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Simulation of Three phase induction motor in Matlab with Direct and Soft starting methods

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ABSTRACT

Asynchronous electrical machines, which are mainly used as electrical induction motors. Starting the induction motor is the most important and dangerous step. The theory behind this project is based on representing the real motor by a set of equations and values in Matlab using the subsystem feature, forming a corresponding idealistic motor in a way where all the physical effects are similar. The motor is started under different loads in two methods: Direct and Soft starting. Each method is studied and discussed using supporting simulation of currents, torque, speed, curves. The three different starting method are being compared to conclude the most suitable and applicable starting method which causes the least severe power quality events.

Keywords:3Ph-induction motor, Star-delta Starter, Auto- transformer Starter, Matlab, Model, Simulation, Direct starting, Soft starting.

1. INTRODUCTION

Asynchronous machines are considered nowadays the most commonly used electrical machines, which are mainly used as electrical induction motors and sometimes as generators. This is mainly due to the simplicity of composition, low price, light weight, high reliability, easy to command and control performance and not containing parts that could easily breakdown compared with DC machines and synchronous machines. Starting the induction motor is the most important and dangerous step, where the motor properties play a major role in the evaluation of all electrical motors, and these properties are defined by the following factors:

Starting Torque
Starting Current
Transient State
Smoothness of the Starting

2.STARTING OF INDUCTION MOTOR

Starting of an electrical drive involves a change in its state from rest to a steady state speed of rotation. The process of starting is the most important phenomenon in the entire operation of the drive. Control of the starting process essentially consists of controlling the acceleration of the driving motor and the latter is basically a problem of modifying the speed torque characteristics of the motor in such a way as to obtain the

desired starting performance. The supply network to which the motor is connected may affect the selection of the starting device from the following viewpoint. The excessive voltage drops due to the peak starting current may interfere with the supply in such a way that it cannot be tolerated by other equipment or other consumers connected to the same power supply network. Since starting is associated with excessive currents, the effect of starting upon the motor itself must be carefully considered. The starting currents will add to the motor heating by an amount that depends upon their rms values and upon the frequency of starting.

Methods of Starting Electric Motor They are as follows: -

1. Full voltage starting: This involves the application of full line voltage to the motor terminals. This is also called 'direct-on-line starting'.

2 .Reduced voltage starting: In order to avoid heavy starting current and the consequent voltage dip in the supply lines majority of motors are started by applying a reduced voltage to their terminals and subsequently increasing it to its normal value.

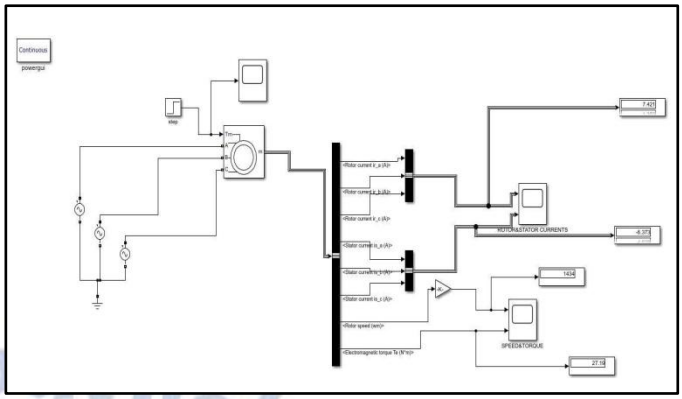
Reduced voltage starting of induction motors is achieved by-

- Stator resistance starting
- Stator reactor starting
- Star-delta starting
- Autotransformer starting
- Soft starter

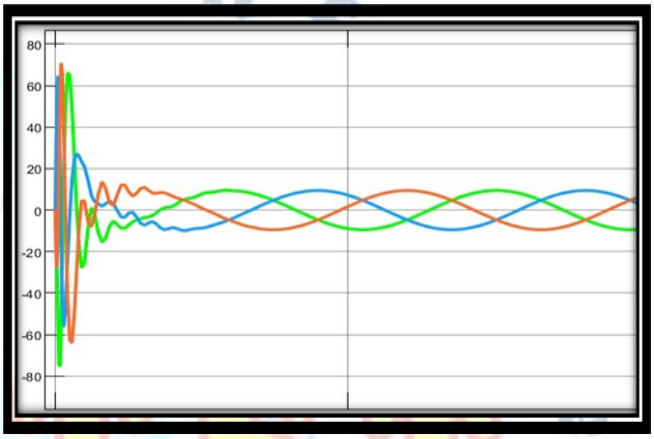
3.Why the starting current is high in the induction motor

