

DESCRIPTION

Method of Controlling Preheating Power and Preheating System

Technical Field

5 The present invention relates to a motor and especially to a technique for maintaining constant power consumption in preheating a compressor motor in an air conditioner. It also relates to a technique for preheating a compressor motor driven by a pulse-width modulation inverter.

10 Background Art

Conventionally, lubricating oil has been employed for reducing friction at a motor bearing. This technique is also employed in compressor motors in air conditioners.

15 The compressor motors in air conditioners in particular handle refrigerant and have the characteristic that at low temperatures, the refrigerant is soluble in refrigeration oil which is lubricating oil. When driven at low temperatures, the compressor motors in air conditioners rotate with the refrigeration oil in small concentrations. Thus, there is a high possibility that sliding portions of the compressors will seize up by friction.

20 To prevent such a problem, there has been employed a technique for providing a crank heater around a compressor motor to preheat the motor before it rotates and thereby to reduce the solubility of refrigeration oil in refrigerant. Further, especially for the purpose of preheating a compressor motor driven by an inverter, there has also been employed a technique for, without providing a crank heater, supplying current
25 from the inverter to the compressor motor on the condition that the motor should not be

rotated. The current waveform not to rotate the motor is achieved, for example, by increasing frequency while reducing supply current or by employing direct current.

The technique in which the inverter supplies current on the above condition so that the compressor motor preheats itself, however, has a problem of being highly susceptible to variations in supply power. For example if the current waveform is determined to give 35W of power consumption by preheating for a receiving voltage of 200 V, an increase of the receiving voltage to 220 V increases the power consumption by preheating to approximately 42 W, i.e., by a factor of $(220/200)^2$. This results in excessive power consumption. A decrease of the receiving voltage to 180 V, on the other hand, reduces the power consumption by preheating to approximately 28 W, i.e., by a factor of $(180/200)^2$. This results in insufficient preheating and thereby raises the possibility that the solubility of refrigeration oil in refrigerant cannot be reduced sufficiently.

15 Disclosure of the Invention

The present invention has been made in view of the above circumstances and provides a technique for permitting constant preheating of a motor irrespective of variations in receiving voltage. The present invention also provides a technique for giving constant preheating power irrespective of a temperature of a coil of a motor.

20

A first aspect of the present invention is directed to a method of controlling preheating power of a coil (L_U , L_W) of a polyphase motor (30), said polyphase motor being driven by an inverter and operated in open-phase to generate heat, including the steps of;

applying current from the inverter to said coil (L_U , L_W) for preheating the polyphase motor,

25

wherein said current is applied with a predetermined period (T), on a condition that said polyphase motor should not be rotated, and as a DC voltage (V_m) applied to said inverter increases, a duty (D) which is the ratio between time during which the voltage is applied to said coil and said period, is set to a smaller value.

According to a second aspect of the present invention, in the method of controlling preheating power according to the second aspect, the current produces no revolving field for the polyphase motor in preheating the polyphase motor.

According to a third aspect of the present invention, in the method of
10 controlling preheating power according to either one of the first through third aspects, the polyphase motor is a compressor motor in an air conditioner.

According to a fourth aspect of the present invention, in the method of
controlling preheating power according to the second aspect, the polyphase motor is a
three-phase motor, the inverter is a three-phase inverter, each phase having a pair of
15 positive and negative switching elements (Q_U , Q_V , Q_W , Q_X , Q_Y , Q_Z), and the period includes: a first period (t_{on}) during which the positive switching element (Q_U) in a first phase (U) is in the on state, the negative switching element (Q_Z) in a second phase (W) is in the on state, and the positive and negative switching elements (Q_V , Q_Y) in a third phase (V) are complementarily in the on state for an equal length of time; and a second
20 period (t_{off}) during which, in all of the first, second, and third phases, either the positive switching elements (Q_U , Q_V , Q_W) are in the on state or the negative switching elements (Q_X , Q_Y , Q_Z) are in the on state.

According to a fifth aspect of the present invention, in the method of
controlling preheating power according to either one of the second and fifth aspects, the
25 duty is set to a value obtained by dividing a product of a known calibrated voltage (V_{ref}),

a known calibrated current (I_{ref}), and a known calibrated duty (D_0) by a product of a current (I_m) and a voltage (V_m) applied to the motor.

According to a sixth aspect of the present invention, in the method of controlling preheating power according to the second aspect, the duty is set to a larger value as a temperature of the polyphase motor increases.

