The Effect of PWM Modulation and Commutation Scheme for Three Phase Buck Matrix type Converter

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***Abstract*: - The paper starts with analysis of PWM schemes for the 3 phase isolated buck matrix type rectifier. An optimal six-segment PWM scheme ("Type A") is proposed. "Type A" PWM scheme has lower duty-cycle loss, maximum output inductor current ripple and minimum switching loss comparing to other PWM schemes when the MOSFET devices are employed. The steady state analysis of duty-cycle loss, inductor current ripple and THD are all compared and verified by the experimental results for "Type A" PWM and eight-segment PWM ("Type E").**

These terms are using in the PWM scheme – Zero voltage switching (ZVS), phase-shifted full-bridge (FB-PS), space vector modulation (SVM).

1. INTRODUCTION:

A direct matrix type rectifier that directly converts the mains-frequency AC voltage into a high-frequency AC voltage .Compared with MOSFETs, the IGBT is slower devices and cannot operate at higher switching frequency and the IGBT has greater conduction loss for medium-power. A zero-voltage switched (ZVS) three-phase isolated buck PWM rectifier using MOSFET. Low switching losses is achieved due to the ZVS operation with high switching frequency.

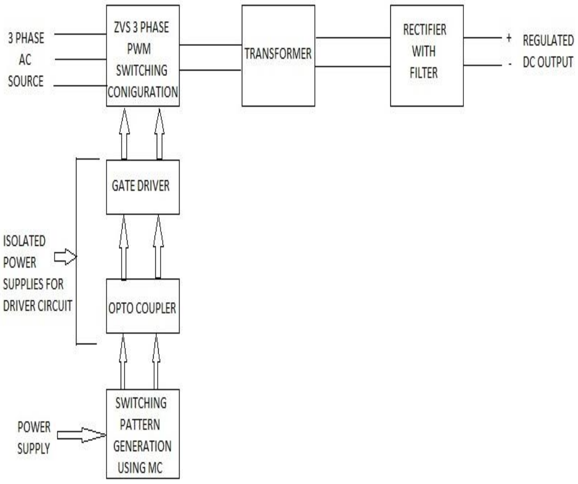


Fig.1.1 Block Diagram

MOSFET such that, the converter can operate at higher switching frequency. A six-segment PWM scheme is proposed in this paper to overcome the aforementioned drawbacks of large duty cycle loss and large output inductor current ripple with eight-segment PWM. The merit of ZVS operation to use MOSFETs is still maintained in the proposed six-segment PWM.

2. PWM SCHEMES :

The three Phase Buck matrix type rectifiers are similar to the current source rectifier (CRS), but all the switches are bidirectional. The space vector modulation is used as to this converter for CSR. Each active vector there are two possible switching states depending on the direction of the current in the primary side of transformer .Ix+, Ix- are the switching vectors Ix and Iy+, Iy- are the switching vectors of Iy. When $i_p > 0$, $i_p < 0$ with equal dwell time.

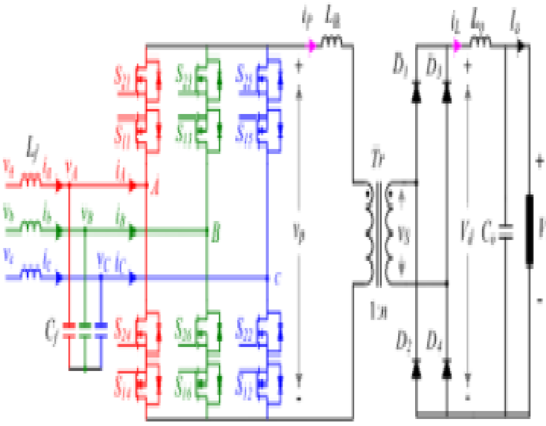


Fig.2.1.PWM Rectifier

2.1 Review of PWM Scheme:

In this analysis I ref is at 0º<θ<30º. During this time the VL (Line Voltage) VAB=VA-VB is lower than VAC= VA-Vc in this analysis switching patterns for six segment eight segment accurse, But six segment PWM with HTL pattern is effective. The switching loss corresponds to the transition from zero vectors to active vector and from active vector to zero vectors must not exhibit signification difference with other switching patterns.

