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Comparison of AC Choppers Fed Single Phase Induction Motor Close Loop Characteristics

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ABSTRACT: This paper presents comparison of closed loop results of single, two and four switch AC Chopper fed single phase induction motor. The Dynamic response of open loop system is poor. Closed loop system is used to improve the dynamic response. This paper deals with modeling and simulation of one switch, two switch and four switch AC Chopper fed single phase induction motor drives.

The pulse width modulated AC chopper fed single phase induction motor is implemented using an Atmel 89C51 microcontroller. The intention is to save energy in operations using induction motors. At no load, 70% of the energy can be saved that decreases with an increase in the load. From the simulation results, it is seen that the pulse width modulated (PWM) AC chopper system has lesser harmonics than the phase controlled AC chopper system, and hence it is used in the present work. Closed –loop control scheme to implement the energy–saving in the single phase induction motor drive system is designed and presented. The possibility of energy saving is explored in loads like cutting, punching and drilling operations, where most of the time induction motors runs at no load

KEYWORDS: AC Chopper, Pulse Width Modulation, Induction motor, Peak overshoot, Settling time, Rise time.

I. INTRODUCTION

Demand for Power requirement in the world is growing faster. The generation is not able to meet the load demand. Therefore, it is better to conserve the energy, so that load demand can minimize. Energy saving in single phase induction motor is dealt by B.Palit (1970)[1] Micro controller - based energy savers have been investigated by Xue and Cheng (2006).

In industrial operation like drilling, cutting and punching, most of the time induction motors run at no load. These motors are always connected to the mains irrespective of the load conditions. Due to the rated voltage at stator terminals, rated iron losses have to be supplied constantly to the motors. These losses mean a waste of energy. If it is possible to reduce the voltage at the stator terminals during no load or partial load conditions, then iron losses can be reduced and some electrical energy might be saved (Hunyar and Veszpremi, 2001)[4]. Voltage controllers are increasingly applied as motor soft starters and sometimes as energy savers, reducing the flux level in the connected induction motor.

The use of a SCR voltage controller results in considerable harmonic distortion and substantial additional losses, which reduce the net energy saving. The main problems associated with the SCR voltage controller are the high harmonic contents in the supply and motor currents, very poor power factor especially at light loads, and low efficiency. The pulse width modulated AC chopper can help in modifying these parameters. With the increased availability of power MOSFETs and insulated gate bipolar transistors, a new generation of simple choppers for AC inductive loads is foreseen. Pulse width modulated AC chopper controllers can replace the AC controllers with thyristor technology, which can overcome the above said drawbacks (Ahmed, Amei and Sakuri, 1999)[3]. The pulse width modulated AC chopper is inferior to the phase angle control scheme for an induction motor (Hongxiang, Min and Yancho, 2004)[5**]**. A dc chopper circuit is connected to the stator in a un-conventional method. Speed of the single-phase induction motor is controlled by chopping frequency of chopper. This drive provides the capability of phase control as well as frequency control(Abdel-rahim G.M et al (1995) [6]). The novel topologies of AC Chopper for single phase and three phase buck, boost and buck-boost (B.H. Kwon, et al (1996) [7]). The ac triac chopper with current impulse commuted is employed to obtain the best possible power factor correction for reactive loads(B. W. Williams (1982) [8]).A single phase series resonant step up or down AC chopper (Chien –Ming Wang et al (2009) [9]).A

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Vol. 4, Issue 11, November 2015

symmetrical PWM technique is used in this proposal power factor is improved by shifting the phase angle (D.H. Jang et al (1991)[10]). AC Chopper with a latest pulse width modulated control technique is Proposed, this technique eliminates harmonics of particular range and controls the basic constituent output voltage (G.H. Choe et al (1989)[11]).

