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Three Phase Cascaded H-Bridge Multi Level Inverter by Using DTC Induction Motor Drives

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Abstract- **As of late, multilevel inverters are winding up more mainstream for high-power and high voltage application. Because of their enhanced consonant profile and expanded power appraisals. Many examinations have been accounted for in the writing on multilevel inverters topologies, control strategies, and applications. In any case, there are few investigations that really talk about or assess the execution of enlistment engine drives related with three-stage multilevel inverter. This paper exhibits a correlation contemplate for a fell H-connect multilevel direct torque control (DTC) enlistment engine drive. For this situation, symmetrical and hilter kilter game plans of five-and seven-level H-connect inverters are contrasted all together with locate an ideal game plan with bring down exchanging misfortunes and advanced yield voltage quality. Recreation comes about are proposed by utilizing MATLAB/SIMULINK show.**

Keywords: **DTC induction motor, H-bridge multilevel inverter, MATLAB, SIMULINK.**

I. INTRODUCTION

Multilevel voltage-source inverters are for the most part considered for high-control applications, and standard drives for medium-voltage mechanical applications. Arrangements with a higher number of yield voltage levels have the capacity to orchestrate waveform switch a superior consonant range and to restrain the engine winding protection worry, then again bring down number of levels either require a somewhat substantial and costly LC yield channel to constrain the engine winding protection stretch. In any case, their expanding number of gadgets has a tendency to lessen the power converter general unwavering quality and proficiency. Many examinations have been led toward enhancing multilevel inverter, for example, Diode-Clamped Multilevel Inverter, Cascaded h-connect multilevel inverter, Flying Capacitor Multilevel Inverter. In our paper we are utilizing fell h-connect multilevel inverter [1]. The benefit of h-connect multilevel topology is that the balance, control, and assurance necessities of each extension are measured. It ought to be called attention to that, not at all like the diode-cinched and flying-capacitor topologies, disengaged dc sources are required for every phone in each stage. The fell H-connect inverter comprises of energy transformation cells, each provided by a detached dc source on the dc side. The uneven multilevel inverter to enhance the yield voltage determination, in symmetrical multilevel inverter all H-connect cells are bolstered by meet voltages, and consequently all the arm cells deliver comparable yield voltage steps. Be that as it may, if every one of the cells are not sustained by rise to voltages, the inverter turns into a hilter kilter one. In this inverter, the arm cells have diverse impact on the yield voltage [2]. Awry multilevel inverter has been as of late examined in every one of these investigations, H-connect topology has been considered and an assortment of determinations of fell cell numbers and dc-sources proportions have been received. The recommended beat width-regulation procedure that keeps up the high-voltage stage to work at low recurrence restrains the source-voltage determination. One of the strategies that have been utilized by a noteworthy multilevel inverter producer is immediate torque control (DTC), which is perceived today as a superior control technique for air conditioning drives. All through this paper, at hypothetical foundation is utilized to outline a technique trance state with half and half fell H-connect multilevel inverter symmetrical and awry design are executed and looked at Experimental outcomes acquired for a hilter kilter inverter bolstered acceptance motor[3]. Capacitors, batteries, and sustainable power source voltage sources can be utilized as the different A multilevel converter has a few favorable circumstances over a regular two-level converter that utilizations high exchanging recurrence beat width regulation (PWM). Shockingly multilevel converters do have a few impediments the more noteworthy number of energy semiconductor switches required.

Besides, rich tweak strategies and control ideal models have been created for multilevel converters, for example, sinusoidal heartbeat width regulation (SPWM), specific consonant disposal (SHE-PWM), space vector adjustment (SVM), and others.

