IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
ISSN: 2278-1676 Volume 2, Issue 5 (Sep-Oct. 2012), PP 10-16
www.iosrjournals.org

Csvpwm and Azsvpwm: A Comparative Approach for Dtc Vsi Fed Induction Motor Drive

V.Raveendra Reddy[1], V.C.Veera Reddy[2], K.Saranya Reddy[3]
[1]Associate professor, Department of Electrical and electronic engineering, RSR E.C, Kadanuthala, A.P, INDIA
[2]Professor and Head of the department, Electrical Engineering, S.V.U.C.E, Tirupati, A.P, INDIA
[3]P.G Student, Power Electronics &Drives, Department of Electrical Engineering ,PBR VITS,Kavali,Nellore D.t,A.P

Abstract : *This paper presents a mathematical and programming model of conventional space vector pulse width modulation(CSVPWM) and mathematical analysis of new approach for designing SVPWM imaginary switching times called active zero space vector pulse width modulation AZSVPWM for reducing the common mode voltage.*V_{cm} *from* $+V_{dc}/2$ *to*$+V_{dc}/6$*.In AZSVPWM method the complexity involved in calculating* V_{ref} *and angle information zero voltage vector are eliminated by simply taking two opposite active voltage vectors.*
Keywords –*AZSVPWM, CSVPWM, SVPWM, Vcm, VSI*

I. Introduction

Induction motors were widely used in industries due to its robustness, low-cost and high reliability [1]. To reduce the steady state ripple space vector pulse width modulation (SVPWM) technique has been proposed in [2-3].This techniques requires angle and sector information and also generates the high common mode voltageVcm. To reduce the complexity involved in calculating the angle and sector information a active zero space vector concept which does not use the zero voltage vectors with equal time intervals.

II. Conventional Space Vector Pulse Width Modulation

In CSVPWM, the reference voltage space vector or V_{ref} vector is sampled in every sub cycle T_s in an average sense. Here two active voltage vectors and zero voltage vectors are used. Given a example figure (1) where V_{ref} in sector 1 is calculated by two active voltage vectors V_1 and V_2 and two zero voltage vectors V_0 and V_7 are used.

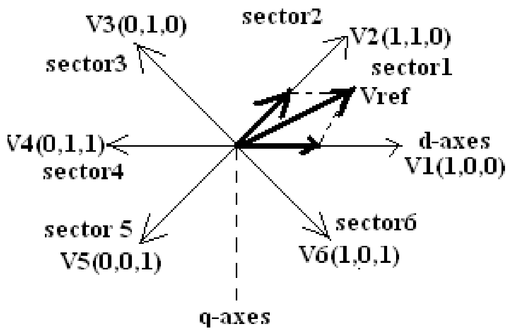


Fig.1.switching states and corresponding voltage vectors of voltage source inverter (VSI)

Sampling time Ts can be calculated from the equations:

$T_1=3/\square*M*\sin(60°-\square)/\sin60°*T_s$------- (1)

$T_2=3/\square*M*(\sin\square/\sin60°)*T_s$------------- (2)

$M=\square*V_{ref}/2*V_{dc}$--------------------------- (3)

Here M=modulation index

$T_z=T_s-(T_1+T_2)$ --------------------------------- (4)

III. Active Zero Space Vector Pulse Width Modulation

In the conventional space vector, it can be observed that the switching times T1 and T2 depends up on the sector calculations mentioned in table (I) .So to eliminate the complexity involved in in calculating the reference vector is minimized by taking instead of zero voltage vector two active opposite voltage vectors with equal time duration are utilized for composing the reference vector by using imaginary switching times and these can be calculated as explained in the Table (1).