A Solution for air movement, pumping and compressor using single phase AC motor is provided its low cost and easy availability of induction motor suits for such applications(Howard Abramowitz (2003) [12]).Forced commutated Analog Pulse Width Modulation AC controller has advantages as compared with line commutated ac controller (L. Salazar et al (1993) [13]).Nabil A Ahmed et al (1999) [14] has offered an ac chopper circuit with three number of controlled switches for single phase machines. P.D. Ziogas et al (1991) [15] proposed an enhanced PWM controller topologies.Phoivas D. Ziogas et al (1985) [16] proposed an essential step towards manufacturing compact low cost static power supplies. A multiple pulse width modulated chopper for three phase power control using 120^{0} as chopping period. Single phase sensing is utilized for three phase control (S.A. Bhat et al 1982) ([17]). A PWM programmed switching for ac motor takes care of the disadvantages of the present current regulators (Prasad N.Enjeti et al (1992) [18]).

II. CIRCUIT DESCRIPTION & SIMULATION RESULTS

2.1 Single switch converter system:

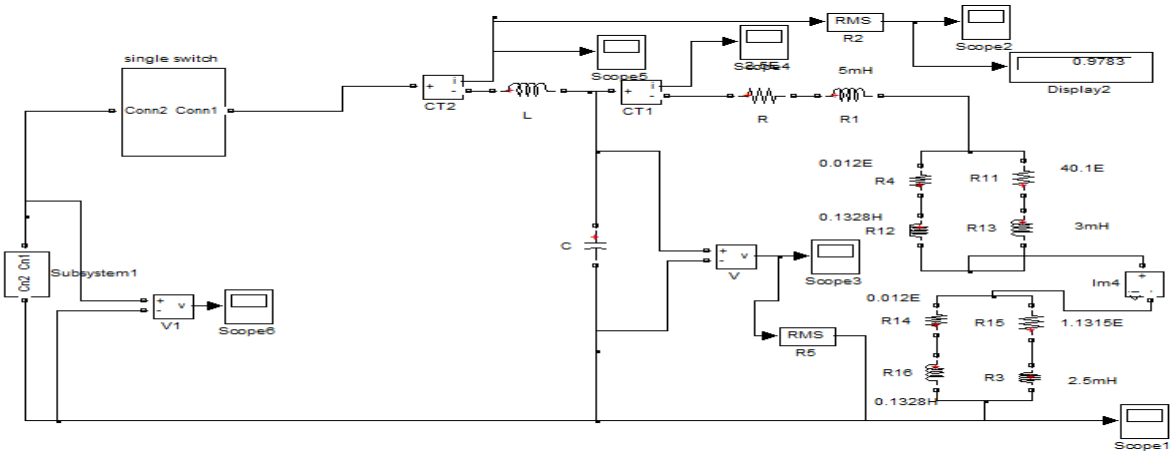

Fig 1 Open loop system for Single switch Converter system

The simulation model for the open loop system with step change in input voltage is shown in Fig 1.The input voltage waveform is shown in Fig 1 a. The RMS value of the voltage applied to the motor is shown in Fig 1 b.

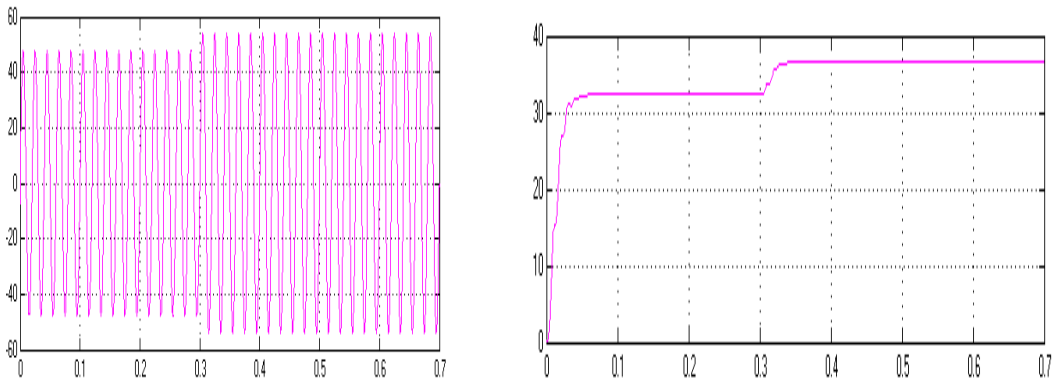

Fig 1a: Input voltage open loop system for Single switch converter system
Fig 1b :RMS output voltage for open loop system of Single switch converter system

