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Simulation of Closed Loop AC-DC Converter for Power Quality Improvement

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***Abstract*— AC-DC converter are widely used for obtaining DC link.In this paper PWM boost rectifier using IGBT for operating at higher frequency is reported. Sinusoidal Pulse width modulation technique is used for switching of IGBTs is explained.This converter providing the desirable dc output voltage with unity power factor and less %THD.The power circuit for this rectifier with closed loop using PI controller is simulated in PSIM.**

Keywords*— *Front end converter,PI controller, SPWM ,Unity power factor

I. INTRODUCTION

Many industrial application make use of controllable dc power such applications are steel rolling mills, paper mills, traction systems, high voltage DC transmission. Earlier diode bridge rectifier are used to produce constant DC output voltage and thyristor rectifier are used to produce variable dc output voltage, but due to non-linear loads non-sinusoidal input currents is drawn and which injects harmonics in supply lines and resulting in poor power factor at supply side,high THD in current and low efficiency of the power system. Conventionally, output dc voltage can be changed by either using tap-changing transformer or auto-transformer along with diode bridge rectifiers. But this scheme is costly, bulky due to the presence of transformer. SCR based rectifier overcomes the above disadvantages with high efficiency. But at lower output voltage it injects lower order harmonics which distort the supply current. In SCR based rectifier power flow is unidirectional. So to overcome the all disadvantages IGBT based AC-DC converter is reported in this paper.[1]

The single phase AC-DC converter with closed loop using PI controller is simulated in PSIM software and works at unity power factor irrespective of load condition and also the harmonics distortion is reduced at the input side.

II. POWER CIRCUIT AND WORKING PRINCIPLE

The power circuit diagram of proposed scheme is as shown in figure 1.The main power circuit consist of IGBT with antiparallel diode and inductor at the supply side and capacitor and variable load is connected at the DC side of the converter. The supply side inductor is for smoothing the line current and performing boost operation. The switches used for this topology is IGBTs for operating s high switching frequency.Here the switches S1,S4 and S2,S3 are complementary pair of switches.

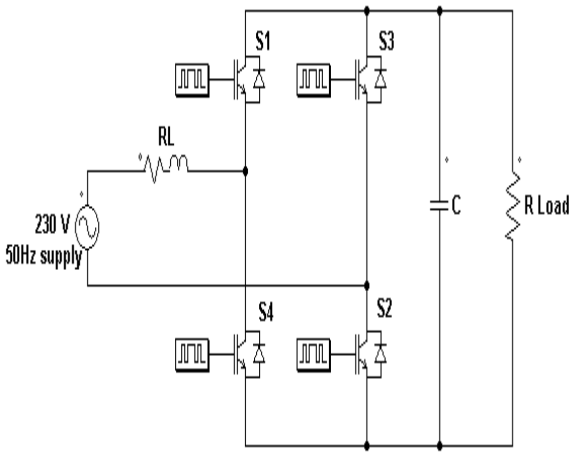

Figure 1 Power circuit of single phase converter

There are many modulation methods but here sinusoidal pluse width modulation (SPWM) scheme is used for generating the gating pluses to fire the IGBTs. In this scheme the reference signal is compared with carrier signal. Input supply voltage is taken as fixed frequency reference signal and triangular signal with higher frequency is taken as carrier signal and compared in comparator for generating the PWM signals as shown in figure 2

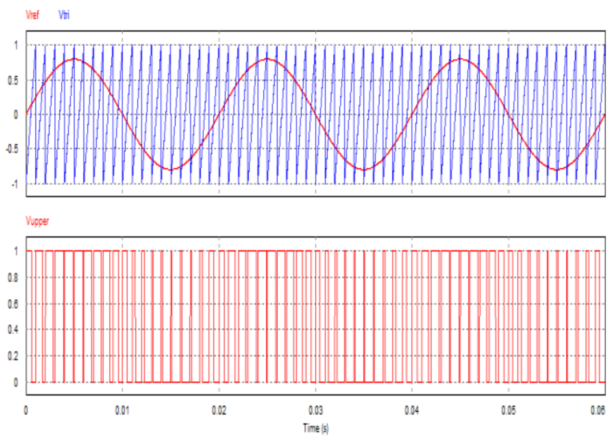

Figure 2 Comparison of sine triangular signals and PWM signals

Here whenever the amplitude of reference signal is higher than carrier signal then the gating pluse is generated.The duty cycle is varied by changing the amplitude of reference signal.

