SCR based Triggering Method for Single Phase Induction Motor

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Abstract: **In this paper a SCR based starting mechanism for single phase induction motor is proposed as the initial current to be drawn by the induction motor is always an important factor in its operation. The circuit uses standard power supply comprising of a step-down transformer from 230Vto 12V and 4 diodes forming a Bridge Rectifier that delivers pulsating dc which is then filtered by an electrolytic capacitor of about 470µF to 1000µF. The filtered dc being unregulated, IC LM7812 is used to get 12V DC constant at its pin no 3 irrespective of input DC varying from 9V to 14V. The input dc shall be varying in the event of input ac at 230volts section varies in the ratio of V1/V2=N1/N2.**

KeyWords: **Single Phase Induction motor, SCR, Triggering Circuit, Inrush Current, OptoIsolator**

I. Introduction

In the last decades, the production of power electronics switches has been plentiful and diverse. Some of these switches are thyristors, Gate-turn-off thyristor (GTO's), bipolar power transistors, Metal Oxide Semiconductor Field-Effect Transistor (MOSFET's) [1, 2]. Even with these devices, the basic thyristor still constitutes a robust, simple and economical device that has many applications. Thyristors are widely used for control of power in both AC and DC systems. This is due to their several advantages such as relatively small size, low losses and fast switching. Apart from many other uses, such a controller is used to control the single phase AC power in induction heating, light control, reactive power control and starting as well as speed control of AC motors. Single phase AC voltage controller has been used with R-L load [1, 2] for various circuit configurations. This technique can be modified to be used with induction motor by reducing the equivalent circuit of induction motor to be just R and L [3]. Single phase AC voltage controller used with single-phase induction motor. Using of single phase AC voltage control in speed control of induction motor has disadvantages such as low efficiency due to extra rotor copper losses. Although it has these disadvantages, but generally, this scheme has some advantages on other aspects, including low cost in installation, ease to maintain and reliable which make this scheme popular option in industry. This scheme has been used in many industrial applications as in driving an overhead travelling crane, an elevator speed control system [5], and starting and stopping means for induction motor [4-7]. In reference [4] a signal from the rotor voltage and current are used to control the speed and torque respectively. But the main disadvantage of this technique is not applicable for squirrel cage induction motor; moreover the control of current without any reference to the power factor leads to a rather nonlinear torque/speed characteristic. In reference [5] a tachometer generator connected to three-phase squirrel-cage induction motor to generate a speed signal representing the actual speed of the induction motor and to compare it with command speed signal to produce a suitable firing signal. In reference [6] and [7] the single phase AC controller with cycle skipping method was used to control, start, and stop the three-phase induction motor.

II. Proposed Work

A single phase induction motor or a lamp is connected in series with two anti-parallels SCR'S and supply of 230V A.C. The gates of the respective SCRS are fed from two Opto-isolator LEDS which are connected in series and are driven by a transistor BC558 IN series with another external LED.