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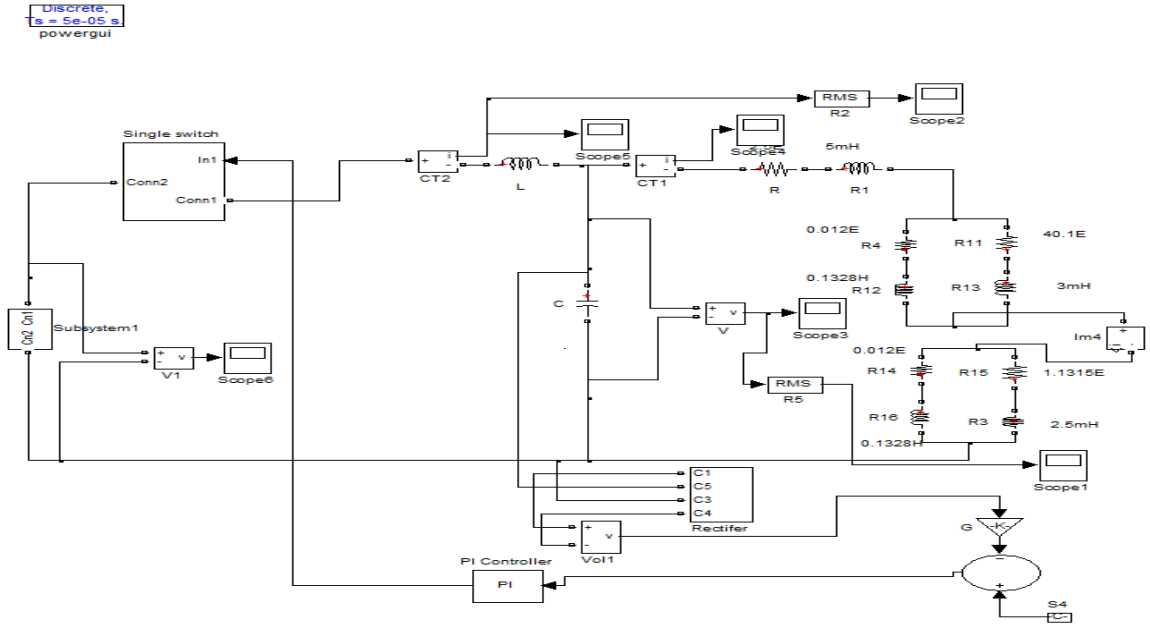
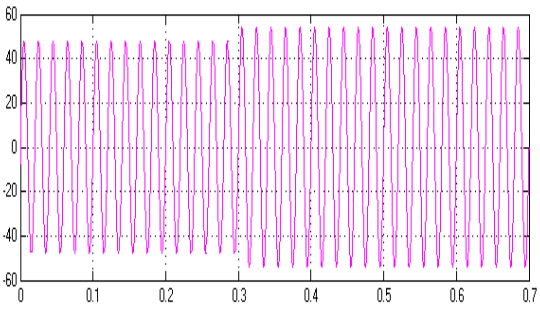


Fig 2 Closed loop system for Single switch converter system



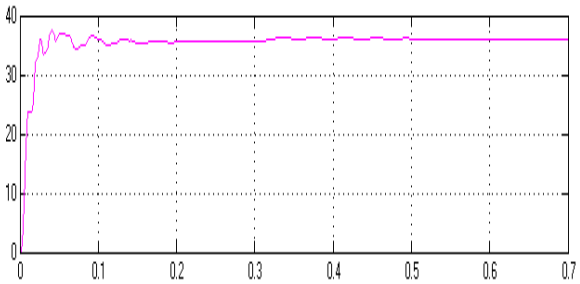


Fig 2a Input voltage of closed loop system for Single switch converter system
Fig 2b RMS output voltage for closed loop system of Single switch converter system

The closed loop single switch controlled system is shown in Fig 2. The step change in input voltage is shown in Fig 2a. The RMS value of the output is shown in Fig 2b. It can be seen that the output voltage increase and then reduces to the normal value due to the action of closed loop system.

