Soft Starter Design for 3 Phase Induction Motor

Laxman S. Balgude, Rakesh H. Shinde, Akash R. Yadav, Mrs. Rupali D. Burungale
[123]Students, [4]Asst.Prof. At SVPM's COE, Malegaon (BK)
Department of Electrical Engineering, Savitribai Phule Pune University.
SVPM's COE, Malegaon (bk),
Baramati, India

Abstract:- **Aim of the paper to study & Starting of an induction motor is a process that creates many challenging problems for the motor, and operations of the power system. The induction motor can be damaged, characteristics can be changed, and performances of the motor can be worsened. We designed an integrated soft starter that includes voltage ramp soft start, current limit soft start, voltage jump soft start based on PIC16F877A. By connecting 6 MOSFETs in anti-parallel manner as switches to give voltage in steps to start motor.**

A soft starter is a relatively new device and is used for smooth start of induction motors, particularly medium voltage motors, and adds flexibility in the operation and the interoperability. It is an integration of complex power control apparatus for reducing starting current in a medium voltage solid state soft- starter. 6 MOSFETs are connected as 2 units for one phase as switches and reduced voltage bye operating MOSFETs in various regions.

Keywords:- Soft Starter, Medium Voltage, MOSFETs, PIC16, Induction Motor, Switches.

I. INTRODUCTION

With day by day development in industry, large equipment are use for their application purpose. It is important to control these equipment in effective way as energy conservation, promoting automation and environmental protection.

Induction motor is used in industry as well as domestic applications. Induction motor is the main power source of these devices, so the startup problem is mostly focused. The power motor starting directly will have larger impact on power grid as well as equipment. Avoiding the problems effective solution is to install the soft start device between motor and mechanical load[1].Starting of induction motors creates many challenging problems to the motor, and to power supply system. Engineers and technicians must take these into consideration and account when deciding on a starting methodology of the induction motor. Required dynamic characteristics during the starting process are in contradiction, and often tradeoffs must be made to satisfy certain requirements. These characteristics include: system robustness, efficiency, equipment cost, and motor lifetime[2]. Whenever a squirrel-cage induction motor is started, the electrical system experiences a current surge, and the mechanical system experiences a torque surge. These current and torque surges can be reduced substantially by reducing the voltage supplied to the motor during starting [3].Soft starter works on principle that by reducing impressed voltage upon the motor during starting, reduces the starting current & torque

pulsation. By properly adjusting the applied effective voltage during start up, the starting torque and current can be reduced [4]. The electronic soft starter avoid the disadvantages and greatly improved production efficiency.

A PIC microcontroller is used to give an instruction to the circuit at which instant and voltage it get started. The switching of MOSFETs is controlled by microcontroller at low voltage having comparatively low starting current and controlled starting torque which protects motor from jerks and high inrush current.

Soft starter works on principle that by reducing impressed voltage upon the motor during starting, reduces the starting current & torque pulsation. This is due to the fact that the starting torque is approximately proportional to the square of the starting current and consequently it is proportional to the square of the starting voltage. Therefore, by properly adjusting the applied effective voltage during start up, the starting torque and current can be reduced.

Because of significantly higher starting current than the rated current, starting of induction motors is a process that can damage, and influence characteristics and performances of the motor and electrical power systems. High voltage fluctuations, dips and sags, can occur in electrical power system associated with the starting of the motor. A soft- starter is a solid-state electronic device that shape the supply voltage prior to connection to the motor terminals.

II. PRINCIPLE OF THE ELECTRONIC SOFT STARTER.

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Electronic soft starter based on three reverse parallel MOSFETs to make the AC voltage regulating device, By Controlling the six way MOSFET angle, the output voltage is increased gradually in some a certain function, until the motor rated. running state. The electronic soft starter cannot only guarantee the starting torque of the motor and the rotating speed of the motor, but also can greatly reduce the starting current and avoid the impact to the large impact current to the power grid. When MOSFET conducted completely, motor will get started.

There are six MOSFETs connected in three sets to supply three phases. As per instruction from PIC controller each phase will get supply in steps and not at same time so that it insures low voltage and smooth supply to all phases and soft start can be achieved.
As the torque of an induction motor is

$$T \propto \phi I_2 \cos \theta_2$$

$$Toeque, \; T = \frac{s \, E_2^2 R_2}{R_2^2 + (sX_2)^2} \times \frac{3}{2\pi N_s}$$

$$or, \; T = K s E_2^2 \frac{R_2}{R_2^2 + (sX_2)^2}$$

So at start, slip s=1, so maximum torque will be produced at starting.

$$T = \frac{sE_2^2 R_2}{R_2^2 + (sX_2)^2}$$

As stator voltage E1 is proportional to rotor voltage, so if it is reduced will reduce E2 and starting current & torque will be controlled.
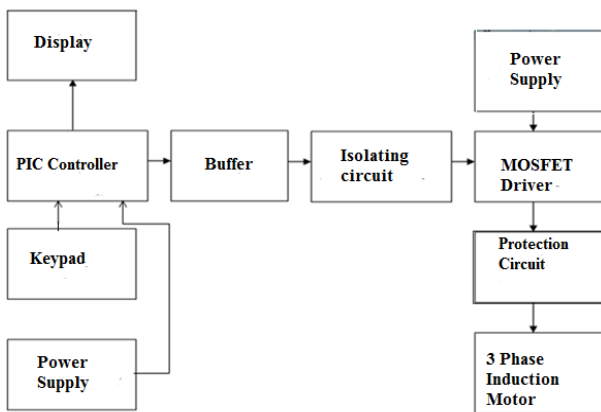
III.BLOCK DIAGRAM & DESCRIPTION