Fell H-connect structure:

The fell H-connect inverter comprises of energy transformation cells, each provided by a separated dc source on the dc side, which can be gotten from batteries, power devices, or ultra capacitors and arrangement associated on the air conditioner side. The upside of this topology is that the adjustment, control, and assurance necessities of each extension are measured. It ought to be called attention to that, not at all like the diode-clasped and flying-capacitor topologies, disconnected dc sources are required for every phone in each phase.[4]

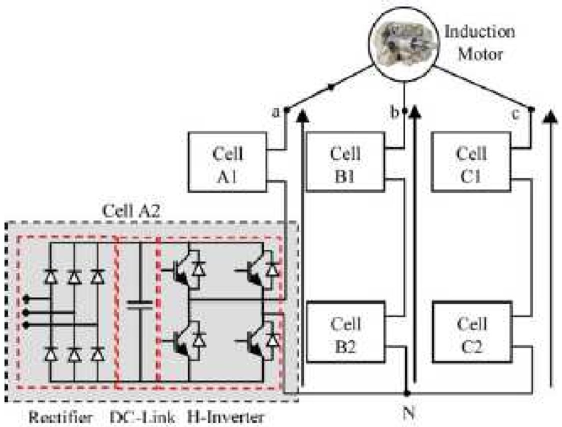

Fig.1: Two-cells cascaded multilevel inverter

Symmetrical cascaded H-bridge:

The Cascaded H Bridge (CHB) multilevel converters are simply a number of conventional two-level bridges, whose AC terminals are simply connected in series to synthesize the output waveforms. Fig.2 shows the power circuit for a symmetrical five-level inverter with two cascaded cells. The CHB inverter needs several independent DC sources which may be obtained from batteries, fuel cells. Through different Combinations of the four switches of each cell, each converter level can generate three different voltage outputs, +Vdc, 0,-Vdc. The AC output is the sum of the individual converter outputs. The number of output phase voltage levels is defined by n=2N+1, where N is the number of DC sources. For instance the output phase voltage swings from -2Vdc to +2Vdc with five levels. Symmetrical CHB inverter topology is known as symmetric CHB inverter in which H bridges are fed by separate DC sources having same magnitude[5].

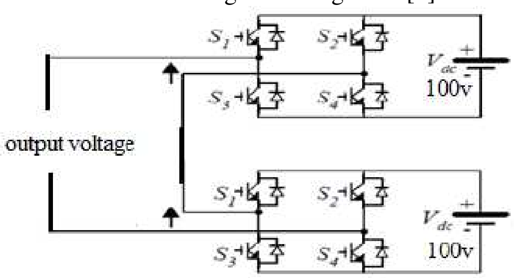

Fig.2: Symmetric (5-level) cascaded multilevel inverter.

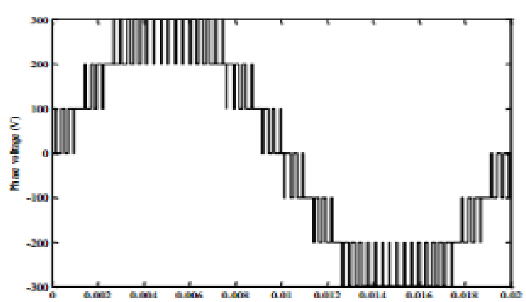

Fig.3: Output phase voltage waveform for symmetric (5 level) MLI using variable frequency.

Asymmetrical cascaded H-bridge inverter:

An asymmetrical multilevel inverter shown in Figure.4 can be defined as a multilevel converter fed by a set of DC voltage source where at least one of them is different to the other one. The main advantage of asymmetrical multi-level converter is, it uses less number of semiconductor switches compared with symmetrical topology. One interest of the asymmetrical configurations is that the number of levels is higher with the same number of cells. The number of levels is higher with the same number of cells in the symmetrical case, whereas it grows exponentially, in the asymmetrical case, the asymmetrical topology requires only twelve switches to obtain 7, 9, 15, 21 level output voltage[6].