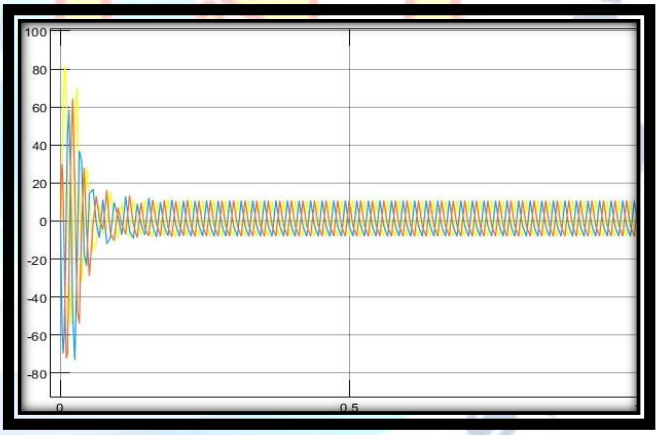
In an induction motor it takes starting current around 7 times the full load current. The reason is during starting when we applied a voltage to stator it produces a rotating magnetic field which is a large amount of magnetic field and when the rotor catches its speed the amount of field cutting the rotor reduce and slip is also low and current become normal.

4.simulation of induction motor without starter



4.1.**Rotor and stator current waveforms**





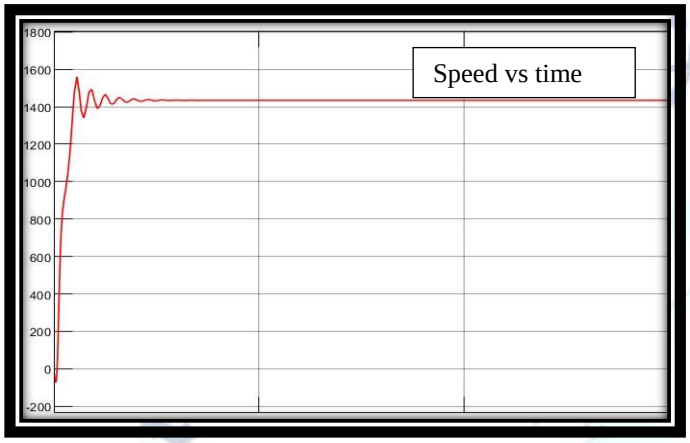
In above figure 4.1.Rotor currents varies with time are rising upto 80 ampere during the starting which are 8 times greater than the rated currents of induction motor.Intially Stator currents are more than rotor currents as we can observe in the above figure (>80 ampere) due to the large amount of magnetic field produced by stator field.Within the few seconds the stator currents settles to a value of 6.359 ampere & the rotor currents settles to a value of 3.991 ampere.

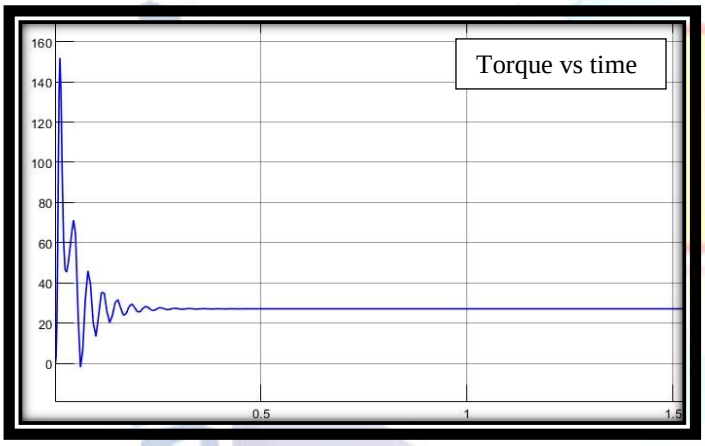
This high inrush currents will effect the windings and performance of the induction motor & damage the motor due to excessive heating during starting as in the case of

without starter.It is dangerous to start the induction motor without starter even though it is self starting.Taking the induction motor rating as 5.4h.p,4k.w,1430r.p.m,50hz,400(Vr.m.s).

