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Simulation of Modified One Cycle Controlled Three Phase Bi-directional AC/DC Converter Using SIMULINK

L. Joseph Anil Kumar[1] G.Venkata kasi viswanadham[2]
[1]M.Tech scholar, Nalanda Institute of Engineering & Technology, Kantepudi, Sattenapalli.
[2]Assistant Professor, Loyola Institute of Technology And Management, Dhulipalla.

Abstract

Rectifiers are widely used in industries and domestic application. But, because of the nonlinear, it draws non sinusoidal current. One cycle controller is used as single/ three phase boost converters, active filters and power factor corrections. But this one controller exhibits instability during light load condition. Also it is not possible to operate in inverting mode. Modified one cycle controller is proposed in this paper and it overcome problems associate with one cycle controller. This paper discuses the design, simulation, and performance evolution of modified one cycle controller for AC/DC bidirectional boost converter.

Keywords— **controlled rectifiers, harmonic elimination, one – cycle controller, power factor improvement.**

INTRODUCTION

Electricity is major commodity for the development of any country. Majority of utilities electricity is generated from fossil fuels. Because of the scarcity, storage devices such as battery, super capacitor, SMES, fuel cell, etc., and hybrid renewable energy systems are used to provide reliable electricity. Storage devices are storing the electricity in direct current (DC) which is derived from alternating current (AC) via rectifiers. These rectifiers pollute the utility with lower order harmonics. Pulse width modulated converters are employed to eliminate these lower order harmonics [1]. The switching frequencies of PWM converters are varied. This leads an attractive feature over one cycle controller [2]-[3]. Moreover these converters cannot shift its operation from rectifying mode to inverting mode of operation. In order to address these problems a modified one cycle controller is presented. This paper deals with the design, mathematical model development, simulation and performance evolution of modified one cycle controller for AC/DC bidirectional boost converter is discussed in this paper.

I. AC/DC CONVERTER

Schematic circuit diagram three phase bidirectional boost converter is shown in fig 1. It consists of six controlled switches, a dc link capacitor, source inductance with three phase AC supply and DC load/battery. The converter is operated in both rectification and inversion mode.

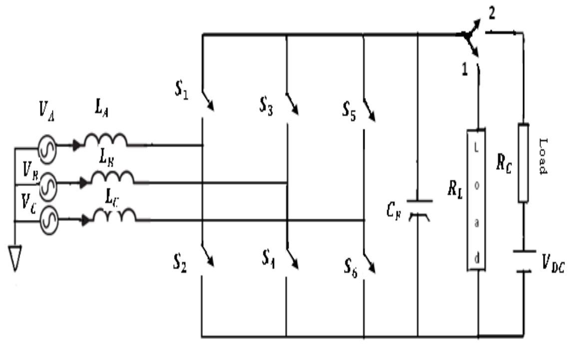


Figure 1.

II. MODIFIED ONE CYCLE CONTROLLER.

The Block Diagram of Modified One Cycle Controller for Three Phase AC/DC Converter is shown in fig 2.

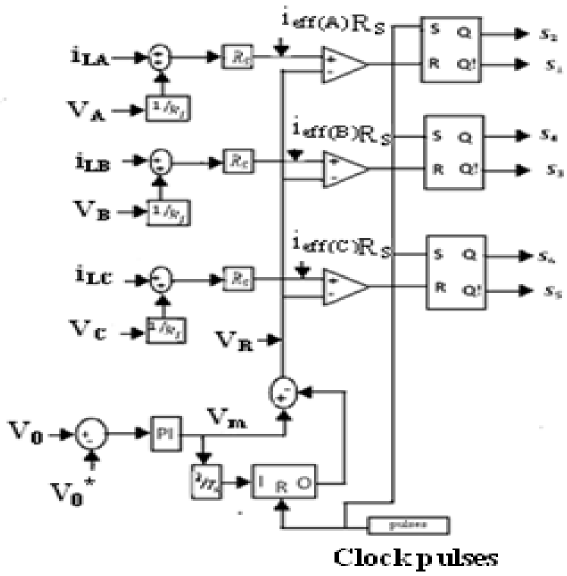


Figure 2.

The DC link capacitor voltage of three phase boost converter is sensed and compared with the desired reference value . This error is processed by a Proportional–Integral (PI) controller to generate a signal V_m. The signal V_m is proportional to the real component of the source current of the converter. This signal is integrated with appropriate gain and subtracted with the same signal to generate bipolar saw tooth waveform. A fictitious current i_F is generated by multiplying the sensed source voltage with the gain $1/R_f$. The fictitious current is added with the sensed source current to obtain $i_{eff(A)}R_S$. The signal $i_{eff(A)}R_S$ is then compared with the bipolar carrier saw tooth waveform to obtain the switching pulses for the controlled switches S_1 and . Similarly, the switching pulses for the rest controlled switches are derived. The logic of generating the switching pulses for six controlled switches of converter is shown in figure 3.