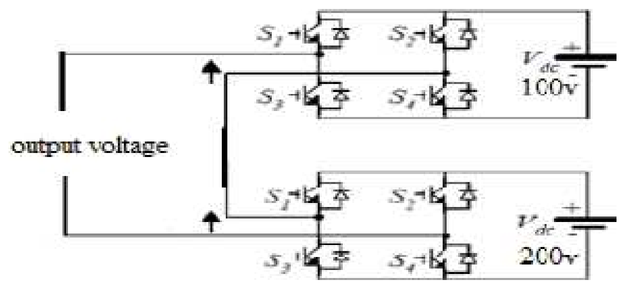

Fig.4: Asymmetric (7-level) cascaded multilevel inverter.

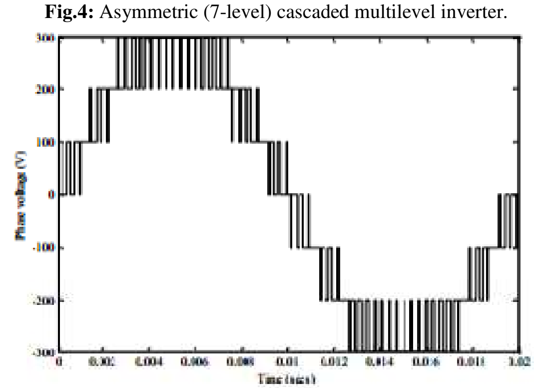

Fig.5: Output phase voltage waveform for asymmetric (7 level) MLI using same frequency.

II. PROJECT CONTROL TECHNIQUE:

Space vector tweak (SVM) is very unique in relation to the PWM techniques. Space vector regards the converter as a solitary unit particularly the converter can be headed to eight exceptional states adjustment is expert by exchanging conditions of the converter. The control methodologies are in advanced frameworks. SVM is a computerized balancing strategy where the goal is produce PWM stack line voltages that are in normal equivalent to given (or reference) stack line voltages. This is done in each inspecting period by legitimately choosing the switch conditions of converter and estimation of the suitable day and age for each state [7].

Space vector regulation (SVM) procedure:

Space Vector regulation (SVM) procedure was initially created as a vector way to deal with heartbeat width balance (PWM) for three-stage converters. It is more complex system

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for creating sine wave that gives a higher voltage to the engine with bring down aggregate consonant contortion. It limits space vectors to be connected by the area where the yield voltage vector is found. An alternate way to deal with PWM adjustment depends on the space vectors portrayal of voltages in the α-β plane. The-β parts are found by changes. The assurance of exchanging moment might be accomplished utilizing space vectors tweak strategy in view of portrayal of exchanging vectors in α-β plane. The space vector adjustment strategy is a propelled, calculation serious PWM method and is perhaps the best among all the PWM strategies for drives applications. As a result of its predominant execution attributes, it is been finding broad application as of late [8].

DTC Technique:

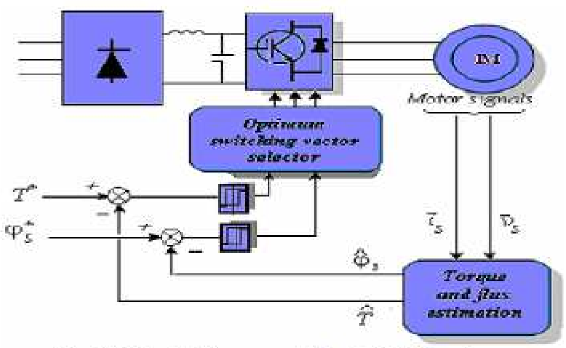

Fig.6: Block diagram of basic DTC scheme.

The fig.6 shows the block diagram of basic DTC scheme, the principle of Direct Torque Control (DTC) is to directly select voltage vectors according to the difference between reference and actual value of torque and flux linkage. Torque and flux errors are compared in hysteresis comparators. Depending on the comparators a voltage vectors selected from a table. Advantages of the DTC are low complexity and that it only need to use of one motor parameter, the stator resistance. For every doubling in sample frequency, the ripple will approximately halve. The problem is that the power switches used in the inverter impose a limit for the maximum sample frequency. The inverter switching frequency is inherently variable and very dependent on torque and shaft speed. The additional degrees of freedom (space vectors, phase configurations, etc.) provided by the multilevel inverter should, therefore, be exploited by the control strategy in order to reduce these drawbacks[9].