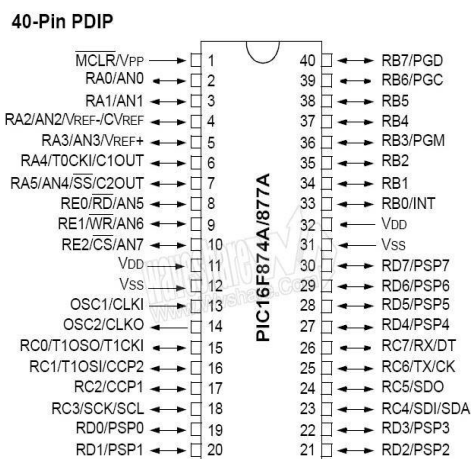Fig.1:- Soft Starter Block Diagram

A. Pic Controller

Fig. 2:- Three point test method

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Peripheral Interface Controller".

We are using PIC16 microcontroller as it is suitable for our requirements and also cost effective.

The microcontroller is a central part of our system, which is continuously present in contact with all monitoring equipment in the system. Here various types of microcontrollers are present in the market, It is easily available with 40 pins in the market, The programming and coding of this controller is also easier.

B. MOSFET Driver

The IR2110/IR2113 are high voltage, high speed power MOSFET and IGBT drivers with independent high and low side referenced output channels. It works on the principle of bootstraps. This driver consists of two inputs and two outputs. When one pair acts for high voltage and another for low voltage.

In this driver unit two IR2110 and 4 MOSFETs are selected to form bridge. Two bootstrap capacitors are used. One is across the high voltage supply and return and another one across low voltage supply and return. Signals from buffer are given to the driver through optoisolator. When the first 2110 receive high voltage input it drives the first mosfet at the same time second 2110 receives low voltage input which triggers the fourth mosfet. Now mosfets 1 & 4 are conducting which connects the motor to the supply and it forms the positive half cycle in a motor.

When the first 2110 receive low voltage input it drives the second MOSFET at the same time second 2110 receives high voltage input which triggers the third mosfet. Now mosfets 2 & 3 are conducting which connects the motor to the supply and it forms the negative half cycle in a motor. Therefore motor gets two half cycles.

C. Buffer & Isolating Circuit

An opto isolator provides isolation between two circuits. i.e. there is no any electrical connection between PIC circuit and MOSFET circuit. It connects two circuits without any electrical connection.

A buffer is a unity gain amplifier packaged in an integrated circuit. Its function is to provide sufficient drive capability to pass signals or data bits along to a succeeding stage. In either case, the buffer protects and the output of the supplying device while providing a sufficiently robust signal to the next stage. Some data buffers are bi-directional, allowing data to pass in either direction.

D. Power Supply

There are two power supplies used in this circuit. One for PIC circuit and one for motor.
PIC circuit requires a 5 volts power supply for its operation and motor gets 230 volts supply through MOSFET driver for its operation.

E. Keypad

A keypad is a set of buttons arranged in a block or "pad" which usually bear digits, symbols and usually a complete set of alphabetical letters. Keypads are found on many alphanumeric keyboards and on other devices such as calculators, push-button telephones, combination locks, and digital door locks, which require mainly numeric input.

It is connected to microcontroller which gives input by keys.

F. Display

Liquid crystal cell displays (LCDs) are used in similar applications where LEDs are used. These applications are display of display of numeric and alphanumeric characters in dot matrix and segmental displays.
The display will show the values of voltage, current, speed etc as it is connected to the controller.

G. Protection Circuit

Simple protection circuit is provided with MOSFET driver in the form of resistors and some electronics circuitry for overload protection, voltage fluctuations etc.

H. Three Phase Induction Motor

An induction motor (IM) is a type of asynchronous AC motor where power is supplied to the rotating device by means of electromagnetic induction. Other commonly used name is squirrel cage motor due to the fact that the rotor bars with short circuit rings resemble a squirrel cage (hamster wheel).

An electric motor converts electrical power to mechanical power in its rotor (rotating part). There are several ways to supply power to the rotor. In a DC motor this power is supplied to the armature directly from a DC source, while in an induction motor this power is induced in the rotating device. An induction motor is sometimes called a rotating transformer because the stator (stationary part) is essentially the primary side of the transformer and the rotor (rotating part) is the secondary side. Induction motors are widely used, especially polyphase induction motors, which are frequently used in industrial drives.

We are using a 0.5 H.P., 3 phase squirrel cage induction motor for which the soft starter is designed.

IV. ADVANTAGES

- It will reduce mechanical stresses on motor and shaft.
- It will extend equipment life.
- Motor will draw less starting & inrush current.
- It will be multifunctional purpose application.

V. APPLICATION

- It will be useful in milling machines with dynamic braking.
- It will be useful in agriculture sector for pumping.
- It will be useful in elevators.
- It will be useful in conveyor system.

VI. CONCLUSION

Hence, based on all the result obtaining, the objective of smooth and reliable motor starting will achieve. It will control starting current and torque of motor will give less starting current. We can calculate starting current and torque by formulas and can prove that motor starts softly.

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[4]. Vishva Pandya, 2vinod Patel, 3hina Chandwani , Electrical Department, Itm Universe, Baroda, India, Electrical Department, M. S. University, Baroda, India ,Amtech,Electronics, Gandhinagar, India.