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Simulation of Three Phase Voltage Controlled Soft Switching Start of Induction Motor Drive

Bibhu Prasad Ganthia, Lipsa Ray, Priyanka Senapati, Subrat Kumar Barik

Abstract*: *In this paper a three phase voltage regulator (thyristor based) with RL load and induction motor load is simulated for fixed firing angle first. As was seen from the results obtained that the induction motor response is highly impaired with this fixed firing angle starting. The transient response as well as the steady state response is highly oscillatory in nature. Then a suitable firing scheme was developed to vary the firing angles of each thyristor in reference to the zero crossing of the respective phase voltages. The control circuit was studied for R-L load first and then the induction motor was simulated with this firing angle control scheme. The basic objective of this work is to improve the transient response of the voltage regulator fed induction motor. One basic requirement for the induction motor to have an improved transient response is that the applied voltage to the motor must gradually increase. The same was achieved with the proposed control logic. Next the fault mode (short circuit and open circuit switch fault) analysis of the induction motor was taken up. Till now not much work has been done on this fault tolerant induction motor drive. Here a 2-phase close loop control was adopted to improve response of the induction motor in fault mode. We used both the voltage control loop as well as the current control loop to do so. Unfortunately not much can be done on this fault tolerant operation as the time was very short. Till the speed and torque pulsation during a short circuited switch fault was greatly improved by adopting this two phase control strategy.

Index Terms*: *Soft Starter, Voltage Control Loop, Current Control Loop, Induction Machine, 2-Phase Control Loop, Fault Tolerant Operation.

I. INTRODUCTION

Poly-phase induction motors have been the workhorse (main prime movers) for industrial and manufacturing processes as well as numerous propulsion applications. The energization of such motors in these processes and applications can be achieved through the following ways:

(1) Direct across-the-line starting
(2) Soft-starting
(3) Adjustable-speed drive (ASD) control

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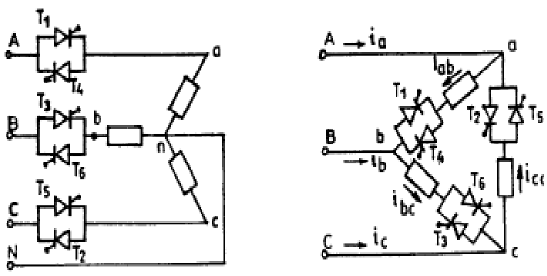
It is well known that direct across-the-line starting of induction motors, which offers absolutely no control capability, is characterized by high starting inrush currents and high starting torque pulsations. In certain applications such as conveyor belt drives, these high starting torque pulsations may result in belt slippage, which consequently may lead to undesirable damage to motor-load systems. Frequent direct across-the-line motor starting may introduce significant electrical and thermal stresses on motor bearings and winding components including insulation, heating in motor windings, as well as mechanical stresses on motor cages, shafts and load couplings. The adverse effects due to such stresses on motors may result in undesirable consequences such as squirrel-cage bar breakages, stator winding damage, and inter-turn short-circuit faults, which may lead to catastrophic failures in motors. The losses during starting or say during no-load make s significant contribution to poor efficiency of the induction motor. More to the cause the transient response in case of adjustable speed drives will be critical concern in case the motor is started by conventional starter. Accordingly, reduced voltage starters, or the so-called soft starters, are often employed as effective means to reduce high starting currents and torque pulsations through use of thyristor based voltage control both during starting as well as in adjustable speed drives. While the basic concept is simple, the problem of optimizing the performance of the so called soft starter is a complex task. Also the selection of the control variable and the control law is pretty important in order to improve the motor performance under various conditions.

II. THREE PHASE VOLTAGE CONTROLLER

The three phase loads that is to be fed from the regulator may be connected in different manner. The different connections are shown below:



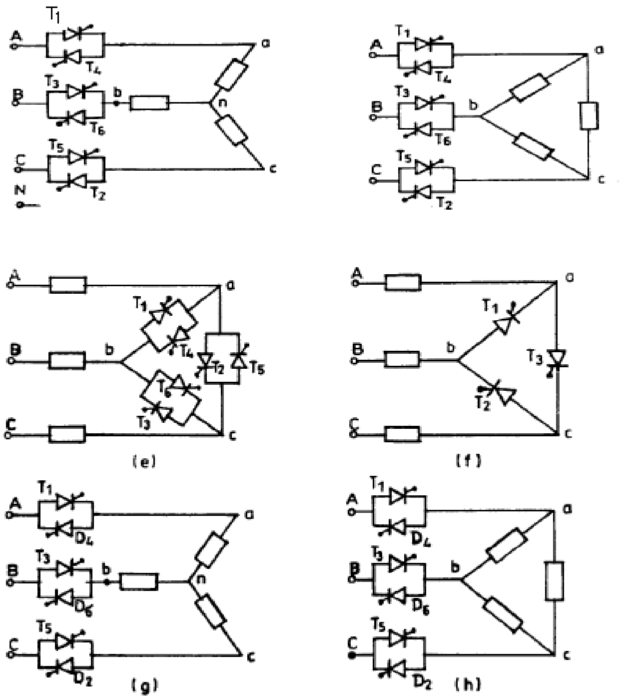


Figure.1 Different configuration three phase voltage regulator configuration [10]

Here we have considered the three phase star connected RL load with isolated neutral.

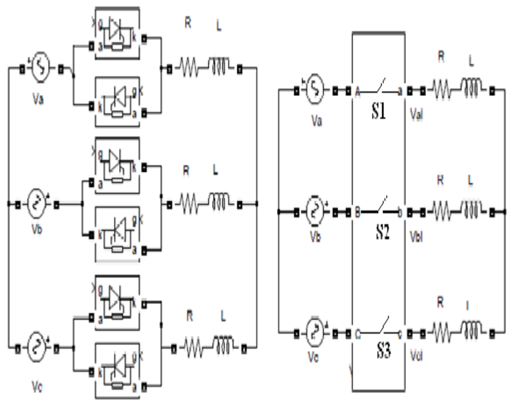


Figure.2 Three phase voltage regulator with RL load

The voltage regulator with Rl load (star connected) is shown in figure (2.2). Let s_1, s_2 and s_3 represents the three thyristor switches such that:

$$s_1 = \begin{cases} 1, \text{when the phase a is conducting} \\ 0, \text{when phase is not conducting} \end{cases}$$

$$s_2 = \begin{cases} 1, \text{when the phase a is conducting} \\ 0, \text{when phase is not conducting} \end{cases}$$

$$s_3 = \begin{cases} 1, \text{when the phase a is conducting} \\ 0, \text{when phase is not conducting} \end{cases}$$

Now at any moment any two phases or three phases are conducting. For this we define a new variable s=1 for any two or three phase conducting and is equal to zero for no phase conducting.

2.1.1. Voltage equations for different conduction modes:

We assume there is no mutual coupling between the phases, the voltage expressions for different modes are as follows-

Mode 1**:** when all three phases are conducting.

In this case s1=1, s_2=1, s_3=1 and s=1. Then from the fig. it is clear that-

$$Val = Va; \quad Vbl = Vb\ ; \ and\ Vcl = Vc$$

Mode 2: when two phases are conducting (phase a and phase b). That is s1=1, s_2=1, s_3=0 and s=1 then from the fig.2.2

$$V_{al} = \frac{1}{2}V_{ab};\ V_{bl} = \frac{1}{2}V_{ba};\ V_{cl} = 0;$$

Mode 3: when two phases are conducting (phase a and phase c). That is s1=1, s_2=0, s_3=1 and s=1 then from the fig.2.2

$$V_{al} = \frac{1}{2}V_{ac};\ V_{bl} = 0;\ V_{cl} = \frac{1}{2}V_{ca};$$

Mode 4: when two phases are conducting (phase b and phase c). That is s1=0, s_2=1, s_3=1 and s=1 then from the fig.2.2

$$V_{al} = 0;\ V_{bl} = \frac{1}{2}V_{bc};\ V_{cl} = \frac{1}{2}V_{cb};$$

Mode 5: when two phases or all three phases are not conducting s1=0, s_2=0 s_3=0 and s=0, so from the fig.2.2

$$V_{al} = 0;\ V_{bl} = 0;\ V_{cl} = 0;$$

So the generalized load voltage for all states can expressed as follows:

$$\left.\begin{aligned} V_{al} &= \frac{s_1}{1+s_2+s_3}\left((s_2+s_3)V_a - s_2V_b - s_3V_c\right) \\ V_{bl} &= \frac{s_2}{1+s_1+s_3}\left((s_1+s_3)V_b - s_1V_a - s_3V_c\right) \\ V_{cl} &= \frac{s_3}{1+s_1+s_2}\left((s_2+s_1)V_c - s_1V_a - s_2V_b\right) \end{aligned}\right\} \quad (2.2)$$

Where V_a, V_b, V_c are the instantaneous supply voltages.