On calculation,defining the full load torque as 26.72N-m and the speed as 149.67 rad/sec.

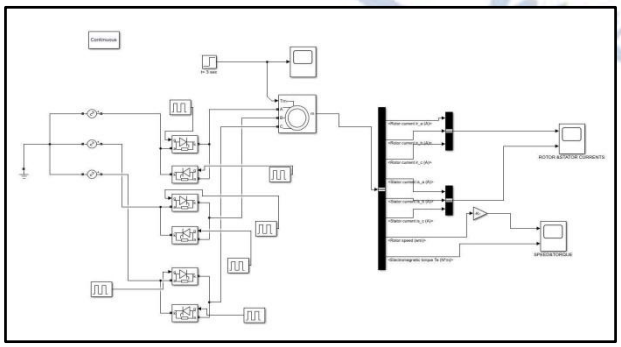
4.2.Speed and torque waveform



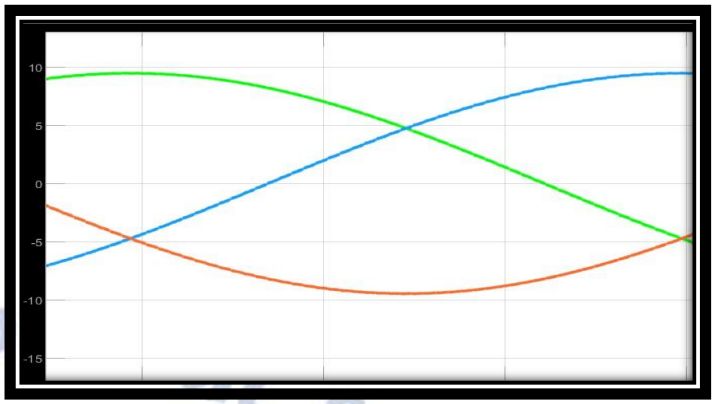


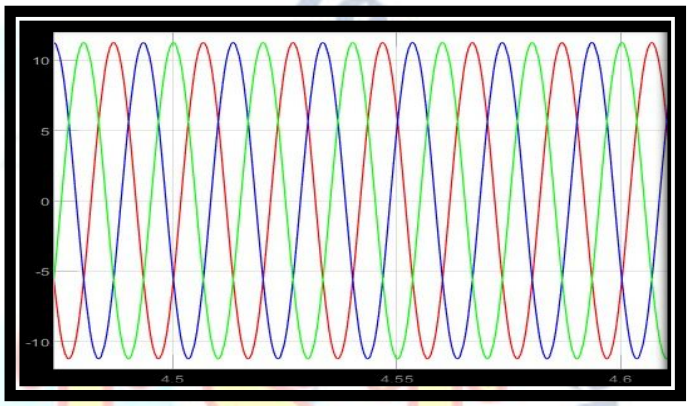
As without starter the induction motor would take higher starting torque of 160 N-m and the higher speed of 1600 R..P.M which is dangerously than base speed of 1430 R.P.M .Finally motor settles at a torque of 27.15 N-m and speed of 1434 R.P.M can be seen in above figure 4.2.

