



DESIGNING PARABOLIC PULSE WIDTH MODULATION FOR INDUCTION MOTOR DRIVE

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Abstract: The proposed hybrid PWM strategy is a combination of Parabolic Pulse Width Modulation (PPWM) and Sinusoidal Pulse Width Modulation (SPWM). It mainly explores Sinusoidal Pulse Width Modulation (SPWM) and Parabolic Pulse Width Modulation (PPWM) to achieve the accurate current control. The PPWM is employed in Voltage Source Converter for getting better current control and the SPWM is employed in Diode assisted Buck-Boost VSI for attaining better voltage regulation. The PPWM method employs a pair of Parabolic PWM carriers (a positive one & a negative one) to determine the switching states of the two switches in a converter phase leg and also controls the current tracking error by applying either the positive maximum or negative minimum DC link voltage. The proposed Parabolic PWM can regulate both DC current and AC current with excellent and accurate dynamic response and also maintain a constant switching frequency by the automatic peak current error adjustment through the PWM process. The Diode assisted Buck-Boost VSI will improve voltage boost capability without using high duty ratio, which is applicable for voltage regulation in AC/DC power conversion. The boosted AC power is fed to the induction motor through capacitor filter. In this paper the operation of parabolic pulse width modulation and diode assisted VSI was discussed. The simulation has been implemented using the MATLAB 2010b.

Keywords: Parabolic Pulse width modulation VSC, diode assisted buck boost VSI, Induction Motor.

I. Introduction

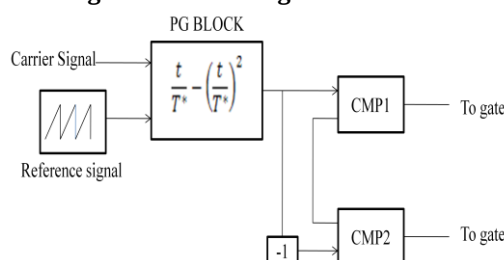
Now-a-days high power and high voltage conversion systems have become very important issues for the power electronic applications. The input voltage fluctuates over a wide range, both voltage buck and boost operations might, at times, be needed for stabilizing the ac output voltage at a desired value [1],[2]. The obvious characteristic in these applications is low dc source voltage supply with wide range voltage drop and high required output ac voltage [3–5]. In the transformer based Z-source inverter the voltage stress is high and control is very complex [12-15]. The nonlinear-carrier (NLC) controller is suitable only for flyback, Cuk, Sepic, and other up-down converters [11]. A resistor-capacitor-diode (RCD) snubber can suppress the voltage stress of the switch, but the leakage energy is dissipated [10]. A passive lossless clamp circuit composed of a diode and a capacitor is added to clamp the turn-off voltage spikes on the switch and recycle the leakage inductance energy [16]. There are a number of direct current control PWM methods in the literature. The first method is based on direct current error control, which includes hysteresis control [6]-[8]. A well-known drawback with this method is the switching frequency variation.

So the proposed technique is used for trigger the pulse to power electronic devices with minimum time period. The technique explores the pulse carriers with upper and lower signal. Due to the power insufficiency the boost techniques are used to improve the voltage for medium and high power application. Comparing of all other boost converters a high voltage can be obtained by connecting Diode Assisted Buck Boost converter. The boosted voltage can converted into AC voltage by adapting the voltage source inverter. The power demand can be lowered by using the proposed technique during the conversion and transmission.

II. PARABOLIC PWM

The parabolic PWM can be implemented in different ways. A simple possible circuit is illustrated in Figure 1, where the PG block is the parabolic carrier generator, CMP1 and CMP2 are two comparators used for detecting the positive and negative peak current errors. The output of the comparator is given as gate pulse to the switch. The gate pulse is 180° phase shift for the switch 2 and switch 3 of the converter.

