Design and Analysis of Novel Dc Link Controller for Induction Motor Drives

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Abstract: A control over induction motor (IM) fed by a VSI can be carried out by an active front end topology so as to improve the power factor (PF). Hence, this study analyses the performance of PI controller based AFE topology. This AFE topology comprises single phase rectifier unit and DC- DC converter. Thus, from the results obtained it is proven that the proposed AFE topology is suitable for IM drives and exhibits lesser THD with high PF.

Keywords: DC-link fluctuations, Induction motor drives, PI controller, Total harmonic distortion

1. Introduction

The combination of inverter with IM have been commonly utilized in traction applications. It is implemented in such applications because of its simple design and higher energy density. But the implementation of IM drives becomes more challenging because of its non-linear characteristics under saturation condition. This in turn results in poor PF, current distortion at the supply side and fluctuations over DC link. This fluctuations caused in DC link makes the control of VSI more difficult. Thus, the poor PF results in higher harmonics content. This results in reduced efficiency of utilizing IM drives.

Thus, by controlling the sinusoidal active front end [AFE], the control over VSI can be improved and in turn, PF can also be enhanced. Recently, many researchers have made a study on AFE converters to improve the performance of the IM based drives [1,3].

This AFE converter comprises semiconductor the turn ON/OFF time of a switches, the harmonics can be reduced to a considerable limit and at the time, the current becomes sinusoidal and hence, PF can be improved [5-6].

Thus, Interleaved boost converter has been designed by hin et al 2012 to improve the PF of a system. This proposed topology also regulates the DC bus voltage at constant value. From the results, it is observed that switching losses will be less because of ZCS.

Shin et al 2009 formulated a PF correction Boost rectifier to improve the PF of a AFE. In this topology, control was carried out using current sensing technique. Sajeev et al 2013 introduced a bridgeless PFC topology for IM drive system. It result in reduced conduction and switching loss. Thus, to supress the fluctuations over a small dc link capacitor, ram Krishnan et al 2013 introduced an active damping technique for small dc link based drive system. Du et al 2012 introduced a active filter to suppress harmonics in system

Thus, a numerous topologies such as damping control, LC filter were utilized for ripple reduction and PF improvement. However, this will results in increased sized of filter and weight of control wait which practically impossible [9,10]. So to mitigate the influence of DC link over inverter control and to improve the PF, this work introduced a novel control topology.

This work formulates a position sensorless IM drive system for HVAC applications. The power to the motor is supplied by a dc-link capacitor inverter fed by a three-phase diode front-end rectifier. A PI control strategy is modelled to control the dc link voltage. Simulation is conducted using MATLAB/Simulink software.

2. Proposed IM Drive Scheme

A representation of the proposed IM drive is shown in Fig. 1.

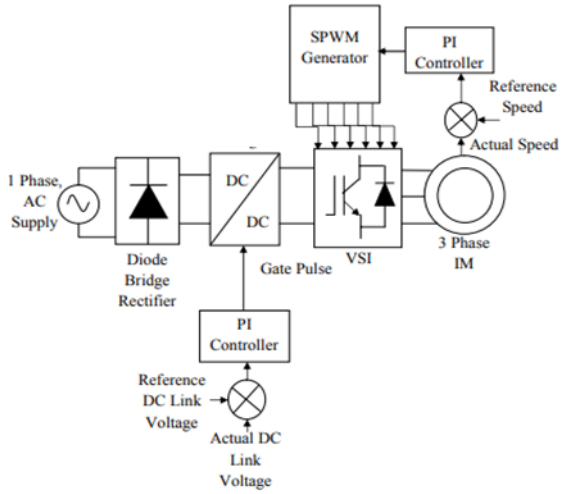


Fig. 1. Block diagram of the proposed IM drive.

Gate control over VSI

In this proposed topology v/f control methodology is adopted for IM. Among the various PWM techniques, SPWM is commonly adopted in many industrial application [1]. An FPGA processer is implemented to generate SPWM topology[12]. It was implemented under open loop control. It utilises two inputs namely, MI and frequency to generator PWM signals and carrier triangular wave.

Thus, the topology adopted to generate PWM is depicted in fig 2. In this, the speed of IM is measured using a sensor. Thus, the speed error produced is processed through PI controller. The output of the PI controller is multiplied with two gains as shown in fig.2. The values of G1 and Q2 can be a MI(0.8) and 50HZ. Based on these values, PWM signal is generated for six pulse VSI.

