Design and Implementation of Active Rectifier to limit Line Current Harmonics

The scope of this project is to develop MATLAB model for three phase active rectifier to minimize harmonic distortion in line current.
Project includes concept design, model development and system realization using MATLAB Simulink.

Outline Specifications

Tools used

MATLAB Simulink for model development and simulation.

Specification

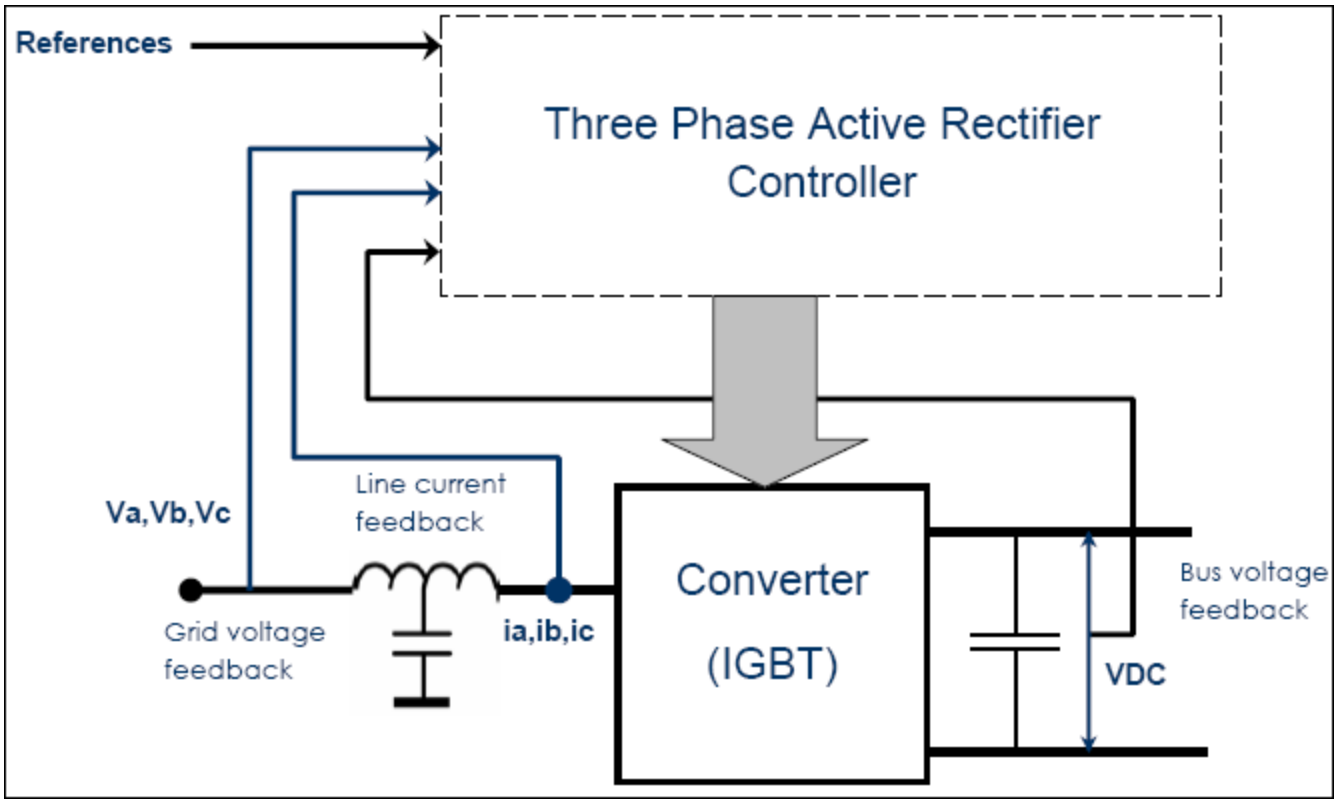
- Sampling time : 100µS Temporary
- Input source voltage : 150VAC peak
- Power electronics : Three phase IGBT converter module
- Nominal DC bus voltage : 350VDC
- Maximum input load : 3.5KW
- Peak inrush current : 220% (not limited)
- Control strategy : Vector control

