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EPWM Technique for Speed Control of Induction Motor

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Abstract: *At high power levels, the inverter can switch only at low frequencies, and the harmonic distortion is quite high. Hence, PWM strategies for high-power drives must aim at reducing the harmonic distortion, subject to low switching frequencies of the inverter. Development and analysis of such PWM strategies are carried out in this paper. Finally using the proposed EPWM algorithm an optimal EPWM based DTC IM drive operating at high line side voltages with reduced ripple is proposed.*

Keywords: *IM, PWM, SVPWM, Reference voltage vector, DTC, EPWM, Flux ripple.*

I. Introduction

In this paper to utilize the freedom of dividing the zero state duration a zero voltage vector distribution variable σ is used to divide the zero state time between two zero states and are defined by

$T_0 = T_Z\,\sigma$
$T_7 = T_Z\,(1-\sigma)$

In Conventional PWM methods the total zero state duration is spent in only one of the two zero states. Hence for, $\sigma = 0$, T_0 becomes zero which ultimately says that the total zero state duration is spent in *V*7 or in other words represents 721 or 7212 sequences and similarly for $\sigma = 1$, $\mathbf{T_7}$ becomes zero which conveys that the total zero state duration is spent in 0 *V* or in other words represents 012 or 0121 sequences . In by varying a single constant variable a Conventional PWM algorithm utilizing the freedom of dividing the zero state time within a sampling [3] period is used to generate different PWM methods. In the present paper the same concept is been used to generate two types of EPWM methods. One of such approach uses clamping sequences 012 and721, and the other approach uses double switching clamping sequences 0121 and 7212. The similarity between these two approaches is that both generate PWM sequences in which one of the three phases clamp to either of the buses for sub cycle duration and the contrast characteristic between these two is that in first approach which uses clamping sequences the active state duration is spent in either of the active states whereas in second approach [2] which uses double switching clamping sequences the total active state duration is divided into two equal halves and applied twice in very sub cycle, which results not only clamping of one of the phases but also switches twice the remaining one of the two phases, for the reason why these sequences are termed as double switching clamping sequences.

To generate EPWM methods in either of the two approaches, the constant variable σ can be applied at any spatial angle γ to yield different conventional PWM methods and when in case of continual and split clamping methods with $\gamma \neq 30^0$ it results in EPWM methods, i.e. two sequences 012 and 721 or 0121 and 7212 were used in each sector according to the set policy, which generates continual and split clamping methods..

II. EPWM Based DTC Induction Motor Drive

The block diagram of the proposed EPWM based DTC is shown in the Fig.1. With the proposed method ripples in torque and flux at high modulation indices are reduced significantly maintaining constant switching frequency.

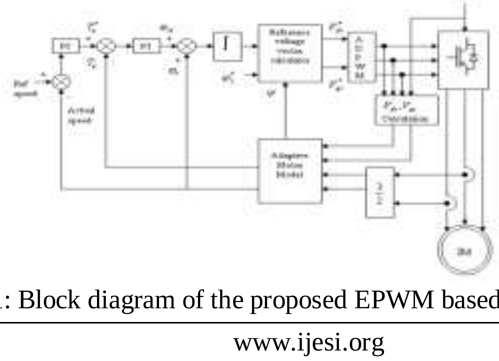

FIG 1: Block diagram of the proposed EPWM based DTC

The proposed DTC retains all the advantages of the Conventional DTC, in addition [5, 6] to this gives enhanced performance in high modulation regions which is a limitation with SVPWM based DTC. Addition of slip speed to the actual speed generated by the adaptive motor model block generates reference stator flux vector. Taking these two as inputs the magnitude and position of the reference voltage vector are calculated and according to the set value of γ the EPWM block generates gating pulses to the inverter based on space vector approach [2, 4]. The adaptive motor model estimates the torque and speed from the d and q axis voltages and currents. The dynamic model of the induction motor is modeled in stationary reference frame

III. Simulation Setup

Simulation of the proposed DTC controlled induction motor drive is done in MATLAB/SIMULINK envir-Ment.simulation is done using fixed step size of $^{10e-6}$.