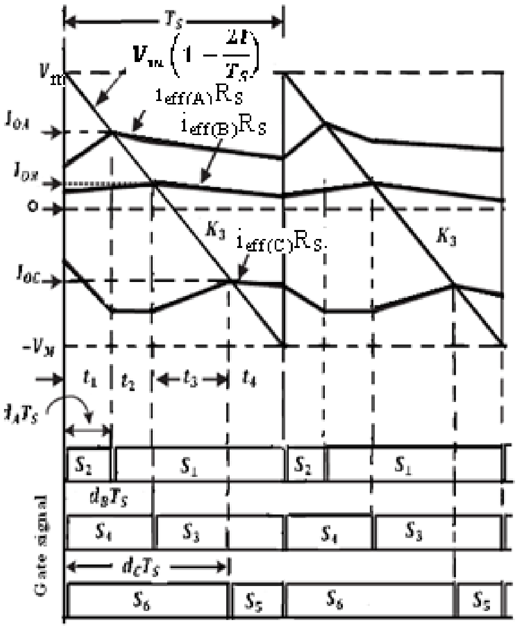


Figure 3.

III. Mathematical Modelling and Analysis of Three Phase Converter

The wave form of the sum of phase current and fictitious currents along with the sawtooth wave form show in figure 3and expressed as follows:

$$R_S\left(i_{nf}+i_{Ln}\right)=R_S\left(\frac{V_n}{R_f}+i_{Ln}\right)\quad \text{n=A, B, C} \quad (1)$$

Time periods of t_2 and t_3

$$t_2=\frac{I_{OA}-I_{OB}}{K_3} \quad (2)$$

$$t_3=\frac{I_{OB}-I_{OC}}{K_3} \quad (3)$$

Change in current in phase A is given

by $\Delta I_A=\frac{v_A}{L_A}T_S-\frac{v_A}{3L_A}\left(t_3+2t_2\right)$

(4)

$$\frac{R\,V_0}{2Vm}i_A+L_A\frac{di_A}{dt}=v_A\left(1-\frac{R_s}{R_f}\frac{V_0}{2V_m}\right) \quad (5)$$

Phase A Current:

$$i_A=\frac{v_A\left(1-\frac{R_S}{R_f}\frac{V_0}{2V_m}\right)}{\frac{R_SV_0}{2V_m}+jwL_A} \quad (6)$$

$\left(\frac{R_S}{R_f}\right)\left(\frac{V_0}{2V_m}\right)$<1 the converter operating as rectifier

$\left(\frac{R_S}{R_f}\right)\left(\frac{V_0}{2V_m}\right)$>1 the converter operating as inverter

The average model of the three phases modified one cycle controller based converter is shown in figure 4.

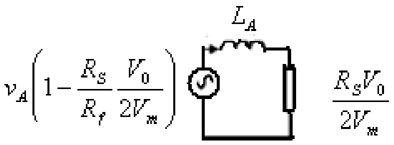


Figure 4.
Average model of the three phases modified one cycle controller based converter.

The power drawn three phase modified one cycle controlled AC/DC converter is expressed as follows:

$$P_0=\frac{3V_mV_S^2}{2R_SV_0} \text{ ------- } (7)$$

IV. Simulation of Modified One Cycle Controlled Three Phase Converter

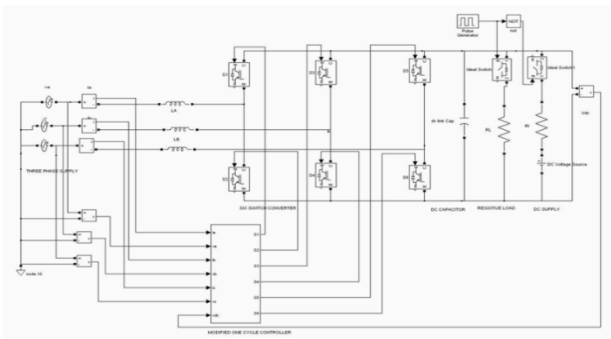
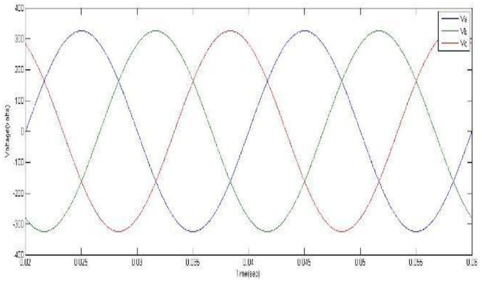


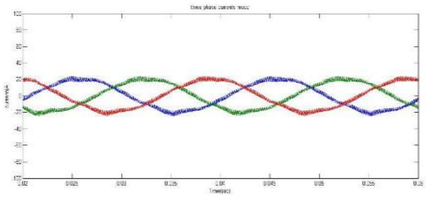
Figure 4.