III. INDUCTION MOTOR SOFT STARTER

A soft starter is normally used to reduce the starting voltage automatically so that the magnetizing inrush reduces. This may be done by using open loop control or close loop control. The open loop control delays the application of the firing pulses to the thyristors and with a set time delay it produces the pulses. Here we go for close control of the soft starter. As mentioned earlier in the previous chapter, soft starter technology is widely employed as effective and low-cost means, as compared to modern PWM adjustable-speed drives, to reduce high starting currents and torque pulsations of medium voltage and large ac motors in numerous critical industrial, manufacturing, and transportation applications through use of thyristor-based voltage control [11][15]. The circuit topology and its control scheme are simple and easy to implement, which will be described in the following subsection.In an induction motor, the set of differential equations in dq representation that govern the instantaneous relationship between the voltages and currents in the synchronously rotating frame of reference can be expressed as follows[21]:

$$v_{qs}^{e} = r_s i_{qs}^{e} + \frac{d\lambda_{qs}^{e}}{dt} + \omega_e \lambda_{ds}^{e}$$
$$v_{ds}^{e} = r_s i_{ds}^{e} + \frac{d\lambda_{ds}^{e}}{dt} - (\omega_e - \lambda_{qs}^{e})$$
$$0 = r_r i_{qr}^{e} + \frac{d\lambda_{qr}^{e}}{dt} + (\omega_e - \omega_r)\lambda_{dr}^{e}$$
(3.28)
$$0 = r_r i_{dr}^{e} + \frac{d\lambda_{dr}^{e}}{dt} - (\omega_e - \omega_r)\lambda_{qr}^{e}$$

Where, $\lambda_{qs}^{e} = L_s i_{qs}^{e} + L_m i_{qr}^{e}$
$$\lambda_{ds}^{e} = L_s i_{ds}^{e} + L_m i_{dr}^{e}$$
$$\lambda_{qr}^{e} = L_r i_{qr}^{e} + L_m i_{qs}^{e}$$
(3.29)
$$\lambda_{dr}^{e} = L_r i_{dr}^{e} + L_m i_{ds}^{e}$$

Here $L_s = L_{ls} + L_m$ and $L_r = L_{lr} + L_m$, where, L_{ls} the stator leakage inductance, L_{lr} is the reffered rotor leakage inductance, and L_m is the magnetizing inductance in the T- equivalent circuit of an induction machine [22]. The first two equations of (3.28) correspond to the dq stator windings, while the last two equations of (3.28) correspond to the dq rotor windings. The equations of (3.29) represent the dq stator and rotor flux linkages. Meanwhile, the terms, ω_e and ω_r, represent the synchronous and rotor speed in radians/sec. subscript denotes synchronously rotating frame. In principle, reducing the impressed voltage upon the motor during starting reduces the starting current and torque pulsations. This is due to the fact that the starting torque or locked rotor torque is approximately proportional to the square of the starting current or locked rotor current, and consequently it is proportional to the square of the starting voltage [17]. Therefore, by properly adjusting the applied effective voltage during startup, the locked rotor torque and current can be reduced. The most common control strategy employed by the soft starter of Figure 2.1 is the open loop voltage control. Such control approach is widely adopted in commercially available soft starters, as well as soft starter designs reported in the literature [18]-[19]. The voltage control is implemented by adjusting either the delay angle, α , or the hold-off angle, γ , of the conduction cycle of the oncoming thyristor with respect to either the zero crossing of the supply voltage (α) or the zero crossing of the line current (γ), respectively, as shown in Figure 2.2. The thyristors are then selectively fired to conduct current in the appropriate phase, and naturally commutate off when the current reaches zero. The larger the delay angle, α, or the hold-off angle, γ , the larger the notch width in the applied motor voltage, which consequently reduces the effective or RMS value of such voltage impressed upon the motor. However, improper control of α or γ firing angles may result in relatively high starting torque and current oscillations. Therefore, optimum starting profiles of the α or γ firing angles have been extensively investigated to produce smooth starting torque and current profiles.

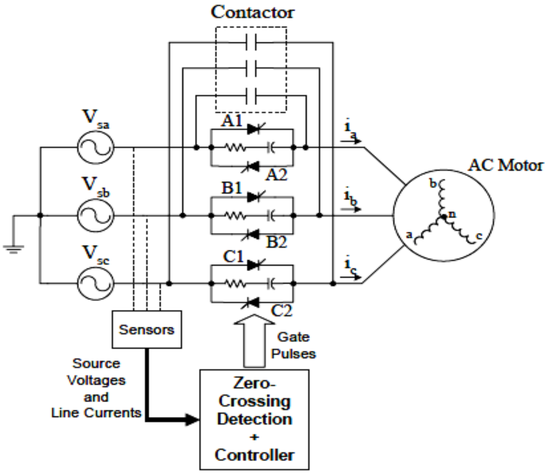
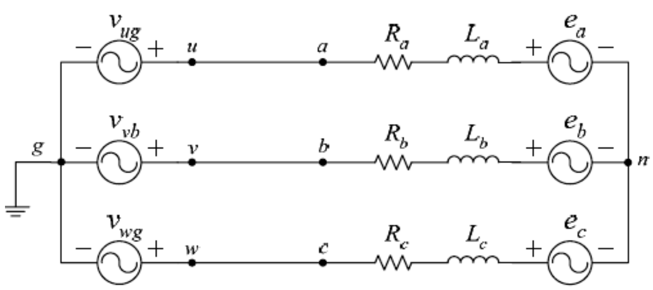


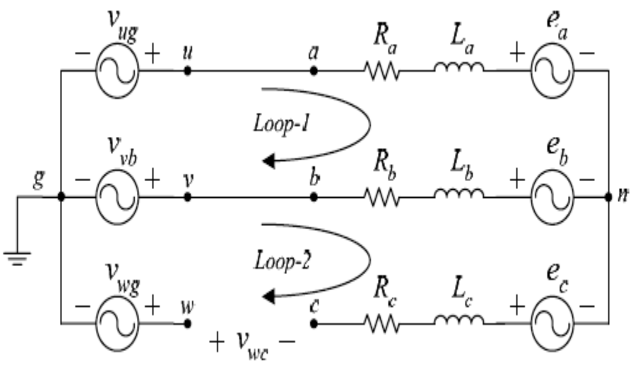
Figure.3 Conventional three-phase soft starter topology

In order to obtain good dynamic characteristics, a symmetrical-triggering firing pulse sequence is necessary. Due to the fact that the thyristor is a half-controlled device, its firing pulse must be synchronized with the ac mains. The six thyristors will be turned on with the proper sequence, and the firing signal is in phase with the zero-crossing of the supply voltage. Since\ there is an inherent delay associated with a thyristor turn-off, the input current of the motor is not continuous, which results in time harmonics in the machine air gap flux. These generated harmonics are generally odd order harmonic terms. In the commercially available soft starters, this firing angle profile is preset by the user based on the initial setting of the locked-rotor torque (LRT) and the ramp time, a simple illustration of which is shown in Figure 3.3. The LRT is the initial starting torque that is required to accelerate the motor during starting, and the ramp time is the time it takes for the voltage to go from the initial voltage value at the LRT setting to the maximum full voltage that is being applied to the motor. By adjusting the ramp time, the acceleration time of the motor can be controlled. Accordingly, the firing angle, which controls the amount of applied motor voltage, is reduced gradually depending on the ramp time during the period of starting until the motor has reached its full speed and rated current, whereupon the contactors are closed to bypass the thyristors. Evidently, such predetermined α or γ firing angle control offers very limited control flexibility. It should be noted from Figure 3.2 that the phase angle, φ , is related to the delay angle, α , and the hold-off angle, γ , by the following relation:

$$\Phi = \alpha - \gamma$$



(a)



(b)

Figure.4 (a) 3-phase conduction mode. (b) 2-phase conduction mode.

IV. FAULT MODE ANALYSIS

The earlier formulations of the closed-form analytical expressions of the motor phase voltages and currents are employed herein to investigate the impact of failure modes in soft starters on the motor transient performance. Two distinct types of failure modes considered in this work are: (1) short-circuit SCR fault (see Figure 4.1(a)), and (2) open-circuit SCR fault (see Figure 4.1(b)), occurring only in one phase of the soft starter. A short-circuit SCR fault can happen in situations such as loose wire in the circuit or breakdown in the snubber circuit. Conversely, an open-circuit SCR fault can occur due to malfunctions either in the gate driver or the pulse generator of the controller.