Trajectory of Stator Flux Vector in DTC Control:

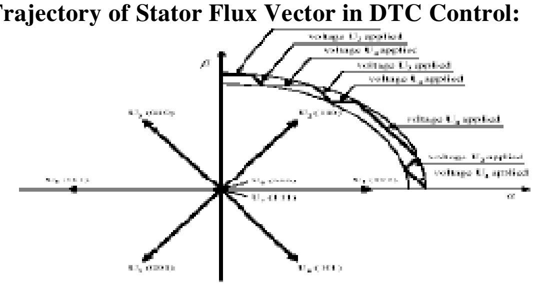

Fig.7: Forming of the stator flux trajectory by appropriate voltage vectors selection

Torque and Flux Estimation:

The stator flux vector an induction motor is related to the stator voltage and current vectors by

$$d\varphi s(t)/dt - vs(t) - Rs\ is\ (t) \qquad (1)$$

Maintaining *vs* constant over a sample time interval and neglecting the stator resistance, the integration of yields

$$\Delta\varphi s(t) = \varphi s(t) - \varphi s(t - \Delta t) = \_tt{-}\Delta tvs\Delta t \quad (2)$$

Equation reveals that the stator flux vector is directly affected by variations on the stator voltage vector. On the contrary, the influence of *vs* over the rotor flux is filtered by the rotor and stator leakage inductance, and is, therefore, not relevant over a short-time horizon. Since the stator flux can be changed quickly while the rotor flux rotates slower, the angle between both vectors θsr can be controlled directly by *vs*.

A graphical representation of the stator and rotor flux dynamic behaviour is below Fig.

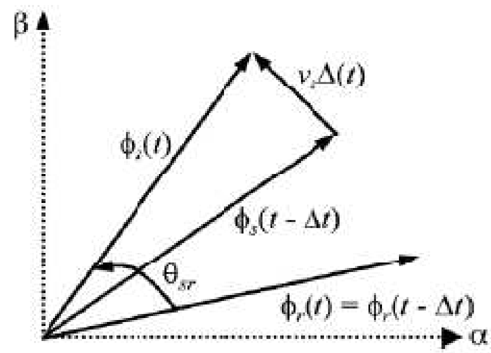

Fig.8: Stator & rotor flux dynamic behavior.

The exact relationship between stator and rotor flux shows that keeping the amplitude of $\varphi\ s$ constant will produce a constant flux φr.Since the electromagnetic torque developed by an induction motor can expressed by

$$Te=3/2pLm/\sigma LsLr\varphi s\varphi r\sin\theta sr \qquad (3)$$

It follows that change in θsr due to the action of *vs* allows for direct and fast change in the developed torque. DTC uses this principle to achieve the induction motor desired torque response, by applying the appropriate stator voltage vector to correct the flux trajectory. Equation reveals that the stator flux vector is directly affected by variations on the stator voltage vector. On the contrary, the influence of *vs*over the rotor flux is filtered by the rotor and stator leakage inductance, and is, therefore, not relevant over a short-time horizon. Since the stator flux can be changed quickly while the rotor flux rotates slower, the angle between both vectors θsr can be controlled directly by *vs*.

A graphical representation shows 127 voltage vectors generated by the inverter at instant *t*=*k*, denoted by *Vks* (central dot). The next voltage vector, to be applied to the load *vk*+1*s*, can be expressed by

$$vk{+}1s - vks{+}\Delta vk \qquad (4)$$

Where Δvks= *{vi |i* = 1 . . .6*}*. Each vector *vi* corresponds to one corner of the elemental hexagon illustrated in gray and by the dashed line in Fig.6.7. The task is to determine which *vk*+1*s* will correct the torque and flux responses. Knowing the actual voltage vector *vks*, the torque and flux errors *ekφ* and *ekT*, and the stator flux vector position (sector determined by angle *θs*). Note that the next voltage vector *vk*+1*s* applied to the load will always be one of the six closest vectors to the previous *vks*; this will soften the actuation effort and reduce high dynamics in torque response due to possible large changes in the reference.