Figure 1 Block Diagram of PPWM



The proposed parabolic PWM represents with an equation, whose [9] input is the instantaneous current error (Δi), between the reference current (i_{ref}) and the converter output current (i), with

$$\Delta i = i - i_{ref} \quad (1)$$

where T_p and T_n are the conduction periods of the switch S_p and S_n , respectively, T is the switching period with $T = T_p + T_n$, and $\Delta i_{p,peak}$, $\Delta i_{n,peak}$ and Δi_{p-p} are the positive peak, negative peak, and peak-to-peak value of Δi , with $\Delta i_{p-p} = \Delta i_{p,peak} - \Delta i_{n,peak}$. The alternative conduction of switches S_p and S_n , the converter output current increases and decreases within a switching period to track the reference at steady state as shown in figure. Assuming that the voltages U_p , U_n , u_s , and the slope of i_{ref} are constant within a switching period, when the upper switch S_p is closed, the following relationship can be

$$L \frac{di}{dt} + Ri = U_p - u_s \quad (2)$$

The proposed parabolic PWM is developed by further assuming that the converter current i tracks the reference i_{ref} continually and symmetrically with $\Delta i_{p,peak} = -\Delta i_{n,peak} = \Delta i_{p-p}/2$, the loci of $\Delta i_{p,peak}$ and $\Delta i_{n,peak}$ can then be obtained as follows:

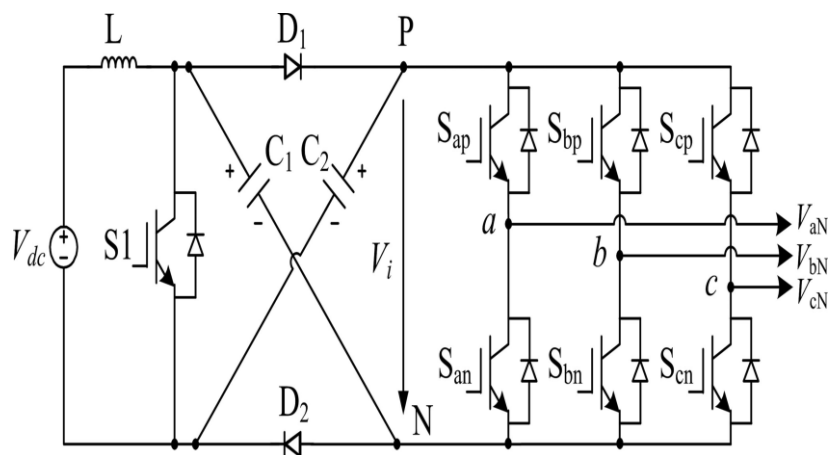
$$\begin{aligned} \Delta i_{p,peak} &= -\Delta i_{n,peak} \\ &= \frac{T}{2L} (U_p - U_n) \left[\frac{T_p}{T} - \left(\frac{T_p}{T} \right)^2 \right] \\ &= \frac{T}{2L} (U_p - U_n) \left[\frac{T_n}{T} - \left(\frac{T_n}{T} \right)^2 \right] \end{aligned} \quad (3)$$

Therefore, in order to control the converter current to track the desired reference, the instantaneous current error can be controlled within the limits between $\Delta i_{n,peak}$ and $\Delta i_{p,peak}$. In the proposed parabolic PWM, this current error control is realized by comparing the current error to a pair of nonlinear parabolic carriers (a positive one and a negative one), where the collisions of the current error and the parabolic carriers determine the switching state of the two switches.

III. DIODE ASSISTED BUCK BOOST VOLTAGE SOURCE INVERTER

Normally the voltage will be in need of more in the high load application. For that situation we want to use boost converter. Here using the diode assisted buck boost VSI. In dc-ac voltage conversion where at the output is very low because it contain some losses. To avoid this we can use diode assisted buck boost voltage source inverter. The boost converter between the VSI and the dc voltage source should have a high voltage gain and a good voltage sag override capability.

Figure 2 Diode Assisted Buck Boost VSI



The new topology integrates an X-shaped diode-assisted capacitor network between the boost inductor and the inverter bridge. Since the diodes in the network are naturally conducting to perform parallel capacitive charging

and are reverse-biased in the next interval to realize series capacitive discharging, the relatively high voltage in the dc-link of the inverter bridge can be easily achieved with the same boost duty ratio and voltage rating of the capacitors. Compared with conventional two-stage dc–dc boosted VSI and Z-source inverter, diode-assisted buck–boost VSI with a greater voltage transfer ratio is more suitable for simultaneously much high and wide range ac voltage output.