The starting torque is limited to 15.8 N-m. Simulation is done on a 3-φ induction motor rated at2KW,1440rpm, four pole, having the following parameters: Rs=8.83 , Rr=8.55 , Ls=0.4751H, Lr=0.4751H, Lm= 0.45351H, J=0.06Kg.m^2 . From the simulation results shown it can be observed that compared with SVPWM and EPWM methods using clamping sequences the proposed EPWM methods results in least harmonic distortion when the drive is operating at near rated speeds. Reduction in stator current ripple can be achieved with the proposed split clamping PWM technique and analytically it is clear that with $\gamma=30^0$, split clamping gives minimum distortion and hence this method is considered as an optimal EPWM method for the drives operating at near rated speeds. Fig.2,3,4 shows the no-load starting and steady state transients in three phase stator currents, torque, speed and stator flux of the SVPWM based DTC induction motor drive. Measured no-load steady state current waveform and its harmonic spectra are also presented for comparison. Fig.5 to Fig.14 shows the simulation results of the split clamping PWM based DTC drive using conventional PWM sequences 012 and 721(with$\gamma= 30^0$) and double switching clamping sequences 0121 and 7212 (with$\gamma=30^0$) respectively. Elaborated simulation results for the above said EPWM based conventional DTC IM drive showing different conditions like starting transients, steady state transients, and transients during step change in load, during speed reversal are presented. It is observed that with the proposed method %THD in line current is reduced significantly. Also, observations from the harmonic spectra reveal that with the CDTC method lower order harmonics dominate whereas with the proposed EPWM method the dominant harmonic components are around the multiples of the switching frequencies.

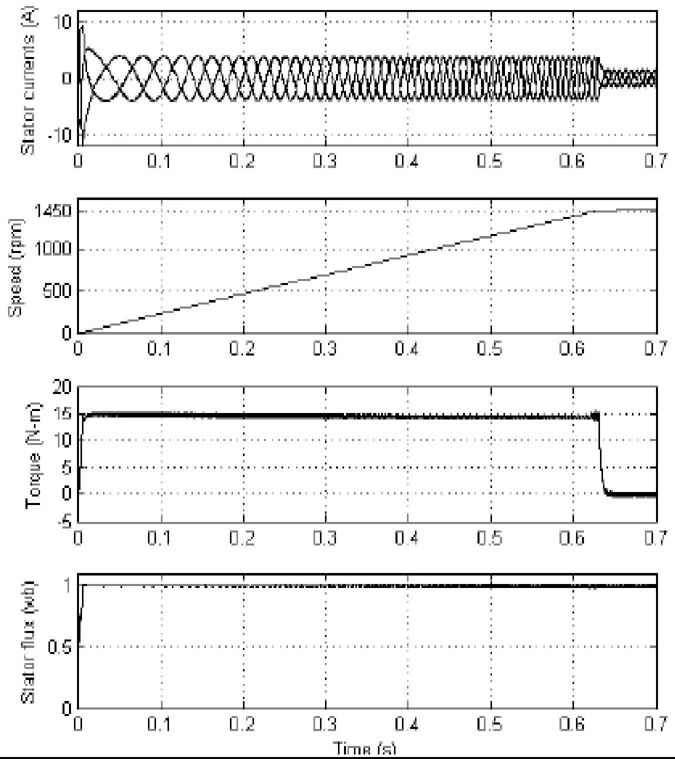

Fig.2. SVPWM based DTC: No-load starting transients.