Technology

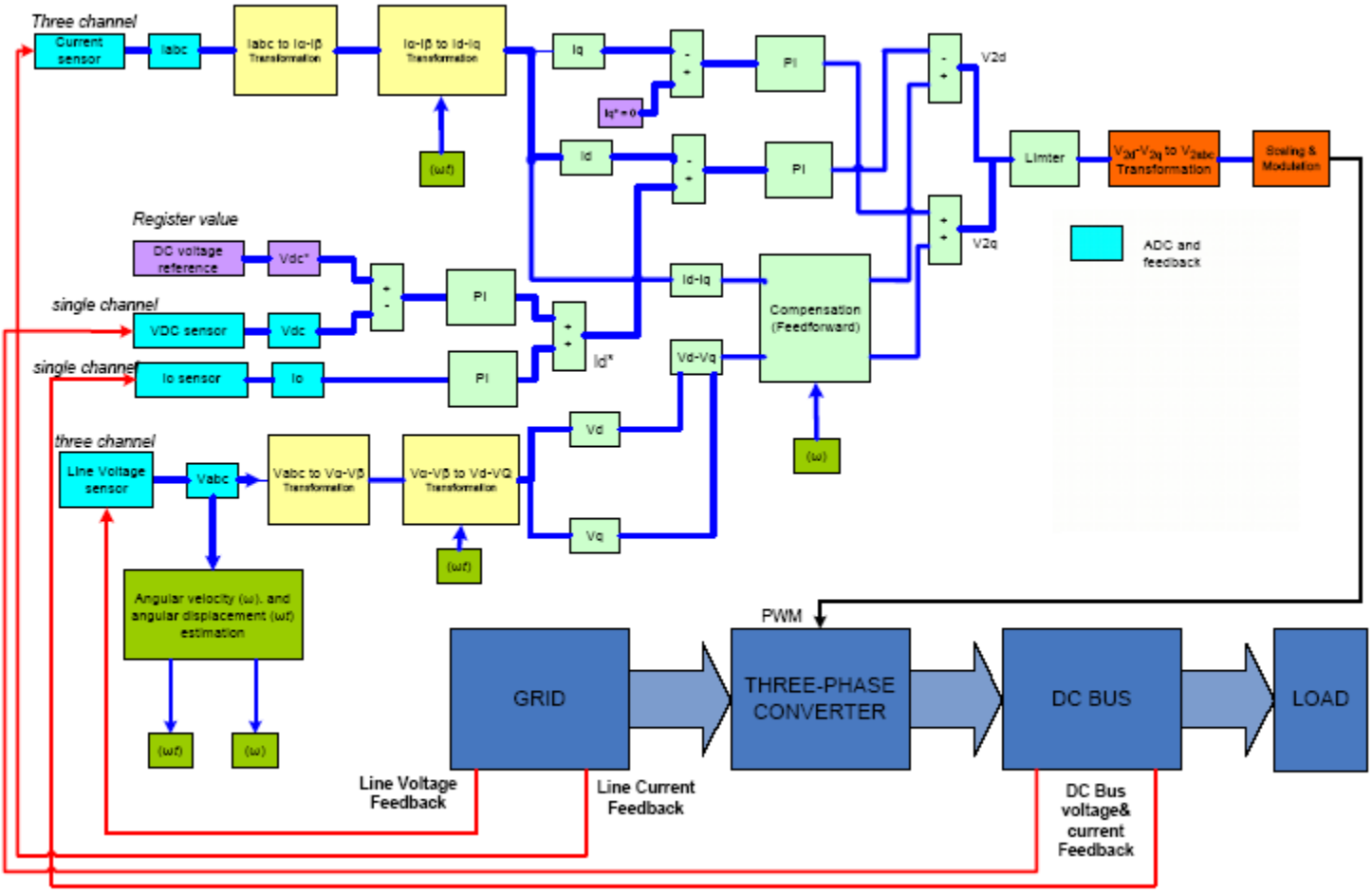
- Space vector modulated PWM generation for controlling IGBT converter module.
- Synchronized vector control of three phase line currents for power factor correction.
- All currents and voltages are in d-q rotation frame for controlling, done by Clarke & Parks transformation.
- Developed three-phase IGBT based power converter model for inverter.
- Real time mode current control.
- Active power factor correction.