Table-1 Imaginary switching times and sector calculations

T1	T2	Angle	sector	Upper switches (s1,s3,s5)	Lower switches (s4,s6,s2)
3/2*Vref/Vdc*Ts	0	0°		0	0
0	3/2*Vref*Ts	60°	1	S1=T1+T2+T0/2 S3= T2+T0/2 S5= T0/2	S4=T0/2 S6=T1+T0/2 S2=T1+T2+T0/2
-3/2*Vref/Vdc*Ts	3/2*Vref/Vdc*Ts	120°	2	S1=T1+T0/2 S3= T1+T2+T0/2 S5= T0/2	S4= T2+T0/2 S6= T0/2 S2=T1+T2+T0/2
-3/2*Vref/Vdc*Ts	0	180°	3	S1=T0/2 S3= T1+T2+T0/2 S5= T2+T0/2	S4= T1+T2+T0/2 S6= T0/2 S2=T1+T0/2
0	-3/2Vref/VdcTs	240°	4	S1= T0/2 S3= T1+T0/2 S5= T1+T2+T0/2	S4= T1+T2+T0/2 S6= T2+T0/2 S2= T0/2
-3/2*Vref/Vdc*Ts	3/2*Vref/VdcTs	300°	5	S1= T2+T0/2 S3= T0/2 S5= T1+T2+T0/2	S4= T1+T0/2 S6= T1+T2+T0/2 S2= T0/2
3/2*Vref/Vdc*Ts	0	360°	6	S1=T1+T2+T0/2 S3= T0/2 S5= T1+T0/2	S4= T0/2 S6= T1+T2+T0/2 S2= $T_2+T_0/2$

From d-q transformation, three phase voltages can be calculated s follows:

$V_{as}= V_{ref}\cos\alpha$---------------------------- (5)
$V_{bs}= -0.5\ V_{ref}\cos\alpha+0.866\ V_{ref}\sin\alpha$—(6)
$V_{cs}= -0.5V_{ref}\cos\alpha-0.866\ V_{ref}\sin\alpha$----- (7)
Where $V_{ref}=\sqrt{V_d^2+V_q^2}$
$\alpha=\tan^{-1}(V_d/V_q)$

Actual switching times in sector 1
$T_{as}= (V_{as}/V_{dc})\ Ts$------------- (8)
$T_{bs}= (V_{bs}/V_{dc})T_s$------------------ (9)
$T_{cs}= (V_{cs}/V_{dc})T_s$------------------ (10)
$T_1=T_{as}-T_{bs}$
$= (T_s/V_{dc})(V_{as}-V_{bs})$----------- (11)
$T_2=T_{bs}-T_{cs}$------------------------------ (12)
$T_2=(T_s/V_{dc})\ (V_{bs}-V_{cs})$ ---------(13)

Where
T_s=sampling time period
In sector one the imaginary switching time proportional to phase A(T_{as}) has minimum value and imaginary switching time proportional to phase C(T_{cs}) has minimum value and switching time proportional to phase B(T_{bs}) has either min or max value as shown below.

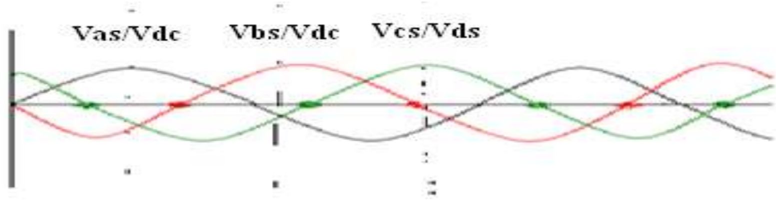


Fig.2 Illustration of imaginary switching States

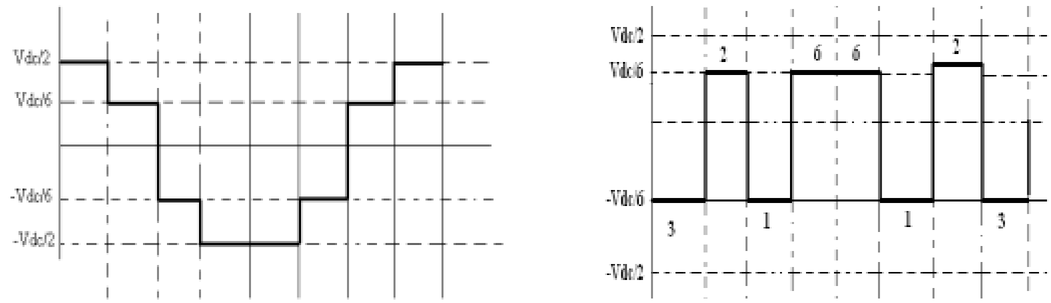
Switching times $T_1$and T_2 in each sector can be expressed as below:
T_{max}=max ($T_{as,}T_{bs,}T_{cs}$)--------(14)
T_{mid}=mid ($T_{as,}T_{bs,}T_{cs}$)------- -(15)
T_{min}=min ($T_{as,}$ Tbs,Tcs)---------(16), Thus
T_1=T_{max}-T_{mid}------------------- (17)
T_2=T_{min}-T_{mid} ------------------ (18)
Switching times for all sectors can be shown below table (2)

