

Different types of unbalance were created to investigate the system without the control front-end rectifier. The first unbalance was created by the reducing the magnitude in phase A to 200 V and allowing the magnitudes of phase B and phase C voltages to be at 230 V. Then, a different type of supply voltage unbalance was introduced by reducing the amplitude of the voltage in phase A from 230V to 200V and increasing the amplitude in phase B to 260 V. A similar situation arises when the voltage amplitude in phase A is reduced to 200V and voltage amplitude in phase C increased to 260V. It was noticed that the reduction of voltage in different input phases results in different phase shifts of voltage pulsations in the DC bus [14].

4. Simulation of the proposed system

The circuit of the active front end rectifier for electric motors is implemented using MATLAB/SIMULINK. The vector control method is employed for the rectifier and switching sequence is provided using space-vector PWM technique. Figure 3 shows complete SIMULINK model of the system comprising of three phase power supply, front-end rectifier, DC bus, voltage source inverter and Induction motor. The front-end rectifier comprises of six IGBT's which are triggered by the gate pulses generated by SVPWM method.

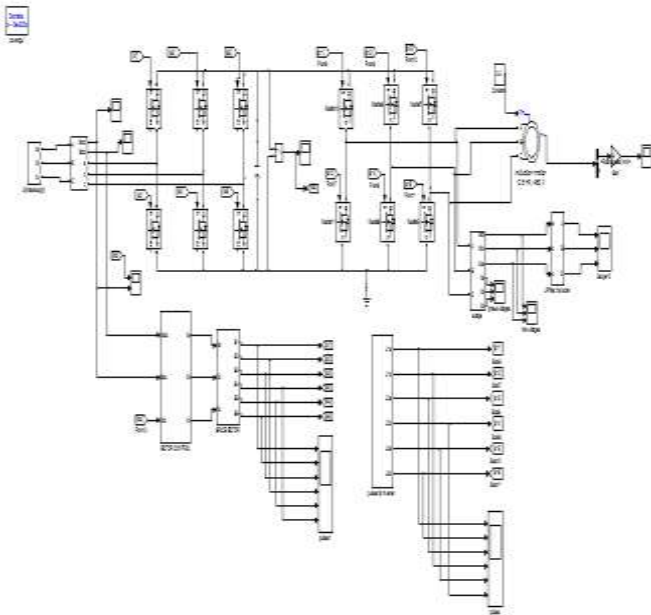


Figure 3: SIMULINK model of the complete system

The voltage source inverter is provided with PWM pulse technique. The subsystem block of Vector control in the SIMULINK model is shown Figure 4.

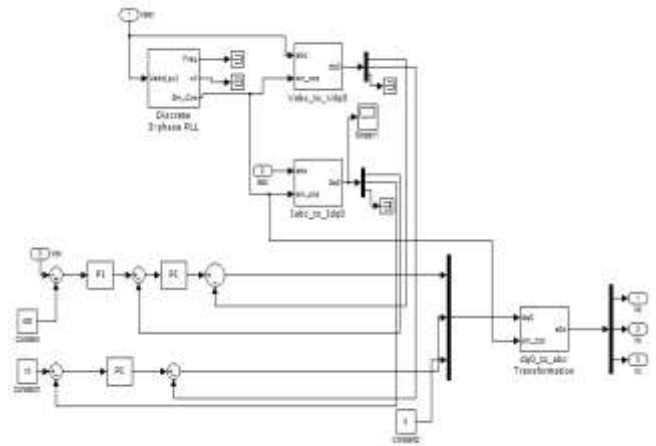


Figure 4: Sub-models of the Vector Control subsystem in SIMULINK

The front-end rectifier is used to regulate the DC link voltage and it is possible by providing proper control technique. The technique chosen for this purpose is space-vector PWM. Three phase voltages are transformed into two phase dq0 quantity to make the three phase analysis easier and then is compared with the reference DC voltage (V_{dc}) (obtained from the front-end output) and fed to the PI controller which increases the speed of the response and also eliminates the steady state error. Similarly three phase currents are also transformed to d-q reference frame then compared with an external reference and fed to the PI controller. Now the dq0 voltages are converted to three phase voltages (ABC) and these are fed to the space vector PWM block as reference voltages. The K_p and K_i values of the PI controller used are shown in Table 3.