In Figure 2 the main circuit and operation principle of diode-assisted buck–boost VSI have been described in detail. The diode-assisted capacitor network introduces an instantaneous intermediate dc-link voltage change of the inverter bridge in one switching time period. However, the PWM strategies presented just utilize active vectors for ac output in the duration when the two capacitors are connected in series. When the switching device S1 is turned OFF, the two capacitors are connected in parallel through two forward-biased diodes and the intermediate dc-link voltage V_i is the same as the capacitor voltage. During this interval, the three-phase VSI operates in null state and output ac voltage is zero. In view of the variable intermediate dc-link voltage of the inverter bridge in one switching time period, sufficient utilization of intermediate dc link voltage can improve the voltage transfer ratio and reduce the voltage rating of the capacitors.

IV. Result

The Parabolic PWM control for VSC and sinusoidal PWM for VSI of induction motor drive is mathematically modeled and simulated using SIMULINK toolbox in MATLAB environment. The output of the parabolic PWM and the induction motor Drive are Observed. The simulation circuit of overall system is shown in Figure 3. The parabolic pulse is generated by using the output and it is feedback to the input. Both the reference and carrier signal is compared and generate the parabolic signal and the diode assisted buck boost voltage source inverter will boost the voltage without using high duty ratio. The sinusoidal pulse is generated by using 180° phase shift for the upper and lower leg. Finally the output of the inverter is given to the induction motor. The induction motor work with high torque and low distortion and speed is attained as high.