Table-2 Calculation of Switching times in six sectors

	S-I	S-II	S-III	S-IV	S-V	S-VI
T_{max}	T_{as}	T_{bs}	T_{bs}	T_{bs}	T_{cs}	T_{as}
T_{min}	T_{cs}	T_{cs}	T_{as}	T_{as}	T_{bs}	T_{bs}
T_1	T_{as}- T_{bs}	T_{bs}- T_{as}	T_{bs}- T_{cs}	T_{cs}- T_{bs}	T_{cs}- T_{as}	T_{as}- T_{cs}
T_2	T_{bs}- T_{cs}	T_{as}- T_{cs}	T_{cs}- T_{as}	T_{bs}- T_{as}	T_{as}- T_{bs}	T_{cs}- T_{bs}

IV. Common Mode Voltage Vcm

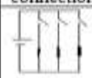
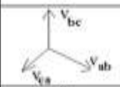
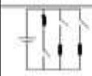
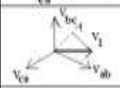
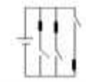
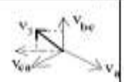
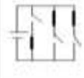
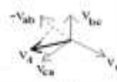
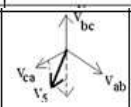
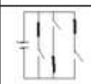
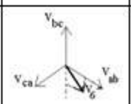
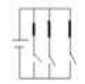
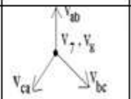
According to switching states common mode voltage V_{CM} is defined as:
V_{CM} = (V_{a0}+V_{b0}+V_{c0})/3 -----------------(19)
Where V_{a0},V_{b0},V_{c0} are the inverter pole voltages.the common mode voltage for the sectors[v1-v6] are shown in table (3).



(a): Common mode vltage-CSVPWM method (b): Common mode vltage-AZSVPWM methods

Fig (3): Comparison of common mode voltage in csvpwm method and azsvpwm methods

Able-3 Sector and Common mode voltages

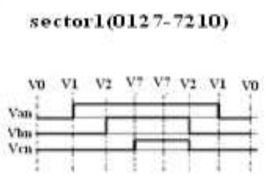
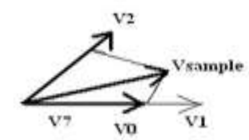
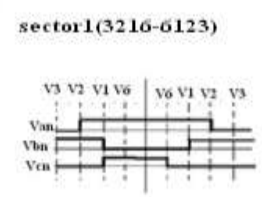
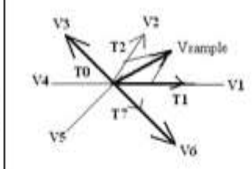
Voltage vectors	Switching states			v_a	v_b	v_c	v_{a0}	v_{b0}	v_{c0}	v_{ab}	v_{bc}	v_{ca}	v_{qs}	V_{ds}	Inverter switch connection	Vector	common mode voltage
V_0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			$-V_{dc}/2$
V_1	1	0	0	v_{dc}	0	0	$-v_{dc}/2$	$-v_{dc/2}$	$-v_{dc/2}$	v_{dc}	0	$-v_{dc}$	2/3 v_{dc}	0			$-V_{dc}/6$
V_2	1	1	0	v_{dc}	v_{dc}	0	$v_{dc/2}$	$v_{dc/2}$	$-v_{dc/2}$	0	v_{dc}	$-v_{dc}$	1/3 v_{dc}	$-v_{dc}/\surd 3$			$V_{dc}/6$
V_3	0	1	0	0	v_{dc}	0	$-v_{dc/2}$	$v_{dc/2}$	$-v_{dc/2}$	$-v_{dc}$	v_{dc}	0	-1/3 v_{dc}	-1/3v_{dc}			$-V_{dc}/6$
V_4	0	1	1	0	v_{dc}	v_{dc}	$-v_{dc/2}$	$v_{dc/2}$	$v_{dc/2}$	$-v_{dc}$	0	v_{dc}	1/3 v_{dc}	-2/3v_{dc}			$V_{dc}/6$
V_5	0	0	1	0	0	v_{dc}	$-v_{dc/2}$	$-v_{dc/2}$	$v_{dc/2}$	0	$-v_{dc}$	v_{dc}	2/3 v_{dc}	-1/3v_{dc}			$-V_{dc}/6$
V_6	1	0	1	v_{dc}	0	v_{dc}	$v_{dc/2}$	$-v_{dc/2}$	$v_{dc/2}$	v_{dc}	$-v_{dc}$	0	1/3 v_{dc}	1/3v_{dc}			$V_{dc}/6$
V_7	1	1	1	v_{dc}	v_{dc}	v_{dc}	$v_{dc/2}$	$v_{dc/2}$	$-v_{dc/2}$	0	0	0	0	0			$V_{dc}/2$

