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# Soft Starter

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***Abstract:** This paper is describes the soft and smooth start to a 3 phase induction motor. The three phase 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 prototype have been developed to give a soft start to the induction motor based on the SCR 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. The working prototype consists of a six anti-parallel SCRs, two for each phase, the output of which is connected to a set of lamps representing the coils of a 3 phase induction motor, capacitors, comparators, opto-isolators to trigger the SCRs etc .This can be enhanced by using IGBTs in place of SCRs with PWM control to reduce harmonic distortions often encountered in SCR triggering mechanism for future scope.***

## I. INTRODUCTION

The project is designed to provide a soft and smooth start to a 3 phase induction motor. The three phase 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 SCR 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 a six anti-parallel SCRs, two for each phase, the output of which is connected to a set of lamps representing the coils of a 3 phase induction motor. The charging and discharging of capacitors is interfaced to comparators resulting in delayed firing pulses during start and then gradually reducing the delay till the motor runs at full speed. Output from the comparators is fed through opto-isolators to trigger the SCRs. Further the project can be enhanced by using IGBTs in place of SCRs with PWM control to reduce harmonic distortions often encountered in SCR triggering mechanism.

## II. PRINCIPLE OF SOFT STARTER

A soft starter is any device which controls the acceleration of an electric motor by means of controlling the applied voltage. Now let us have a brief recall of the need for having a starter for any motor.

An Induction motor has the ability to self-start owing to the interaction between the rotating magnetic field flux and the rotor winding flux, causing a high rotor current as torque is increased.

As a result the stator draws high current and by the time the motor reaches to full speed, a large amount of current (greater than the rated current) is drawn and this can cause heating up of the motor, eventually damaging it. To prevent this, motor starters are needed.

Motor starting can be in 3 ways,

*A.* Applying full load voltage at intervals of time: Direct On Line Starting.
*B.* Applying reduced voltage gradually: Star Delta Starter and Soft starter.
*C.* Applying part winding starting: Autotransformer starter.

In technical terms, a soft starter is any device which reduces the torque applied to the electric motor. It generally consists of solid state devices like thyristors to control the application of supply voltage to the motor. The starter works on the fact that the torque is proportional to the square of the starting current, which in turn is proportional to the applied voltage. Thus the torque and the current can be adjusted by reducing the voltage at the time of starting the motor.

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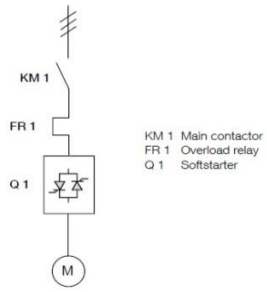
There can be two types of control using soft starter:

1) *Open Loop Control:* A start voltage is applied with time, irrespective of the current drawn or the speed of the motor. For each phase two SCRs are connected back to back and the SCRs are conducted initially at a delay of 180 degrees during the respective half wave cycles (for which each SCR conducts). This delay is reduced gradually with time until the applied voltage ramps up to the full supply voltage. This is also known as Time Voltage Ramp System. This method is not relevant as it doesn't actually control the motor acceleration.
2) *Closed Loop Control:* Any of the motor output characteristics like the current drawn or the speed is monitored and the starting voltage is modified accordingly to get the required response. The current in each phase is monitored and if it exceeds a certain set point, the time voltage ramp is halted.

Thus basic principle of soft starter is by controlling the conduction angle of the SCRs the application of supply voltage can be controlled.