5.With soft starter using back to back Scr



5.1.Rotor and stator currents with soft starter

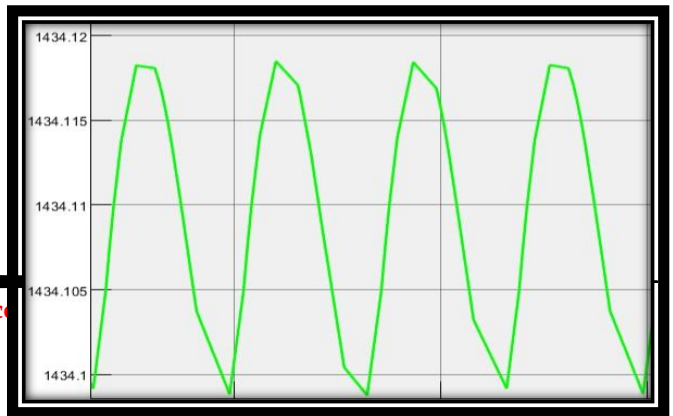




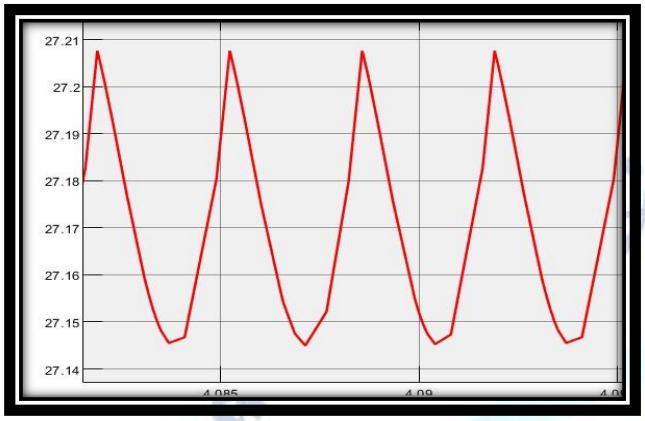
As with soft starter using back to back scr, the independent control of initial voltage can be possible in return it reduces

the initial in- rush current to the rated value of 10 ampere as shown in above figure 5.1.This starter also smoothens the output waveform of stator and rotor currents .This is the best option available in market for small and medium power ratings upto 25h.p.By using I.G.B.T in place of scr, further harmonics can be reduced and faster operation possible.

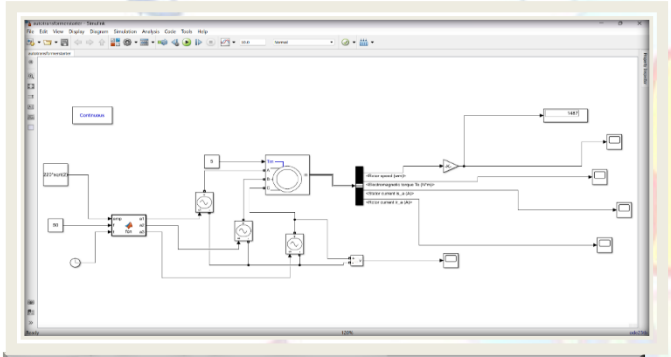
5.2. Speed and torque with soft starter waveforms

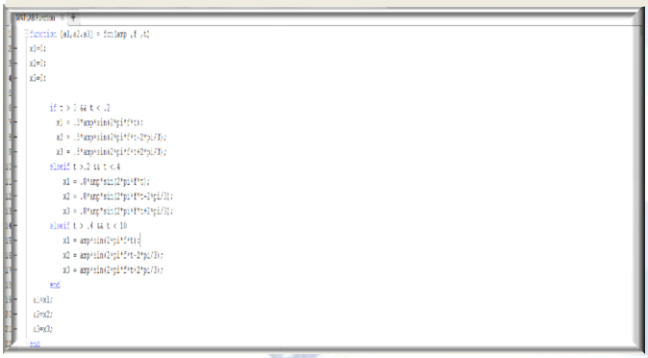


With Traic, the starting torque can settle to 27.15 N-m (~=Full Load Torque of 26.72), the startingspeed settles to speed 1434 R.P.M(~=Base Speed of 1430 R.P.M). Due to these values ,soft start and soft stop is possible as shown in above figure 5.2.

