Single Phase Induction Motor with Soft Starter

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Abstract-
The project is designed to provide a soft and smooth start to the induction motor. An induction motor during the initial starting condition draws up much higher current than its capacity and the motor instantly reaches the full speed.
This results in a mechanical jerk and high electrical stress on the windings of the motor.
Sometimes the windings may get burnt. The induction motor should start smoothly and gradually catch up the speed for a safer operation.
This project is designed to give a soft start to the induction motor based on the TRIAC firing triggered by heavily delayed firing angle during starting and then gradually reducing the delay till it reaches zero voltage triggering.
This results in low voltage during start and then gradually to full voltage. Thus the motor starts slowly and then slowly picks up to full speed.
This project consists of one TRIAC in the power circuit, one TRANSISTOR in the driving circuit, Opto-coupler for bridging the circuit, and the output of which is connected to a lamp representing the coil of the induction motor.
When the supply is given to the circuit resulting in delayed firing pulses during start and then gradually reducing the delay till the motor runs at full speed. The Output is fed through opto- coupler to trigger the TRIAC.

1. INTRODUCTION

BACKGROUND: Necessity for Motor Protection : It could be assumed that properly planned, dimensioned, installed, operated and maintained drives should not break down. However, in real life, these conditions are hardly ever ideal. The frequency of different motor damage differs since it depends on different specific operating conditions. The induction motor is the most widely used motor in the industry due to its simple and rugged construction. It requires least maintenance as compared to other electrical motors. Therefore, induction motor protection plays an important role in its long life service. Researchers have done costly and limited protection for stator winding protections, broken rotor bars protection, thermal protection etc. Mainly the induction motor needs protection from variation of the input supply for small motors which is in common use, not only in big industry but also in small scale industries. The small scale industries are not able to provide costly protection to the drives in use as it will increase their capital cost. Therefore a cheap and compact design has been done for protection of induction motors against unbalanced voltages, under voltages, short circuits etc. Most breakdowns are caused by an overload, insulation faults leading to earth faults, turn-to turn or winding short circuits are caused by excess voltage or contamination by dampness, oil, grease, dust and chemicals

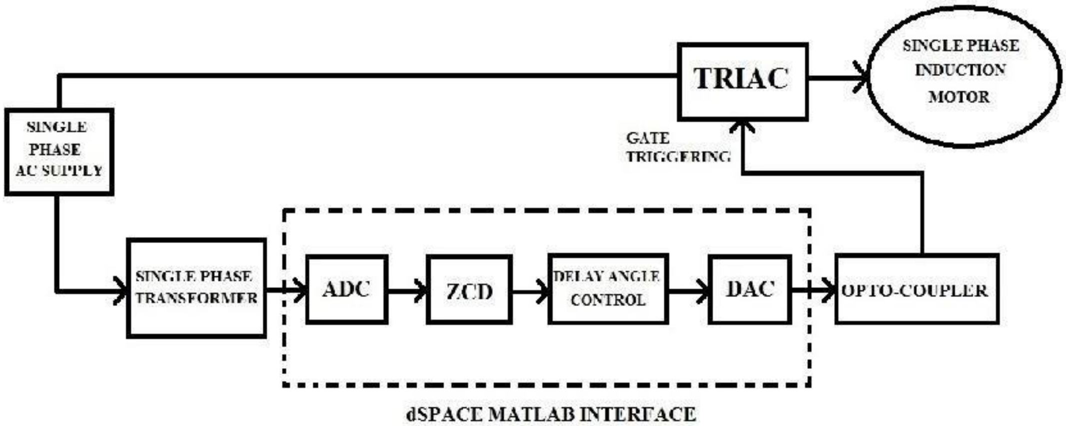
The approximate percentages by the seindividual fault sare

Table1-1BreakdowninMotors	
Overload	**30%**
Insulationdamage	**20%**
PhaseFailure	**14%**

Bearing	**13%**
Ageing	**10%**
Rotordamage	**5%**
Others	**8%**

2. BLOCKDIAGRAM

Block Diagram of Soft starter InductionMotor



3. PROBLEM STATEMENT

The pump motor draws more current than its rated capacity during their starting condition which may lead to the damage of the windings of the motor. In order to avoid this problem, applied voltage is gradually increased from low to high so that the soft start of the pump motor is performed.

PROBLEM STATEMENT To guarantee fault-free operation of an electrical drive the following points must be observed

1. Correct design: a suitable motor has to be selected for each application.
2. Professional operation: professional installation and regular maintenance are preconditions for fault-free operation It must not be tripped before the motor is put at risk
3. Good motor protection: this has to cover all possible problem areas. If the motor is put at risk, the protection device has to operate before any If damage cannot be prevented, the protection device has to operate quickly in damage occurs. order to restrict the extent of the damage as much as possible.