According to a seventh aspect of the present invention, in the method of controlling preheating power according to the second aspect, the preheating is performed on refrigeration oil in a compressor.

An eighth aspect of the present invention, is directed to a preheating system comprising: a polyphase motor (30) having coils (L_u , L_w); and an operation control unit for operating the polyphase motor open-phase to generate heat, wherein

the operation control unit includes an inverter (15), the inverter applying current to the polyphase motor with a predetermined period (T), on a condition that the polyphase motor should not be rotated, and as a DC voltage (V_m) applied to the inverter increases, a duty (D) which is the ratio between time during which the voltage is applied to the coil and the period, is set to a smaller value.

According to a ninth aspect of the present invention, in the preheating system according to the tenth aspect, in the preheating of the polyphase motor, the current produces no revolving field for the polyphase motor.

According to a tenth aspect of the present invention, in the preheating system according to either one of the ninth through eleventh aspects, the polyphase motor is a compressor motor in an air conditioner.

According to an eleventh aspect of the present invention, in the preheating system according to the tenth aspect, the polyphase motor is a three-phase motor, the

inverter is a three-phase inverter, each phase having a pair of positive and negative switching elements (Q_U , Q_V , Q_W , Q_X , Q_Y , Q_Z), and the period includes: a first period (t_{on}) during which the positive switching element (Q_U) in a first phase (U) is in the on state, the negative switching element (Q_Z) in a second phase (W) is in the on state, and the positive and negative switching elements (Q_V , Q_Y) in a third phase (V) are complementarily in the on state for an equal length of time; and a second period (t_{off}) during which, in all of the first, second, and third phases, either the positive switching elements (Q_U , Q_V , Q_W) are in the on state or the negative switching elements (Q_X , Q_Y , Q_Z) are in the on state.

According to a twelfth aspect of the present invention, in the preheating system according to either one of the tenth and thirteenth aspects, the duty is set to a value obtained by dividing a product of a known calibrated voltage (V_{ref}), a known calibrated current (I_{ref}), and a known duty (D_0) by a product of a current (I_m) and a voltage (V_m) applied to the motor.

According to a thirteenth aspect of the present invention, in the preheating system according to the tenth aspect, the duty is set to a larger value as a temperature of the polyphase motor increases.

According to a fourteenth aspect of the present invention, in the preheating system according to the tenth aspect, the preheating is performed on refrigeration oil in a compressor.

In the method of controlling preheating power according to the first aspect of the present invention and in the preheating system according to the eighth aspect, the polyphase motor is operated open-phase to generate heat and thereby to be preheated.

In the method of controlling preheating power according to the first aspect of the present invention and in the preheating system according to the eighth aspect,

since variations in the DC voltage applied to the inverter are compensated by varying the duty, preheating can be achieved with predetermined power irrespective of the variations in the DC voltage. This avoids excess power consumption and insufficient preheating.

5 In the method of controlling preheating power according to the second aspect of the present invention and in the preheating system according to the ninth aspect, since no revolving field is provided for the polyphase motor, the polyphase motor can be preheated without being rotated. This prevents the occurrence of such mutually contradictory phenomena that heat generation causes the bearing to be worn out.
10 Besides, the generation of sound can be minimized because a so-called "slip" is not utilized which is a phenomenon that the revolving field is produced but the motor is not rotated.

In the method of controlling preheating power according to the third aspect of the present invention and in the preheating system according to the eleventh aspect, the
15 solubility of lubricating oil in refrigerant which is handled by the compression motor in the air conditioner, can be reduced. This prevents a situation in which, with refrigeration oil which is lubricating oil being dissolved in refrigerant and reduced in concentration, the motor is rotated and thereby the bearing will seize up by friction.

In the method of controlling preheating power according to the fourth aspect of
20 the present invention and in the preheating system according to the twelfth aspect, during the first period, the positive and negative switching elements in the third phase are complementarily in the on state for an equal length of time; therefore, substantially no current flows to the coil in the third phase in the polyphase motor. During the second period, the inductance of the coils in the first and second phases in the motor
25 maintains the current flow occurring during the first period. Accordingly, current

continues to flow in the same direction to the series connection of the coils in the first and second phases, which allows almost constant current to continuously flow to the motor without generating a revolving field.

5 In the method of controlling preheating power according to the fifth aspect of the present invention and in the preheating system according to the thirteenth aspect, the duty is the value obtained by dividing desired power by the product of current and voltage applied to the motor. This allows constant preheating power to be given irrespective of the values of current and voltage applied to the motor.

