

"AN ELECTRONIC CIRCUIT FOR A SINGLE PHASE INDUCTION
MOTOR STARTING".

This invention refers to a single phase induction motor and, more specifically, a starting electronic device for a single phase induction motor.

Single phase induction motors have widely been used due to their constructive simplicity, rigidity and high performance, attending the Low power range wherein the household appliances are generally located, such as refrigerator hermetic compressors, wash machine motors, fans, and some industrial applications as well.

Single phase induction motors are substantially made up of a cage type rotor and a coiled stator, basically having two windings, one being for the main coil and the other for the starting coil.

When an alternate voltage source is applied only to the main coil of a single phase induction motor, a magnetic field fixed in space and alternating in magnitude is created which does not develop any torque to start the rotor movement.

Then it is necessary to create a turning magnetic field to take the rotor from said static condition, thereby the starting is initiated.

Such turning field can be achieved by feeding the starting coil with a current time-displaced to the current flowing in the main coil preferably at an angle as near as possible to 90°. The current phase angle in the starting coil in relation to the current in the main coil can be achieved by construction differences, by designing the starting coil with a power factor higher than that of the main coil or can be achieved also by installing an external impedance connected in series to the starting coil, which impedance usually being a resistor or a

capacitor.

Therefore, it is necessary to install a device in series with the starting coil circuit which temporarily connects this circuit to the power source until the rotor has reached a speed near to the synchronous , thereby giving rise to the starting.

In motors in which a much higher efficiency is required, the starting coil is not fully disconnected from the feed source after the starting, with a capacitor being kept in series with this winding; said running capacitor or permanent capacitor, which allows now a current flow much lower than the current during the starting, but keeping a double phase feed condition for the motor, thereby increasing its maximum torque and increasing its efficiency.

For a motor having such configuration, employing a permanent capacitor, it is known a type of starting device as described in the patent document PI 201.210 consisting of a resistor having a positive temperature coefficient PTC. This device, which is connected in series to the starting coil, has a low resistance at room temperature, thereby allowing a high current to flow during the starting, and after a predetermined time, due to a self heating effect, will arrive a very high resistance, then practically acting as an open circuit. During a normal motor running, the voltage over the PTC is high, and it is kept hot, thereby dissipating a amount of power varying from 1.5 to 5W or higher, depending upon the constructive form and the room temperature. Such power expended by PTC during the whole motor running period decreases the efficiency thereof, thus being undesirable.

Another known starting device is the current relay which keeps the starting coil circuit on while the current in the main coil is high. Although it is a very simple device and does not consume any power during the normal motor running period, it is not advantageous because cannot be used in configurations having a permanent capacitor. Such a fact is due to the delays inherent to relays which cause the contacts thereof to close

right after the motor has been powered, then the permanent capacitor will already have accumulated a very high amount of energy and such energy will be dissipated when contacting the relay at the time it is closed thereby quickly causing its destruction.

Another known starting device is described in the patent document US 4,605,888 consisting of an electronic circuit which uses a TRIAC. Although consuming a small quantity of power during the normal motor running, it is not allowed to be used jointly with a permanent capacitor.

The above cited objects are achieved from an electronic circuit for starting a single phase induction motor, having a cage type rotor; a coiled stator having at least a main winding and a starting winding; and a permanent capacitor connected in series with the starting winding and an alternate current source having first and second terminals, the permanent capacitor and the starting winding being connected in parallel to said source

terminals and the main winding being connected in series with said terminals.

According to the present invention, the electronic circuit comprises: a TRIAC having a first terminal connected to the first terminal of the alternate current source, a second terminal connected to the starting winding and to the permanent capacitor and a GATE terminal; a triac trigger circuit connected to the second terminal and to the GATE terminal of the TRIAC; a bilateral switch having control terminals and being connected to the GATE terminal and to the first terminal of the TRIAC; and a timer circuit connected to the control terminals of the bilateral switch and to the first and second terminals of the alternate current source, said timer circuit defining the time elapsed from the motor powering up till the interruption of the TRIAC conduction by turning on the bilateral switch, the triac trigger circuit repeatedly triggering the TRIAC to a turn on condition at the beginning of each current half-cycle while the bilateral switch remains cut off by the timer circuit. Contrarily to the known starting devices, the described circuit can temporarily connect the starting coil to the alternate current source until the motor acceleration has occurred and without consumption of power in the permanent rating condition. Another advantage of the proposed circuit is to allow the operation in conjunction with the permanent capacitor or in conjunction with a starting capacitor and the permanent capacitor.