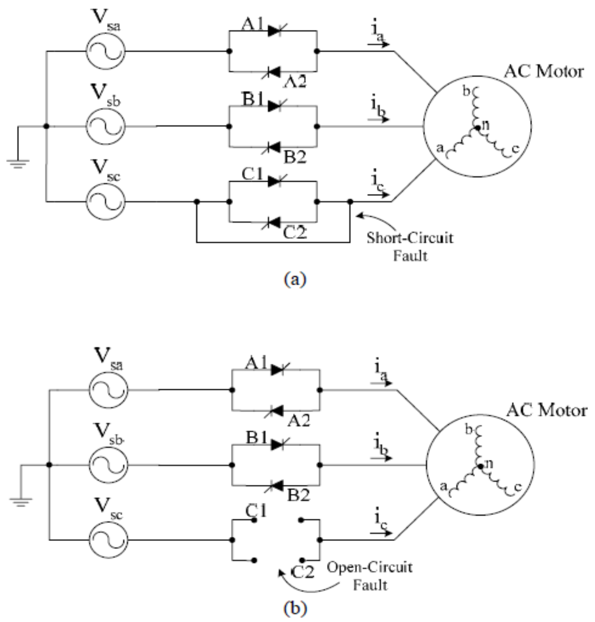


Figure.5 Failure modes in soft starter circuit (a) Short-circuit fault. (b) Open-circuit fault

V. SIMULINK MODEL AND RESULTS

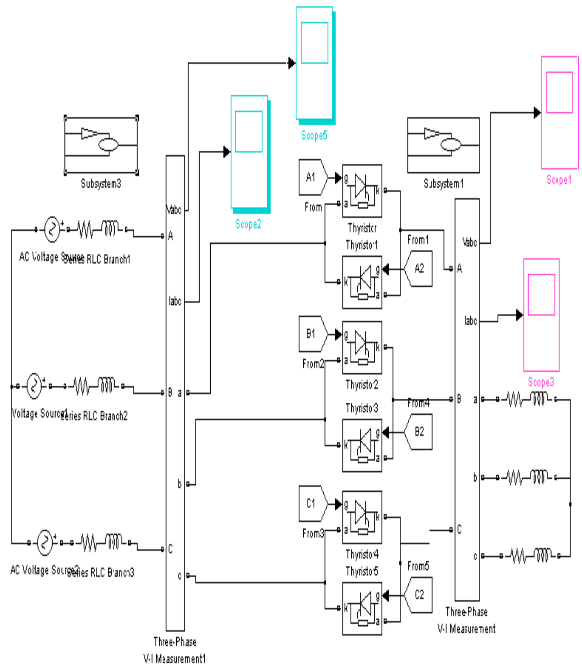


Figure.6 Simulink model of RL load

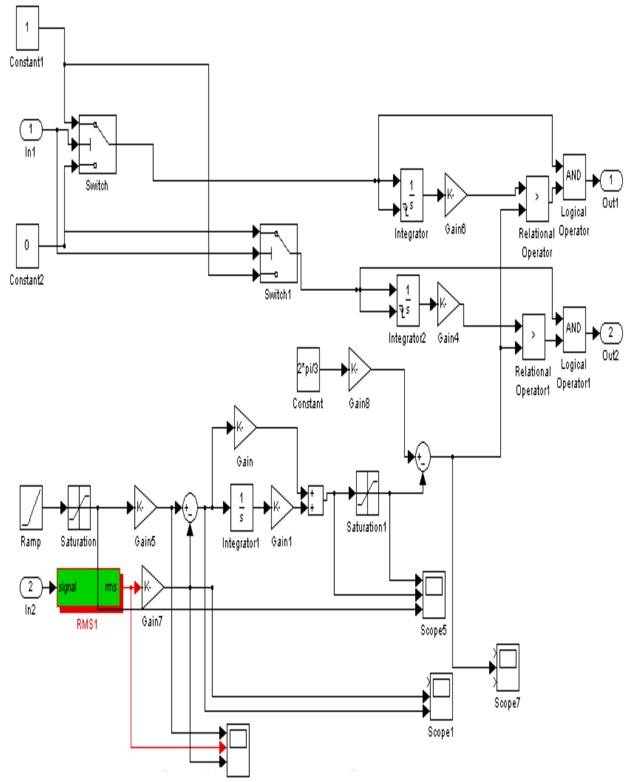


Figure.7 Firing circuit model for RL load

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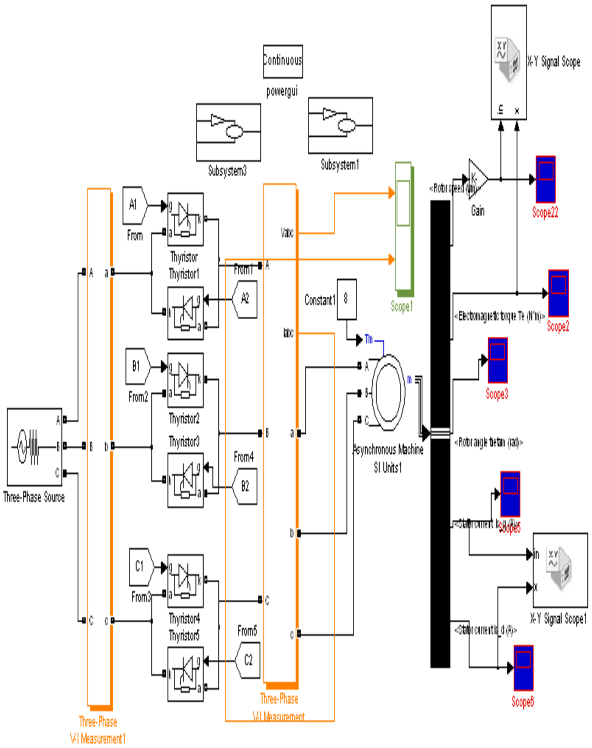

Figure.8 Induction motor model in healthy mode (soft starting)

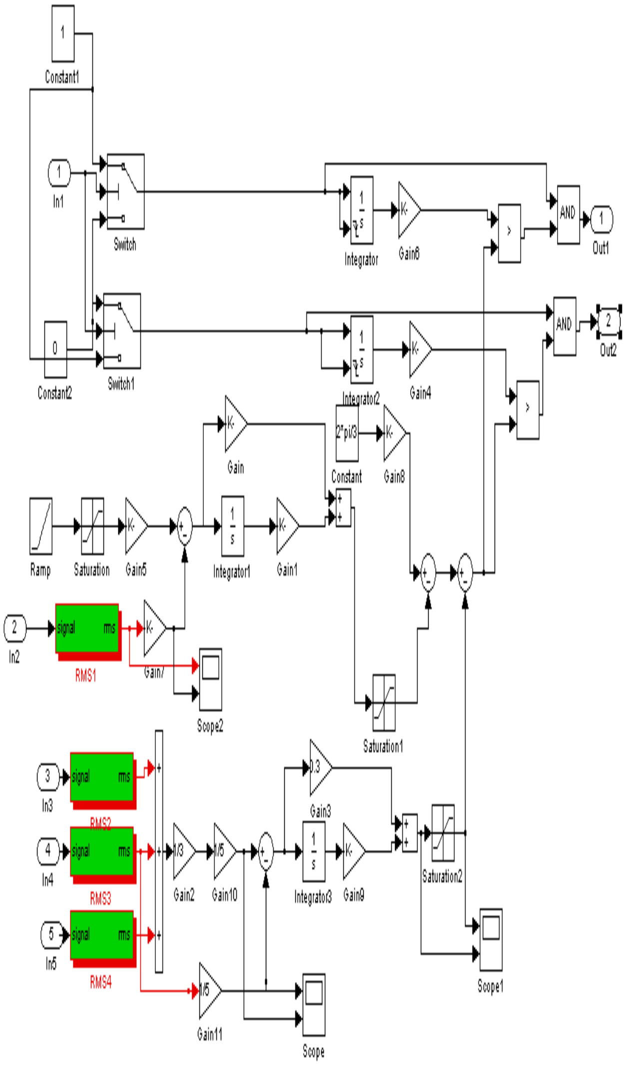

Figure.9 Proposed Control circuit model in fault mode (2-phase close loop control)