Figure 3 Simulation circuit of Overall System

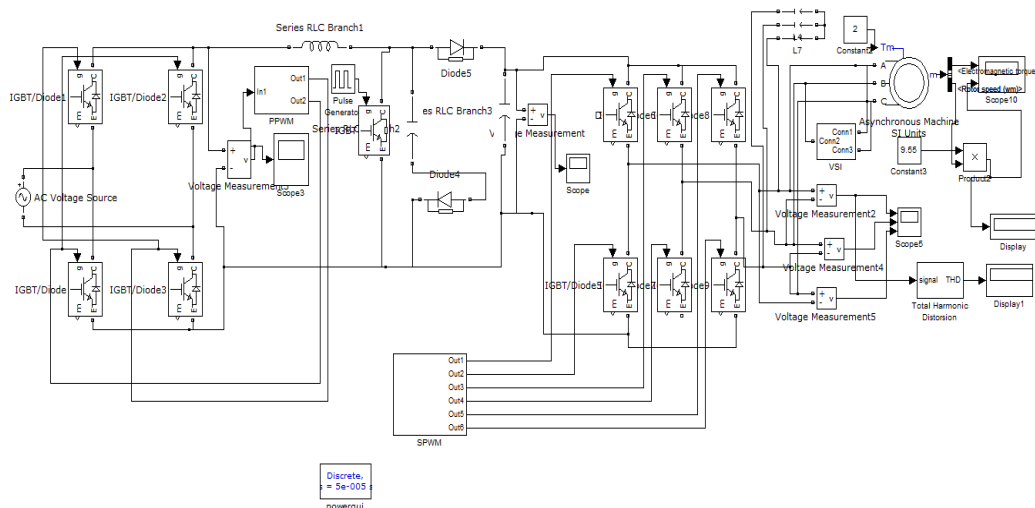


Figure 4 Output Graph of Parabolic PWM

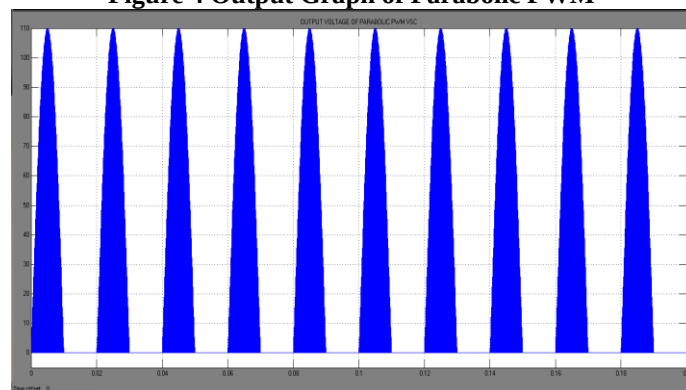
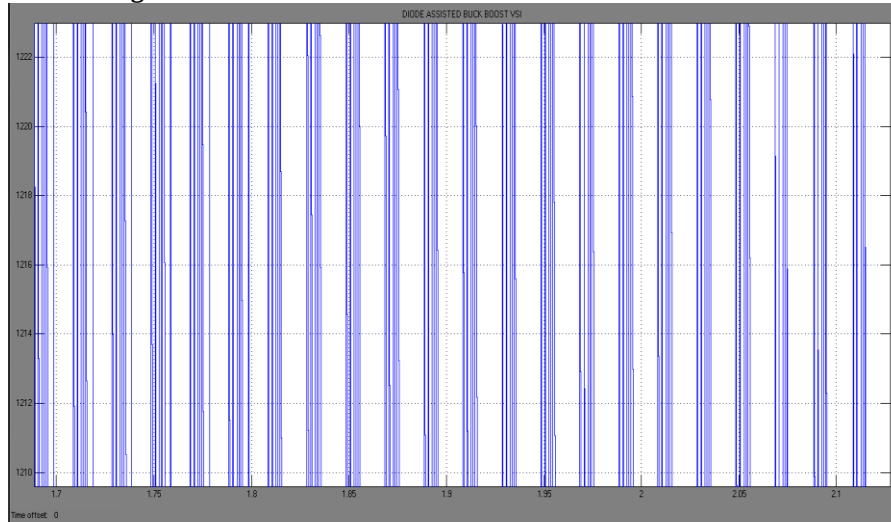


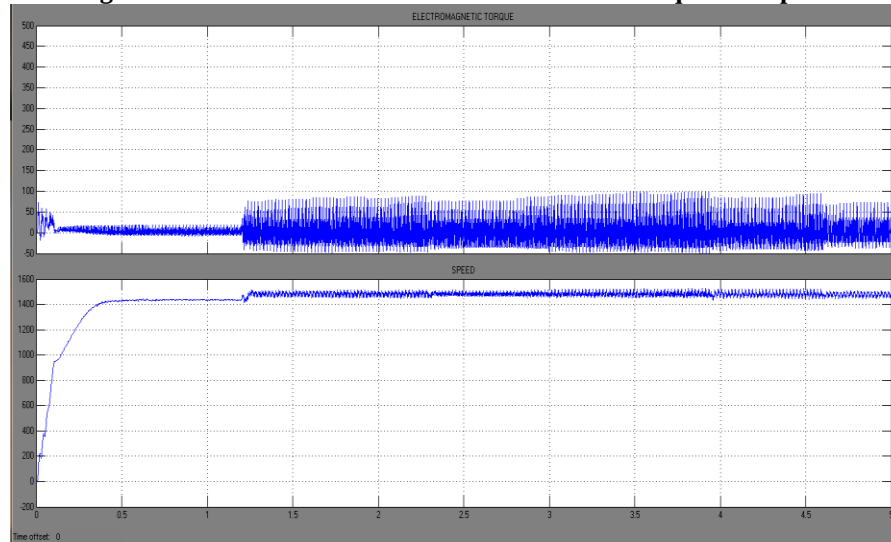
Figure 4 shows the output graph of Parabolic PWM. The parabolic Pulse Width Modulation used only in converter. During the conversion process the proposed system does not produced any distortions which are observed. Here the input voltage is 110 V and the output is obtained as same without any losses during the conversion.

Figure 5 Simulation Result of Diode Assisted Buck Boost VSI



The Figure 5 represents the output waveform of diode assisted buck boost VSI. The output of the converter is 110 V and it is given to the diode assisted buck boost voltage source inverter. The voltage is boosted up to a 450 V for each phase. The boosted voltage is used for high power applications.

Figure 6 Simulation Results of Induction Motor Torque and Speed



The Figure 6 represents the output waveform of voltage source Inverter. The torque produced by the proposed system was 6.256 N-m and speed was 1414 rpm.

V. Conclusion

The work of parabolic pulse width modulation (PPWM) is implemented in VSC so that accurate current control at the output side of VSC is achieved. Diode Assisted Buck Boost Converter is connected with VSC to boost the voltage and boosted voltage is given to VSI and Sinusoidal Pulse Width Modulation (SPWM) is implemented in VSI to improve the voltage regulation. The output of VSI is fed to the Induction Motor. The proposed scheme is designed and analyzed through simulation under MATLAB/SIMULINK environment.

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