III. BLOCK DIAGRAM

The basic block diagram of proposed scheme is as shown in below figure 3.

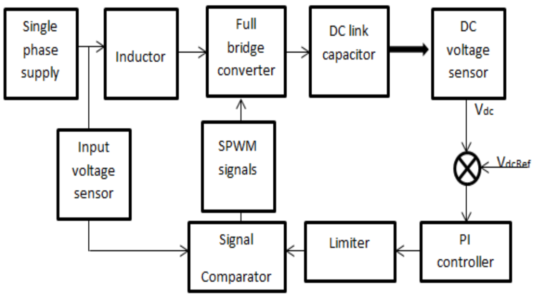

Figure 3 block diagram of proposed converter

In the proposed scheme the control strategy is obtained by using the PI controller.In this scheme the PI controller is used to controlling the gating pluses of the IGBTs of the converter. The dc output voltage at the capacitor is sensed and compared with reference dc voltage and then error signal is processed through PI controller.the corrected signal in PI controller is multipled with the input voltage and compare with carrier signal and accordingly the switching pattern of IGBTs is modified. The switching sequence of converter makes works as rectifier and also by optimizing the switching sequences the power factor is controlled. The PI controller is tuned using trial and error method. The objective of this control scheme is to maintain the constant output voltage,reducing the harmonics at input side and to achieving the unity power factor.

IV DESIGN CONSIDERATION

In the proposed converter the value of line side inductor and dc link capacitor is calculated as follow. The voltage drop across inductor is taken as 3 % of the line voltage.The value of line side inductor is calculated as under :

$$X_L = \frac{0.03 \times V_S}{I_S}$$

$$\therefore L = \frac{0.03 \times V_S}{2\pi f \times I_S}$$

The value of the capacitor is calculated as under :

$$\Delta V \geq \frac{Vs \times Is}{2 \times V_{dc} \times 2\omega C}$$

1

$$\therefore C = \frac{Vs \times Is}{\Delta V \times 2V_{dc} \times 4\pi f}$$

Where the V_S is supply voltage ,f is supply frequency ,I_S is supply current.For the simulation paratmeters were taken as 1000W outpit power,supply voltage 230V,supply frequency 50Hz,supply current 4.6A, ripples in dc voltage is 2.60 V and output dc voltage is 400V. The values of inductance and capacitance obtained as 4.7mH and 780µF.

IV SIMULATION AND RESULTS

For varifing the proposed topology of single phase converter the simulation is carried out in PSIM software.The single phase supply of 230V with frequency 50Hz is taken. The inductor for boosting the input voltage is 4.7mH with small internal resistance is connected at the ac side and capacitance of dc link capacitor is taken as 780µF.Here the switching frequency has been taken as 5kHz.The circuit diagram shown in figure 4 is the closed loop simulation of converter with R loading .

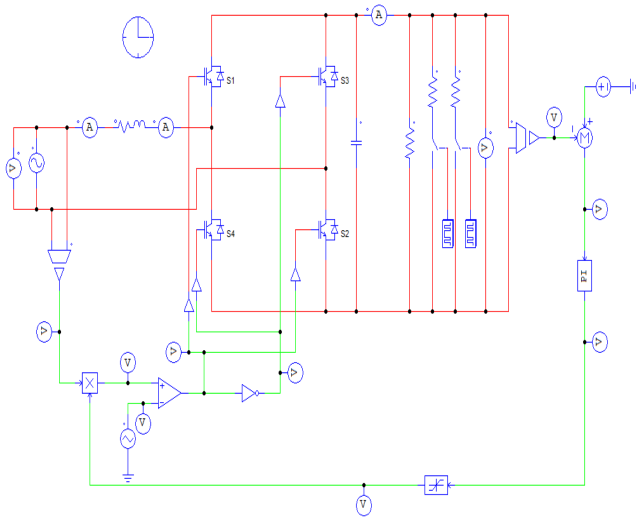

Figure 4 circuit diagram of closed loop system

The waveform of output voltage shown in figure.5 when R=500ohm and at t=1sec, resistor R=600ohm and at t=2sec,resistor R=700ohm inserted and again loading R=500ohm is restored at t=2.5sec.Figure.6 shows the input line current and source voltage which are in phase,that indicate the unity power factor operation of the converter.The desired dc output voltage is set at 400V.The waveform of load voltage is as shown in figure.5,the load voltage is maintain at 400V with changing the loading. The power factor is maintain unity as shown in figure.7. The spectrum of harmonics of the supply current is shown in figure.8 which has only 2.76% THD. The %THD value is within prescribed harmonic standards. Thus the proposed control strategy of the converter maintains the DC bus capacitor voltages under all the conditions of load and also improves the power quality.