a. Simulation results for the RL load

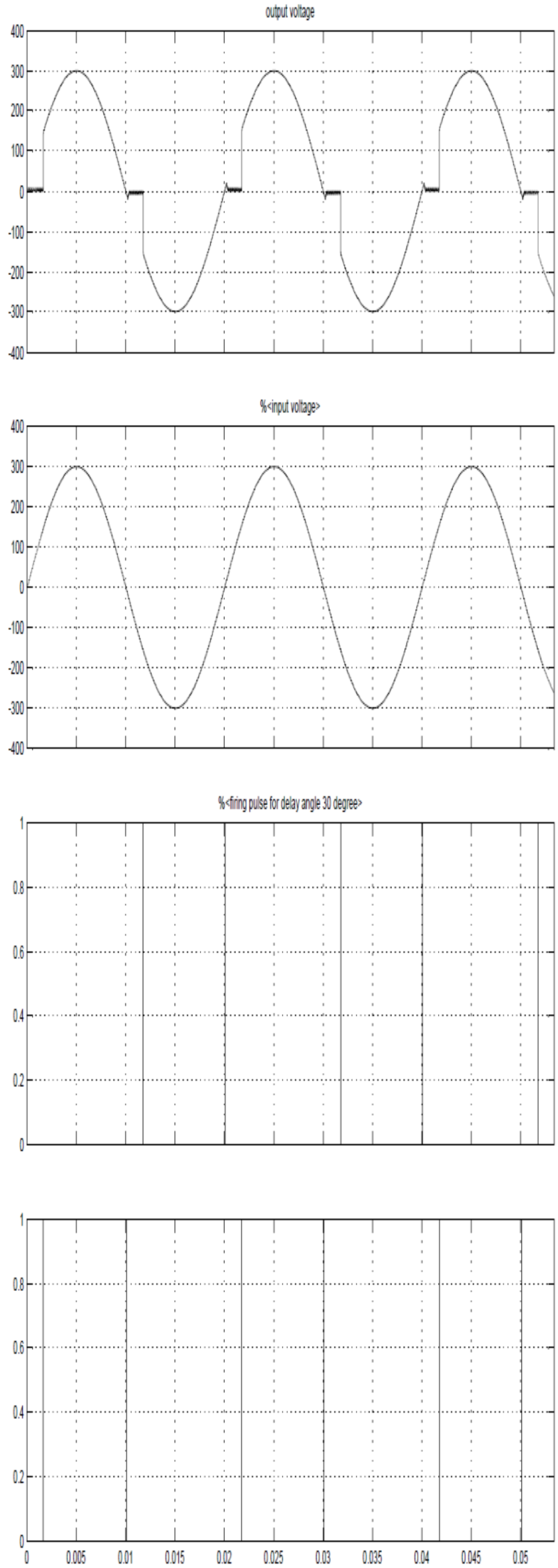

Figure.10 Voltage waveform with RL load for $\alpha = 30^0$

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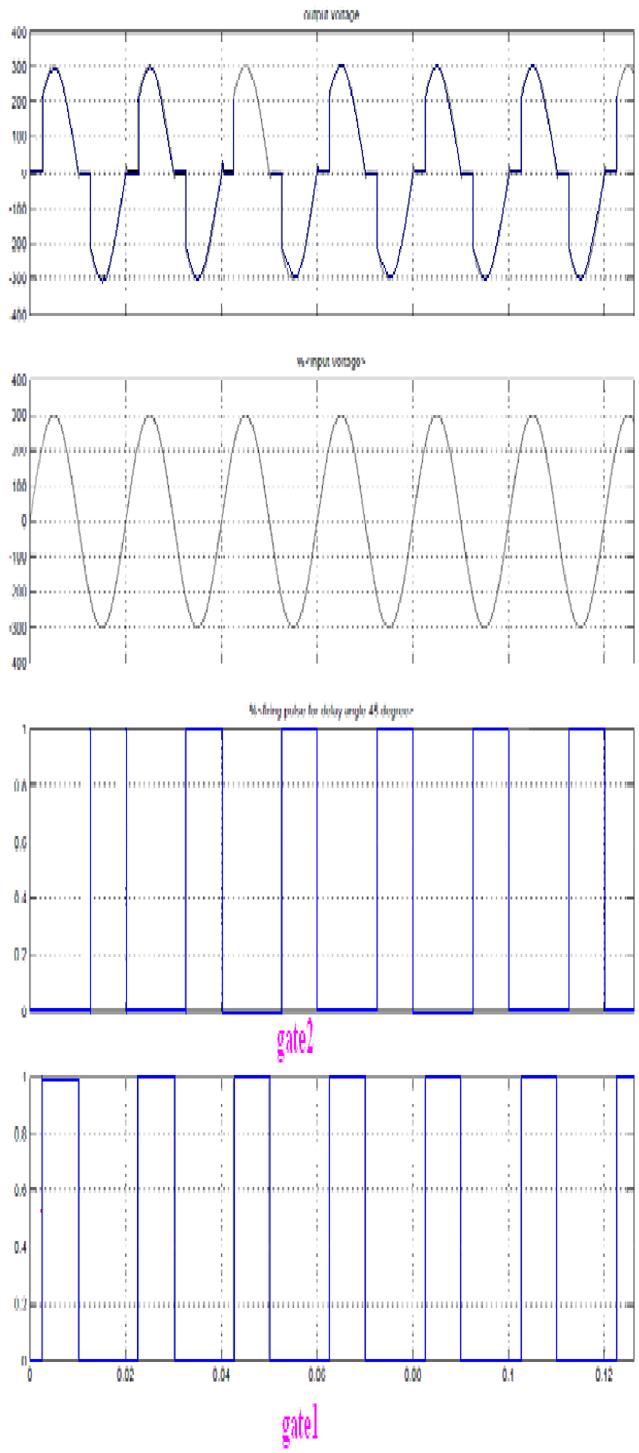

Figure.11 Voltage waveform with RL load for $\alpha = 45^0$

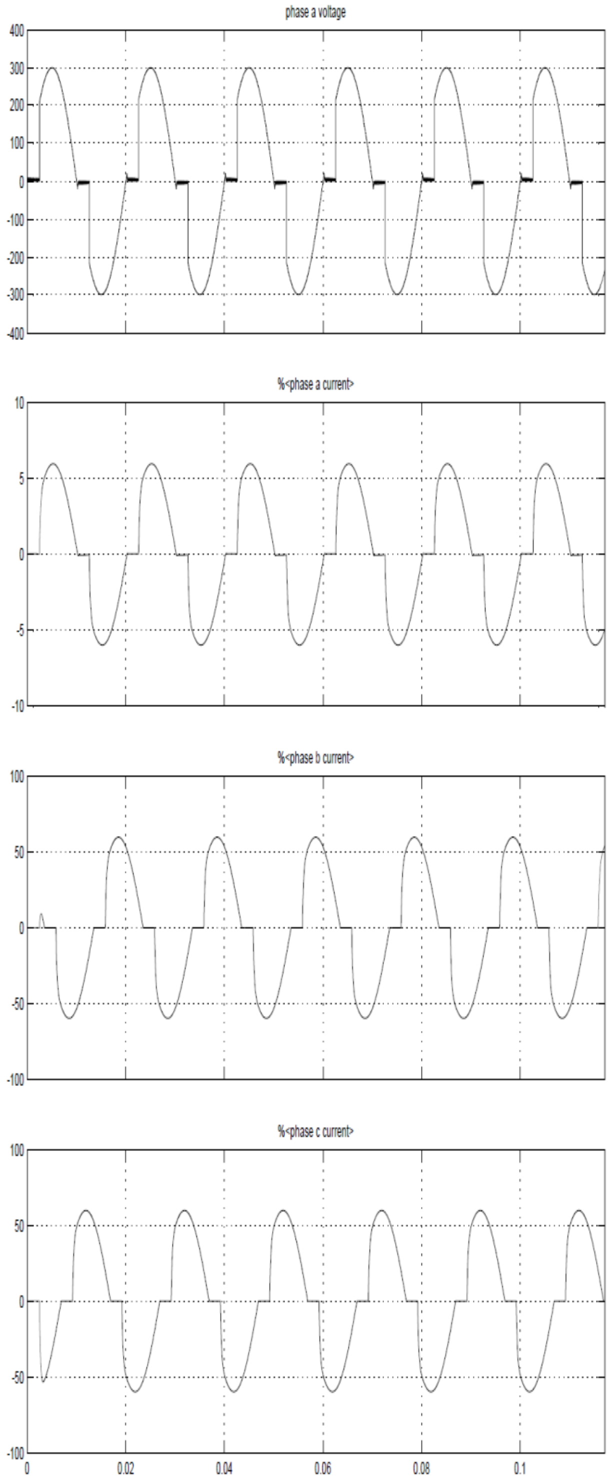

Figure.12 Current waveform with rl load for $\alpha = 45^0$

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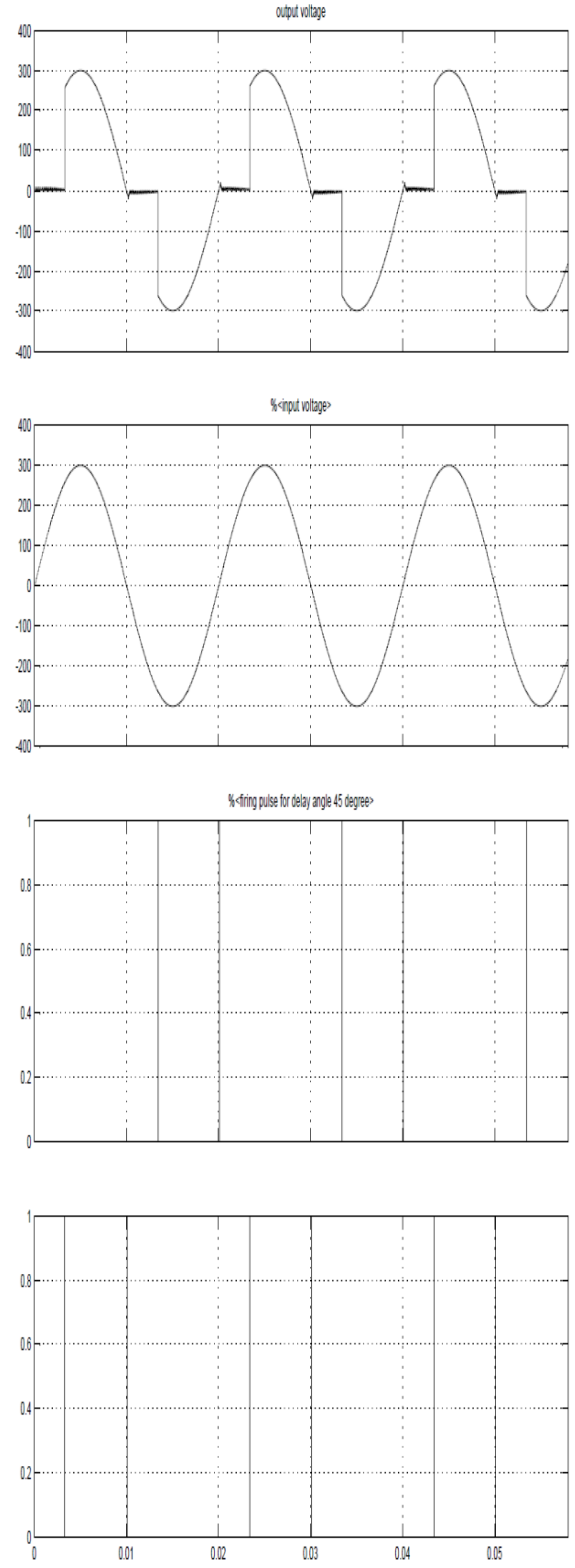