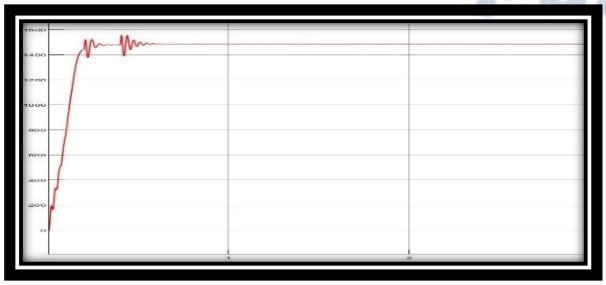


6.Simulation of induction motor with auto-transformer starter

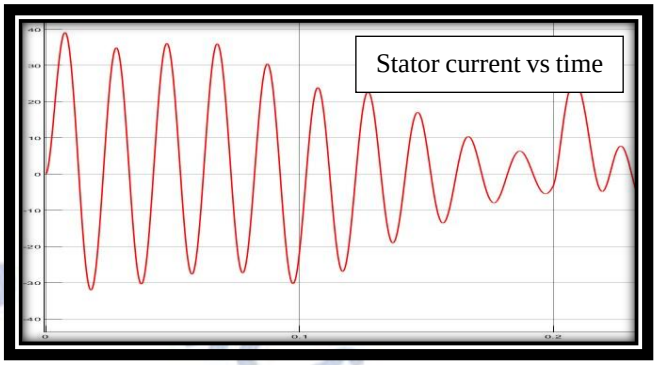




As the auto- transformer starter works on tapping ,so the starter matlab function code is given with tappings at different time intervals @t<0.2 &@0.2<t<0.4 &0.4<t<10 as shown above.



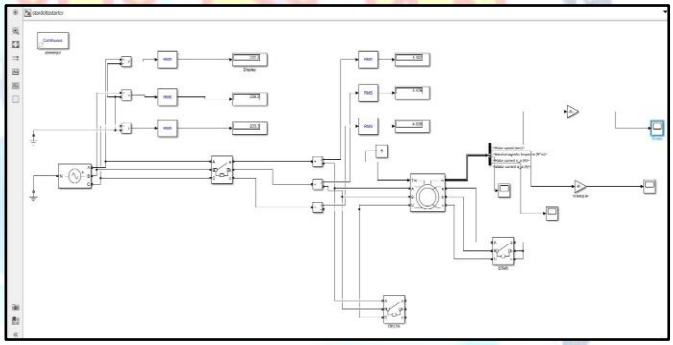
6.1. Speed and stator currentwith *auto-transformer waveform*



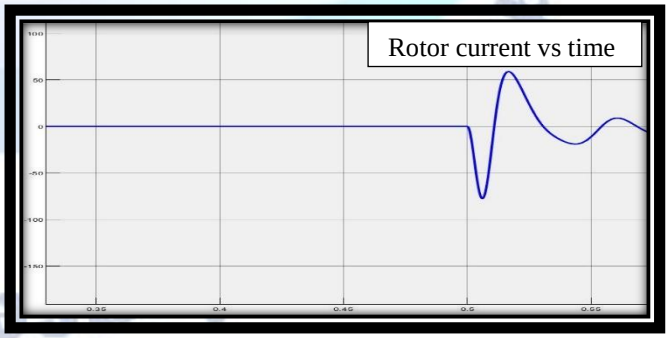
Provided different tappings in- between t=0 sec to t=1 sec, the starting stator current and starting speed is fluctuating &reached to 40A, 1500R.P.M. The output waveforms is discontinuous as shown in above figure 6.1. and the motor prone to jerking and operational failure. The smooth waveform is not achieved in this case. It is economical to above 15h.p motors.

7.Simulation of induction motor with star-delta

7.1..MATLAB CIRCUIT OF STAR CONNECTED STARTER:

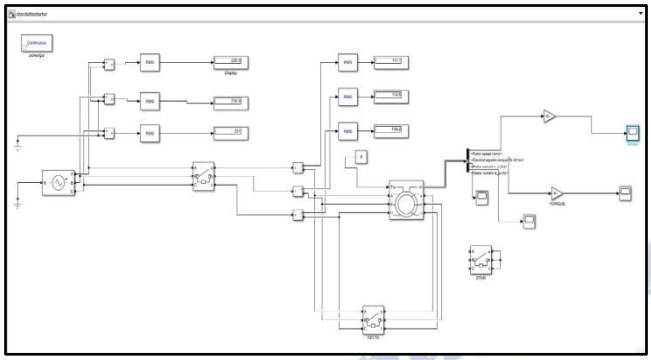


7.1.1. Rotor current with star connected starter waveform

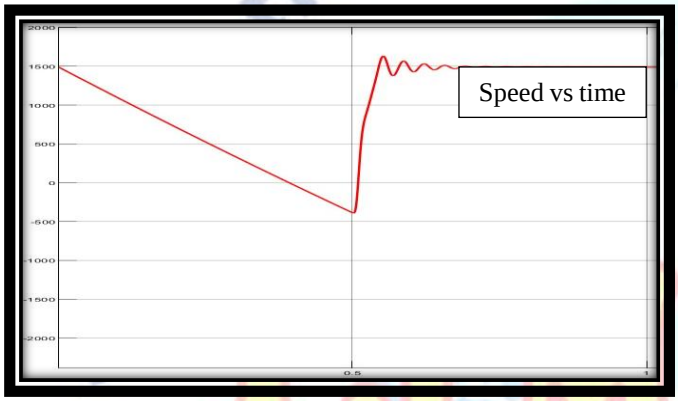


With star-connected starter, the full line voltage is reduced by 1/1.732 times . The inrush current is limited to 60 ampere. It is economical to 5h.p to 10 h.p motors .It is discontinuous operation and fixed to operate after time t=0.5 sec as shown in above figure 7.1.1.

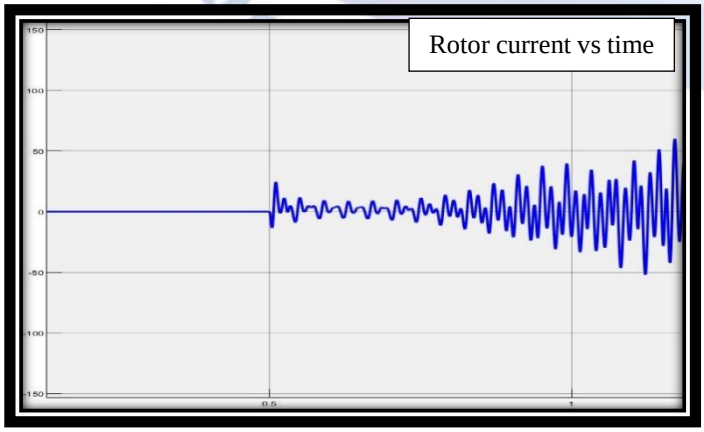
7.2. MATLAB CIRCUIT OF DELTA CONNECTED STARTER :



7.2.1. Speed and Rotor current with delta connected starter waveforms



With delta-connected mode, the full supply voltage will be resumed. The speed of the induction motor is 1380 R.P.M in star-connected mode as in delta connection, the speed of the induction motor becomes 1490 R.P.M. Due to the full supply voltage; the running time speedof theinduction motor increases over the time than initial/starting speed of the motor (i.e. star-connection) as shown in above figure 7.2.1. The starting currents in this type of starter is less when compared with no starter. But the settled value of current is 60 ampere. This is discontinuous .



Waveform as shown in above figure 7.2.1. and prone to heating and jerking dangerously for higher rating induction motors above 10 h.p. As we can observe the picking up of current and speed discontinuous at regular intervals and leads to permitting of harmonics into the rotor part.

8.Comparison of starters

S.No	parameters	Without starter	Star-delta	autotransformer	Soft-starter
1	Inrush current(A)	80	60	40	10
2	Speed(R.P.M)	1600	1380(Y)&1490(D)	1500(T<10 SEC)	1434

9.FutureScopeConclusion

From the characteristics we observed that the staring current in soft starter is much less as compared with the other three starting methods. It provides smoother waveform with less harmonics in case of soft starter.The induction motor is able to run at its base speed without overheating with soft starter.

Soft starter is more efficient than other three starting methods as it is very costly also.But, in view of safety soft starter is the best choice upto 25hp among these starters.There is a scope in future to use the I.G.B.T in place of Traic to reduce harmonics.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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