The circuit thus described is very simple and the number of components thereof is reduced.

The invention will hereinafter be described with reference with the attached drawings, wherein:

Figure 1 shows the electronic circuit of the present invention; and

Figure 2 shows, in a simplified way, the starting circuit connection as proposed in a motor configuration using an external impedance in the starting circuit and permanent capacitor.

Referring now to figure 1, the alternate voltage source F supplies voltage to the single phase induction motor M having a main coil B_1 and a starting coil B_2 . The voltage supplied to terminals 1 and 2 of the source F is directly applied to the main coil B_1 and is also applied to a starting circuit DP comprising the starting coil B_2 .

The starting coil B_2 is connected also to the voltage source F by a permanent capacitor C_p which is in parallel with the starting circuit DP as well.

Immediately after the motor M is powered by the source F, the voltage between terminals A_1 and A_2 of a TRIAC S begins to increase. Such variation in the voltage causes the current IG to flow through a TRIAC trigger circuit formed by a first capacitor C_1 and a first resistor R_1 , and which, in the condition wherein a bilateral switch defined by a pair of first and second transistors T_1 and T_2 , in cut off, will follow to the GATE terminal G of the TRIAC S, hereby causing the same to turn on. Such conduction condition will be kept at most during a half cycle, when the current in TRIAC is extinguished and the opposed half-cycle begins.

Immediately after the opposed half-cycle begins, the voltage between terminals A_1 and A_2 of the TRIAC S starts to increase again, now in the opposed direction.

Said voltage variation between terminal A_1 and A_2 in TRIAC S in the opposed direction causes the current IG to flow through the circuit formed by the first capacitor C_1 and first resistor R_1 in the opposed direction as well. Supposing the first and second transistors T_1 and T_2 yet cut off, the current IG flows to the GATE terminal G of the TRIAC S, thereby causing the triac to turn on again.

Such TRIAC S conduction condition in the opposed direction will be kept at most during a half-cycle. So, TRIAC S is newly triggered every time at the beginning of each half-cycle, and that will repeatedly occurs whenever first and second transistors T_1 and T_2 should remain cut off.

This TRIAC S trigger circuit, formed by first capacitor C_1 and first resistor R_1 is featured to allow a current I_G to flow to the TRIAC GATE terminal which reaches the maximum value thereof exactly in the beginning of each half-cycle, thus triggering the TRIAC S when the voltage between the terminals A_1 and A_2 thereof is minimum. Thus, the energy stored in the permanent capacitor C_p when the TRIAC S turns on will be very low, thereby warranting that the intensity of the discharge current pulse of the permanent capacitor C_p through TRIAC S to be low as well, avoiding any damage to the TRIAC.

The first capacitor C_1 value is computed so as that the time variation rate of the voltage between terminals A_1 and A_2 causes a passage of a current I_G sufficient to trigger the TRIAC S. First resistor R_1 is calculated to limit the pulse intensity of the first capacitor C_1 discharge current through the GATE terminal G of the TRIAC S to levels not impairing the durability thereof. The total TRIAC S conduction period during the starting is defined by a timer which, after a predetermined time is elapsed suddenly alters the voltage applied to third and fourth resistors R_3 and R_2 from zero to a value sufficient to first and second transistors T_1 and T_2 saturation, which will deviate the current I_G thereby avoiding TRIAC S to trip.

During the normal motor running, first and second transistors T_1 and T_2 are saturated so as in the positive semi-cycles of current I_G , first transistor T_1 conducts thereby avoiding TRIAC S to trip and in the negative semi-cycles of the current I_G , second transistor T_2 conducts thereby avoiding TRIAC S to trip.

The timer is formed by a feed source and a trigger and works as hereinafter described. Immediately after the powering of the circuit, a second capacitor C_2 is discharged. During the positive semi-cycles, a second diode D_2 is directly polarized, thus allowing a current I_t from the source F to flow towards a second capacitor C_2 , thereby increasing the voltage upon thereof. In the negative semi-cycles, the current I_t is directly deviated by a third diode D_3 to the source F, thereby loading a third capacitor C_3 .

This way, in the following positive semi-cycle, a current I_t will

flow again through the third capacitor C_3 and second diode D_2 , thereby increasing once more the voltage upon second capacitor C_2 . Thus, the voltage upon the second capacitor C_2 gradually increases by the successive charge which are transferred from the third capacitor C_3 to the second capacitor C_2 in the positive semi-cycles.