Figure.13 Voltage waveform with rl load for $\alpha = 60^0$

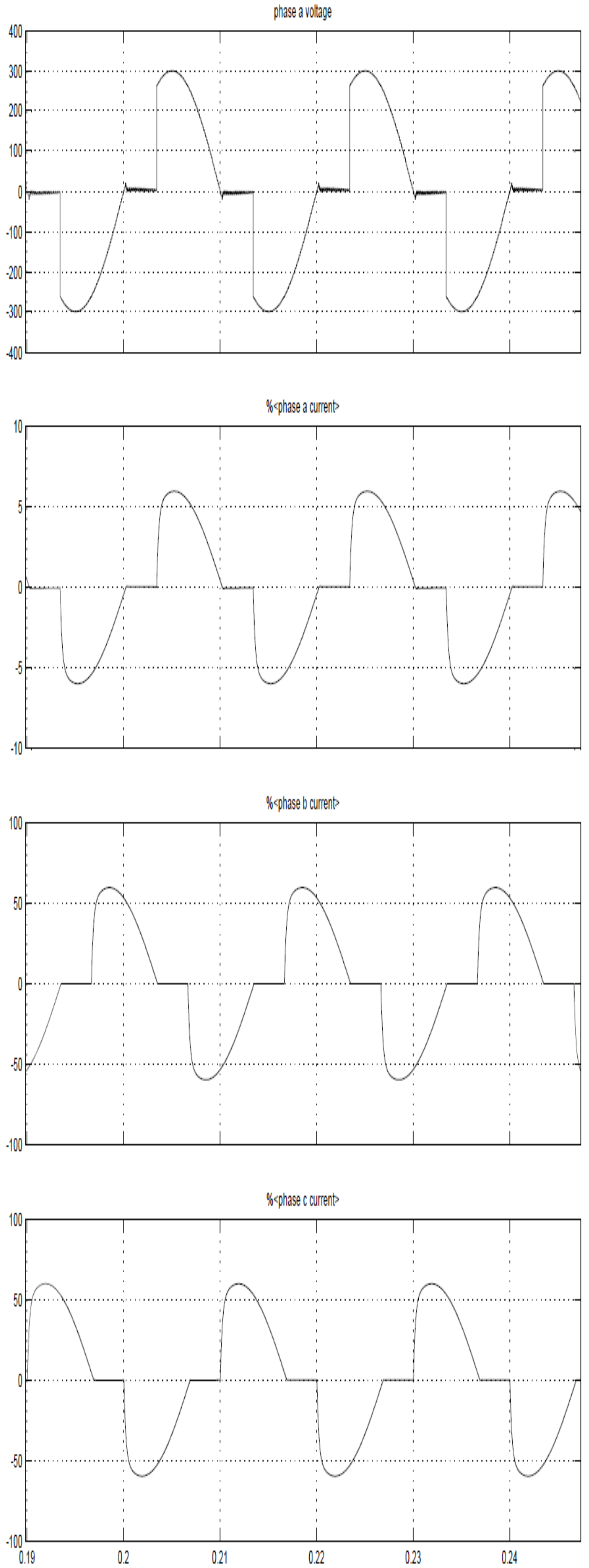

Figure.14 Current waveform with rl load for $\alpha = 60^0$

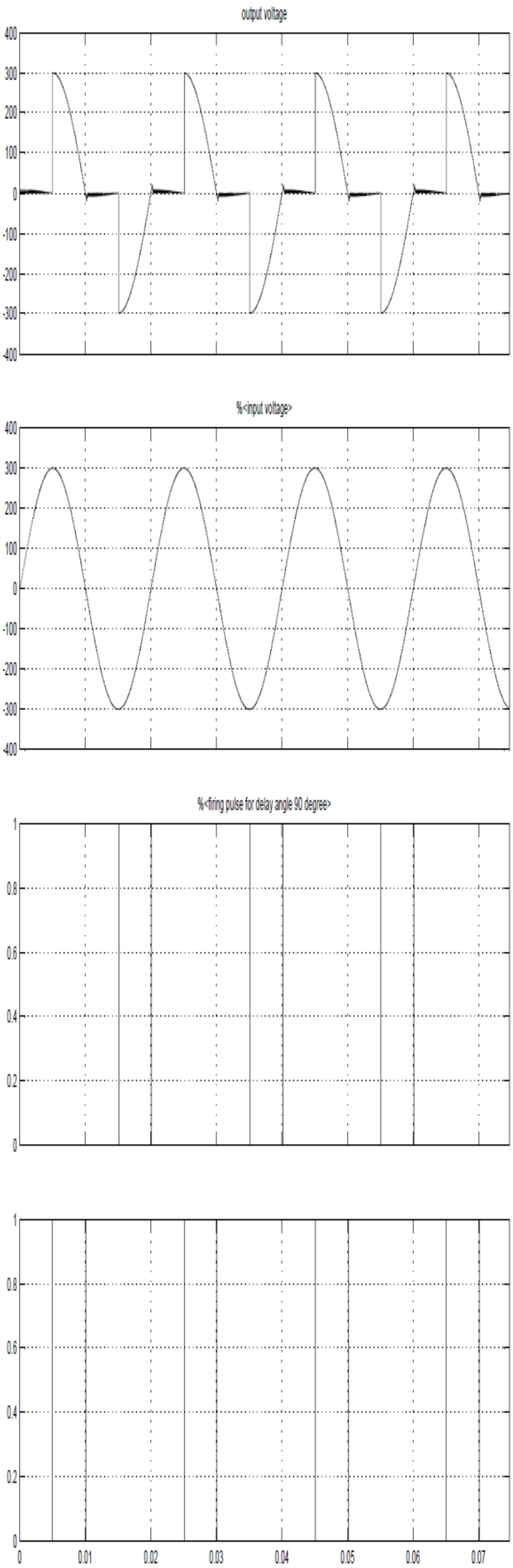

Figure.15 Voltage waveform with rl load for $\alpha = 90^0$

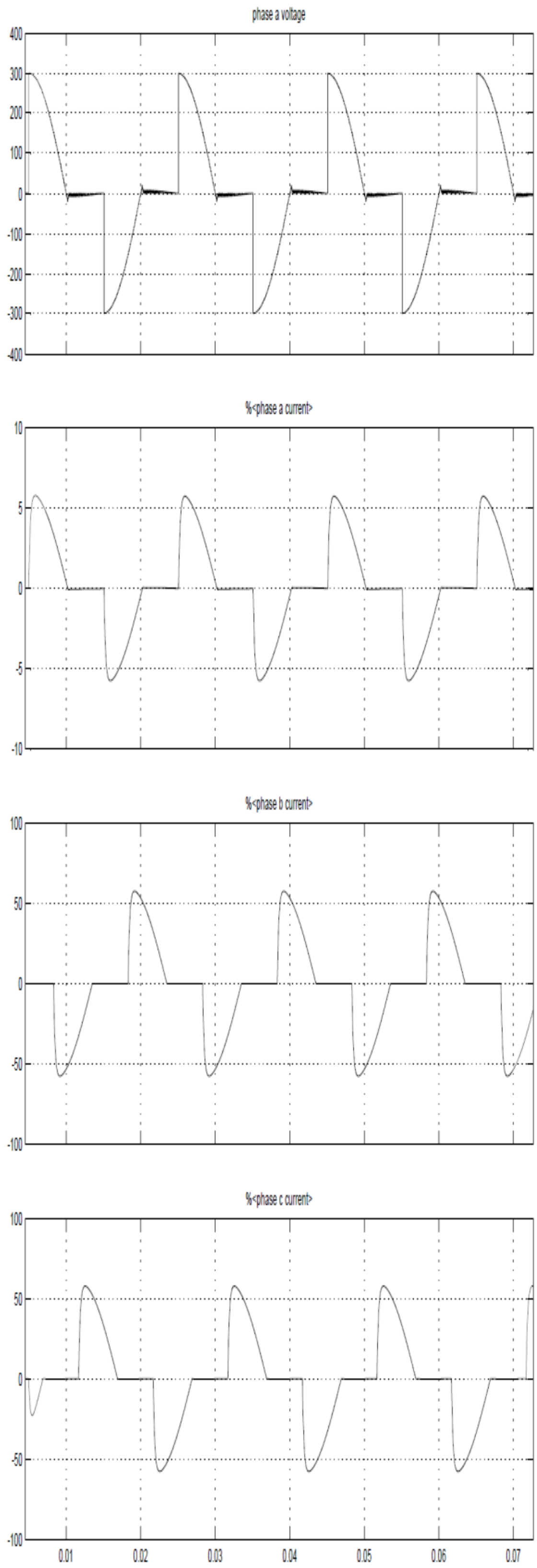

Figure.16 phase voltage and Current (a,b,c) waveform with rl load for $\alpha = 90^0$

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Simulation result for R=30Ohm and L=50Mho