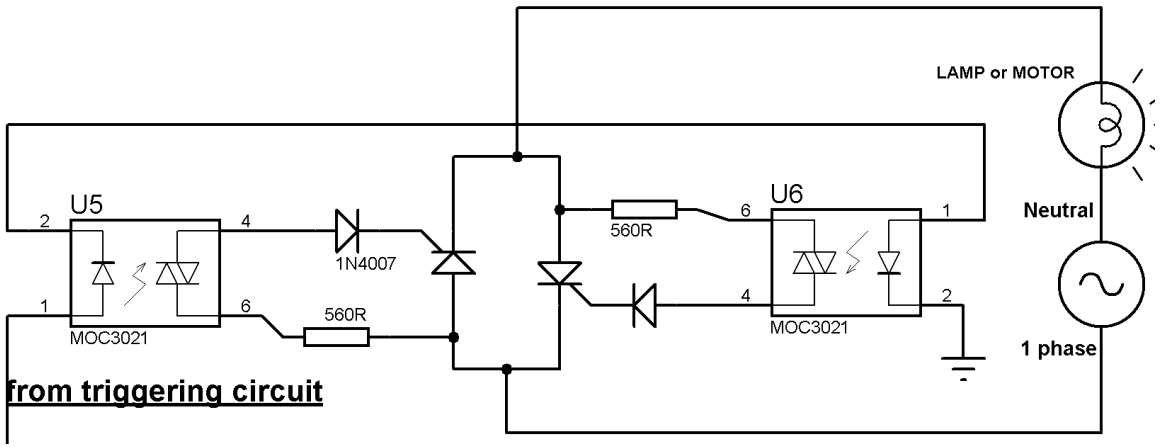

Fig.1 Triggering Circuit

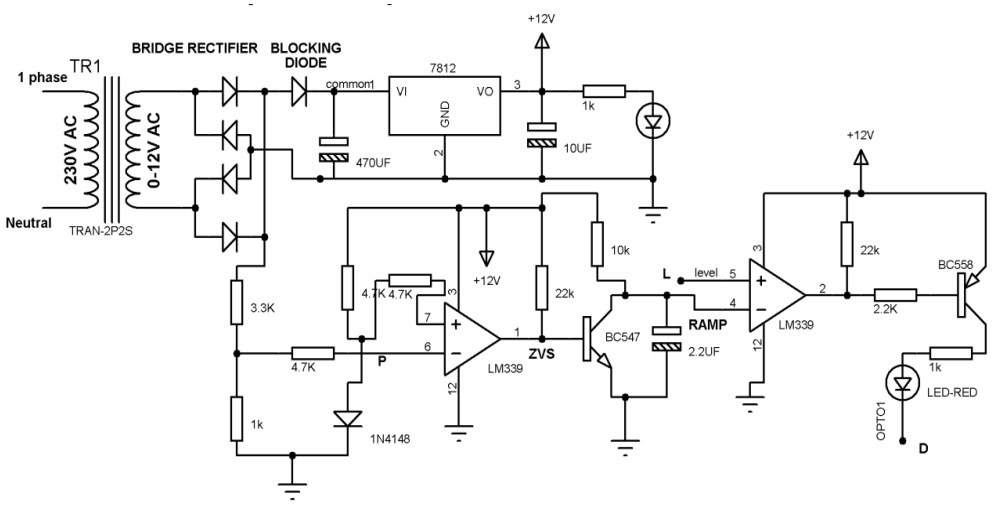

Fig.2 Power Supply Circuit for Single Phase Induction Motor

The 1 phase induction motor should not be given full voltage at a time of starting, because in off condition the back EMF of the motor is very low, so initially it draws high current. To start the motor with low current, two SCR'S are connected back to back and are triggered slowly initially by delayed firing angle and gradually the triggering pulse is increased by decreasing the delay in firing angle till zero delay so that motor current slowly rises without any excessive current during the starting of the motor.To trigger the gates of SCRS, the operational amplifiers are used i.e. LM339 and LM324. Lm324 op-amp is configured to get a level voltage comparison at its input that will initially be high and gradually full to zero. To achieve the above operations +12v DC supply is required. So we generate our own DC power supply as follows.One step-down transformer is used to step down 230v AC to 12v AC; bridge rectifier is connected to convert 12v AC to DC. The AC supply is not constant always so a 7812 voltage regulator is employed to get the fixed 12v DC supply. A 10uf capacitor is connected at the output of 7812 for stability; a LED with a series resistor 1k is connected to indicate the power.

For generating level voltage a p-n-p BC 558 transistor is used whose emitter is connected to the +12v supply and base is connected to a ceramic capacitor 0.4uf and the collector is connected to an electrolytic capacitor 2.2uf via 10k resistor. Initially at the time of switch on the base of transistor allows current flow from emitter to base and charges the 0.4uf capacitor as well as current flows from emitter to collector and charges 2.2uf capacitor.

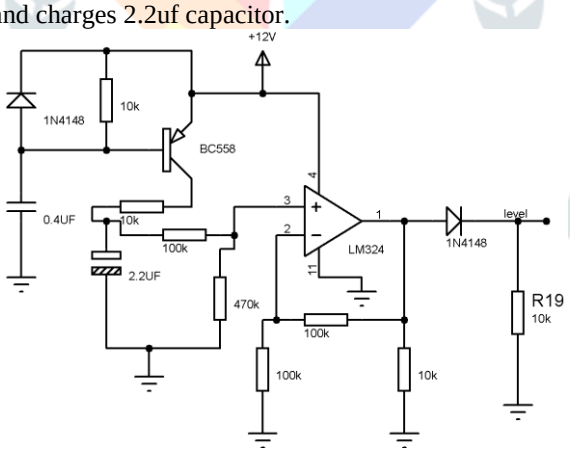

Fig.3 LM324 Circuit Diagram

When 0.4uf is fully charged, the base becomes high due to which the current stops flowing from emitter to base and collector. The positive terminal of 2.2uf capacitor is connected to the non-inverting pin of LM324 comparator, the inverting terminal of comparator is fed from a fixed voltage. When the 2.2uf capacitor is charging the voltage at non-inverting terminal is greater than the inverting terminal, hence the output of comparator is high during this time. When the 2.2uf capacitor starts discharging the voltage at the output of comparator also falls gradually because the voltage at non inverting terminal falls lower slowly than the inverting terminal. Hence the level of the voltage is initially high and gradually falls down; this level voltage L is fed to another comparator of Op-amp LM339.