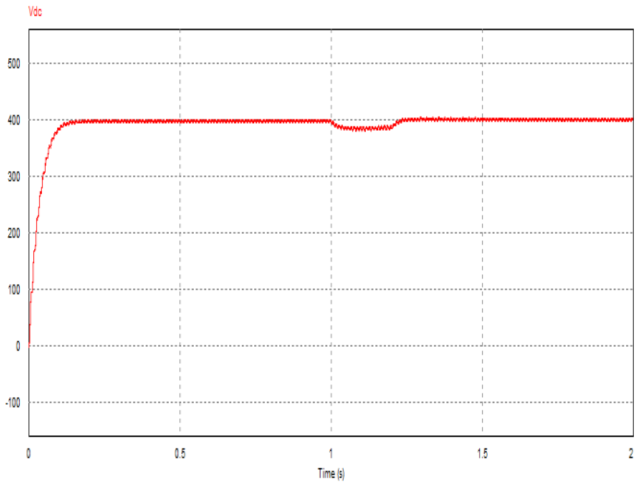

Figure .5 waveform of output DC link voltage

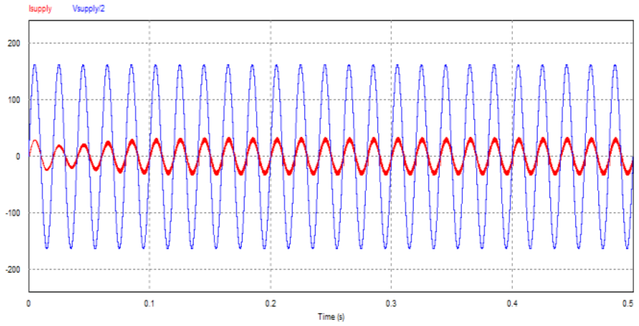

Figure. 6waveform of supply voltage and line current

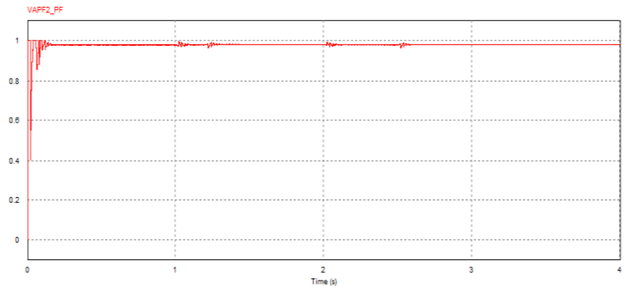

Figure.7waveform of power factor

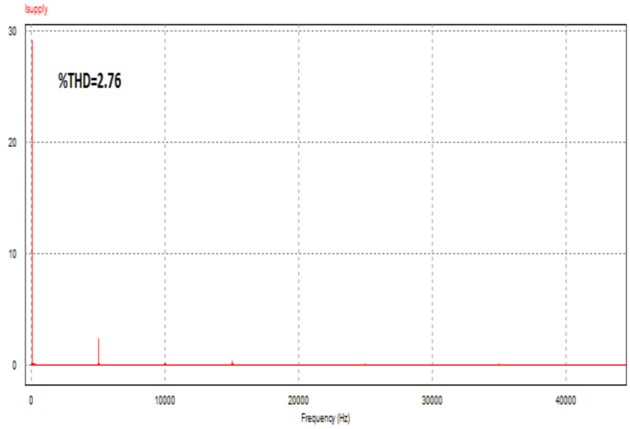

Figure.8 harmonics spectrum of line current

V CONCLUSION

Simulation of single phase front end converter is carried out and desired dc output voltage with unity power factor is achieved. The %THD of supply current 2.7%, which is within the standards issued by regulatory agencies such as IEEE-519,IEC1000, IEC 61000-3-2.

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