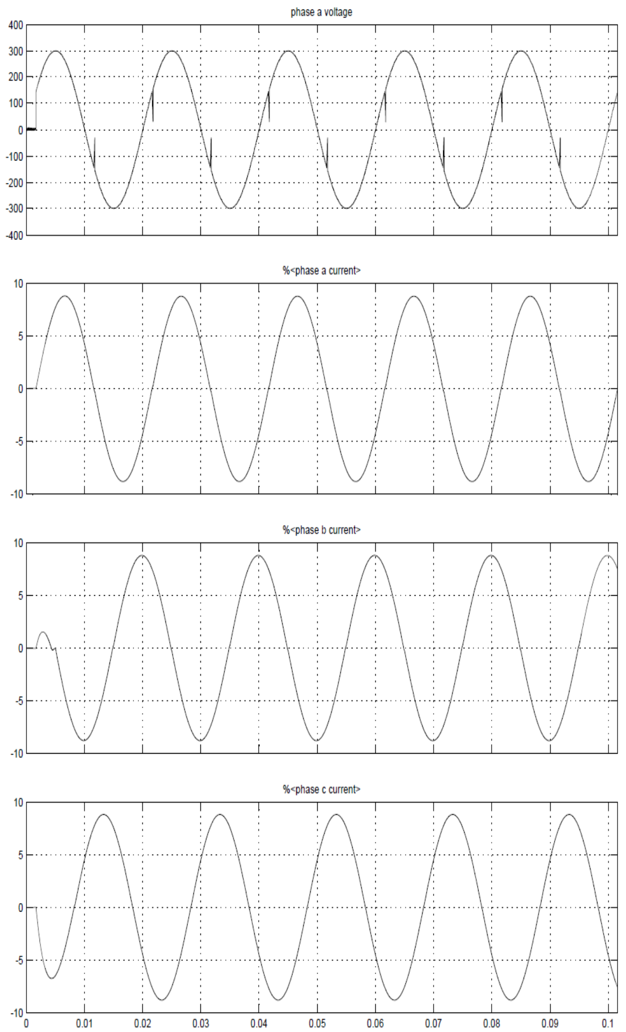

Figure.17 (a): Phase Voltage and current waveform with rl load for $\alpha = 30^0$

b. Simulation results for the 3-phase voltage regulator fed induction motor

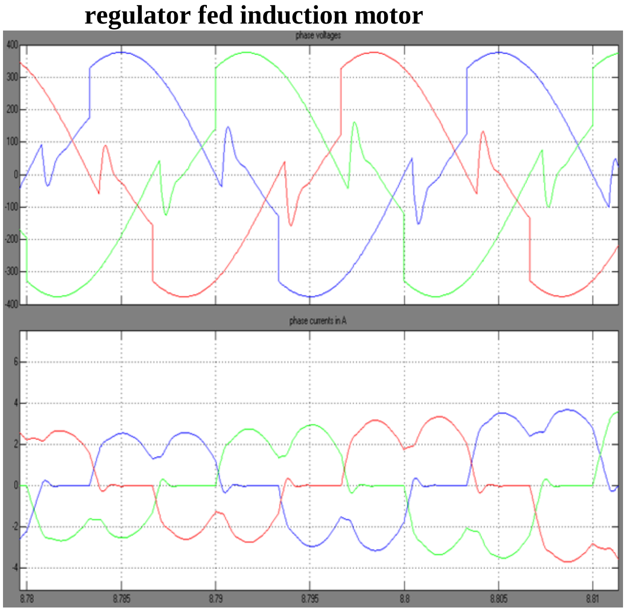

Figure.18 Phase voltage and current for delay angle 60^0

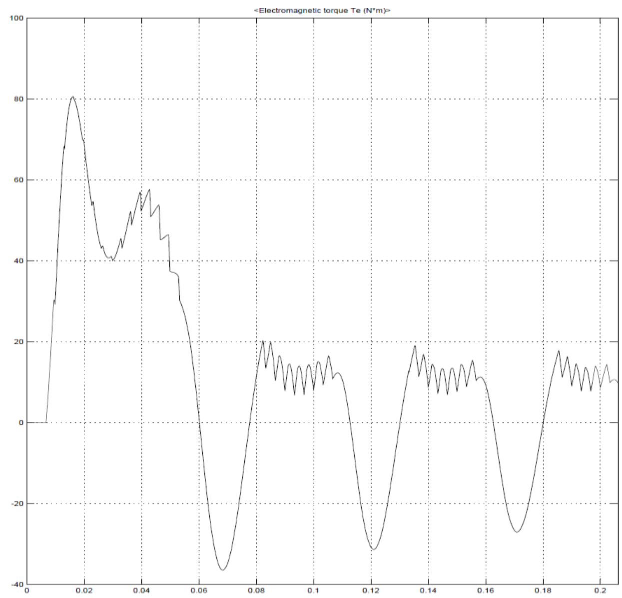

Figure.19 First few cycles of torque for delay angle 60^0

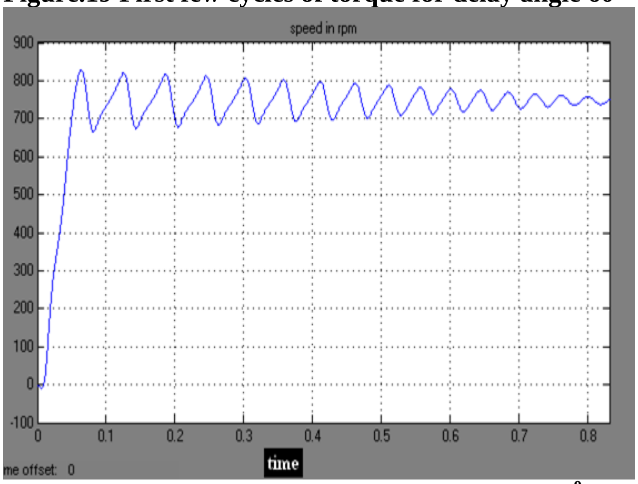

Figure.20 Speed versus time for delay angle 60^0

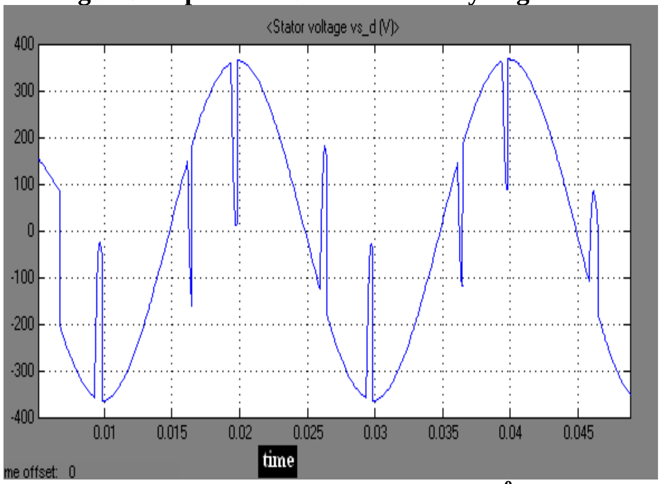

Figure.21 Phase voltage for delay angle 60^0 and 50% load torque

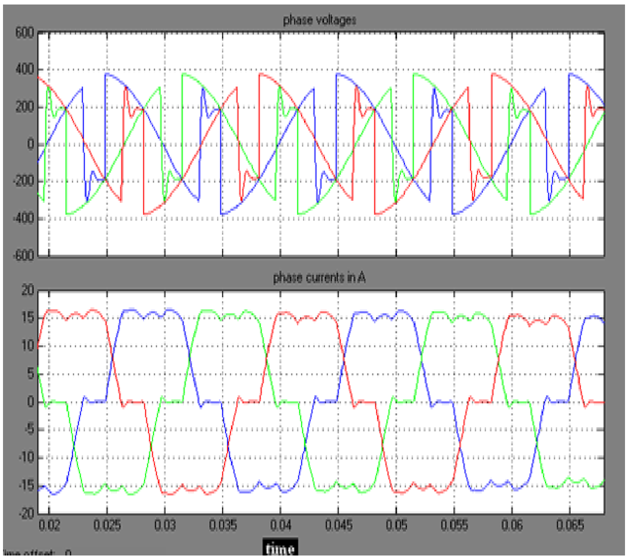

Figure.221st few cycles of phase current and phase voltages for delay angle 90^0 and 50% load torque