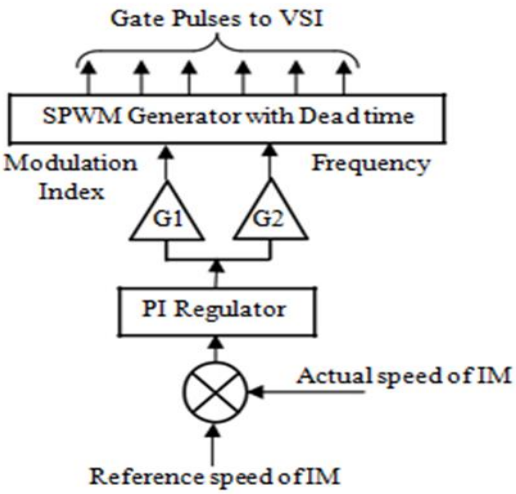
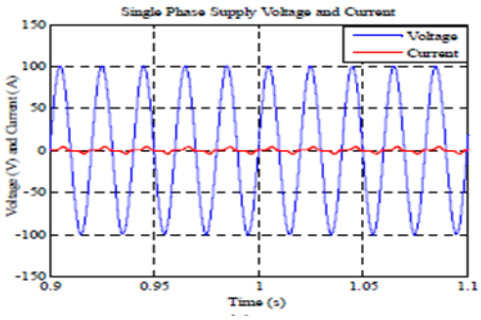


Fig. 2. Gate control strategy of the VSI.

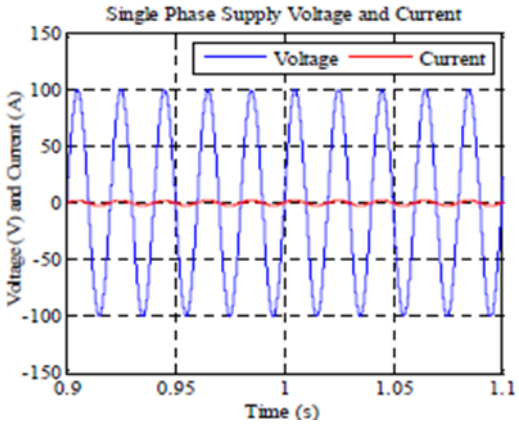
3. Results and Discussion

Thus, to examine the performance of the proposed topology simulation is carried out in MATLAB/Simulink environment.

Fig.3 depicts the voltage and current measurements at the supply end. From 3a, it is noted that the current is out of phase with the voltage and hence, PF is not unity in the absence of APE topology. From 3b, it is proven that with the utilization of proposed AFE the current and voltage at the supply side becomes in phase and PF remains unity. The dc-link voltage at no load and full load is depicted in fig.4

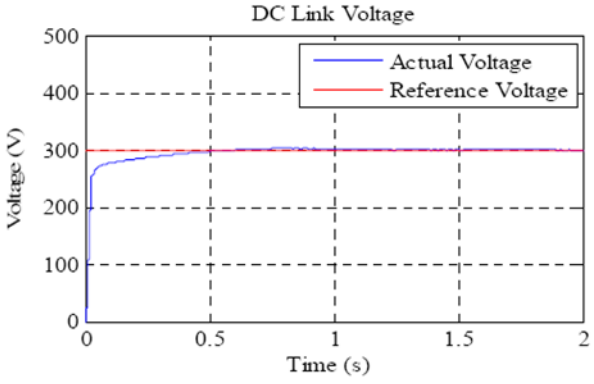


(a)

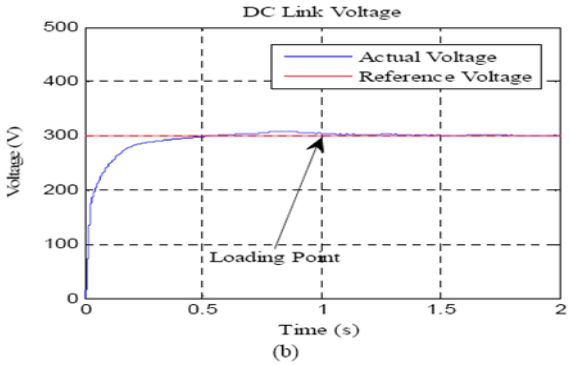


(b)

Fig 3. Supply voltage/ current (a) without AFE, (b) with AFE.