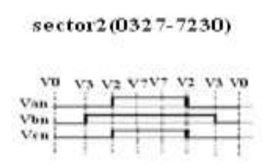
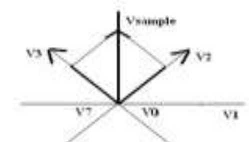
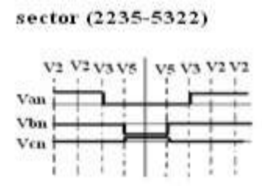
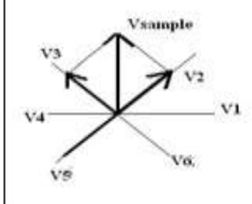
IV. Space Vector Pulse Width Modulation-Advanced Techniques

V.I.Active Zero Pulse Width Modulation 1 &2:

In this method the classical active (adjacent) voltage vectors are complemented with either two near opposing active vectors[4].The switching states and vector representation are shown in Table(4) & Table (5)

Table 4.Switching states and Vref or Vsample Calculation(CSVPWM and AZSVPWM 1&2)

CSPWM	REF.VECTOR CALCULATION FOR CSPWM	AZPWM1	REF.VECTOR CALCULATION FOR AZPWM1
			

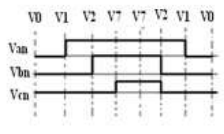
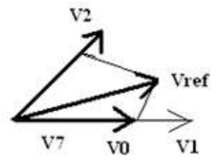
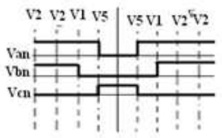
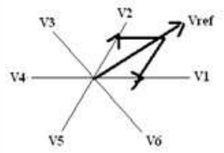
CSPWM	REF.VECTOR CALCULATION FOR CSPWM	AZPWM2	REF.VECTOR CALCULATION FOR AZPWM2
			

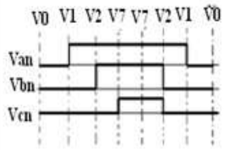
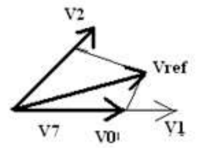
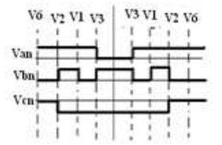
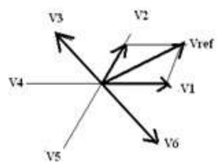
Above table shows how to calculate the reference vector by using two active opposite voltage vectors

V.II. Active Zero Pulse Width Modulation 3 &4:

In this method one of adjacent states and its opposite vector with equal time to effectively create voltage vectors. The switching states and vector representation are shown in Table (5) .