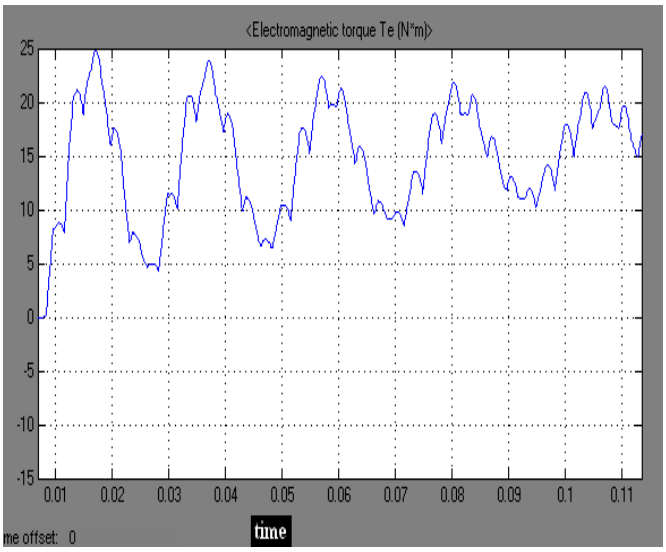

Figure.25First few cycles of torque for delay angle 900 rated load

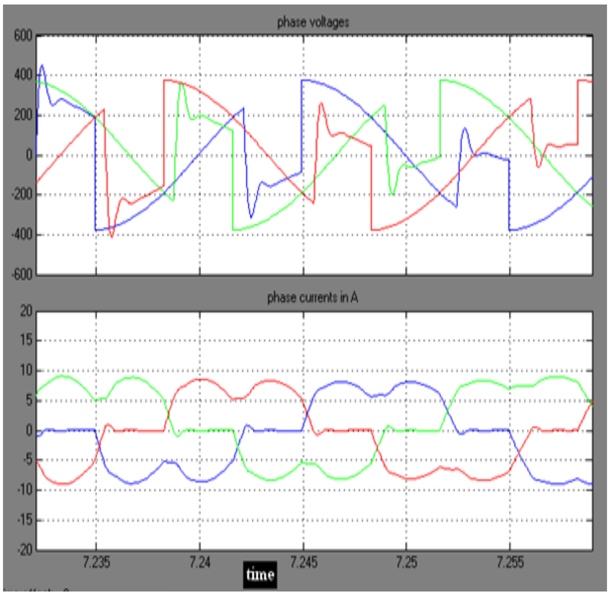

Figure.231st few cycles of phase current and phase voltages for delay angle 900 and 50% load torque

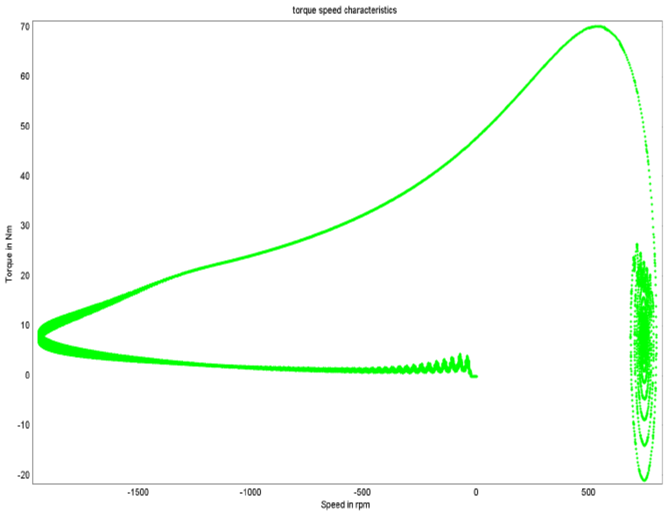

Figure.26 Torque versus speed characteristics of close loop controlled induction motor

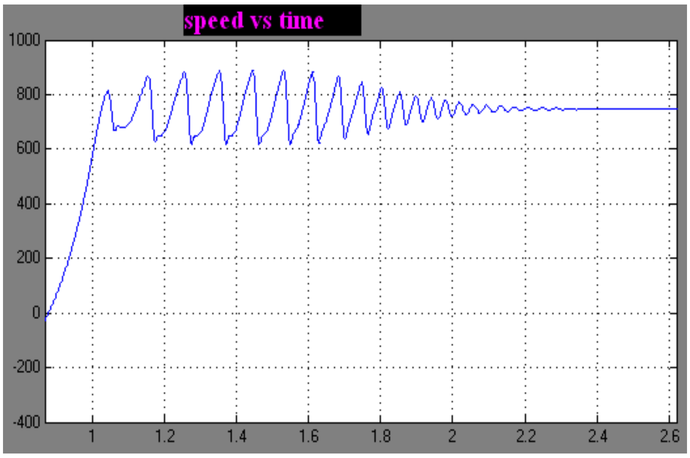

Figure.27 Speed versus time characteristics of close loop controlled induction motor

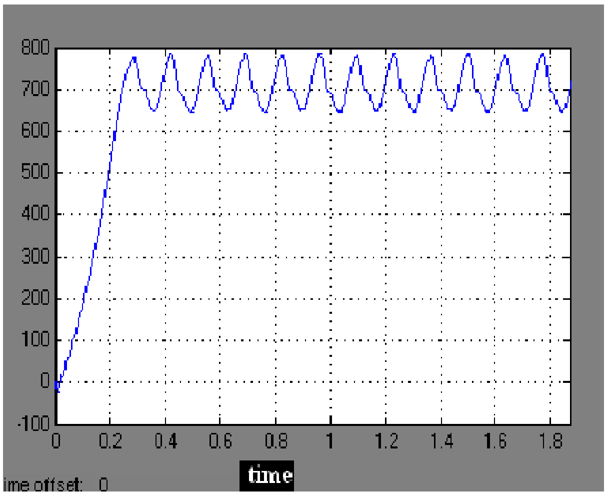

Figure.24 Speed versus time for delay angle 900

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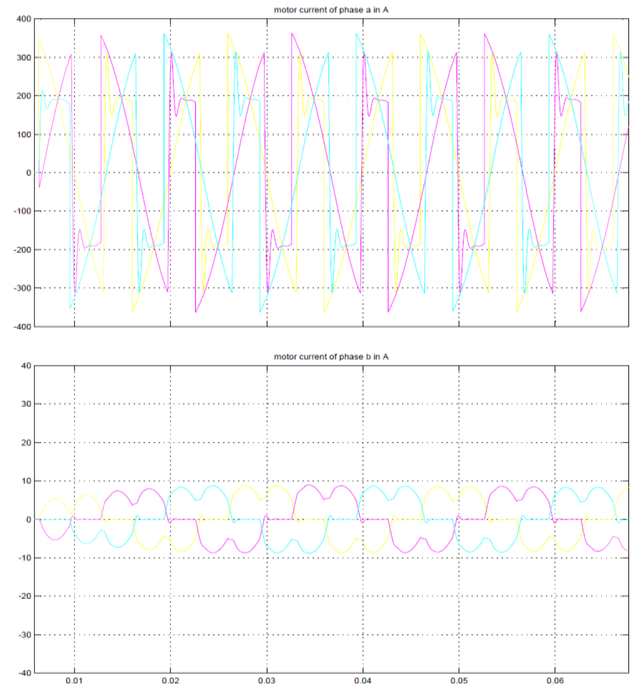

Figure.28 Transient voltage and current of close loop controlled induction motor

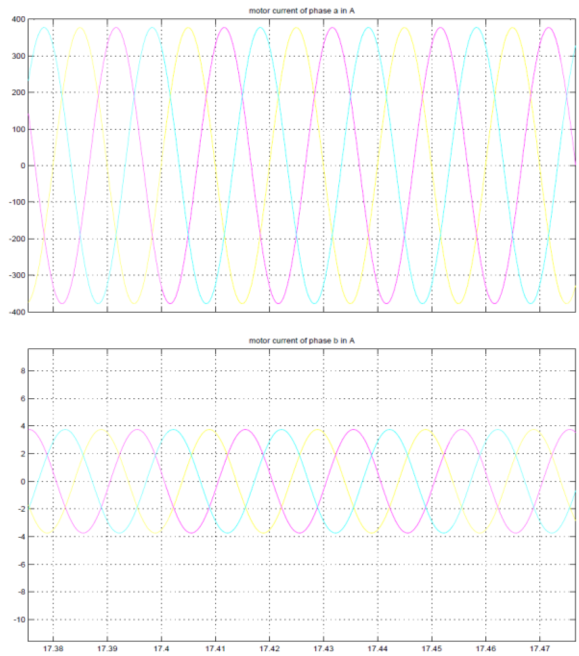

Figure.29 Steady state voltage and current of close loop controlled induction motor

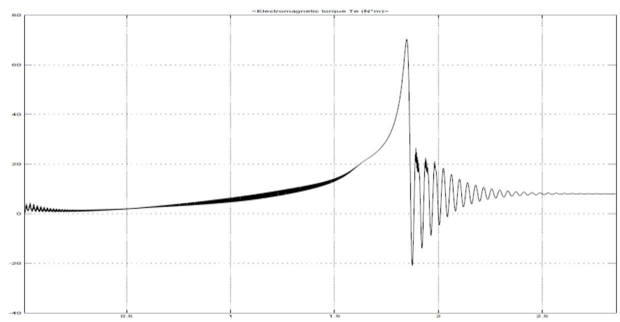

Figure.30 Torque versus time 1st few cycles of close loop controlled induction motor

