One-Cycle Controlled Three Phase Boost Converter with PFC

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Abstract--- One cycle controller is used as a controllerin single /three phase boost converter, active filter, and power factor corrections. Three phase Rectifier are widely used in industries application like electrochemical processes, arc furnaces, and adjustable speed drive. In this paper, a three phase six-switch standard boost rectifier with one cycle control technique is proposed. For the standard bridge boost rectifier, a high power factor and low total harmonic distortion can be realized in all three phase with a simple circuit that is composed of one integrator, and some logic and linear component. It does not require multiplier and PLL or any other synchronization circuit. In addition, they offer fast dynamic response due to presence of the current control loop, it employs constant switching frequency modulation that is desirable for industrial application. The proposed control approach is simple and reliable. Detail simulation study is carried out to verify the effectiveness of the scheme.

Keywords:- One-Cycle Control (OCC), Three phase AC to DC converter, Constant Power Factor, Phase Controlled Rectifier(PCR).

I. INTRODUCTION

In most of the power electronics application, AC/DC converter is widely used as a first stage rectifier. DC obtained from this rectifier is further converted into desired amplitude and frequency. Most common topology of rectifier is three phase controlled rectifier (PCR). This PCR is capable of delivering controlled DC voltage but it has a very low input power factor at low conduction angle and introduces unwanted distortion in AC mains. These traditional diode or thyristor bridge rectifier pollute the utility with low-order harmonics, which are difficult to filter [1].

Pulse width modulated converter are employed to eliminate these lower order harmonics and they draw a near sinusoidal input current while providing a regulated output DC voltage[2]. The PWM boost converter's control structure consists of an inner current and outer voltage control loop [3]. The PWM controller need to sense input current and need phase information of the utility voltage or current, Which is obtain by employing PLL or Current phase observer technique[4]. Presence of PLL reduces the robustness of controller.

One cycle control technique provides fast dynamic response, excellence power source disturbance rejection, robust performance and automatic switching error correction. This technique can be extended to control variable frequency switches also. The one cycle control technique is suitable for control of pulse-width-modulated (PWM) converter and resonant based converter for either voltage or current control. [4].

Here one cycle control technique is employed to three phase boost standard bridge bidirectional converter. These grid connected converter based on one cycle control (B-OCC) do not require the service of PLL or zero crossing detectors to synchronize with grid and can be designed to supply power almost unity power factor. As a result they are becoming growing popular. In these scheme the switching devices are operated with constant switching frequency, which is an added advantages for medium and high power application [5]. Detail analytical and simulation studies are carried to verify effectiveness of the scheme.

II. ONE CYCLE CONTROLLED AC TO DC CONVERTER

The schematic circuit diagram of single phase full bridge and three phase six-switched boost bidirectional converter are shown in Fig.1 and Fig.2 respectively. Single phase full bridge consist of four controlled switches, a DC link capacitor, source boost inductance with AC supply and DC Load/Battery. Three phase six-switched boost bidirectional converter consist of six controlled switches, a DC link capacitor, source inductance with three phase Ac supply and DC load/ battery. Both converter single phase and three phase bidirectional converter are operated in both rectification and inversion mode.

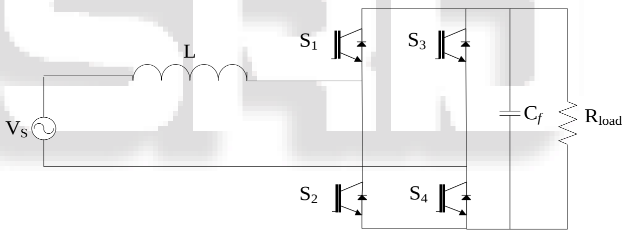

Fig. 1: Single Phase Full Bridge Converter

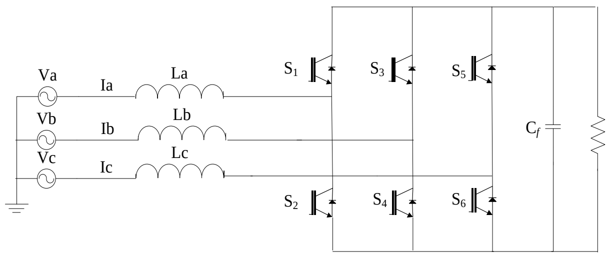

Fig. 2: Three-phasesix-switch boost converter.

The common path requirement also applies to all other dc/dc converters such as boost converter, buck converter, buck boost converter etc. in fact, based on this general structure, and any dc/dc converter can be used to form.