10 With increase in temperature, the DC resistance of the coil increases and the current flowing to the motor decreases. In the method of controlling preheating power according to the seventh aspect of the present invention and in the preheating system according to the fifteenth aspect, however, preheating power can be increased by increasing the duty. Accordingly, the preheating power can be set to a desired value irrespective of the temperature of the polyphase motor.

15 In the method of controlling preheating power according to the seventh aspect of the present invention and in the preheating system according to the fourteenth aspect, refrigeration oil is hardly soluble in refrigerant and thus the motor can be prevented from being rotated with the refrigeration oil reduced in concentration. This prevents a sliding portion of the compressor from seizing up by friction.

20 These and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

Brief Description of Drawings

25 Fig. 1 is a circuit diagram for explaining a first embodiment of the present

invention;

Figs. 2 to 5 are circuit diagrams for explaining operations according to the first embodiment of the present invention;

Fig. 6 is a graph for explaining the operations according to the first
5 embodiment of the present invention; and

Fig. 7 is a circuit diagram for explaining a second embodiment of the present invention.

Best Mode for Carrying Out the Invention

10 First Embodiment

Fig. 1 is a circuit diagram illustrating a compressor motor 30 and its driving circuit in an air conditioner, to which a control method according to a first embodiment of the present invention is applied. For example, a voltage supplied from a three-phase AC power supply 10 is converted into a DC current with a ripple by a diode
15 bridge 11 of a well-known configuration. The DC current is then passed through, for example, a choke input filter and a DC voltage is applied to an inverter 15. The inverter 15 performs switching of pulse-width modulation under the control of a control circuit 20 and supplies, for example, a three-phase AC voltage to a motor 30.

The choke input filter, as shown in Fig. 1, is configured of a capacitor 13
20 having one end connected to a negative output terminal of the diode bridge 11 and the other end, and an inductor 12 interpolated between the other end of the capacitor 13 and a positive output terminal of the diode bridge 11. The negative output terminal of the diode bridge 11 is grounded, for example.

The control circuit 20 is configured for example of a central processing unit
25 and controls the operation of the inverter 15. In normal operation, as a matter of

course, the inverter 15 is caused to rotate the motor 30, while in preheating operation, the inverter 15 is caused to perform switching of power supply to the motor 30 without rotating the motor 30. The control circuit 20 has two analog input ports AN0 and AN1, the former receiving a detected value of voltage V_m from a voltage detecting circuit 21 and the latter receiving a detected value of current I_m from a current detecting circuit 22.

The voltage detecting circuit 21 is configured for example of a filter. It measures a voltage at the junction between the inductor 12 and the capacitor 13 and outputs it as the detected value of voltage V_m . The current detecting circuit 22 is configured for example of a peak hold circuit or an averaging circuit. It measures a current flowing between the negative output terminal of the diode bridge 11 and the inverter 15 and outputs it as the detected value of current I_m . For the current measurement, a resistor 14 is interpolated, for example, between the negative output terminals of the diode bridge 11 and the inverter 15, and a voltage drop at the resistor 14 is measured. As long as the voltage and current applied to the motor 30 can be measured, the measurements may be made in ways other than the above embodiment; for example, the voltage and current may be measured at positions closer to the AC voltage supply 10 than to the diode bridge 11.

Figs. 2 to 5 are circuit diagrams for explaining the operation of the inverter 15, in which, for the purpose of preheating a coil of the motor 30, a DC current is supplied so that the motor 30 generates heat through its so-called open-phase operation. In either of the drawings, the voltage applied between the positive and negative input terminals of the inverter 15 is indicated as a virtual power supply E_d . Transistors Q_U , Q_V , Q_W , Q_X , Q_Y , and Q_Z are respectively a positive switching transistor in U phase, a positive switching transistor in V phase, a positive switching transistor in W phase, a

negative switching transistor in the U phase, a negative switching transistor in the V phase, and a negative switching transistor in the W phase. The motor 30 further has a Y connection of a U-phase coil L_U , a V-phase coil L_V , and a W-phase coil L_W .

A pair of the transistors Q_U and Q_X , a pair of the transistors Q_V and Q_Y , and a pair of the transistors Q_W and Q_Z each are connected in series between the positive and negative input terminals of the inverter 15. In each phase, a connection is established between the junction of the pair of transistors and the coil of the motor 30. In each pair, the positive and negative switching transistors are never turned on at the same time. The description in this embodiment is given without reference to a so-called dead time during which both the positive and negative transistors are turned off at the same time.