Voltage Vector-Selection Lookup Table:

Sector	$\text{sign}(e_\phi^k, e_T^k)$			
	(+,+)	(+,–)	(–,+)	(–,–)
1	V_2	V_6	V_3	V_5
2	V_3	V_1	V_4	V_6
3	V_4	V_2	V_5	V_1
4	V_5	V_3	V_6	V_2
5	V_6	V_4	V_1	V_3
6	V_1	V_5	V_2	V_4

III. SIMULATION MODEL AND RESULTS:

Simulation model of symmetrical cascaded H-bridge five levels inverter:

The simulation model of cascade h bridge multilevel inverter is developed by using MATLAB .

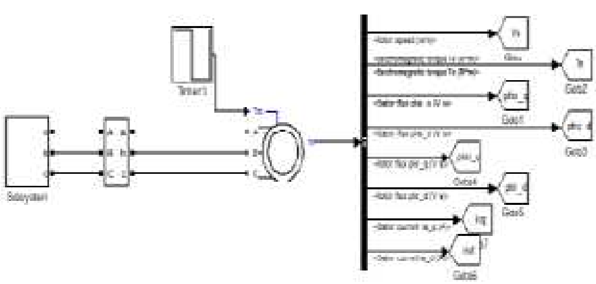

Fig.9: Simulation model of symmetrical cascaded H-bridge five levels inverter

Simulation model of symmetrical cascaded H-bridge five levels inverter output wave form:

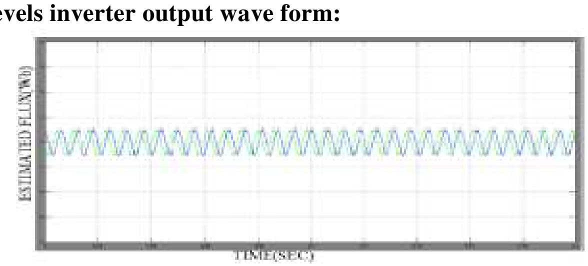

Fig.10: symmetrical five-levels cascaded h-bridge inverter Motor flux waveforms

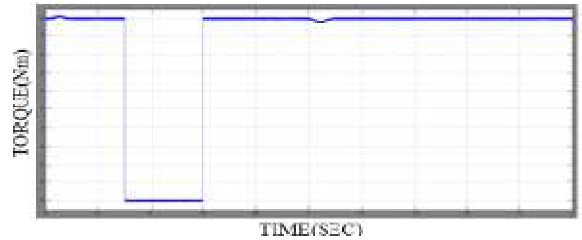

Fig.11: Symmetrical five-levels cascaded h-bridge inverter motor torque waveforms.

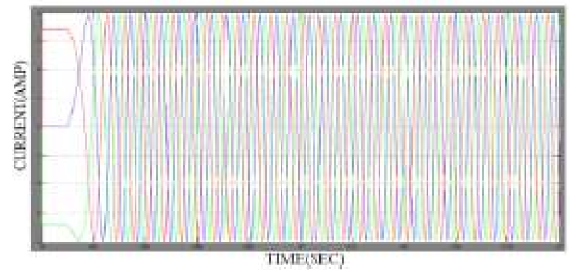

Fig.12: Symmetrical five-levels cascaded h-bridge inverter output current waveforms.