Generally, the control structure of a three-phase six-switch PWM boost converter consist so fan inner current control loop and an out er voltage control loop[4]. The current controller senses the input current and compares it with a sinusoidal current reference. To obtain this current reference, the phase information of the utility voltages or currentisrequired.Generally,thisinformationisobtainedbyemp loying either a phase-locked loop(PLL)or a current phase observer digital technique [5]. To simplify the control structure of these grid-connected systems, one-cycle-control (OCC)based ac-to-dc converters have been proposed[5].This control technique does not require the service of the PLL. Moreover, in these schemes, the switching frequency of the power semi conductor devices is held constant ,which is an added advantage for medium-and high-power applications. However, the schemes based on OCC exhibit in stability in operation when the magnitude of the load current falls be low a certain level or when the converter is operating in the inverting mode of operation[5],[6].

In this paper, one-cycle controller for ac-to-dc bi directional boost converter is proposed. This control scheme not only addresses the above-mentioned limit at ion but also can seamlessly transfer the mode of operation from rectifying to inverting and viceversa. This is realize dusing only dc link voltage information. In this technique , three fictitious current signals, which are proportional to there spective phase voltages and in phase with three utility voltages, are synthesized. These current signals are added to the actual source current signals, and their sum is compared with the saw tooth wave form to generate gating pulses for the converter switches. Moreover, it does not need to select positive and negative peak voltage sas reference current vectors, as required in[6].Detailed simulation studies are carried out to verify the effectiveness of the proposed scheme.

The schematic power circuit diagrams of single-phase full-bridge and three-phase six-switch boost bidirectional converters are shown in Figs.1and2,respectively. The control block diagram of the scheme for the single- phase full-bridge converter is shown in Fig.3. The dc link capacitor voltage v_O is sensed and compared with the desired value Vo^*. This error is processed by a proportional–integral(PI) controller to generate a signal V_M. There fore,at steady state, when v_O I sequal to V^*,the signal V_MI s proportional to the real component of the source current of the converter. Using the signal V_M, a bipolar saw tooth wave form of amplitude V_M and having at imeperio do fT_S is synthesized. This is achieved by integrating the signal V_M with a time constant $T_i$so that

$$T_i = \frac{T_s}{2}$$

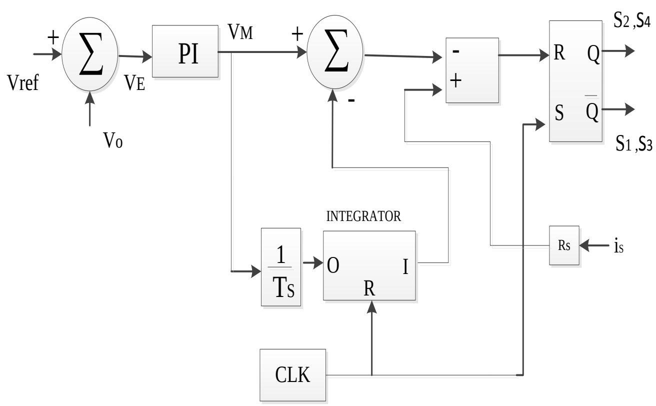

Fig. 3:Controlblockdiagramforthesingle-phaseOCC-basedconverter[6].

Where T_S is the time period of clock pulses, which resets the integrator. The switching frequency of the converter devices is the same as that of the frequency of the clock pulses.

The control equation for the converter as given in [7] is presented as follows:

$$V_M(1-2d) = R_S i_S \quad (1)$$

It is also shown in [7]that the expression for the peak value of current in each switching cycle is

$$i_s = \frac{V_M v_s}{V_O R_s} \quad (2)$$

Where,

R_S=gain of the source current sensor

V_S =rms value of the source voltage

It can be inferred from (2) that the source current is proportional to the source voltage and, hence, is in phase with it.. As V_M , V_O , and R_S are constants for a given steady-state condition, therefore, is can be expressed as

$$i_s = \frac{v_s}{R_e} \quad (3)$$

Where in

$$R_e = \frac{V_M}{R_s V_O} \quad (4)$$

Hence, R_e represents the effective or emulated resistance that the converter is offering to the utility. The principle of operation of the controller for a three-phase Converter shown inFig.4 is similar to that of the single-phase converter[6].

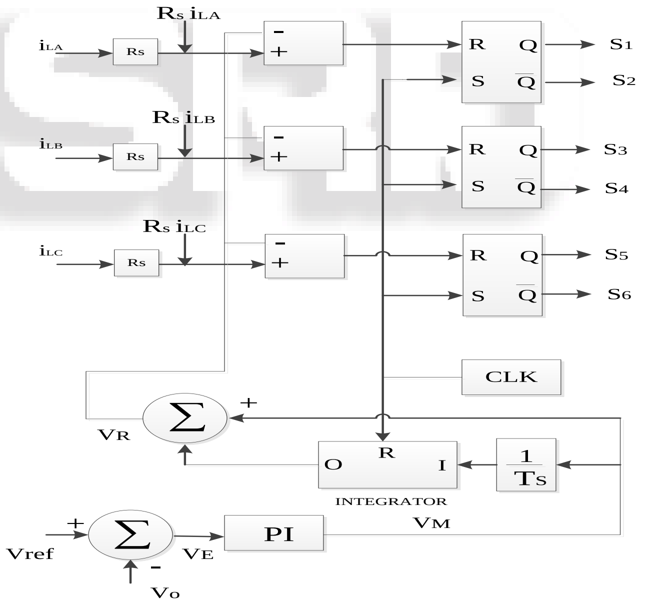

Fig. 4:Control block diagram for the single-phase OCC-based converter[6].