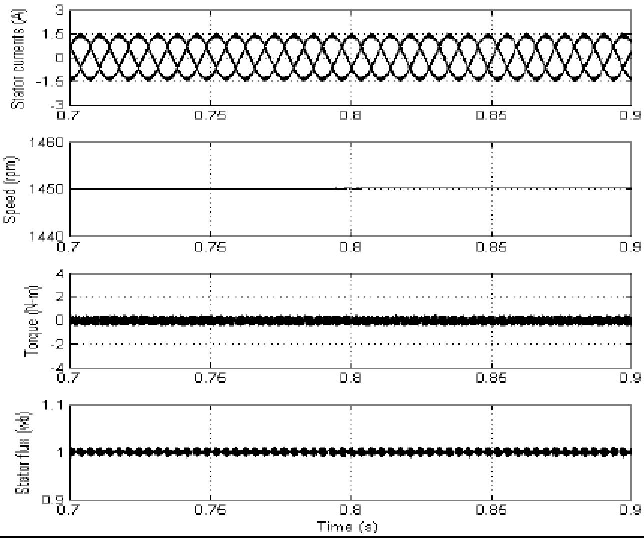

Fig.3. SVPWM Based DTC: Steady state transients

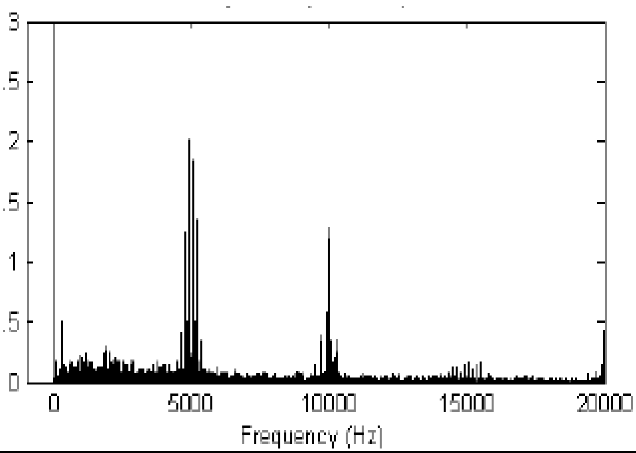

Fig.4: SVPWM Based DTC: No load Steady state line current harmonic spectra (% of fundamental)

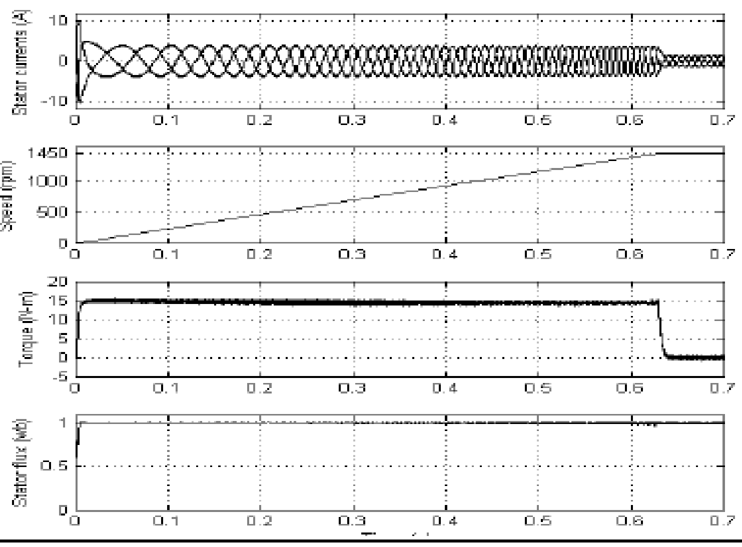

Fig.5. Split clamping EPWM Based DTC Using Conventional sequences 012 and 721(with Gama = 30^0): No load starting transients

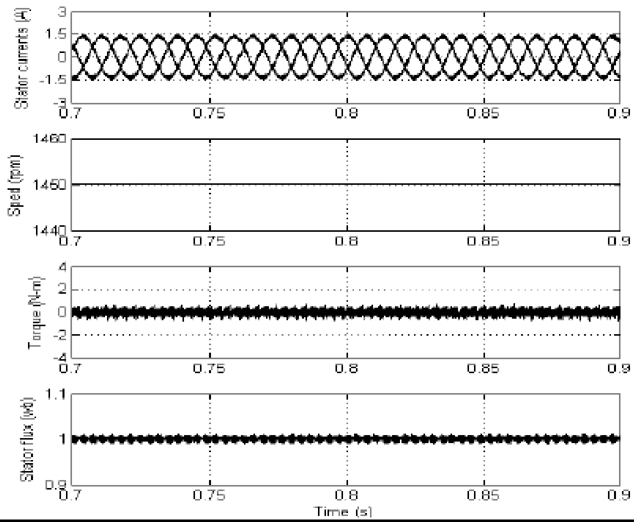

Fig.6.Split clamping EPWM Based DTC Using Conventional sequences 012 and 721(with Gama = 30^0): Steady state transients