2.1.1 Switching Transitions:

There are so many switching transitions such as HTL, LTH, Hybrid pattern with Six Segment and eight segments. Here six segments with HTL pattern is used because it has so many merits than others. There are two turn-on actions and one turn off action related to this transition turn on action is ZVS or Non-ZVS. The Non-ZVS switch is very low because the MOSFET is turned on with Zero current and very low drain source voltage, the turn off loss of MOSFET is low due to very small overlapping of the voltage and current during this transition. The turn off action occurs at low voltage transition. Turn On losses due to the hard switching and due to reverse recovery produces large.

2.1.2 PWM:

Pulse width modulation has so many types TYPE-A, TYPE-B, TYPE-C, TYPE-D and TYPE-E Generally Type – A and Type – E are preferred in these type of sections.

2.1.3 Duty Cycle Loss Analysis:

Type –A and Type –E are compared to analysis the duty cycle loss. The major Problem of operating at higher switching frequency and is duty cycle loss. The Selection of transformer turns ratio, modulation index depends on the switching frequency. The O/P Voltage contains low frequency harmonics to eliminate the effects the secondary duty cycle has to be calculated.

$$D_{sx}(\theta) = -\,ma\,(I_b(\theta) / I_m) \quad \text{------ (1)}$$

$$D_{sy}(\theta) = -\,ma\,(I_c(\theta) / I_m) \quad \text{------ (2)}$$

Compared with “Type-A” PWM the “Type-E” has two additional duty cycle loss Δ Dy. The total duty cycle loss of Type-A & Type-E PWM schemes is compared at different angle θ.

Type-A PWM can achieve ZVS with high load range by using large value of LIR. Hence it reduces the turn on switching losses at lighter load.

3. *The Effect of PWM for MOSFET Devices:*

The transformer of primary voltage waveforms with different PWM schemes. Type-A is preferred because Type-B always maintains LTH Switching Pattern, Type-D PWM Pattern is rarely used because of the drawback of asymmetrical voltage pulses across the transformer primary winding. Type-A is the optimal scheme for the MOSFET devices used in Three Phase isolator buck matrix type rectifier. HTL transition exhibits lower switching losses compares to transition of LTH if MOSFET employed in the converter. Hence the “Type-A” PWM is employed for the six segment PWM to eliminate the turn on loss with ZVS Implementation.

4. *Operation Principle of Type-A:*

During the interval of -30º<θ<30º the time voltages VAB=VA-VB, VAC= VA-Vc are positive and they attain their maximum in this interval. In each 60 º interval the phase legs of high (or) Low voltage potential is shown by the “Bridge X” and “Bridge Y”.

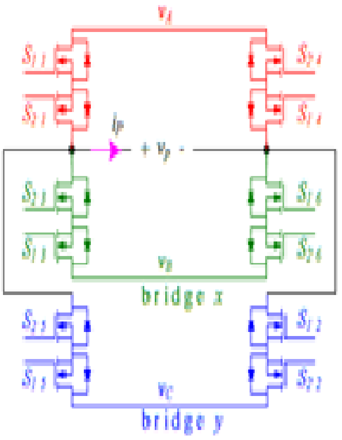


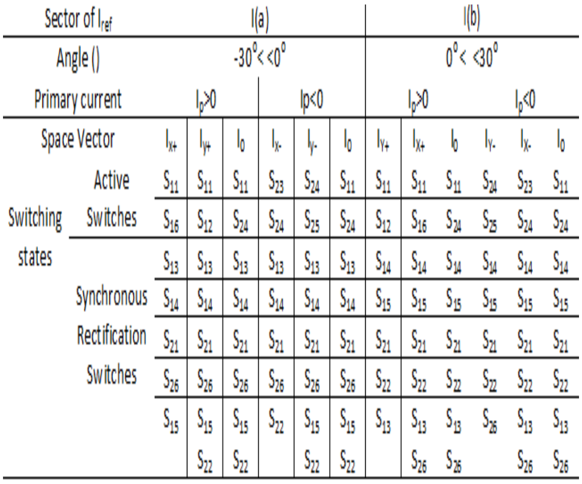
Fig.3.1Three Phase Converter

When the Switches of “Bridge X” are turned on with the time $T_x/2$ creating a positive voltage pulse VP=VAB and a current pulse from Phase A into Phase B with magnitude IP. The given Ma the duty cycle of current Pulses for each phase is proportional to the current.

