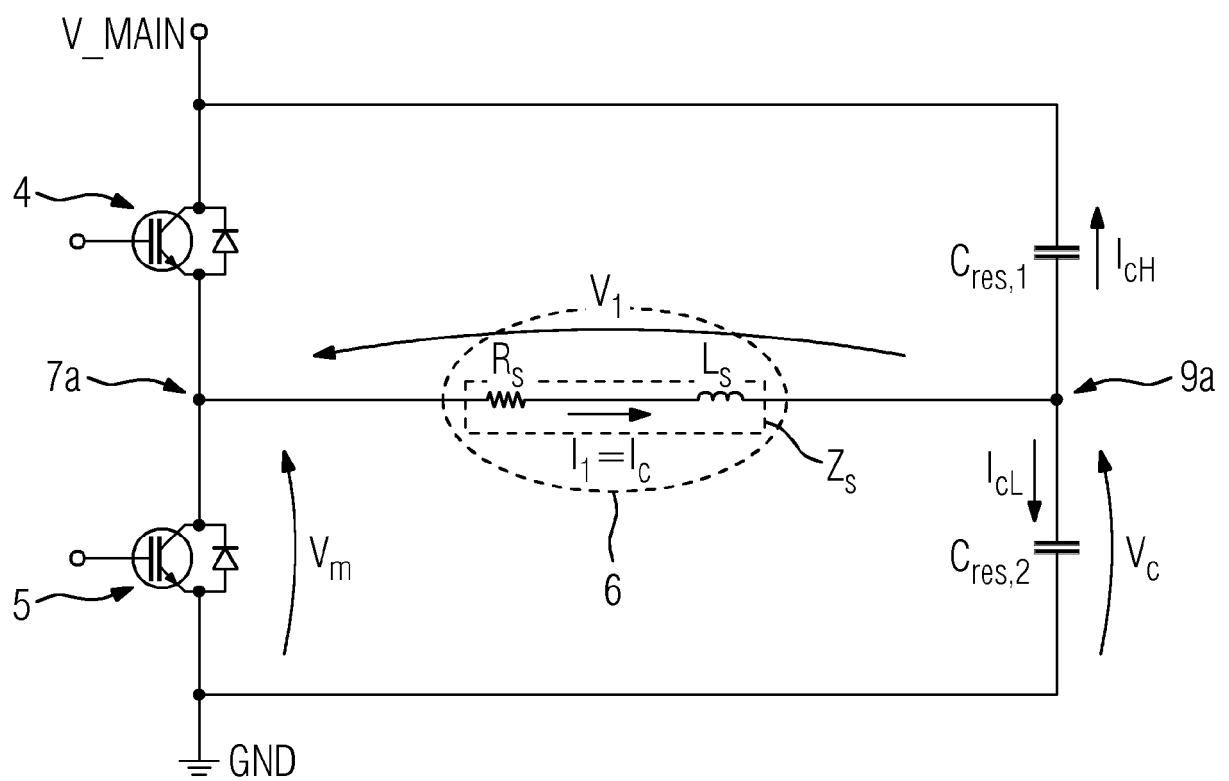


FIG 4





EUROPEAN SEARCH REPORT

Application Number
EP 18 15 9692

5

10

15

20

25

30

35

40

45

50

55

1

EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 3 030 041 A1 (BSH HAUSGERÄTE GMBH [DE]) 8 June 2016 (2016-06-08)	1,14,15	INV. H05B6/06
A	* abstract * * paragraph [0004] - paragraph [0007] * * paragraph [0013] - paragraph [0017] * * paragraph [0021] - paragraph [0022] * * paragraph [0025] - paragraph [0027] * * paragraph [0030] - paragraph [0037] * * figures 1-4 *	2-13	
X	EP 2 334 142 A1 (PANASONIC CORP [JP]) 15 June 2011 (2011-06-15)	1,15	TECHNICAL FIELDS SEARCHED (IPC)
A	* abstract * * paragraph [0011] * * paragraph [0019] - paragraph [0021] * * paragraph [0038] - paragraph [0039] * * paragraph [0047] * * paragraph [0062] - paragraph [0066] * * paragraph [0070] - paragraph [0072] * * paragraph [0091] - paragraph [0093] * * figures 1-10 *	2-14	
A	EP 1 528 839 A1 (LG ELECTRONICS INC [KR]) 4 May 2005 (2005-05-04)	1-15	H05B
	* abstract * * paragraph [0006] * * paragraph [0035] - paragraph [0039] * * paragraph [0047] - paragraph [0050] * * figures 2-6 *		
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 9 August 2018	Examiner Chelbosu, Liviu
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 15 9692

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-08-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 3030041 A1	08-06-2016	EP 3030041 A1	08-06-2016
		ES 2573144 A1	06-06-2016
		ES 2643542 T3	23-11-2017

EP 2334142 A1	15-06-2011	CN 102177765 A	07-09-2011
		EP 2334142 A1	15-06-2011
		JP 5309148 B2	09-10-2013
		JP W02010041354 A1	01-03-2012
		US 2011192838 A1	11-08-2011
		WO 2010041354 A1	15-04-2010

EP 1528839 A1	04-05-2005	CN 1612646 A	04-05-2005
		EP 1528839 A1	04-05-2005
		JP 2005129539 A	19-05-2005
		KR 20050039970 A	03-05-2005
		US 2005087526 A1	28-04-2005