Table 3: Design values of PI controller

Type of controller	K_p	K_i
voltage	0.81	0.0049
current	0.14	0.01

5. Results and Discussions

Various Waveforms obtained by simulating the system in MATLAB/SIMULINK are shown and discussed.

5.1 Input Voltage

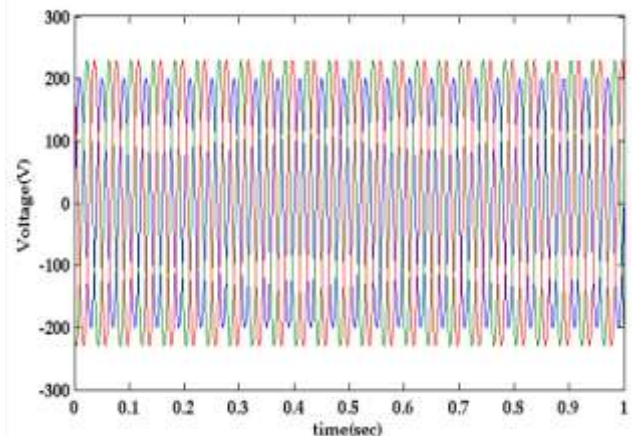


Figure 5: Waveform showing three phase unbalance voltage

Figure 5 shows, unbalanced system of three phase voltages is formed by reducing the phase A voltage to 200V while keeping the phase B and phase C voltage at 230V

maintained at 10A by current controller of the vector control block.

5.2 Input current

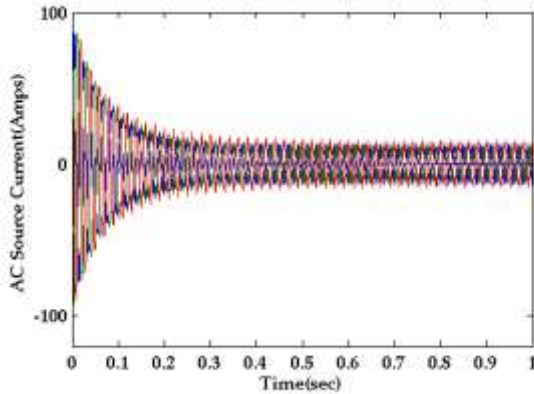


Figure 6: Waveform showing three phase input current

Figure 6 shows, input current is in same phase with the source voltage with the control of front-end rectifier. Hence, unity power factor operation is performed.

5.3 DC Output Voltage

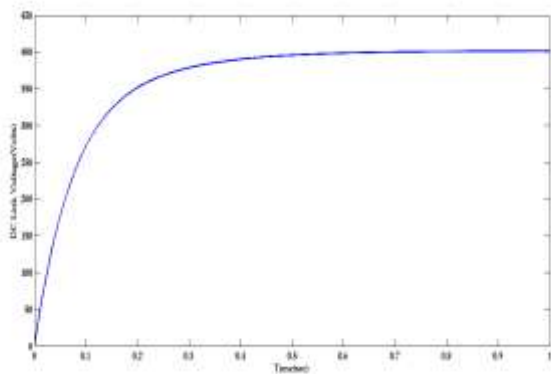


Figure 7: Waveform showing DC link voltage

Figure 7 shows constant voltage obtained at the DC link of the voltage source inverter. The DC bus voltage was set to be 400 V by the closed loop vector control of front-end rectifier.

5.4 DC Output Current

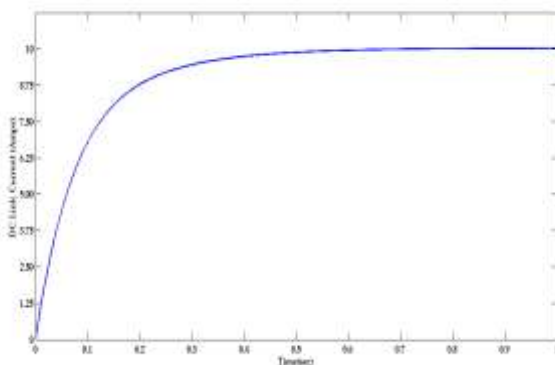


Figure 8: Waveform showing DC link current

Figure 8 Shows constant DC link current obtained at the input of the voltage source inverter. The DC bus current was