The Modulation index, which is in the range of 0≤ Ma≤1. The Ma is used to adjust the three phase current magnitude without affecting this sinusoidal shape.

4.1 Switching State and commutation:

MOSFET’s are employed in the main converter some of the switching functions as synchronous rectification to reduce the conduction loss switching states and space vector in sector I. During the interval of -30º<θ<0º, Voltage potential VA>VC >VB, the bridges X is kept on at all time since the diodes are forward biased.



Sector of I_{ref}		I(a)						I(b)					
Angle ()		$-30^0< <0^0$						$0^0< <30^0$					
Primary current		$I_p>0$			Ip<0			$I_p>0$			$I_p<0$		
Space Vector		I_{x+}	I_{y+}	I_0	I_{x-}	I_{y-}	I_0	I_{Y+}	I_{X+}	I_0	I_{Y-}	I_{X-}	I_0
Switching states	Active Switches	S_{11}	S_{11}	S_{11}	S_{23}	S_{24}	S_{11}	S_{11}	S_{11}	S_{11}	S_{24}	S_{23}	S_{11}
		S_{16}	S_{12}	S_{24}	S_{24}	S_{25}	S_{24}	S_{12}	S_{16}	S_{24}	S_{25}	S_{24}	S_{24}
	Synchronous Rectification Switches	S_{13}	S_{13}	S_{13}	S_{13}	S_{13}	S_{13}	S_{14}	S_{14}	S_{14}	S_{14}	S_{14}	S_{14}
		S_{14}	S_{14}	S_{14}	S_{14}	S_{14}	S_{14}	S_{15}	S_{15}	S_{15}	S_{15}	S_{15}	S_{15}
		S_{21}	S_{21}	S_{21}	S_{21}	S_{21}	S_{21}	S_{21}	S_{21}	S_{21}	S_{21}	S_{21}	S_{21}
		S_{26}	S_{26}	S_{26}	S_{26}	S_{26}	S_{26}	S_{22}	S_{22}	S_{22}	S_{22}	S_{22}	S_{22}
		S_{15}	S_{15} S_{22}	S_{15} S_{22}	S_{22}	S_{15} S_{22}	S_{15} S_{22}	S_{13}	S_{13} S_{26}	S_{13} S_{26}	S_{26}	S_{13} S_{26}	S_{13} S_{26}

Fig.4.1Switching States

Some of the constraints needed to be applied in bridge Y to prevent short circuit between VB and VC. The Switching states of active and synchronous rectification.

Switching losses has been compared for Type A and Type E in which turn off action with high voltage and low voltage differs each other. During the comparison it results Type E has noticeable turn off actions are switched at high voltage transition. So Type A is Preferred.

5. RESULTS:

5.1 Duty Cycle loss:

The reduction of duty cycle losses also enables the operation of the converter at higher Ma and reduces the power losses caused by the circulating current in primary side switches.

Fig.5.1Simulation Result

5.2 Inductor Current Ripple:

The output inductor current ripple of Type -A and Type-E PWM's varying with phase angle θ due to the variable off-time of V_d. In the summary the minimum current ripple in the Type-A PWM θ=0° is higher than Type-E PWM by two times whenever the maximum current ripple in Type-A PWM at θ=±30° is smaller than that of Type-E PWM. The frequency across the transformer with Type-E is double of the Type-A PWM..The lower core loss and smaller core of the transformer can be expected with Type-E PWM. At the time of θ=±30°, one of the two active vectors attained its maximum magnitude and other is minimum. As a result both attains it maximum flux density but the transformer operating frequency of TYPE-A.

5.3 Switching loss comparison:

Switching losses can be analyzed for the turn-on and turn-off actions within a switching cycle. Switching loss is also a function of the voltage transition across the switching device since the voltage transition between two joint active vectors is only the difference between of two line voltages the turn off losses.

6. CONCLUSION:

Type-A PWM Feature has lower switching Loss Lower duty cycle loss and lower maximum output inductor current ripple a low THD can be also achieved with duty cycle compensation. The three-phase isolated Buck matrix type rectifier using MOSFETs is used in AC-DC applications such as front-end power converters for high voltage direct current (HVDC) and telecommunication. PWM schemes used for this topology are investigated and an optimal six-segment.

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