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2.2 Two switch converter system:

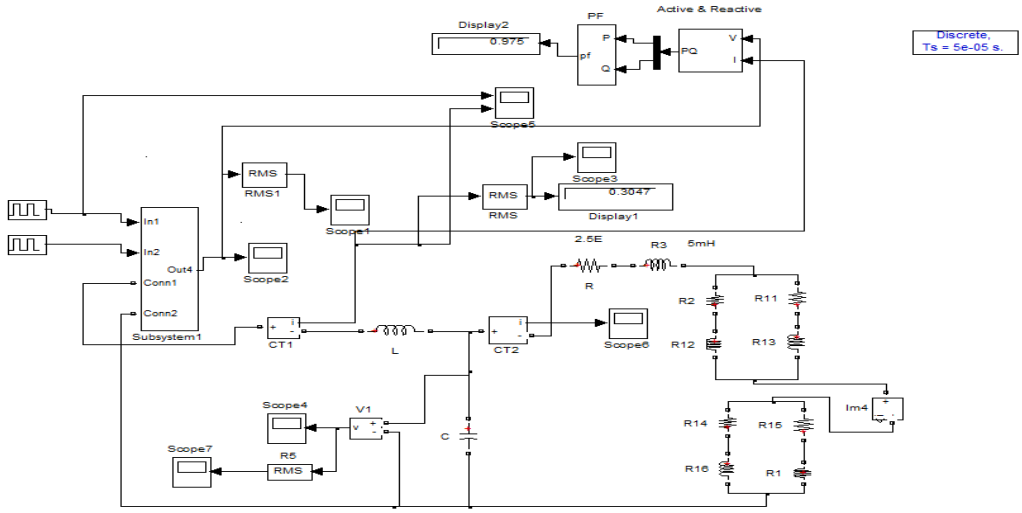
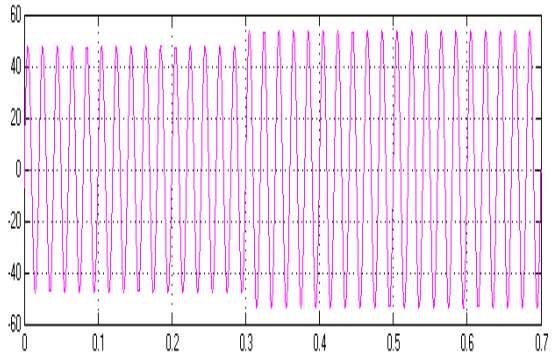


Fig 3 Open loop system for two switch converter system.



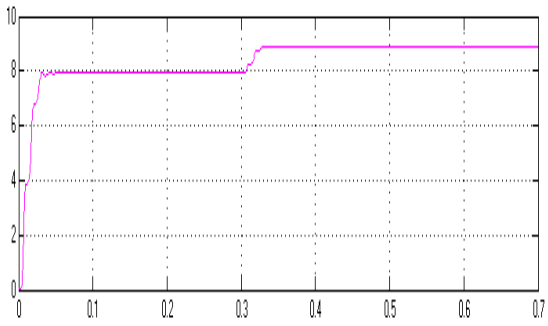


Fig 3a Input voltage of open loop system for two switch converter system
Fig 3b RMS output voltage for open loop system of two switch converter system.