In the drawings, both the thick and thin solid lines indicate conducting paths, and the broken line indicates non-conducting paths. The thick solid line indicates a path through which current substantially flows, whereas the thin solid line indicates a path through which current does not flow substantially. Hereinbelow, this embodiment illustrates the case where the current substantially flows from the U phase to the V phase, but it goes without saying that those phases may be any other combination of two phases.

Figs. 2, 3, 4, and 5 illustrate the paths of current flowing responsive to voltage vectors V_0 , V_4 , V_6 , and V_7 , respectively. The expression of the voltage vector V_k can be determined from $k = 2^2 B_U + 2^1 B_V + 2^0 B_W$, where B_U , B_V , and B_W are variables for the U, V, and W phases, respectively, each representing the "ON" state of the positive switching transistor as a value of 1 and the "ON" state of the negative switching transistor as a value of 0. A transition from such one voltage vector to another is achieved by the control circuit 20 that controls voltages applied to the gates

of the switching transistors Q_U , Q_V , Q_W , Q_X , Q_Y , and Q_Z .

Referring to Fig. 2, in either of the U, V, and W phases, the negative switching transistor Q_X , Q_Y , or Q_Z is in the on state; therefore, no voltage is applied to the motor 30. However, the inductance of the U-phase coil L_U , the V-phase coil L_V , and the W-phase coil L_W of the motor 30 maintains the current flow responsive to the other voltage vectors. In voltage vector forms described later, current flows from the U-phase coil L_U to the W-phase coil L_W ; thus, the maintenance of such current flow is illustrated in Fig. 2.

Referring to Fig. 3, the positive switching transistor Q_U in the U phase and the negative switching transistors Q_Y and Q_Z in the V and W phases are in the on state. Thus, a voltage E_d is applied to the series connection between the U-phase coil L_U and the W-phase coil L_W . At this time, the voltage E_d is also applied to the series connection between the U-phase coil L_U and the V-phase coil L_V ; therefore, a transient current can flow from the U-phase coil L_U to the V-phase coil L_V .

Referring to Fig. 4, the positive switching transistors Q_U and Q_V in the U and V phases and the negative switching transistor Q_Z in the W phase are in the on state. Thus, the voltage E_d is applied to the series connection between the U-phase coil L_U and the W-phase coil L_W . At this time, the voltage E_d is also applied to the series connection between the V-phase coil L_V and the W-phase coil L_W ; therefore, a transient current can flow from the V-phase coil L_V to the W-phase coil L_W .

Referring to Fig. 5, in either of the U, V, and W phases, the positive switching transistor Q_U , Q_V , or Q_W is in the on state; therefore no voltage is applied to the motor 30. However, as in the case of the voltage vector V_0 , the current flow from the U-phase coil L_U to the W-phase coil L_W is maintained, which is illustrated in Fig. 5.

These four voltage vector forms are periodically repeated by the inverter 15. In

the cases of the voltage vectors V_4 and V_6 , the flows of current to the V-phase coil L_V are opposite in direction. Thus, if the inverter 15 is driven for an equal length of time in both the above cases and the four voltage vector forms are repeated at some frequency, little current flows to the V-phase coil L_V on account of the inductance.

5 Accordingly, substantially no current flows to the V-phase coil L_V when the current flows from the U-phase coil L_U to the W-phase coil L_W .

If the four voltage vector forms V_0 , V_4 , V_6 , and V_7 are repeated in this order with a period T , no voltage is applied to the motor 30 throughout the periods of the voltage vectors V_0 and V_7 , whereas the voltage E_d is applied to the motor 30 throughout the
10 periods of the voltage vectors V_4 and V_6 . Besides, although the current continues to flow to the motor 30, no revolving field is provided and thus the motor 30 generates heat without being rotated. This prevents the occurrence of such mutually contradictory phenomena that heat generation causes the bearing to be worn out and thereby allows preheating of refrigeration oil in the motor 30.