In this circuit, the voltage upon the second capacitor C_2 , which is also applied to the voltage divider made up of eighth and seventh resistors R_8 and R_7 , will increase until the base-emitter junction of a third transistor T_3 is directly polarized causing a current to flow through the collector of the third transistor T_3 , which current will flow part through second resistor R_2 and other part to a fourth transistor T_4 base, thereby also polarizing the base-emitter junction of this fourth transistor T_4 causing the collector of this transistor to drain current which will be added to the current already flowing through the resistor R_7 , and accordingly increases the third transistor T_3 polarization. This chain reaction causes the third and fourth transistor T_3 and T_4 to suddenly saturate, thereby increasing the voltage in the collector of the third transistor T_3 and in the emitter of the fourth transistor T_4 to a value very near to the point 5 voltage, thus saturating first and second transistors T_1 and T_2 . The voltage in the point 5 wherein the trip occurs is defined by the relationship between the eighth and seventh resistors R_8 and R_7 and the base-emitter junction polarization voltage of the third transistor T_3 which typically is 0.6 V. The connection of the second resistor R_2 to the fourth transistor T_4 base avoids that the leakage currents through the third transistor T_3 collector cause a undesirable trigger of the timer. The voltage divider made up of the seventh and eighth resistors R_7 and R_8 will also operate to discharge the second capacitor C_2 when the motor stops, and replaces the circuit in the initial condition for another starting.

The time elapsed from the motor powering up to TRIAC S conduction interruption is basically defined by the second capacitor C_2 and the third capacitor C_3 values. The third capacitor C_3 value which is responsible for limiting said current It is computed so as to

supply a circuit consumption current which is drained under permanent regime by the second and third resistors R_2 , R_3 , and seventh and eighth resistors R_7 and R_8 .

The use of capacitor C_3 as a current limiter replacing a resistors reduces the circuit consumption of the circuit to a greatly negligible minimum level.

Capacitor C_2 is computed to delay any increase in the voltage in the point 5 during the starting, by defining the time the starting device operates.

Resistor R_6 which is connected in series to capacitor C_3 , works as a protecting device thereby limiting said current it supplied to the circuit during eventual transient voltage supplied by the voltage source F.

Figure 2 shows in a simplified way the electronic circuit connection for starting the single phase induction motor hereinabove described, in a motor configuration using an external impedance Z_e and the permanent capacitor C_p . In this configuration, the external impedance Z_e which also can be a starting resistor or a starting capacitor is inserted between a terminal 3 of the starting circuit and the connection point of the starting coil to the permanent capacitor C_p . After the starting of the motor, the external impedance Z_e , which is in series with TRIAC S, will be disconnected from the circuit, and only the permanent capacitor C_p will stay connected to the starting coil B_2 .

As hereinabove described, the circuit shown in figure 1 then starts the single phase induction motor, thereby dissipating a negligible amount of power and allowing it to be used in conjunction with a permanent capacitor or a permanent capacitor and a starting capacitor or individually by temporarily connecting it to a starting coil.



CLAIMS

1- An electronic circuit for starting a single phase induction motor of the type having a cage type rotor and a stator with at least a main winding and a starting winding; a permanent capacitor connected in series with the starting winding; and an alternate current source having first and second terminals, the main winding being connected with the alternate current source terminals, the permanent capacitor and the starting winding being connected in parallel to said terminals, characterized in that it comprises: a TRIAC (S) having a first terminal (A_1) connected to the first terminal (1) of the alternate current source (F), a second terminal (A_2) connected to the starting winding (B_2) and to the permanent capacitor (C_p) and a GATE terminal (G); a TRIAC trigger circuit (C_1 , R_1) connected to the second terminal (A_2) and to the GATE terminal (G) of the TRIAC (S); a bilateral switch (T_1 , T_2) having control terminals and being connected to the GATE terminal (G) and to the first terminal (A_1) of the TRIAC (S); and a timer circuit (TP) connected to the control terminals of the bilateral switch and to the first (1) and second (2) terminals of the alternate current source (F), said timer circuit defining the time elapsed from the motor powering up till the interruption of the TRIAC conduction by turning on the bilateral switch (T_1 , T_2), the TRIAC trigger circuit (C_1 , R_1) repeatedly triggering the TRIAC (S) to a turn on condition at the beginning of each current half-cycle while the bilateral switch (T_1 , T_2) remains cut off by the timer circuit (TP).

2- An electronic circuit, according to claim 1, wherein the TRIAC trigger circuit comprises a first capacitor (C_1) having one terminal connected to the second terminal (A_2) of TRIAC (S) and another terminal connected to the GATE terminal (G) of TRIAC (S) through a first resistor (R_1).