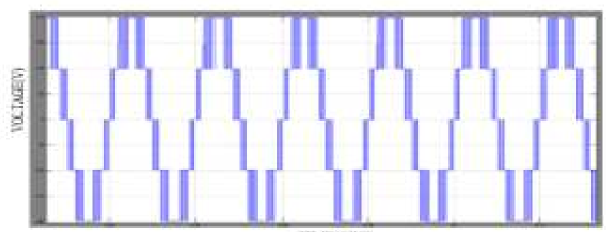

Fig.13: Symmetrical five-levels cascaded h-bridge inverter output voltage waveforms

Simulation Model of Asymmetrical H-Bridge seven Levels:

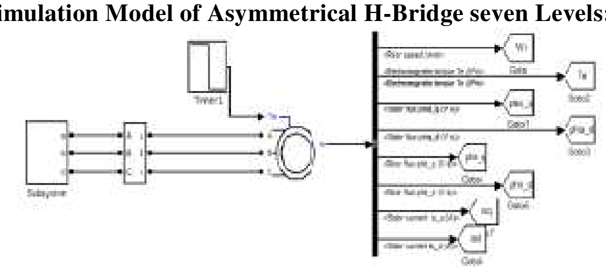

Fig.14: Simulation model of asymmetrical cascaded h-bridge five levels

Asymmetrical output Waveforms of Seven Levels:

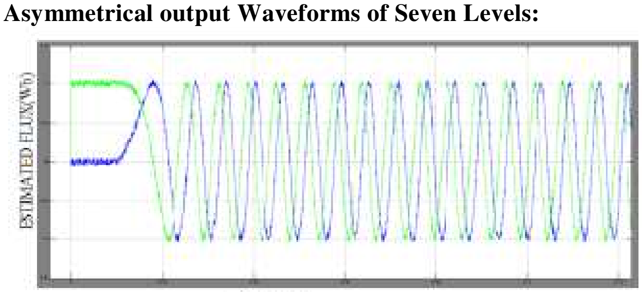

Fig.15: Asymmetrical seven-levels cascaded h-bridge inverter Motor Stator Flux waveform.

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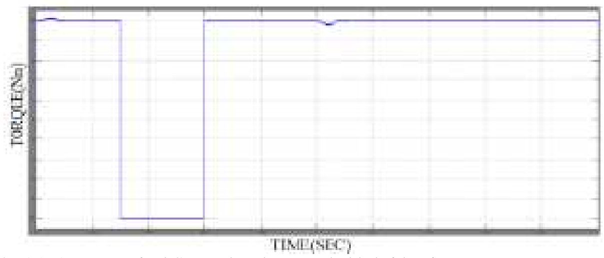

Fig.16: Asymmetrical Seven-levels cascaded h-bridge inverter Motor Torque

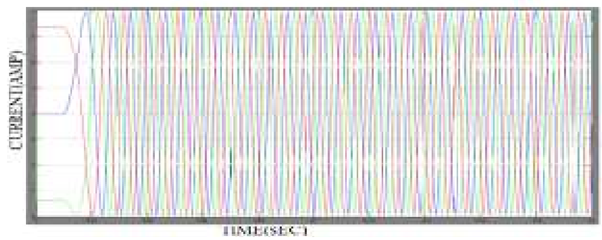

Fig.17: Asymmetrical seven-levels cascaded h-bridge inverter output current waveforms.

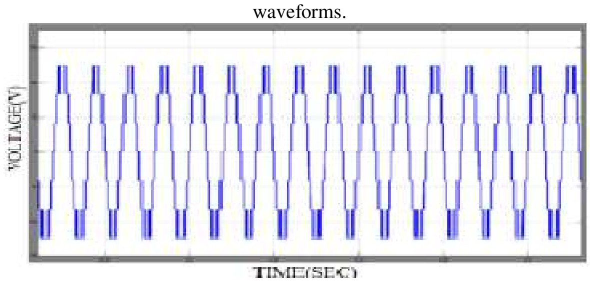

Fig.18: Asymmetrical seven-levels cascaded h-bridge inverter output phase voltage waveform.