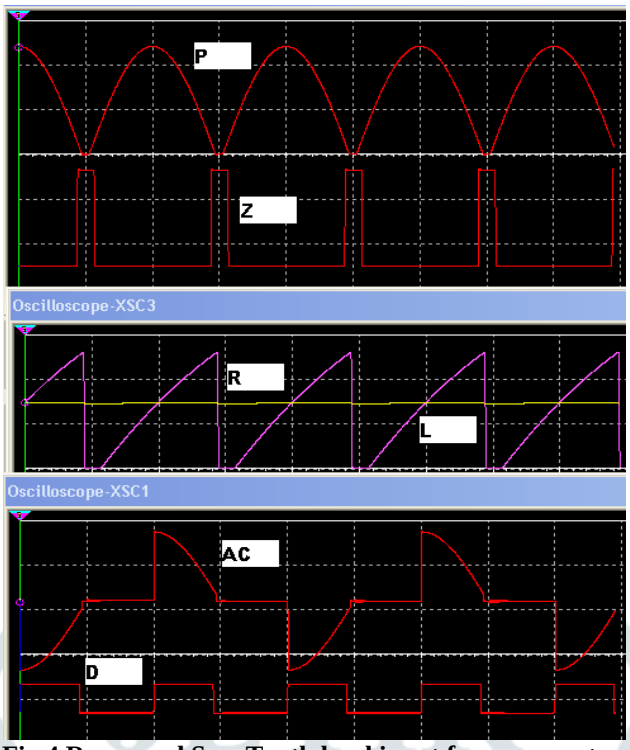

Fig.4 Ramp and Saw Tooth level input for comparator

The ramp or saw tooth and level voltages are fed to the comparator. When the level voltage "L" is high the pulse width of output pulse is more, which is inverted by a p-n-p transistor BC 558 to get small pulse width initially to the Opto LED. As the level voltage falls down the pulse width of the optoLED from the output of p-n-p transistor increases, hence triggering the gates of the SCRs earlier and finally without any delay while the width is the maximum. Thus the motor starts with low voltage and gradually gets full voltage to avoid sudden inrush of current.

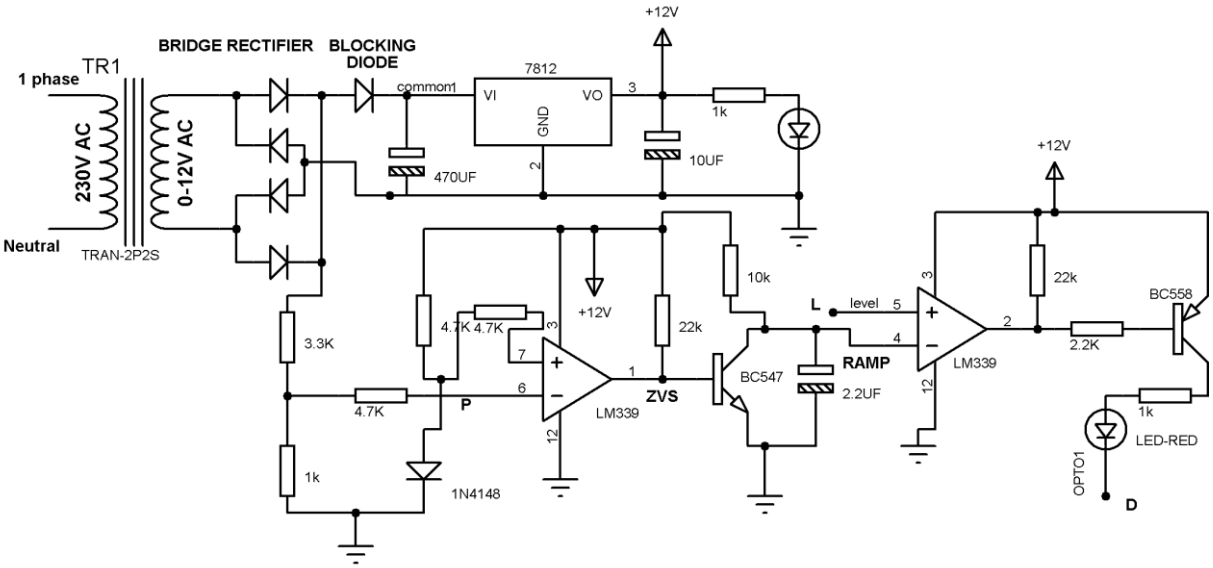

Fig.5 Circuit Diagram for Power Supply

Two SCR'S are connected back to back and are triggered from Opto-isolators. MOC3021 Opto-isolator is a LED-DIAC combination. Two Opto-isolator input leds are connected in series while their output diac are used for triggering each SCR.

III. Results and Conclusion

During the positive half cycle of main current, the current flows from phase to the motor through SCR, and SCR is triggered slowly. During negative half cycle flows from motor side to the phase during this time another SCR comes into picture.

Delay Angle	I/P Voltage	O/P Voltage at Thyristor
30	75.7	63.5
60	45	32.7
90	30	22.1
120	18.2	12.8
150	18.2	12.8

Table.1 Delay Angle, I/P Voltageand V_{out}

Hence it can be concluded that the main current is initially low when the SCR is triggered gradually and as the pulse width of triggering pulse increase the main current also increases and full current flows after a very little time delay and thus the motor is protected from initial high current.

References

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