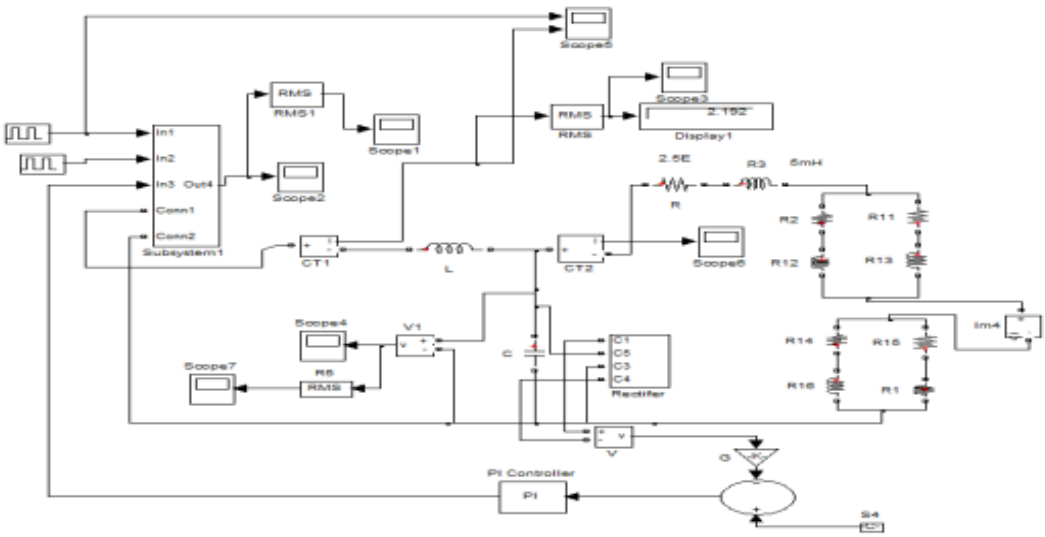


Fig 4 Closed loop system for two switch converter system

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Vol. 4, Issue 11, November 2015

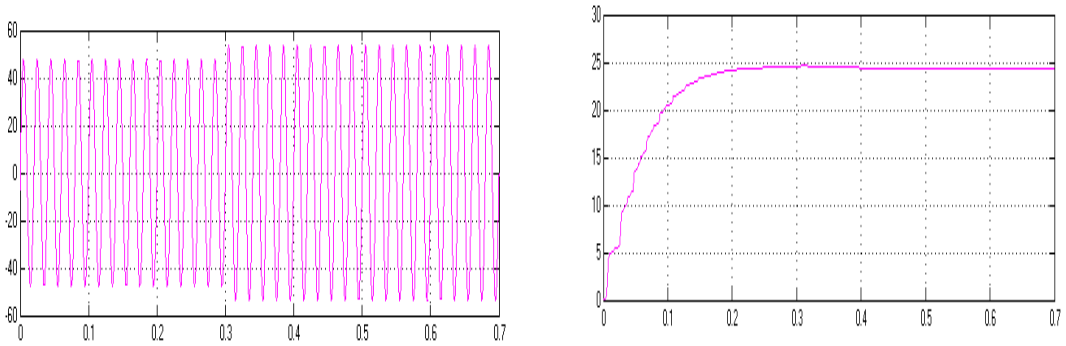

Fig 4a Input voltage of closed loop system for two switch converter system
Fig 4b RMS output voltage for closed loop system of two switch converter system.

The open loop controlled two switch AC chopper fed induction motor is shown in Fig 3. The input voltage with step change is shown in Fig 3a. The RMS output voltage is shown in Fig 3b. It can be seen that there is a step increase in the output voltage.

Closed loop controlled two switch AC chopper fed drive system is shown in Fig 4. The actual voltage is compared with the reference voltage and the error is applied to the PI controller. The output of the PI controller is used to adjust the pulse width of the AC chopper. The input voltage is shown in Fig 4a. The RMS output voltage is shown in Fig 4b. The output voltage increases and then reduces to the steady state value.