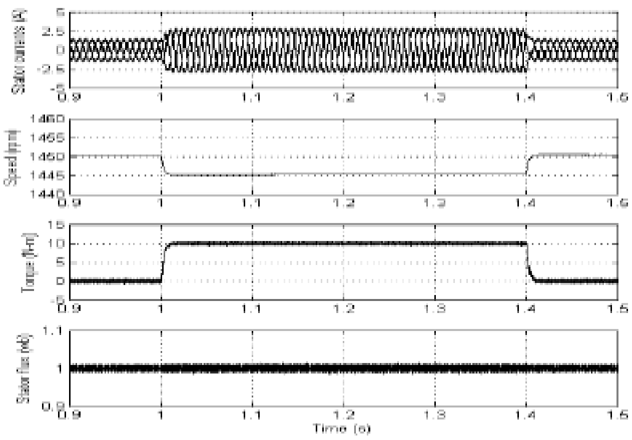

Fig.7: Split clamping EPWM Based DTC Using Conventional sequences 012 and 721(with Gama = 30^0) : Transients during step change in load (A load of 10 Nm Is applied at 1 Sec and removed at 1.4 sec

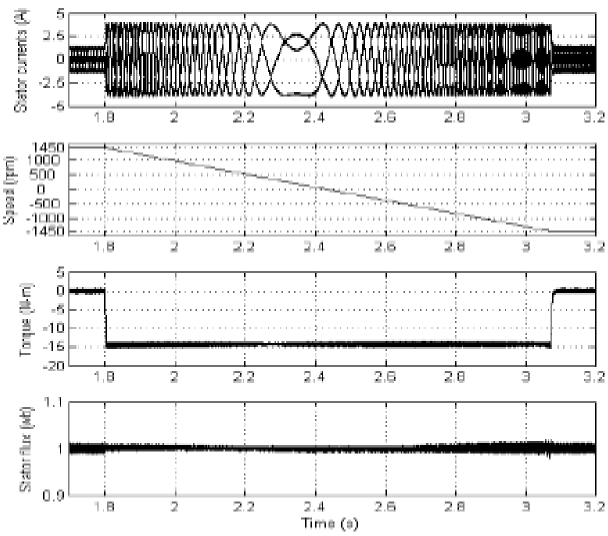

Fig.8: Split clamping EPWM Based DTC Using Conventional sequences 012 and 721(with Gama = 30^0) : Transients during reversal of speed (Speed reversal command is given at 1.8 sec to change the speed from +1400 RPM to -1400 RPM)

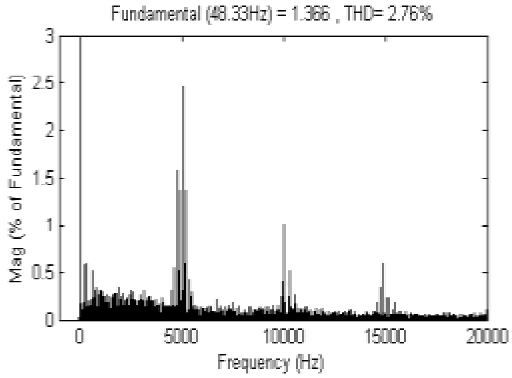

Fig.9: Split clamping EPWM Based DTC Using Conventional sequences 012 and 721(with Gama = 30^0): No load steady state line current harmonic spectra (% of fundamental)