3- An electronic circuit, according to claim 1, wherein the first capacitor value (C_1) allows that the voltage variation rate in time, between first and second terminals (A_1 , A_2) of TRIAC (S),



causes the flow of a current (IG) to the GATE terminal (G) of the TRIAC (S), sufficiently to trigger the TRIAC.

4- An electronic circuit, according to claim 2, wherein the first resistor (R_1) limits the discharge current pulse intensity of the first capacitor (C_1) through the GATE terminal (G) of TRIAC (S), to a security level in relation to TRIAC.

5- An electronic circuit, according to claim 1, wherein the bilateral switch comprises a first (T_1) and a second (T_2) bipolar of NPN type transistor, with the emitter of the first transistor (T_1) connected to the first terminal (A_1) of TRIAC (S) and the collector connected to the GATE terminal (G) of the TRIAC, with the collector of the second transistor (T_2) being connected to the first terminal (A_1) of the TRIAC (S) and the emitter connected to the GATE terminal (G) of the TRIAC (S), and with the bases of said first and second transistors (T_1 , T_2) being connected to the timer circuit (TP) through a second (R_2) and a third (R_3) resistor.

6- An electronic circuit, according to claim 1, wherein the timer circuit (TP) comprises a current limiter (R_6 , C_3) connected between the second terminal (2) of the alternate current source (F) and the inlet of a rectifier circuit (D_2 , D_3); a timer capacitor (C_2) connected between the outlet of said alternate current source (F); a voltage trigger circuit (T_3 , T_4 , R_7 , R_8) having an inlet connected to a point (5) linking the rectifier outlet and the first terminal of the timer (C_2); a reference terminal connected to the first terminal (1) of the alternate current source (F) and outlet terminals connected to said second and third resistors (R_2 , R_3).

7- An electronic circuit, according to claim 6 wherein the current limiting circuit comprises a third capacitor (C_3) with a terminal being connected to the second alternate current source (F) terminal (2), and the other terminal connected to the rectifier circuit inlet through a sixth resistor (R_6).

8- An electronic circuit, according to claim 6, wherein the rectifier circuit comprises a first rectifier diode (D_2) with



the anode being connected to the current limiting circuit (C_3 , R_6) and the cathode connected to the first terminal (5) of the timer capacitor (C_2) and a second rectifier diode (D_3) with the cathode being connected to the anode of the first rectifier diode (D_2) and the anode being connected to the first terminal (1) of the alternate current source (F).

9- An electronic circuit, according to claim 6, wherein the voltage trigger circuit comprises a third bi-polar transistor (T_3) of PNP type with the emitter thereof being connected to the first terminal (5) of the timer capacitor (C_2), with the collector being connected to said second resistor (R_2); a resistor (R_7) interconnecting the base and the emitter of said third transistor (T_3); a fourth bi-polar transistor of NPN type with its base connected to the collector of said third transistor (T_3), the collector being connected to the base of said third transistor (T_3) and the emitter being connected to said third resistor (R_3); a resistor (R_8) interconnecting the collector of said fourth transistor (T_4) and the first alternate current source (F) terminal (1).

10- An electronic circuit, according to claim 7, wherein the current (I_t) limitation is substantially given by said third capacitor (C_3).

11- An electronic circuit, according to claim 7, wherein said sixth resistor (R_6) limits the current (I_t) during eventual transient voltage supplied by the alternate current source (F).

12- An electronic circuit, according to claim 1, wherein it is provided an external impedance (Z_e) connected between the second terminal (A_2) of TRIAC (S) and the starting coil terminal (B_2) connected to the permanent capacitor (C_p).

13- An electronic circuit, according to claim 12, wherein the external impedance (Z_e) is in the form of a resistor or a starting capacitor.



14. An electronic circuit for starting a single phase induction motor,

the motor having a stator having at least one drive coil and a starter coil, and an alternating current source connected to the coils,

the electronic circuit comprising a triac and an R-C type trigger circuit,

the triac having a first terminal connected to the alternating current source,

a second terminal connected to the starter coil, and a gate terminal,

the second terminal and the gate terminal both being connected to the trigger circuit, the trigger circuit being operative to trigger the triac to a turn-on condition of conduction at substantially the beginning of each alternating current half cycle to send a current signal to the starter coil out of phase with the alternating current signal supplied to the main coil.

15. An electronic circuit according to claim 14 having a timer circuit operative to switch on a bilateral switch after a predetermined time, the switch being disposed between the gate of the triac and the alternating current source, the switch being operative when switched on to conduct current so as to bypass the triac gate and thereby prevent triggering of the triac.