2.3 Four switch AC chopper fed drive:

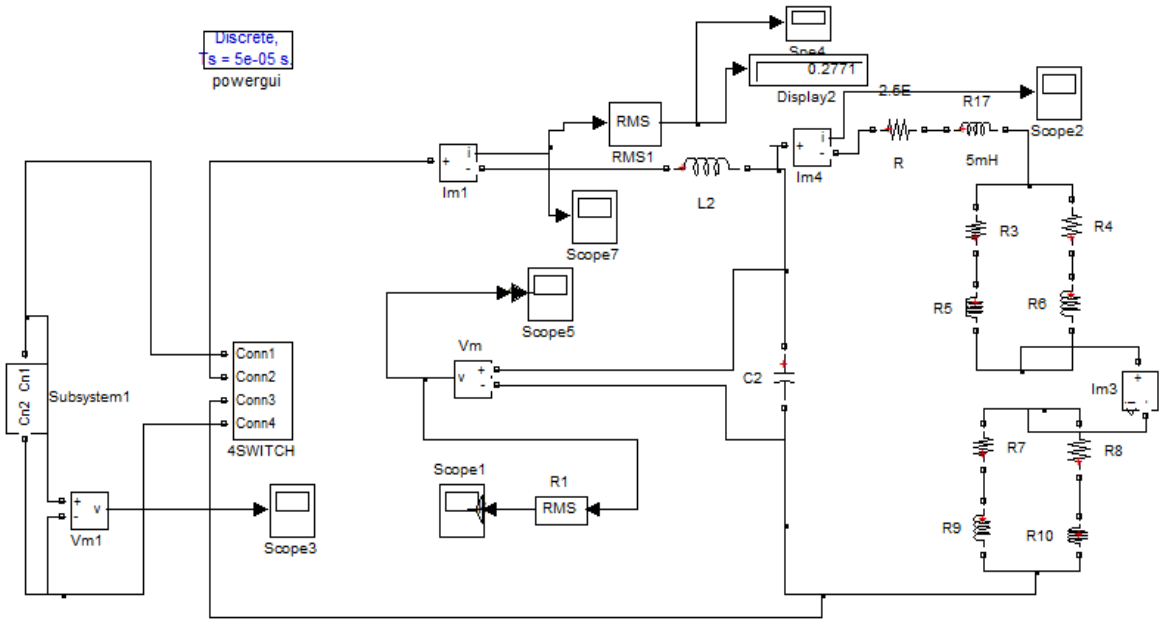

Fig 5 Open loop system for four switch converter system.

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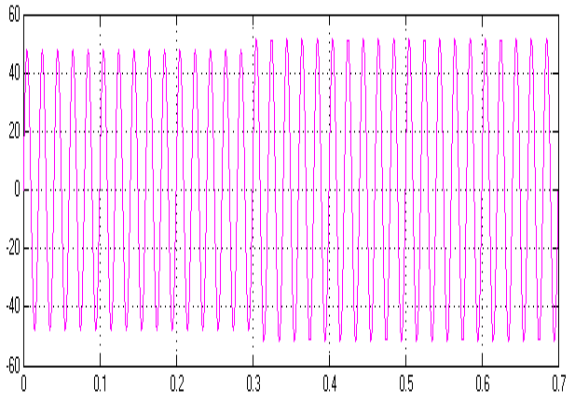


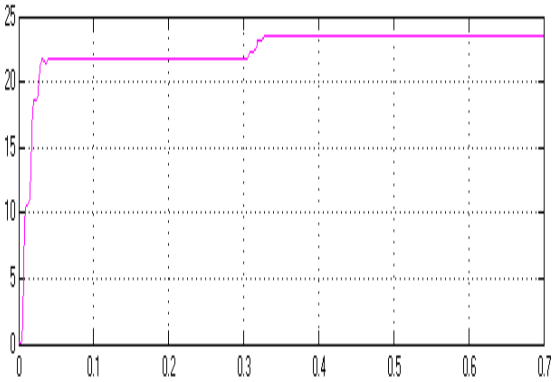


Fig 5a Input voltage of open loop system for four switch converter system
Fig 5b RMS output voltage for open loop system of four switch converter system