Asymmetrical Waveforms of Nine Levels:

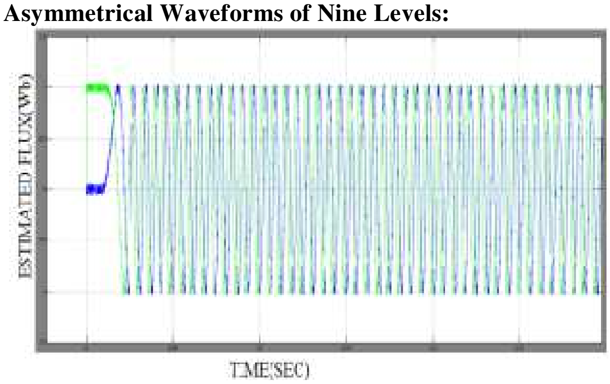

Fig.19: Asymmetrical Nine-levels cascaded h-bridge inverter Stator Flux waveforms.

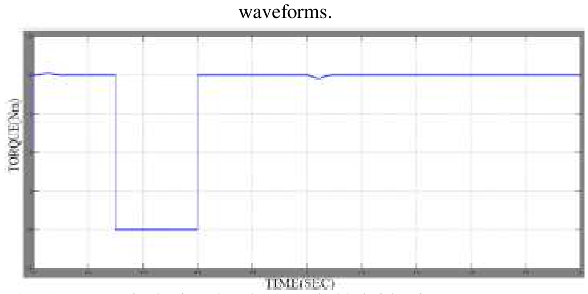

Fig.20: Asymmetrical Nine -levels cascaded h-bridge inverter motor torque waveform.

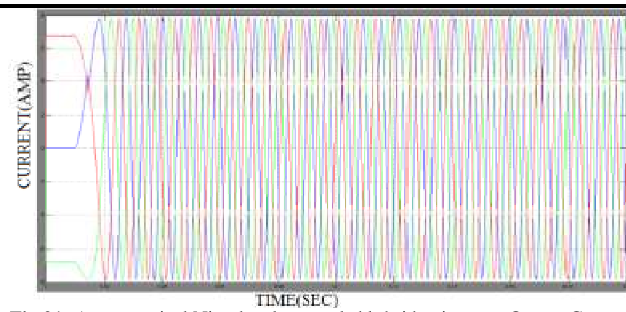

Fig.21: Asymmetrical Nine-levels cascaded h-bridge inverter Output Current waveforms.

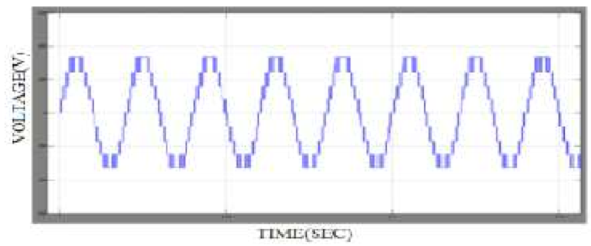

Fig.22: Asymmetrical Nine -levels cascaded h-bridge inverter Stator phase voltage waveform.

Over All Comparisons Of The Paper At Different Loads:

Name	5-level			7-level			9-level		
Load torque (il)	V	I	THD	V	I	THD	V	I	THD
$T_L(0)$ Nm	170	5	31%	180	5	23.7%	350	5	20.2%
TL (2.5) Nm	170	5	26%	180	5	17.8%	350	5	13.5%
TL(5) Nm	170	6	26.1%	180	6	17.7%	350	6	13.5%
TL(7.5)Nm	170	7	26.2%	180	6	17.8%	350	7	13.5%
TL(10) Nm	170	7	26.2%	180	7	17.9%	350	8	13.5%

IV. CONCLUSION

This paper managed a correlation think about for a fell H-connect multilevel DTC acceptance engine drive. In fact, symmetrical and deviated courses of action of five-and seven-levels H-connect inverters have been contrasted all together with locate an ideal game plan with bring down exchanging misfortunes and advanced yield voltage quality. The completed reproduction comes about demonstrates that an awry setup gives almost sinusoidal voltages low bending, utilizing less exchanging gadgets. What's more, torque swells hilter kilter multilevel inverter empowers a DTC answer for high-control enlistment engine drives, not just because of the higher voltage capacity gave by multilevel inverters, however mostly because of the decreased exchanging misfortunes and the enhanced yield voltage quality, which gives sinusoidal current without yield channel.

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