4. PROBLEM OBJECTIVE

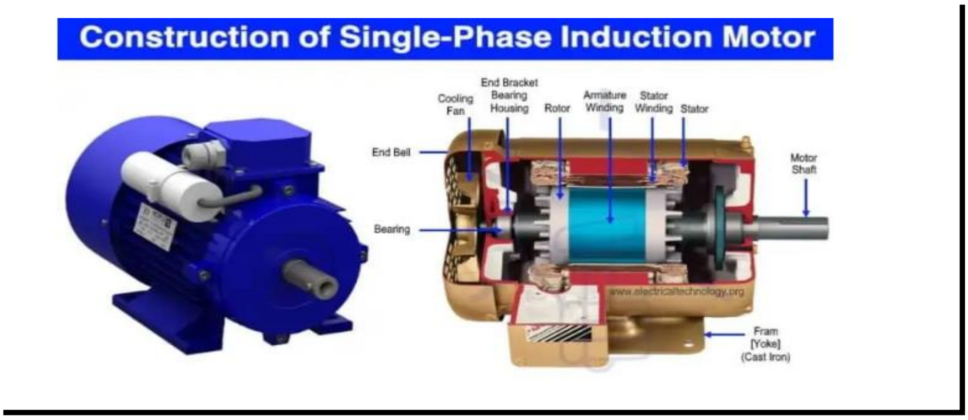
The main intention of this project is to provide protection for a single-phase pump motor by applying initial voltage gradually from low to high for obtaining soft start. The pump motor draws more current than its rated capacity during their starting condition which may lead to the damage of the windings of the motor.

1. Design a soft starter of an induction motor by using DSpace.
2. Reduced voltage starting through delayed triggering angle control of TRIAC.
3. Bypass the TRIAC causing direct voltage supply to the motor once the motor reaches desired speed.

5. Construction of Single-Phase Induction Motor

A single phase induction motor is similar to the three phase squirrel cage induction motor except there is single phase two windings (instead of one three phase winding in 3-phase motors) mounted on the stator and the cage winding rotor is placed inside the stator which freely rotates with the help of mounted bearings on the motor shaft.

The construction of a single-phase induction motor is similar to the construction of a three-phase induction motor.



Similar to a three-phase induction motor, single-phase induction motor also has two main parts

- **Stator**
- **Rotor**

Stator
In stator, the only difference is in the stator winding. The stator winding is single-phase winding instead of three-phase winding. The stator core is the same as the core of the three-phase induction motor.
In a single-phase induction motor, there are two winding are used in stator except in shaded-pole induction motor. Out of these two windings, one winding is the main winding and the second is auxiliary winding. The stator core is laminated to reduce the eddy current loss. The single-phase supply is given to the stator winding (main winding)

Rotor
Rotor of single-phase induction motor is the same as a rotor of squirrel cage induction motor. Instead of rotor winding, rotor bars are used and it is short-circuited at the end by end-rings. Hence, it makes a complete path in the rotor circuit. The rotor bars are braced to the end-rings to increase the mechanical strength of the motor.
The rotor slots are skewed at some angle to avoid magnetic coupling. And it also used to make a motor run smooth and quiet.

The following fig shows the stator and rotor of a 1-phase induction motor.

6. Working of Single-phase Induction Motor

Single-phase AC supply is given to the stator winding (main winding). The alternating current flowing through the stator winding produces magnetic flux. This flux is known as the main flux.

Now we assume that the rotor is rotating and it is placed in a magnetic field produced by the stator winding. According to Faraday's law, the current start flowing in the rotor circuit it is a close path. This current is known as rotor current.

Due to the rotor current, the flux produced around the rotor winding. This flux is known as rotor flux.

There are two fluxes; main flux which is produced by stator and second isthe rotor flux which is produced by the rotor.

Interaction between main flux and rotor flux, the torque produced in the rotor and it starts rotating.

The stator field is alternating in nature. The speed of the stator field is the same as synchronous speed.

The synchronous speed of the motor depends on the number of pole and supply frequency.

It can represent by two revolving fields. These fields are equal in magnitude and rotating in the opposite direction.

Let say Φ_m is a maximum field induced in the main winding. So, this field is divided into two equal parts and that is $\Phi_m/2$ and $\Phi_m/2$.

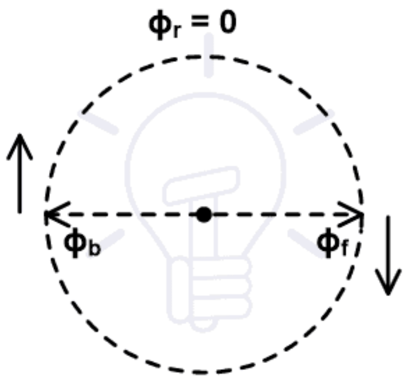
Out of these two fields, one field Φ_f is rotating in an anticlockwise direction and the second field Φ_b is rotating in a clockwise direction. Therefore, the resultant field is zero.