Block Diagram

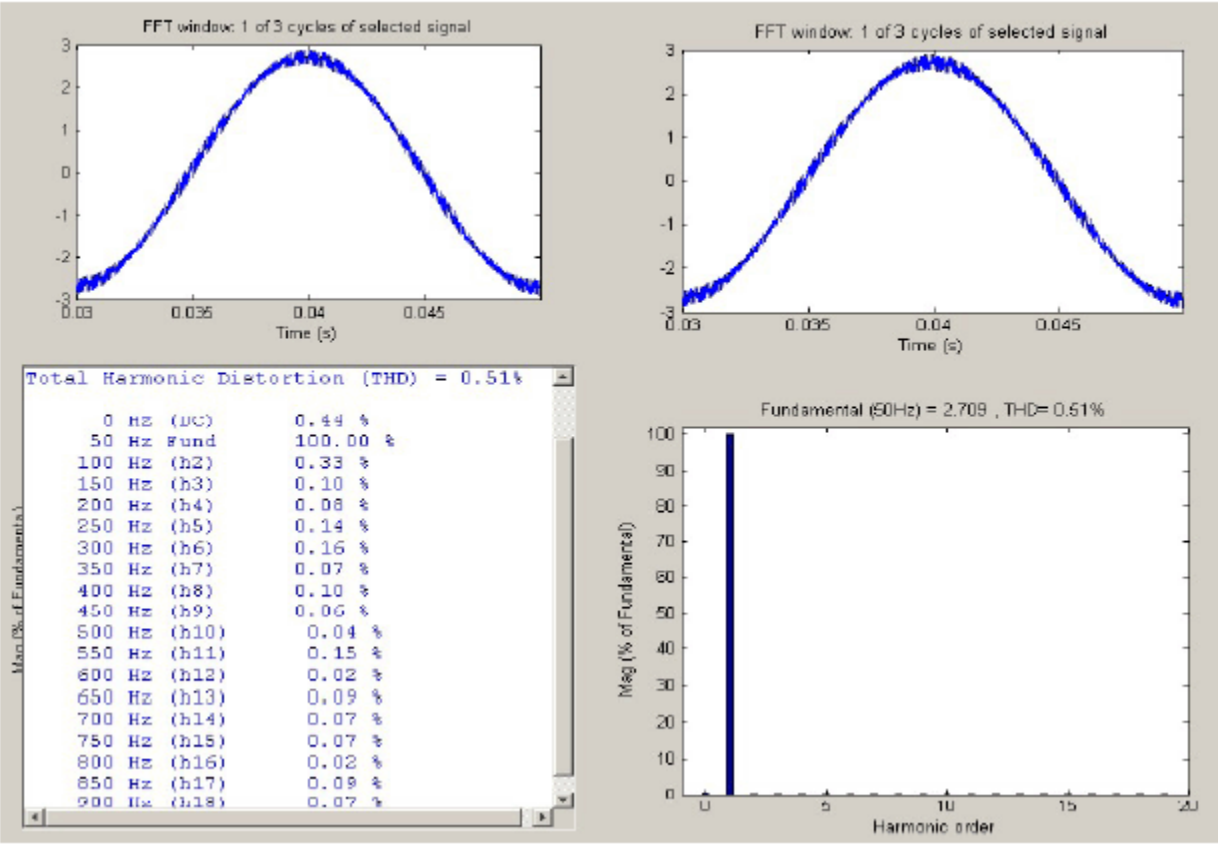
Basic control scheme of Active Rectifier



Active Rectifier Block Diagram (MATLAB MODEL)



FFT Analysis result of Line Current of Active Rectifier



Line Current Harmonics in Diode Rectifier and Active Rectifier analyzed from simulation results

IEC Limits of Harmonics in input current	*Analyzed in Diode Rectifier.*	*Analyzed in Active Rectifier.*
(Harmonic order). Odd harmonics	*Odd harmonics*	*Odd harmonics*
h3 = 2.3A	h3 = 0.97% = 0.145A	h3 = 10% = 1.5A
h5 = 1.14A	h5 = 22.9% = 3.45A	h5 = 5.68% = 0.852A
h7 = 0.77A	h7 = 10% = 1.5A	h7 = 4.03% = 0.604A
h9 = 0.44A	h9 = 0.49% = 0.073A	h9 = 3.09% = 0.46A
h11 = 0.33A	h11 = 5.6% = 0.84A	h11= 2.52% = 0.37A

Red colored are exceeded IEC limits

Salient Features

- Space vector modulated PWM to improve inverter switching loss and to achieve higher DC Bus utilization.
- Algorithms for three-phase line current estimation based on standard MATLAB model.
- Algorithms for three phase voltage and current reading and transformation from abc to d-q frame and reverse transformation.
- Algorithms for DC bus controlling with reference value and current control with closed loop.
- Feedforward control scheme is implemented in current controller for quick response to disturbance, and to maintain steady state response.
- Intelligent power module used to reduce size and performance in modeled in MATLAB.
- Hall sensor to monitor the output current very accurately.
- Vector control provides Very good dynamic performance in varying load system.
- Near unity powerfactor at full load, verified by simulation in MATLAB.
- DC bus voltage reference control for preset range.
- Model capable to control power converter at extensive range of power level, by changing parameters.
- Inrush current limiting and softstart protection is included in design.

Challenges

- Conversion voltage and current three phase time varying quantities into d-q rotating frame in MATLAB
- Angular velocity and angular displacement calculation in real time with minimum error

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