Table 5.Switching states and Vref or Vsample Calculation(CSVPWM and AZSVPWM 3&4)

CSPWM	REF.VECTOR CALCULATION FOR CSPWM	AZPWM3	REF.VECTOR CALCULATION FOR AZPWM3
Sector1:**(0127-7210)** 		**Sector1:(2215-5122)** 	

CSPWM	REF.VECTOR CALCULATION FOR CSPWM	AZPWM4	REF.VECTOR CALCULATION FOR AZPWM4
Sector1:**(0127-7210)** 		**Sector1:(6213-3126)** 	

V. Implementing SVPWM

The block diagram for proposed PWM algorithams based direct torque controlledInduction Motor Drive is shown below Fig.3 in the proposed method induction motor torque is controlled by controlling the inverter pole voltages by selecting appropriate switching states

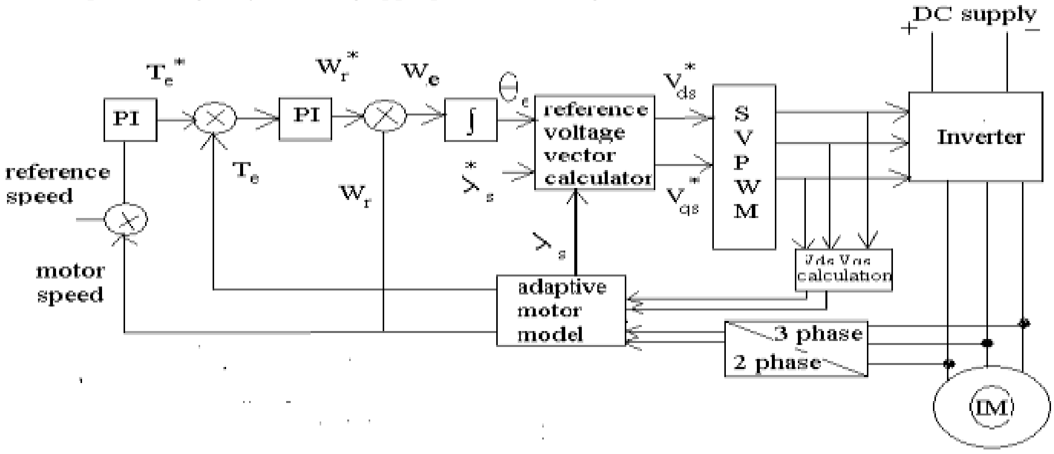


Fig 4: Block diagram of proposed PWM –DTC Algorithm

VI. Simulation Results

To validate the proposed PWM Algorithm, numerical simulation studies has been carried out by using MATLAB/SIMULINK.Here the results of CSVPWM and AZSVPWM techniques have been posted and compared for the following specifications of 3-phase,400V ,inductor motor drive.

Rr=1.9;
Rs=1.635;
Lls=0.086;
Llr=0.086;
lm=0.243;