## III. SOFTSTARTER

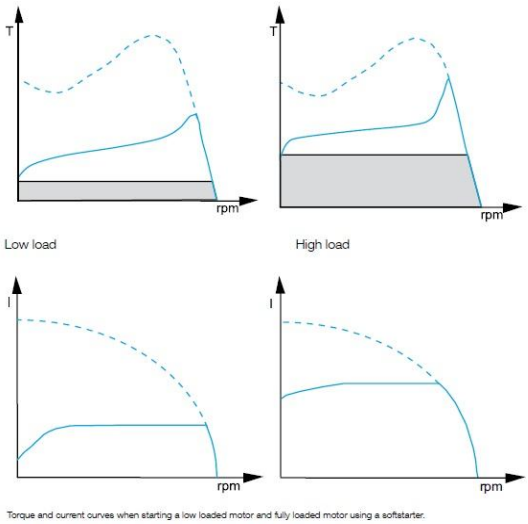
A softstarter does not change the frequency or the speed like a drive. Instead it ramps up the voltage applied to the motor from the initial voltage to the full voltage. Initially, the voltage to the motor is so low that it is only able to adjust the play between the gear wheels or stretching driving belts etc to avoid sudden jerks during the start. Gradually, the voltage and the torque increase so that the machinery starts to accelerate. One of the benefits with this starting method is the possibility to adjust the torque to the exact need, whether the application is loaded or not.




Single line diagram for a softstarter. The line contactor is not required and sometimes the overload is built-in."

Using a softstarter will reduce the starting current and thereby avoid voltage drops in the network. It will also reduce the starting torque and mechanical stress on the equipment, resulting in reduced need for service and maintenance.

Just as for a drive, the softstarter can perform a soft stop, eliminating water hammering and pressure surges in pumping systems and avoiding damage to fragile material on conveyor belts.




Torque and current curves when starting a low loaded motor and fully loaded motor using a softstarter.

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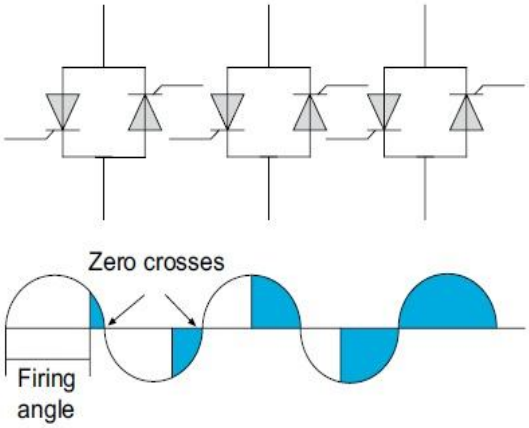
## IV. SOFTSTARTER FUNCTIONALITY

A softstarter consists of a number of anti-parallel thyristors; two in each phase. These thyristors are semiconductor components which normally are isolating but by sending a firing signal, they can start to conduct, allowing the voltage and the current to pass through.

When performing a soft start, a firing signal is sent to the thyristors so that only the last part of each half period of the voltage sinus curve passes through. Then during the start, the firing signal is send earlier and earlier allowing a bigger and bigger part of the voltage to pass through the thyristors. Eventually, the firing signal is sent exactly after passing zero, allowing 100% of the voltage to pass through.

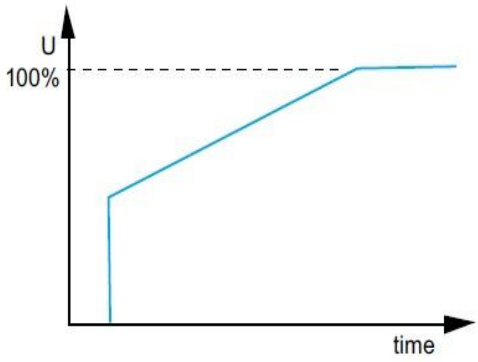
By allowing more and more of the voltage to pass through the thyristors, this can be seen as a ramping up of the voltage from something called the initial voltage to the full voltage.

When performing a soft stop, the opposite happens. At first, the full voltage is allowed to pass through the thyristors and as the stop proceeds, the firing signal is sent later and later allowing less and less of the voltage to pass through until the end voltage is reached. Then no more voltage is applied to the motor and the motor stops.




1) *Start:* The thyristors let part of the voltage through at the beginning and then increase it, according to the set ramp time for the start.
2) *Stop:* The thyristors are fully conducting and when soft stopping, they decrease the voltage according to the set ramp time for stop.

*a) Off :* Thyristor is non-conducting
*b) On :* Thyristor is conducting




Since the voltage to the motor is reduced during the start, both the current and the torque will also be decreased. In fact, if the voltage is decreased to 50% of the full voltage, the current will be decreased to about 50% of the maximum current at that speed and the torque will be decreased to about 25% of the maximum torque.