$\Phi_r = \Phi_f - \Phi_b$

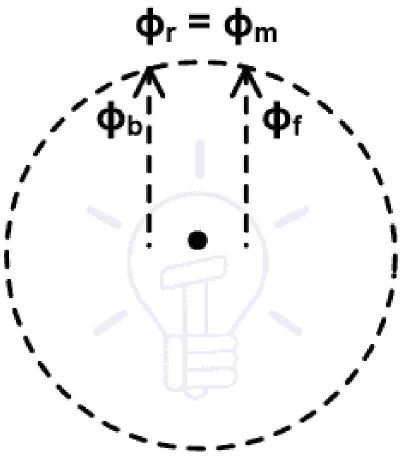
$$\Phi_r = \frac{\Phi_m}{2} - \frac{\Phi_m}{2}$$

$\mathbf{\Phi_r = 0}$

Now consider the resultant field at different instants.



When a motor starts, two fields are induced as shown in the above figure. These two fields are the same magnitude and opposite direction. So, resultant flux is zero.
In this condition, the stator field cannot cut by rotor field and resultant torque is zero. So, the rotor cannot rotate but it produces humming.



Now consider after the rotation of 90˚, both filed are rotated and pointing in the same direction. Therefore, the resultant flux is a summation of both fields.

$\Phi_r = \Phi_f + \Phi_b$

$$\Phi_r = \frac{\Phi_m}{2} + \frac{\Phi_m}{2}$$

$\Phi_r = 0$

In this condition, the resultant filed is equal to the maximum field induced by the stator. Now, both fields rotate separately and it is alternative in nature.

So, both fields cut by the rotor circuit and EMF induced in the rotor conductor. Due to this EMF, the current starts flowing in the rotor circuit and it induces a rotor flux

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Due to the interaction between stator flux and rotor flux motor continues to rotate. This theory is known as Double Revolving Theory or double field revolving theory**.**

Now, from the above explanation, we can conclude that the single-phase induction motor is not self-starting.

To make this motor self-starting motor, we need stator flux rotating in nature instead of alternating nature. This can be done by various methods. Single-phase induction motor can be classified according to starting methods.

Types of Single-phase Induction Motors

The single-phase induction motors are classified as

- Split Phase Induction Motor
- Shaded Pole Induction Motor
- Capacitor Start Induction Motor
- Capacitor Start Capacitor Run Induction Motor
- Permanent Capacitor Induction Motor

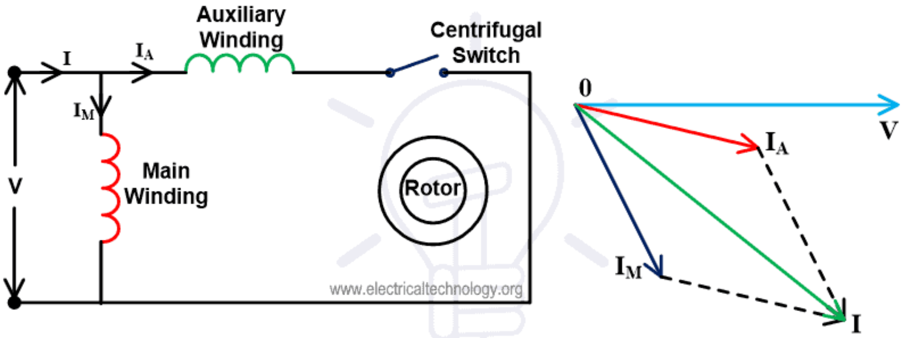
6. Split Phase Induction Motor

In this type of motor, an extra winding is wounded on the same core of the stator. So, there are two windings in the stator.

One winding is known as the main winding or running winding and second winding is known as starting winding or auxiliary winding. A centrifugal switch is connected in series with the auxiliary winding.

The auxiliary winding is highly resistive winding and the main winding is highly inductive winding. The auxiliary winding has few turns with a small diameter.

The aim of auxiliary winding is to create a phase difference between both fluxes produced by the main winding and rotor winding.