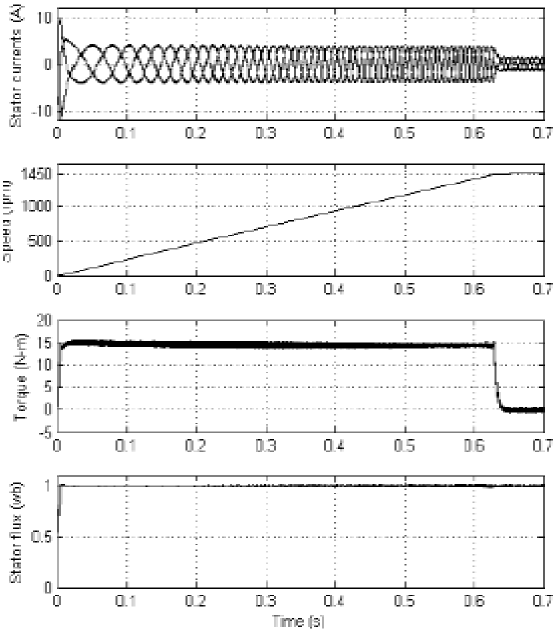

Fig.10: Proposed EPWM based DTC using conventional PWM sequences 0121 and 7212: No load starting transients.

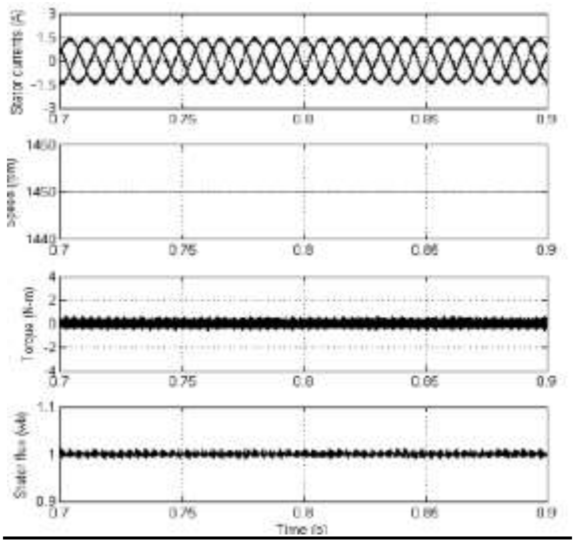

Fig.11: Proposed EPWM based DTC using conventional PWM sequences 0121 and 7212: Steady state transients

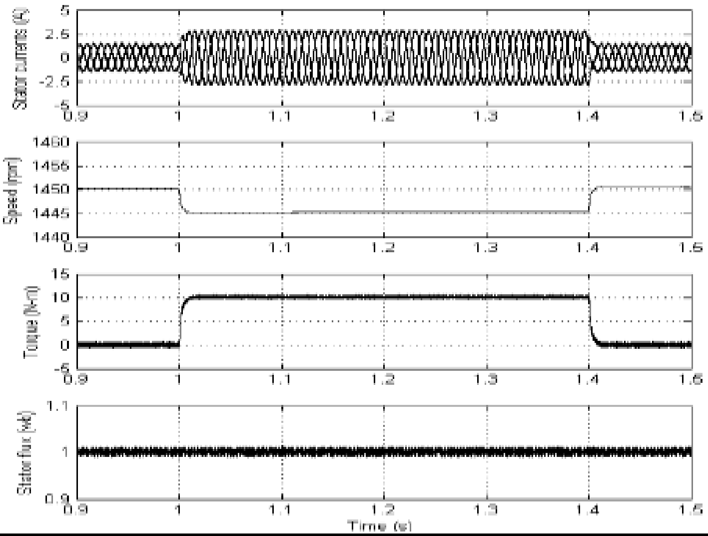

Fig.12: Proposed EPWM based DTC: Transients during step change in load (A load of 10 Nm is applied at 1 Sec and removed at 1.4 sec)