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## V. APPLICATIONS

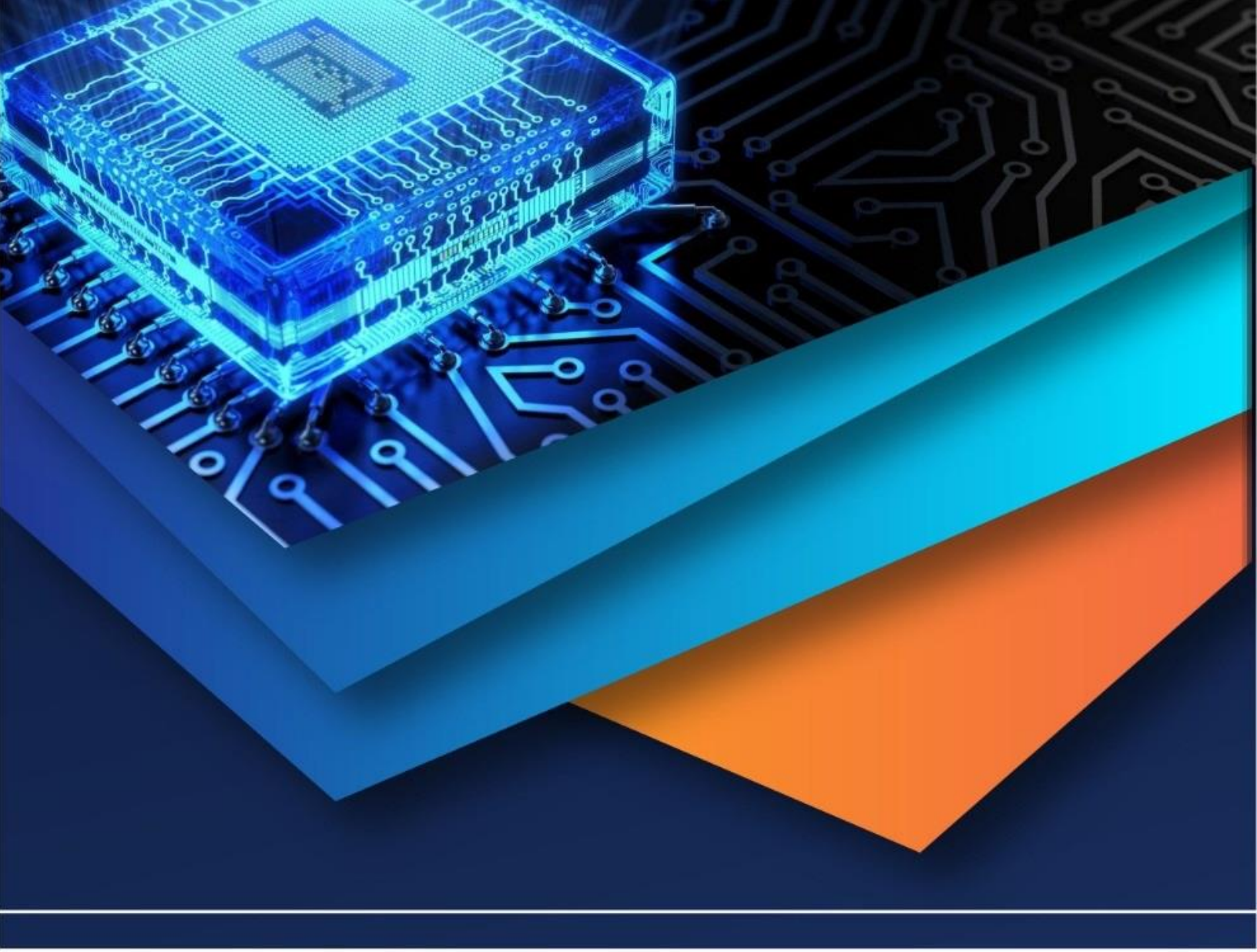
All motors are used for starting and running different applications.

*A.* Fans.
*B.* Pumps.
*C.* Compressors.
*D.* Conveyor belts.
*E.* Crushers and mills.

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