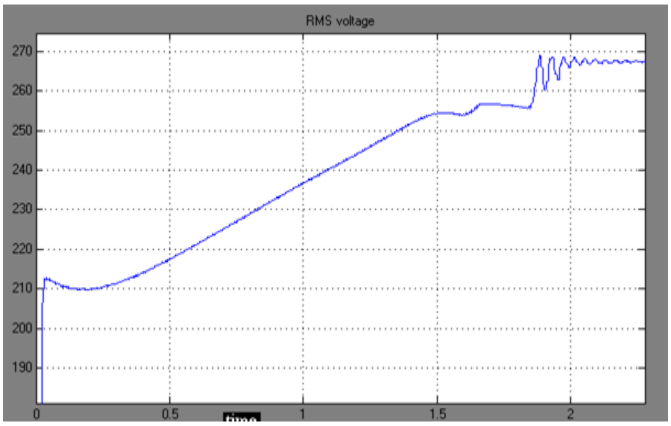

Figure.31 RMS output voltage (phase B) of close loop controlled induction motor

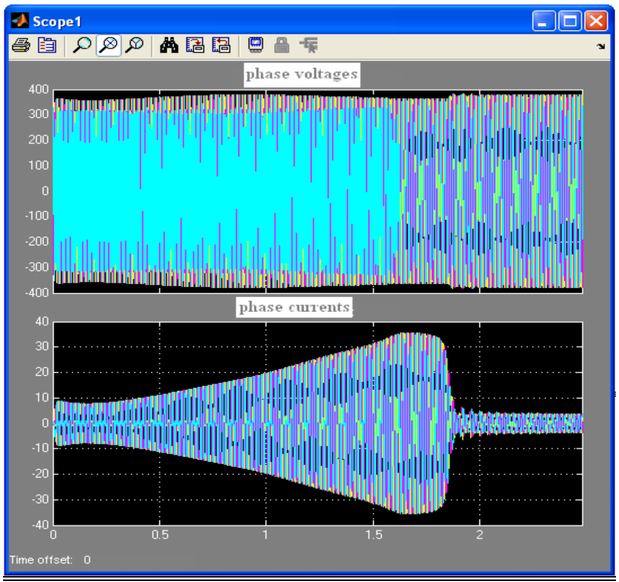

Figure.32Phase voltages and phase currents of close loop controlled induction motor

Simulink Results of Fault Mode

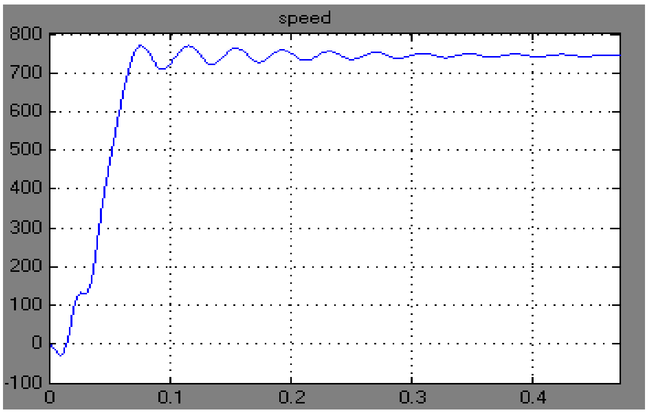

Figure.33 Speed versus time graph in case short circuit fault

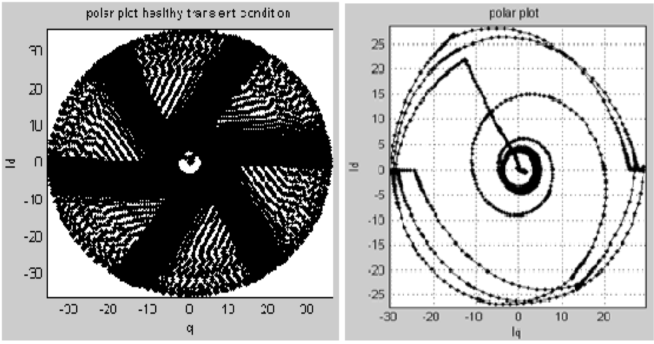

Figure.34 Polar plot (healthy condition) and Polar plot (short ckt)

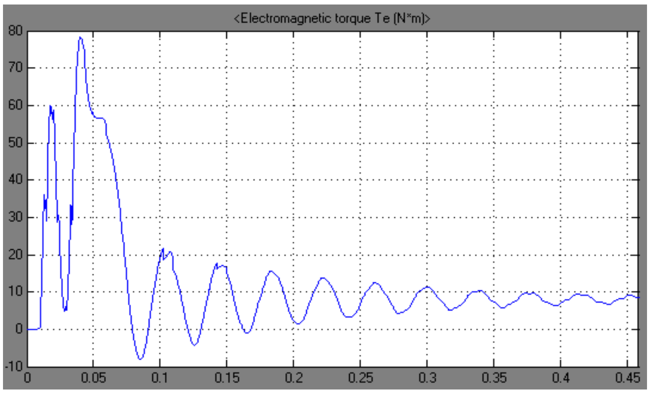

Figure.35 Torque versus time during a short circuit fault

VI. CONCLUSION

This paper is based on a simulation study of a three phase voltage controller with RL and induction motor load. Both the cases were also simulated for soft starting. The results obtained are pretty satisfactory. The initial magnetic inrush is greatly reduced with the help of a soft starter (thyristor voltage regulator based) along with the torque pulsation reduction. Also closed form derivation of the induction motor is conceived to analyze the transient performance during soft starting. Next the fault tolerant operation of the induction motor under various switch faults was studied. An analytical study was carried out but the simulation could not be carried satisfactorily because of shortage of time. But still the results obtained for the short circuit fault seems to be highly improved by this 2- phase close loop control method.

APPENDIX

Machine ratings

Rated Power 2 hp (1492 Watts)
Rated Voltage (Line-Line) 460 Volts
Rated Current 3.0 Amps
Rated Frequency 50 Hz
Rated Speed 1440 rpm
Rated Torque 8.169 Nm
Phase 3
Number of Poles 4
Stator Resistance, R_s=3.850 Ω
Rotor Resistance, R_r= 2.574 Ω
Stator Leakage Inductance, $L_{ls} = L$ 17.5594 mH
Rotor Leakage Inductance, L_{lr} = 17.5594 mH
Magnetizing Inductance, L_m = 0.372674 H
Moment of Inertia, J 0.028 kg.m2
Load Coefficient, k_L= 0.24493×10 Nm/ (m. rad/s) ^{2}

REFERENCES

1. Riyaz A., Atif Iqbal, Shaikh Moinoddin, SK. MoinAhmed, "*Comparative performance analysis of Thyristor and IGBT based induction motor soft starters*",International Journal of Engineering, Science and Technology Vol. 1, No. 1, 2009, pp. 90-105.
2. Li Wen-Xiong, Jian-gou Lu and Ming-sheng-liu, "*Design of intelligent soft-start controller for induction motor*", Proceedings of the Third International Conference on Machine Learning and Cybernetics, Shanghai, 26-29 August 2004.
3. Wu. Jing, Rongxiang Zhao, Zhe Shang, "*The Design of Soft Starter for AC Motors Based on Single Neuron PI Regulator*", Proceedings of the 6th World Congress on Intelligent Control and Automation, June 21 - 23, 2006, Dalian, China
4. P. C. Krause, O. Wasynczuk, and S. D. Sudhoff, "*Analysis of Electric Machinery and Drive Systems*", John Wiley & Sons, Inc., 2nd Edition, 2002.
5. Bibhu Prasad Ganthia, Aditi Abhisikta, Deepanwita Pradhan, Anwes Pradhan, A Variable Structured TCSC Controller for Power System Stability Enhancement, Materials Today: Proceedings, Volume 5, Issue 1, Part 1, 2018, Pages 665-672, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2017.11.131.
6. Chia-Chou Yeh, Nabeel A.O. Demerdash, **"***Fault tolerant soft starter control of induction motor with reduced transient torque pulsations*", IEEE Transaction on Energy Conversion, Vol. 24, No. 4, pp. 848-859, Dec. 2009.
7. Bibhu Prasad Ganthia, Prashanta Kumar Rana, Tapas Patra, Rosalin Pradhan, Rajashree Sahu, Design and Analysis of Gravitational Search Algorithm Based TCSC Controller in Power System, Materials Today: Proceedings,Volume 5, Issue 1, Part 1,2018, Pages 841-847, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2017.11.155.
8. W. J. Lukitsch, "*Soft start versus AC drives –Understand the differences*," Conference Proceedings of IEEE Textile, Fiber and Film Industry, pp. 1-5, May 1999.
9. W. Deleroi, J. B. Woudstra, and A. A. Fahim, "*Analysis and application of three-phase induction motor voltage controller with improved transient performance*," IEEE Transactions on Industry Applications, Vol. 25, No. 2, pp. 280-286, Mar./Apr. 1989.
10. V. V. Sastry, M. R. Prasad, and T. V. Sivakumar, "*Optimal soft starting of voltage controller-fed IM drive based on voltage across thyristor*," IEEE Transactions on Power Electronics, Vol. 12, Issue 6, pp. 1041-1051, Nov. 1997.
11. F. Blaabjerg, J. K. Pedersen, S. Rise, H. H. Hansen, and A. M. Trzynadlowski, "*Can softstarters help save energy?*," IEEE Industry Applications Magazine, Vol. 3, No. 5, pp. 56-66, Sept./Oct. 1997.
12. B. P. Ganthia, R. Pradhan, S. Das and S. Ganthia, "Analytical study of MPPT based PV system using fuzzy logic controller," *2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS)*, Chennai, India, 2017, pp. 3266-3269.
13. S. S. Murthy and G. J. Berg, "*A new approach to dynamic modeling and transient analysis of SCR controlled induction motors*," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-101, pp. 219-229, Sept. 1982.
14. Ganthia B.P., Pritam A., Rout K., Singhsamant S., Nayak J. (2018) Study of AGC in Two-Area Hydro-thermal Power System. In: Garg A., Bhoi A., Sanjeevikumar P., Kamani K. (eds) Advances in Power Systems and Energy Management. Lecture Notes in Electrical Engineering, vol 436. Springer, Singapore

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