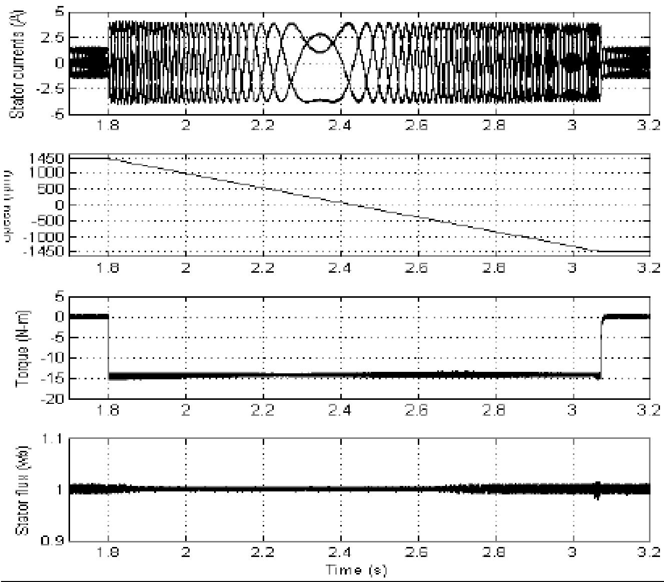

Fig.13: Proposed EPWM based DTC: Transients during reversal of speed (Speed reversal command is given at 1.8 sec to change the speed from +1400 RPM to -1400 RPM)

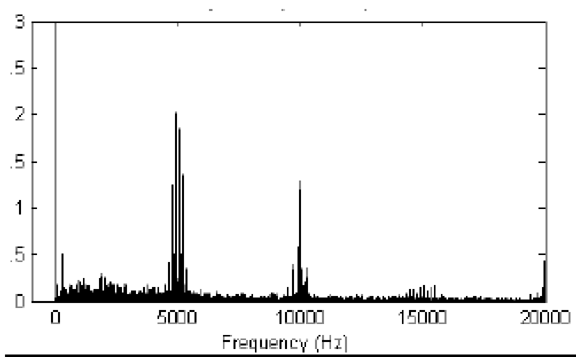

Fig.14: Proposed EPWM based DTC using Conventional PWM sequences 0121 and 7212: No load steady state line current harmonic spectra (% of Fundamental)

IV. Conclusions

Conventional DTC, though simple, because of the limitations like steady state ripple in torque and flux, variable switching frequency, search for PWM technique that gives an apt solution is one of the fascinating areas for researchers. SVPWM based DTC gave answer to some tribulations and now the search on how to reduce the ripple in line current particularly in high modulation regions. Conventional techniques can be used effectively to reduce either the switching losses or the harmonic distortion as may be required. The Conventional sequences can also be used effectively to reduce the harmonic distortion and their undesirable effects in the higher speed ranges of the drive. The triplen frequency components required in all the above Conventional methods can be generated using the3-phase sinusoidal modulating waves themselves. In this paper with a special category of Conventional sequences an optimal EPWM based DTC induction motor drive is proposed which can exercise a particular value of gamma or might select according to a set policy. It is shown that split clamping gives minimum ripple than with continual, SVPWM as well as the EPWM methods using clamping sequences predominantly in high modulation regions. Since the proposed split clamping with gamma equal to 30^0 gives minimum ripple, which in this context referred as an optimal EPWM method is proposed for the drive operating at high line side voltages or near rated speeds. Simulation results conclude that with the proposed PWM method ripple in steady state line current is reduced significantly when compared with Conventional DTC, SVPWM based DTC, and EPWM based DTC using clamping sequences.

REFERENCES

[1] J. Holtz. 1992. Pulse width modulation-A Survey. IEEE Trans. Ind. Electron. 39(5): 410-420.
[2] J. Holtz. 1994. Pulse width modulation for electronic power conversion. Proc. IEEE. 82(8): 1194-1214.
[3] Keliang Zhou and Danwei Wang. 2002. Relationship between Space Vector Modulation and Carrier-Based PWM: A Comprehensive analysis. IEEE Trans. Ind. Electron. 49(1): 186-196.
[4] G. Narayanan and V. T. Ranganathan. 2000. Triangle comparison and space vector approaches to Pulse width modulation in inverter-fed drives. J. Indian Inst. Sci. Vol. 80, pp. 409-427.
[5] Joohn-Sheok Kim and Seung-Ki Sul. 1995. A novel voltage modulation technique of the space vector PWM. In: Proc. IPEC, Yokohama, Japan. pp. 742-747.
[6] Dae-Woong Chung, Joohn-Sheok Kim and Seung-Ki Sul. 1998. Unified voltage modulation technique for real-time three-phase power conversion.
[7] G. Narayanan and V.T. Ranganathan, "Synchronised PWM strategies based on space vector approach. Part 1: Principles of waveform