(a)



(b)

Fig 4. DC-link voltage at (a) 0% load , (b) full load.

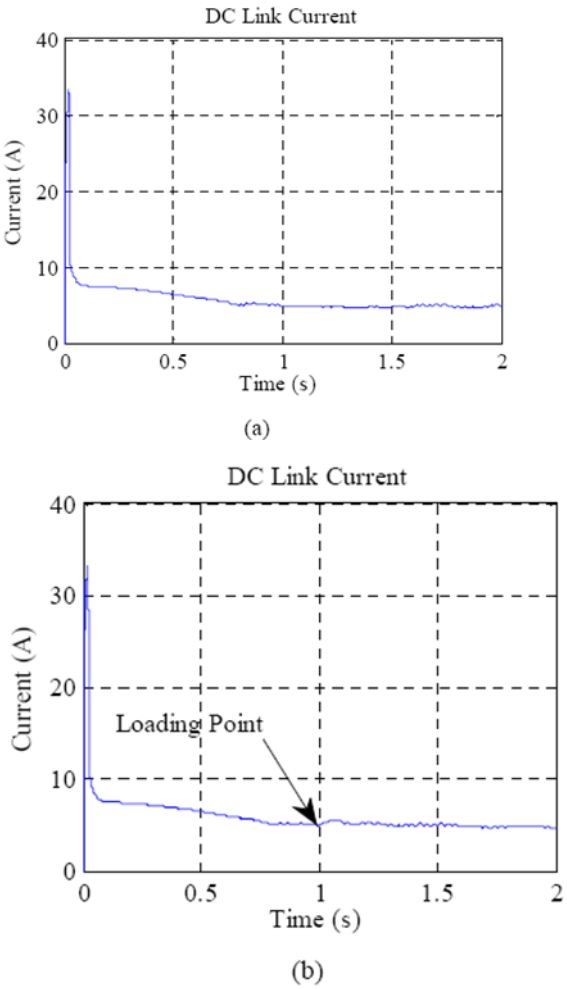
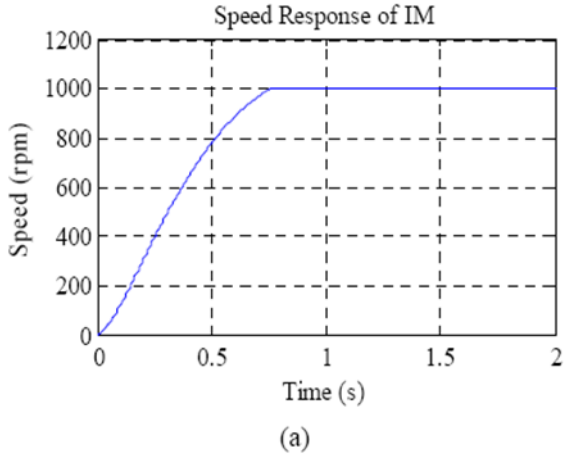
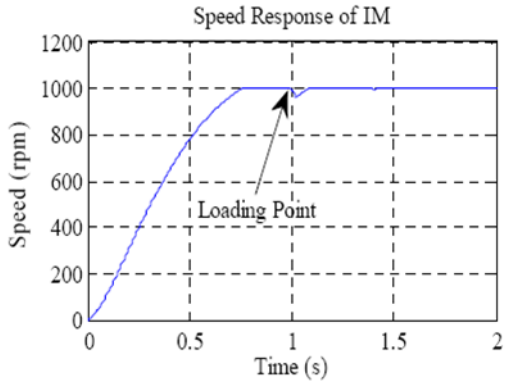


Fig 5. DC-link currents (a) 0% load , (b) full load.

Even under the presence of load, the voltage remains constant due to the presence of PI controller and it is ripple free. It attains it constant value at 0.04 s itself

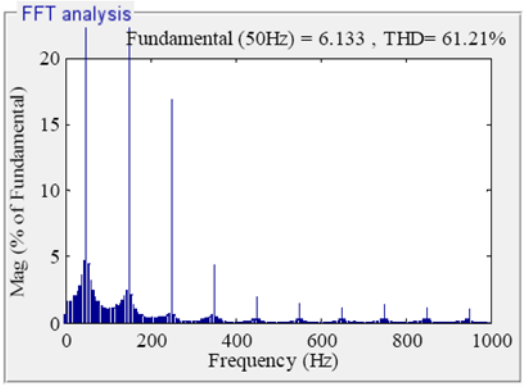
Similarly, the speed response of the IM under no/ full load condition is revealed in fig 6. At a full load condition, torque about 2.5Nm is applied over the motor. However, from the figure 6, it is observed that the change in speed with respect to load disturbance is recovered within 1s.