It can be concluded from (2) that the respective phase currents and voltages are in phase.

III. SIMULATION AND EXPERIMENTAL RESULTS

The proposed one-cycle-controlled constant power factor three-phase converter is simulated on MATLAB/Simulink. The schematic power circuit diagram used for the study is shown in Fig. 2. Simulated three phase boost converter shown in Fig. 5 and results are shown in Fig. 6, Fig 7, and Fig. 8. The reference voltage set to 800V and output voltage is followers the reference within one cycle with almost unity power factor, is shown in Fig. 7. Simulation results taken on load of resistance of 75Ω and inductance of 10mH. The value of capacitor is 500uf. The switching frequency of switches is 10 KHz. Input inductance of 5mH.

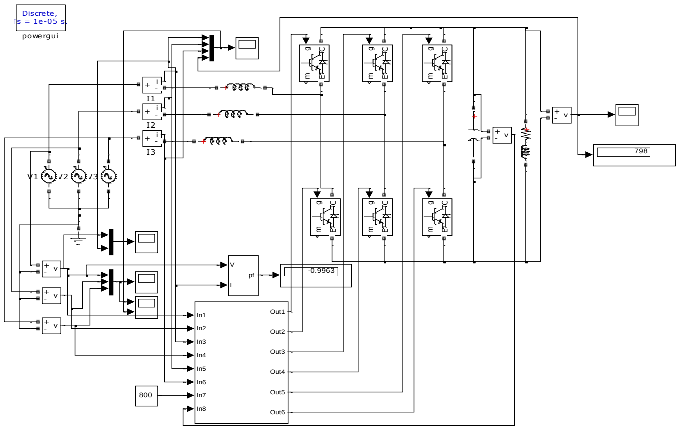

Fig. 5: Simulated Circuit of Three Phase Boost Converter

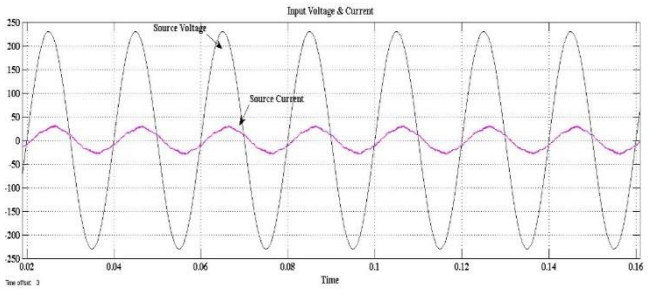

Fig. 6: Simulated Result of Input Source Voltage & Current

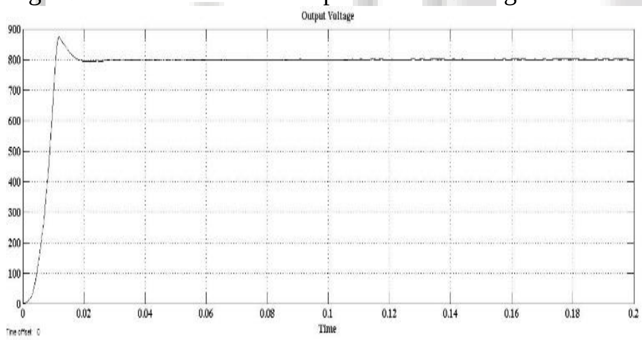

Fig. 7: Simulated Result of Output Voltage

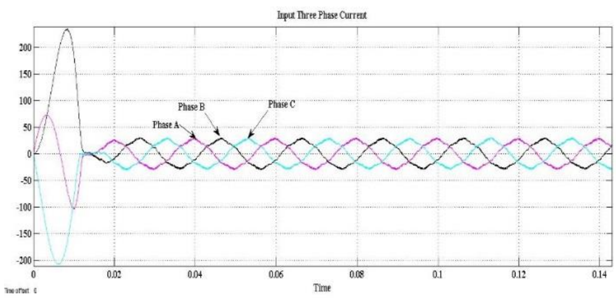

Fig. 8: Simulated Three Phase Input Current

IV. CONCLUSION

One cycle controlled three phase boost bidirectional AC/DC converteris proposed. The one cycle controller exhibits variability in current controllability during light load and inverting mode of operation. The inherent restrictions of OCC converter are overcome in proposed scheme, one-cycle controller for a bidirectional three- phase boost ac-to-dc converter is proposed. Power factor from source side is almost unity with low THD. The overall control structure is simple. Detailed simulation studies are carried out to verify the effectiveness of the scheme.

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