15 Fig. 6 is a graph illustrating the voltage applied to the series connection between the U and W phases, i.e., between the U-phase coil L_U and the W-phase coil L_W , with the passage of time. The period t_{on} is the sum of the periods during which the voltage vectors V_4 and V_6 are realized, and the period t_{off} is the sum of the periods during which the voltage vectors V_0 and V_7 are realized. In other words, the period t_{on}
20 is the period during which the positive switching transistor Q_U in the U phase and the negative switching transistor Q_Z in the W phase are in the on state and the positive and negative switching transistors Q_V and Q_Y in the V phase are complementarily in the on state for an equal length of time. The period t_{off} is the period during which, in all the phases, either the positive switching transistors Q_U , Q_V , and Q_W are in the on state or
25 the negative switching transistors Q_X , Q_Y , and Q_Z are in the on state. As above

described, without reference to the dead time, the following equation holds:

$T = t_{on} + t_{off}$. A duty that the voltage E_d is on during the period T can be expressed as

$$D = t_{on} / T.$$

Now, power consumption that would be desirable for preheating is
 5 predetermined as W_{ref} . Further, the detected values of voltage V_m and current I_m for
 the receiving voltage of 200 V, for example, are previously stored in the control circuit
 20 as a calibrated voltage V_{ref} and a calibrated current I_{ref} , respectively. To give the
 desired power consumption W_{ref} by controlling the inverter 15, it is desirable that
 $D = W_{ref} / (V_{ref} \cdot I_{ref})$ since it is assumed that the motor 30 receives a voltage of
 10 $(V_{ref} \cdot D)$ on average and the current I_{ref} continuously flows throughout all the periods.
 The value of the duty D at this time is also stored as a calibrated duty D_0 . That is,
 when the receiving voltage is a predetermined voltage, the duty D is varied while
 measuring preheating power consumed by the motor 30, whereby the duty D and the
 detected value of current I_m at the time of the preheating power W_{ref} is defined as the
 15 calibrated duty D_0 and the calibrated current I_{ref} .

In preheating after such calibration, the duty D is controlled to be equal to
 $D_0 \times (V_{ref} \cdot I_{ref}) / (V_m \cdot I_m)$. This gives $D \cdot V_m \cdot I_m = D_0 \cdot V_{ref} \cdot I_{ref} = W_{ref}$, thereby
 allowing the generation of desired preheating power. As has previously been
 described, the detected values of voltage V_m and current I_m are given into of the
 20 control circuit 20 via the analog input ports AN0 and AN1 respectively, and the
 calibrated duty D_0 , the calibrated current I_{ref} , and the calibrated voltage V_{ref} are stored in
 the control circuit 20. Therefore, if the control circuit 20 controls the periods during
 which the voltage vectors V_0 , V_4 , V_6 , and V_7 are realized, the duty D can be varied
 according to the above equation.

25 With the above operations, even if the detected values of voltage V_m and

current I_m change with variations in the receiving voltage, those changes can be cancelled by the duty D . This allows preheating with constant power consumption W_{ref} , i.e., avoids both excessive power consumption and insufficient preheating.

While the present invention has been described with reference to the embodiment that employs the voltage vector forms which do not produce the revolving field, even if the revolving field is produced, the transition of the voltage vectors should be made at frequencies not to rotate the motor 30. In this case, however, a so-called "motor slip" occurs and thereby the sound from the motor becomes louder. From this point, this embodiment is more advantageous.

Second Preferred Embodiment

Fig. 7 is a circuit diagram illustrating the compressor motor 30 and its driving circuits in the air conditioner, to which a control method according to a second embodiment of the present invention is applied. This embodiment differs from the first embodiment in that the motor 31 comprises a temperature sensing element 31, from which the control circuit 20 receives data.

The magnitude of the impedance of the motor 30 can be generally expressed by $Z = (\omega^2 L^2 + R^2)^{1/2}$, where R is the DC resistance of a coil of the motor, L is the inductance, and ω is the frequency of a given current. If the current flow is constant as in the first embodiment, the impedance can roughly be determined by the DC resistance R .

Here, the DC resistance R of the coil has temperature dependence that it increases with temperature. Thus, where the detected value of voltage V_m is constant, the detected value of current I_m decreases with increasing temperature, and where the duty D is also constant, preheating power decreases as well. Compensation for

preheating can be made even with such temperature variations in the impedance of the motor 30.

More specifically, the temperature of the motor 30 is measured by the temperature sensing element 31 and the data obtained is transmitted to the control circuit 20. By previously inputting the temperature dependence of the DC resistance R to the control circuit 20, control can be exercised to cancel the temperature dependence by increasing the value of the duty, for example, with increasing temperature obtained from the temperature sensing element 31. The reason for increasing the value of the duty is to increase an average value of the voltage applied to the motor and thereby to increase preheating power. That is, preheating power can be set to a desired value irrespective of the temperature of the motor 30.