5.5 Three Phase Space Vector PWM Signal

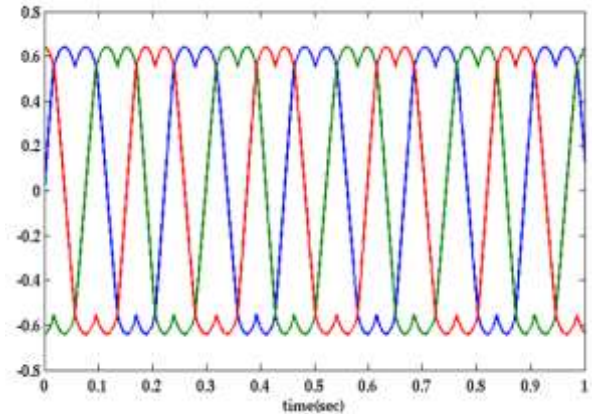


Figure 9: Waveform showing space vector control signals

Figure 9 shows three phase SVPWM signals for the voltage source inverter. The SVPWM method is employed with a carrier frequency of 5 KHz.

5.6 Unit Vectors

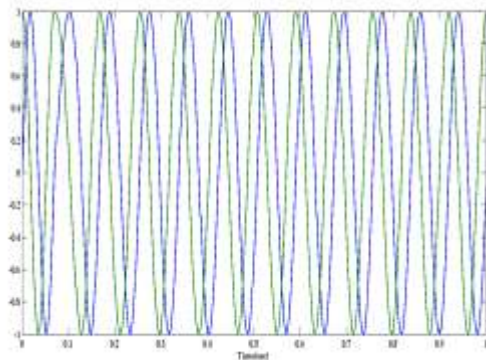


Figure 10: Sine and Cosine Unit Vectors

Figure 10 shows the unit vectors. The components of the revolving unit vector i.e., sine and cosine are generated. The control algorithm will be initiated as soon as these quantities reaches steady state.

5.7 Three Phase Inverter Voltages

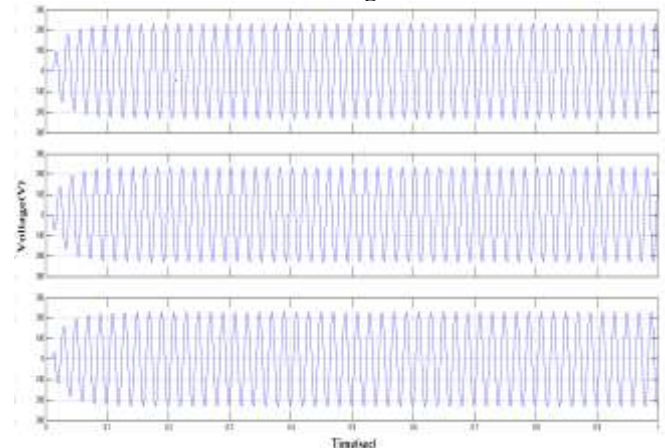
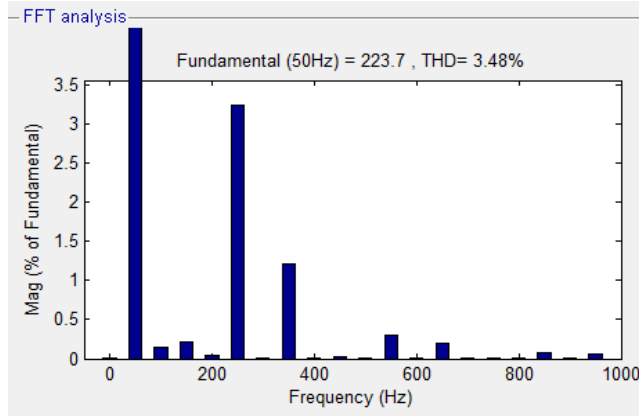


Figure 11: Waveform showing three phase VSI voltages

Figure 11 shows three phase voltage of the inverter with an amplitude of 223.7V.

5.8 Total Harmonic Distortion

Figure 12 shows the THD value of phase A of the inverter output voltage to be 3.48%.



6. Conclusion

In this paper Active front end rectifier is used for an Induction motor and vector control strategy applies. The steady state design considerations for the front end rectifier have been discussed. The block diagram for Vector control have been developed using MATLAB/SIMULINK and satisfactory results are obtained. With the use of AFE rectifier THD value is reduced to 3.48%. Hence, AFE rectifier is effective in eliminating DC-link voltage pulsations occurring due to the unbalance while operating in unity power factor.

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