V. Results and Discussion

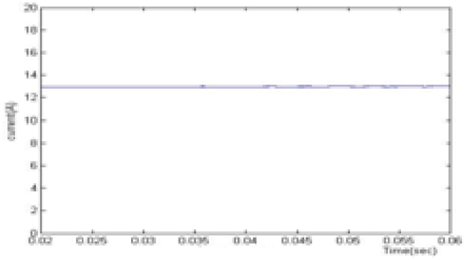
The simulation is carried out in MATLAB 7.2/SIMULINK platform. The current and voltage wave forms of varies units are observed and presented in figure 5.



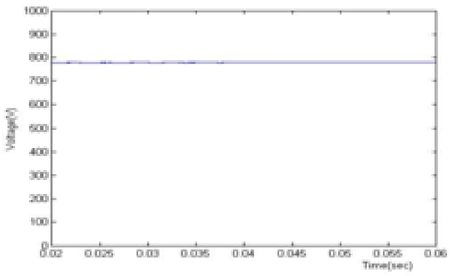
a) source voltage



b) source current



c) load current

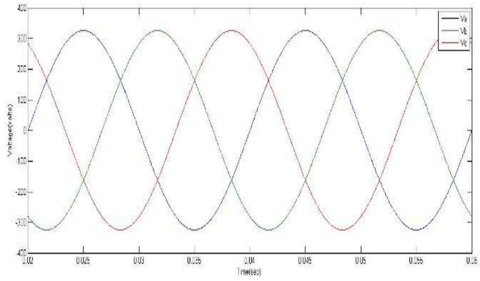


d) load voltage

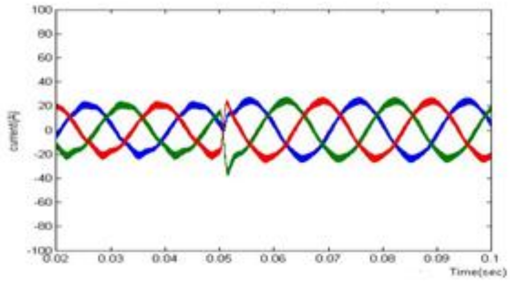
Figure 5.

Observed waveforms from the simulation of modified one cycle controlled converter operated in rectification mode

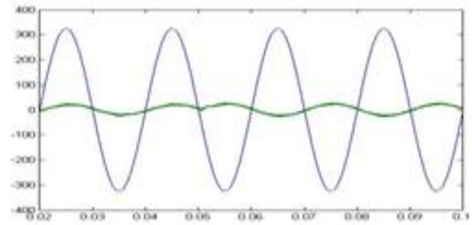
From the figure 6 it is observed that the dc load draws sinusoidal current and voltage from the three phase AC source. The modified one cycle controlled converter is operating in both inversion and rectification mode. Figure 7 shows the observed waveforms from simulation to justify the operation in both inversion and rectification mode.



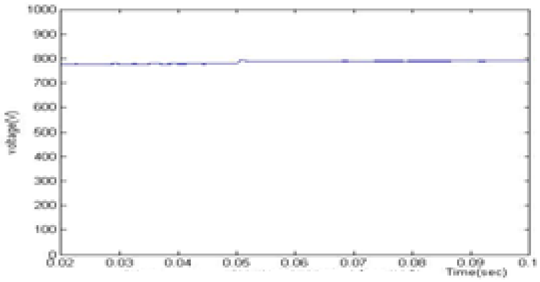
a) source voltage



b) source current



c) current and voltage waveform in phase A



d) output voltage

Figure 6.

Observed waveforms from the simulation of modified one cycle controlled converter operated in both rectification and inversion mode.

CONCLUSION

Modified one cycle controlled three phase boost bidirectional AC/DC converter is proposed. The conventional one cycle controller exhibits instability in current controllability during light load and inverting mode of operation. The inherent limitations of conventional OCC converter are overcome in proposed scheme. The simulation results of modified one cycle controlled three phase boost rectifier and bidirectional AC/DC converter are presented.

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About the Author's

	**L. Joseph Anil Kumar** is pursuing M.Tech (Power Electronics) in Nalanda Institute of Engineering &Technology, Kantepudi. He worked as Assistant Professor for 2 years in Loyola Institute of Technology& Management, Dhulipalla. His Areas of Interest are Power systems, Power Electronics & Neural Networks
	**G. Venkata kasi viswanadham** He received the M.Tech degree in Electrical & Electronics engineering from NIT, Calicut in 2011. He is Currently working as Assistant professor at Loyola Institute of Technology& Management, Dhulipalla. His Areas of Interest are Electrical Machines,Power Electronics & Neural Networks