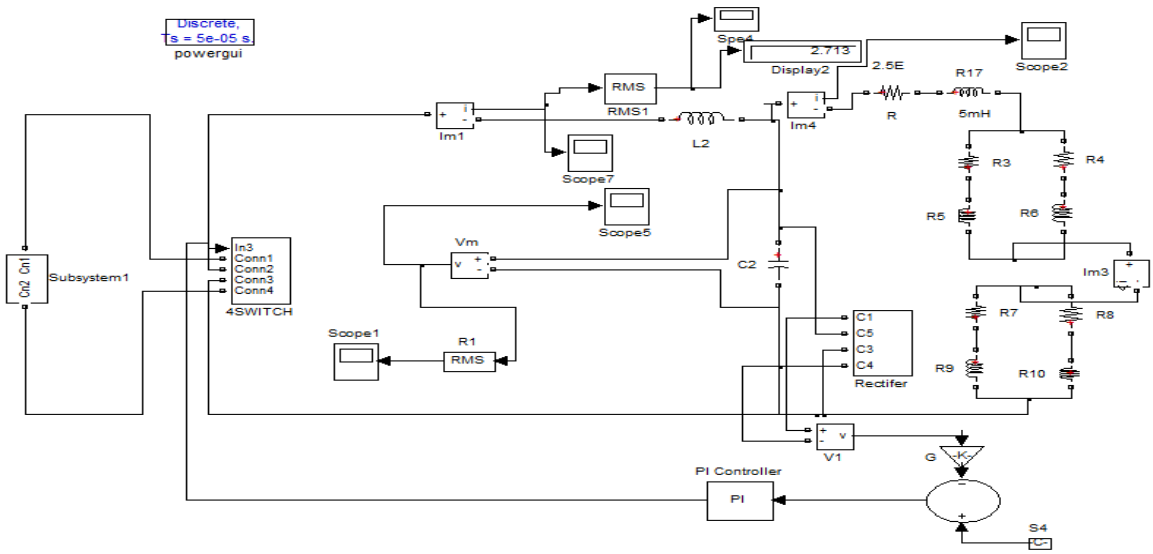
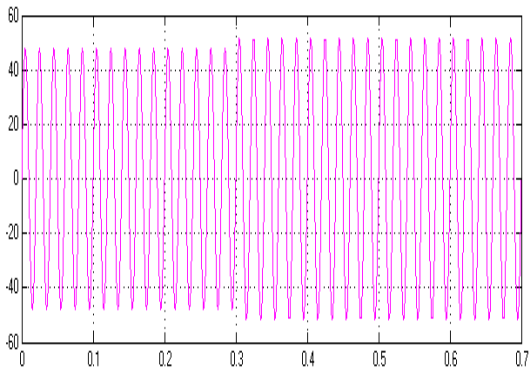


Fig 6 Closed loop system for two switch converter system



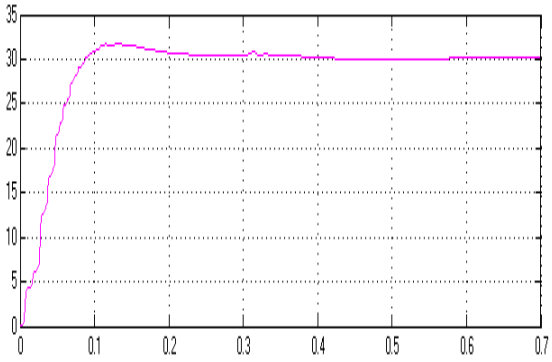


Fig 6a Input voltage of closed loop system for four switch converter system
Fig 6b RMS output voltage for closed loop system of four switch converter system

Open loop controlled four switch AC chopper fed drive is shown in Fig 5. The step raise in the AC input voltage is shown in Fig 5a. The RMS value of the input voltage is shown in Fig 5b.

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Vol. 4, Issue 11, November 2015

The closed loop circuit is shown in Fig 6. The input voltage of closed loop system is shown in Fig 6a. The RMS output voltage is shown in Fig 6b. It can be seen that the steady state error in the output voltage is reduced by using closed loop control.

Table:1 Comparison of close loop characteristics.

Sl. No.	Type	Rise time t_r sec	settling time t_s sec	Peak Overshoot V_p (Volts)
1.	Single Switch	0.1	0.15	3
2.	Two Switch	0.3	0.15	0
3.	Four Switch	0.2	0.28	1.5

Table No.1 shows comparison of closed loop characteristics.

III CONCLUSION

This paper presents the comparison of closed loop results of single switch, two switch, four switch AC chopper fed drive systems. The speed reaches constant value in all the case.

The output of single switch AC Chopper system reaches steady state within 0.1 sec. The output of two switch AC Chopper reaches steady state in 0.3 sec. The output of four switch system reaches steady state in 0.2 sec.

Therefore single switch converter system has faster dynamic response. Single switch AC Chopper system has slightly higher overshoot compared to other systems.

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Vol. 4, Issue 11, November 2015

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