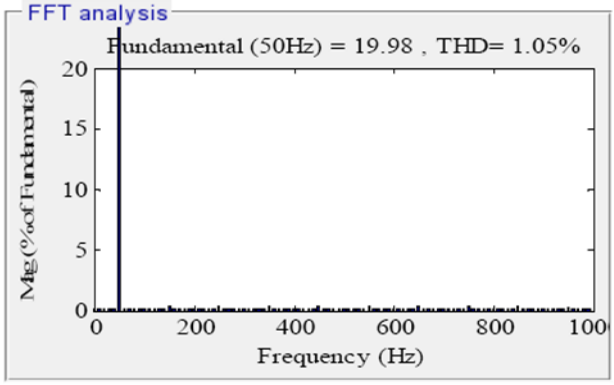


(b)

Fig 6. Speed response of the IM (a) 0% load and (b) full load.



(a)



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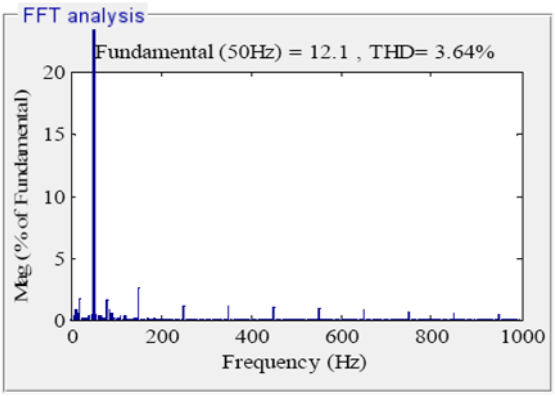
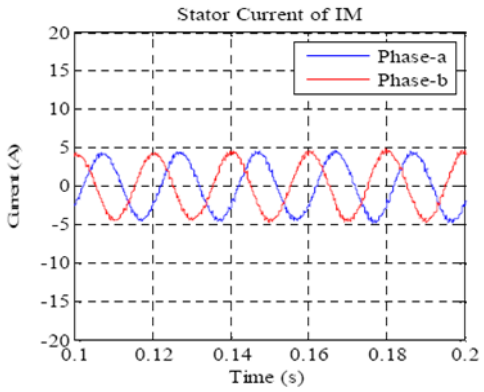
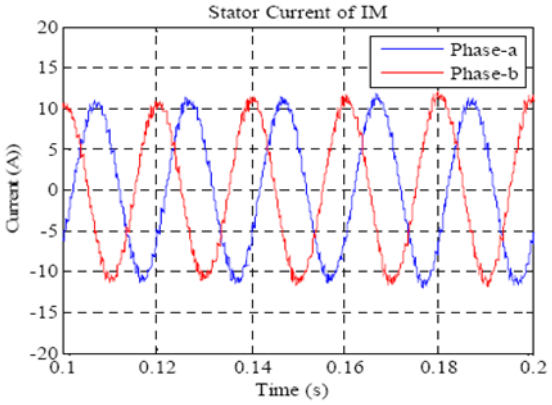


(c)

Fig. 7. THD in supply current (a) in the absence of the AFE, (b) in the presence of AFE @no load, and (c) in the presence of AFE under load disturbance.



(a)



(b)

Fig 8. Stator currents

The THD in the supply current is investigated, and the corresponding results are depicted in Fig. 7.

While in the absence of AFE topology, the THD is about 61.21% and in the presence of AFE, it is around 1.05% at no load and 3.64% at full load condition. Thus, it is understand that with the presence of AFE, the THD remains low.

The stator current across the IM is portrayed in fig. 8. Thus, due to the presence of AFE, the current does not exhibit any nipples in it. As a result, failure of insulation problem can be eliminated.

4. Conclusion

The design of AFE topology which implements DC converter integrated with 3ϕ IM drive system is proposed in thus work. Thus, the performance of dc link voltage and IM were studied. From the results, it is proven that the proposed topology improves the PF at the supply end and also reduces the THD of the source current. Thus, the PI controller Utilised in this scheme effectively controls both the dc link voltage and speed of the IM drive.

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