Split Phase Induction Motor

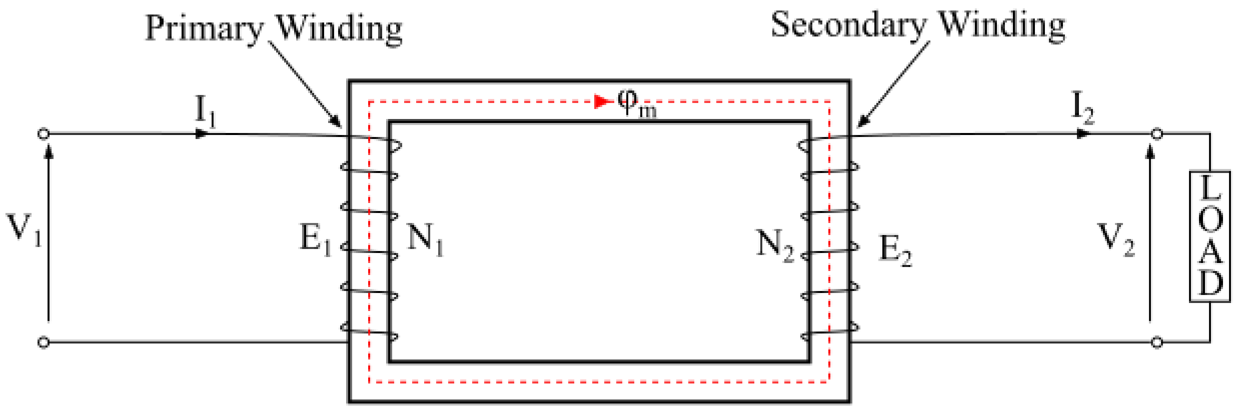
The connection diagram is as shown in the above figure. The current flowing through the main winding is I_M and current flowing through the auxiliary winding is I_A. Both windings are parallel and supplied by voltage V.
The auxiliary winding is highly resistive in nature. So, the current I_A is almost in phase with supply voltage V.

7. TRANSFORMER

Electrical power transformer is a static device which transform electrical energy fromone circuit to another without any direct electrical connection and with the help ofmutualinductionbetweentwowindings.Ittransformspowerfromonecircuitto another circuit without changing its frequency but may be in different voltage level.

8. Working Principle of Transformer

The working of the transformer is based on the principle of mutual inductance between two coils which are magnetic coupled.



According to the principle of mutual inductance, when an alternating voltage is applied to the primary winding of the transformer, an alternating flux ϕ_m which is called as the mutual flux is produced in the core. This alternating flux links both the windings magnetically and induces EMFs E_1 in the primary winding and E_2 in the secondary winding of the transformer according to Faraday's law of electromagnetic induction. The EMF (E_1) is called as primary EMF and the EMF (E_2) is known as secondary EMF and being given as,

E1=−N1dφmdtE1=−N1dmdt
And
E2=−N2dφmdtE2=−N2dmdt
Therefore,
E2E1=N2N1E2E1=N2N1

From the above expression it can be seen that the magnitude of EMFs E_1 and E_2 depend upon the number of turns in the primary and secondary windings of the transformer respectively, i.e., if $N_2 > N_1$, then $E_2 > E_1$, thus the transformer will be a step-up transformer and if $N_2 < N_1$, then $E_2 < E_1$, thus the transformer will be a step-down transformer.If a load is now connected across the secondary winding, the EMF E_2 will cause a load current I_2 to flow through the load. Therefore, a transformer enables the transfer of power from one electric circuit to another with a change in voltage level.

9. Advantage

1. It allows the motor to ramp up slowly to reduce the inrush current to our motor because ofthis it saves an operating cost.
2. Itallowsustoincreasethelongevityofourmotorbecausewearenotputtingsomuch torque and wear and tearon that motor upon startup.

10. Result

The motor driver prototype is composed of five separate modules; the TRIAC-based cycloconverter, the Opto-Isolatorcircuit, an interface board, microcontroller, and the power supply for both the driver and the cycloconverter. The cycloconverter is built using six TRIACs (IXYS Corporation CPC1998J). The microcontroller has two functions; measuring the signal sent by the Opto-isolator and generating the pulses needed for the TRIACs to generate de waveforms for the main and auxiliary windings. The waveforms can be manipulated in order to control the motors start-up as well as the rotor speed. In order to test the motor driver prototype, a Lab-Volt Single Phase Capacitor Run Motor is used. The motor operates with a standard 120V, 60Hz AC source, and is able to reach speeds of 1710r/min. The rotor speed of the SPIM is measured with the use of an electronictachometer. The tachometer has a voltage output that represents 500r/min/V per voltage division in the oscilloscope. illustrates the proposed SPIM driver prototype. illustrates the test bed for the motor drive, the SPIM, and all the necessary connections in place while illustrates the pulses generated by the microcontroller ...

11. Conclusion

The main objective of the project is to reduce the terminal voltage of the induction motor , so that the motor could start smoothly from rest and thereby increasing the terminal voltage across the motor in steps, as the motor gains speed. In this way, the starting current of the motor which is 4-6 times of thefull load current. The motor is protected from any electrical disturbances which can damage the motor. We have successfullybuild a soft starter byusing a triac and an optocoupler, which can initially reduce the terminal voltage across the motor during starting and gradually increase the voltage once the motor starts.

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