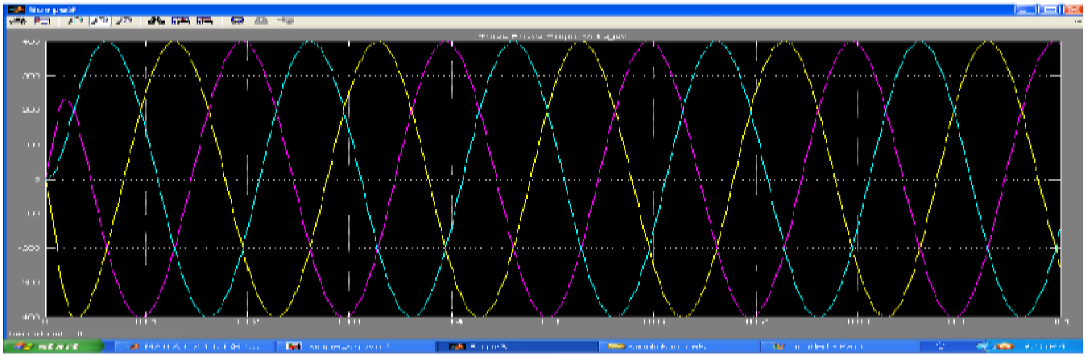


Fig.5. stator voltages of active zero space vector pulse width modulation

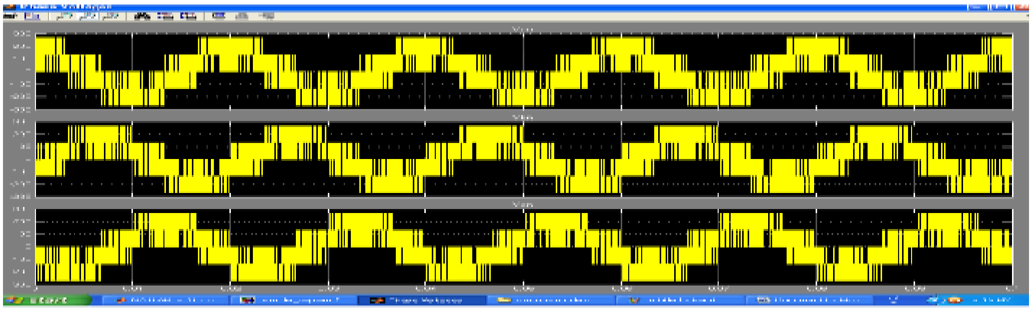


Fig.6. Line to line voltages of active zero space vector pulse width modulation

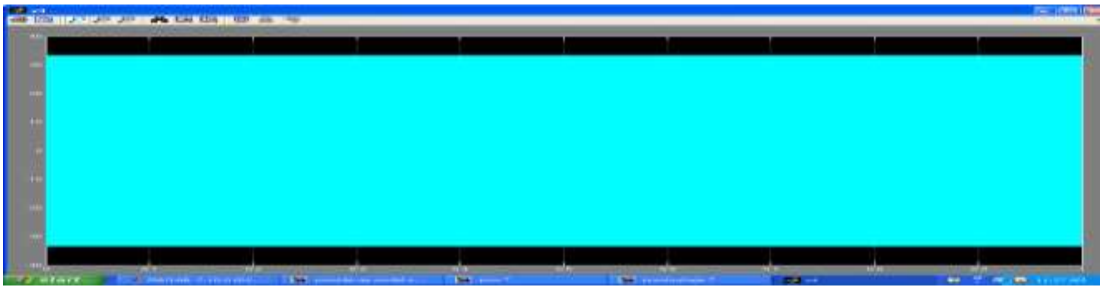


Fig.7. Common mode voltage for CSPWM method

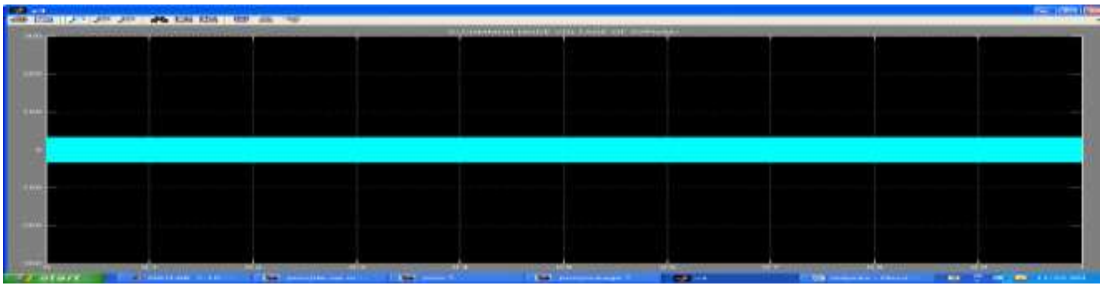


Fig.8. Common mode voltage for AZPWM method

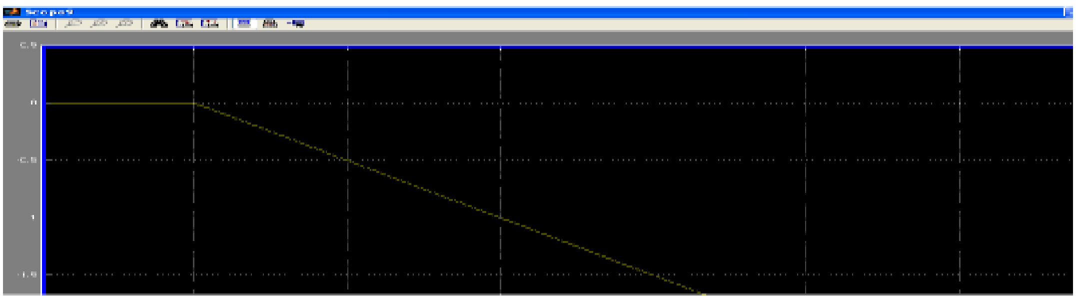


Fig.9. Speed curve of Induction Motor Drive

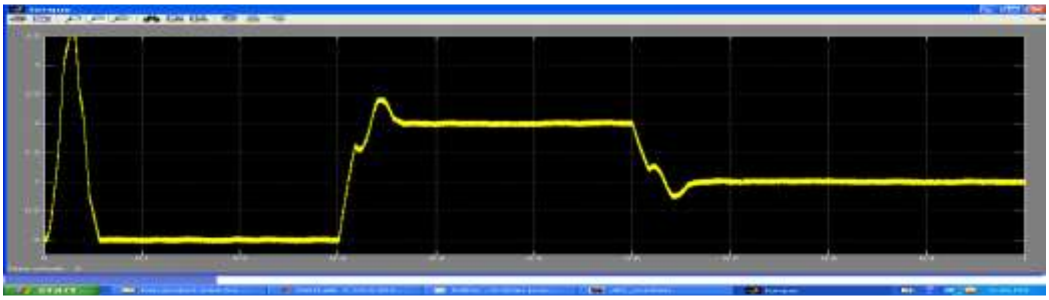


Fig.10. Torque curve of Induction Motor Drive

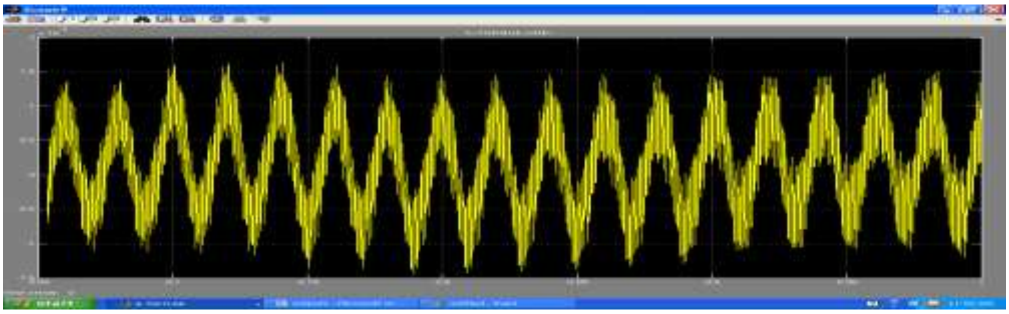


Fig.11.Shunt field current in quadrature axis

VII. Conclusions

This paper reviewed the complexity involved in calculating the reference vector in conventional space vector pulse width modulation and the simplicity involved in proposed algorithm. In this paper calculation of reference vector in both conventional and active zero space vector pwm method has compared in Table 4 & 5. . The common mode voltage Vcm has been reduced from Vdc /2 in csvpwm to Vdc/6 in the proposed active zero svpwm and the result has been compared in Fig 2.

References

[1]. F.Blaschke "The principle of field orientation as applied to new trans vector closed loop control system for rotating field machines", Siemens Review,1972,PP 217-220.

[2]. Thomas G.Habetler and Leon M.Tolbert"Direct torque control of induction machines using space vector modulation".,IEEE Trans.Ind.Appl., Vol.28,No.5,PP.1045-1053,SEPTEMBER/OCTOBER 1992

[3]. Heinz Willi Van Der Broeck,Hans-Christoph Skudelny,Member IEEE,and Georg Viktor Stanke" Analysis and Realization of a pulse wuidth modular Based on voltage space Vectors "IEEE Trans.Ind.Appl.,Vol 24,no 1.jan/Feb,1998.

[4]. Isao Takahashi and Toshihiko Noguchi, "A New Quick Response and high efficiency control strategy of and induction motor,"IEEE Trans .Ind.Applicat. Vol IA-22, no.5,sep/oct 1986,pp.820-827.