This technique is also applicable to the case where alternating current is applied to the motor 30 for heat generation.

While the invention has been shown and described in detail, the foregoing description is in all aspects illustrative and not restrictive. It is therefore understood that numerous modifications and variations can be devised without departing from the scope of the invention.

Claims

1. A method of controlling preheating power of a coil (L_U , L_W) of a polyphase motor (30), said polyphase motor being driven by an inverter and
5 operated in open-phase to generate heat, including the steps of:
applying current from the inverter to said coil (L_U , L_W) for preheating the polyphase motor,
wherein said current is applied with a predetermined period (T), on a condition that said polyphase motor should not be rotated, and as a DC voltage (V_m) applied to said
10 inverter increases, a duty (D) which is the ratio between time during which the voltage is applied to said coil and said period, is set to a smaller value.
2. The method claimed in claim 1, wherein
in said preheating of said polyphase motor, said current produces no revolving field
15 for said polyphase motor.
3. The method claimed in claim 1 or claim 2, wherein
said polyphase motor is a compressor motor in an air conditioner.
- 20 4. The method claimed in claim 1, wherein
said polyphase motor is a three-phase motor,
said inverter is a three-phase inverter, each phase having a pair of positive and negative switching elements (Q_U , Q_V , Q_W , Q_X , Q_Y , Q_Z), and
said period includes:
25 a first period (t_{on}) during which said positive switching element (Q_U) in a first phase (U) is in the on state, said negative switching element (Q_Z) in a second phase (W) is in the on state, and said positive and negative switching elements (Q_V , Q_Y) in a third phase (V) are complementarily in the on state for an equal length of time; and
a second period (t_{off}) during which, in all of said first, second, and third phases,
30 either said positive switching elements (Q_U , Q_V , Q_W) are in the on state or said negative switching elements (Q_X , Q_Y , Q_Z) are in the on state.

- 17 -

5. The method claimed in claim 1 or claim 4, wherein
said duty is set to a value obtained by dividing a product of a known calibrated
voltage (V_{ref}), a known calibrated current (I_{ref}), and a known calibrated duty (D_0) by a
5 product of a current (I_m) and a voltage (V_m) applied to said motor.
6. The method of controlling preheating power according to claim 1, wherein
said duty is set to a larger value as a temperature of said polyphase motor increases.
- 10 7. The method of controlling preheating power according to claim 1, wherein
said preheating is performed on refrigeration oil in a compressor.
8. A preheating system comprising:
a polyphase motor (30) having coils (L_U , L_W); and
15 an operation control unit for operating said polyphase motor open-phase to generate
heat, wherein
said operation control unit includes an inverter (15),
said inverter applying current to said polyphase motor with a predetermined period
(T), on a condition that said polyphase motor should not be rotated, and
20 as a DC voltage (V_m) applied to said inverter increases, a duty (D) which is the
ratio between time during which the voltage is applied to said coil and said period, is set to
a smaller value.
9. The preheating system according to claim 8, wherein
25 in said preheating of said polyphase motor, said current produces no revolving field
for said polyphase motor.

- 18 -

10. The preheating system according to either one of claims 8 and 9, wherein said polyphase motor is a compressor motor in an air conditioner.

11. The preheating system according to claim 8, wherein

5 said polyphase motor is a three-phase motor,

said inverter is a three-phase inverter, each phase having a pair of positive and negative switching elements (Q_U , Q_V , Q_W , Q_X , Q_Y , Q_Z), and

said period includes:

10 a first period (t_{on}) during which said positive switching element (Q_U) in a first phase (U) is in the on state, said negative switching element (Q_Z) in a second phase (W) is in the on state, and said positive and negative switching elements (Q_V , Q_Y) in a third phase (V) are complementarily in the on state for an equal length of time; and

15 a second period (t_{off}) during which, in all of said first, second, and third phases, either said positive switching elements (Q_U , Q_V , Q_W) are in the on state or said negative switching elements (Q_X , Q_Y , Q_Z) are in the on state .

12. The preheating system according to either one of claims 8 and 11, wherein

20 said duty is set to a value obtained by dividing a product of a known calibrated voltage (V_{ref}), a known calibrated current (I_{ref}), and a known duty (D_0) by a product of a current (I_m) and a voltage (V_m) applied to said motor.

13. The preheating system according to claim 8, wherein

said duty is set to a larger value as a temperature of said polyphase motor increases.

25 14. The preheating system according to claim 8, wherein

said preheating is performed on refrigeration oil in a compressor.