FOUR SWITCH THREE-PHASE INVERTER FED INDUCTION MOTOR DRIVES: A REVIEW

[1]Ranvijay Kumar Singh, [2]Prof. Rohit Gupta
[1]Research Scholar, [2]Assistant Professor
Department of Electrical Engineering
Lakshmi Narain College of Technology, Bhopal, India

Abstract— Inverters designed using reduced active semiconductor devices can be of interest to the industry because of their lower cost and enhanced reliability linked to their less complex gating and control circuitries. This paper review of four switch three phase inverter for the grid connected application in an effort to reduce the cost of the inverter is investigated. Admittedly, this topology warrants higher voltage ratings of the semiconductor devices used and the dc-link split capacitors used with respect to a conventional six-switch three-phase inverter for a specific set of grid voltages.

Keywords— Four switch inverter, Sinusoidal pulse width modulation, Micro grid.

I. INTRODUCTION

A staggered inverter (MLI) conspire is proposed for four-shaft (4-post), nine-stage (9-stage) induction motor (IM) drives with further developed dc transport usage as well as diminished gadget count. The proposed MLI is acknowledged with nine three-switch inverter legs (3-SIL) and a solitary dc source. In the proposed MLI, every 3-SIL is used for invigorating the two indistinguishable voltage profile loops/period of the four-shaft (4-post) stator winding, and that implies every leg must be regulated with two references. These two autonomous references/leg will restrict the adjustment file (M.I) of 3-SIL-based proposed MLI. This lower M.I will bring about a prerequisite of the greater size of dc-connect voltage to accomplish the evaluated load voltage necessity [1]. The three-level full-span (TLFB) dc-dc converter has been generally utilized in high-voltage, high-power applications. In the trial test, the impartial point voltage deviation shows up; besides, it has additionally been figured out that assuming the flying capacitors are presented, the info capacitor voltages could understand self-balance regardless of whether no dynamic it are embraced to adjust arrangements. In the past distributions, the job of flying capacitors is by and large considered to expand the scope of delicate exchanging; notwithstanding, oneself equilibrium capacity has not been referenced or researched in any distributions [2].

Superior execution induction motor (IM) drives require quick powerful reactions, vigorous to boundary varieties, endure load unsettling influence, stable control frameworks, and backing simple equipment/programming execution. Fluffy rationale control (FLC) for speed regulators is collecting consideration from scientists, since it is demonstrated to create better outcomes contrasted and the ordinary PI speed regulators. In any case, fixed boundary FLC encounters execution corruption when the framework works from the plan point or is impacted by boundary varieties or burden aggravations. The IM drive utilized an indirect field-arranged control (IFOC) technique took care of by a hysteresis current regulator (HCC). The decent boundary FLC for the primary speed regulator involves nine guidelines that are tuned to accomplish the best exhibition. Then, at that point, a straightforward self-tuning instrument is applied to the vitally fluffy rationale speed regulator. Everything recreation work was finished involving Simulink and fluffy devices in the MATLAB programming [3].

Two most generally utilized induction motor control strategies are the scalar (V/f) and vector (field-situated) control methods. V/f control has great consistent state reaction and heartiness against the variety in machine boundaries, yet the it are more unfortunate to result torque elements. Vector control accomplishes better unique execution by decoupling the transition and torque-creating parts of the stator current. Vector-controlled strategies are intensely subject to the machine boundaries and are delicate to the variety in machine boundaries [5].

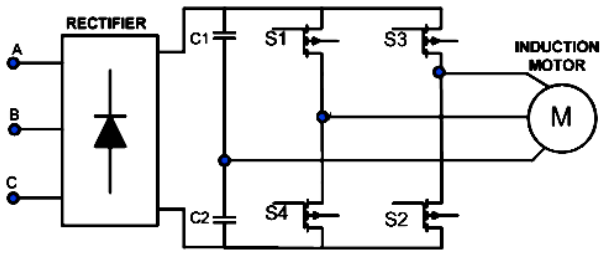

Figure 1: Basic Four Switch Three-Phase Inverter

The four-switch three-stage (B4) inverter, having a lower number of switches, was first introduced for the chance of diminishing the inverter cost, and it turned out to be extremely alluring as it tends to be used in shortcoming lenient control to tackle the open/cut off of the six-switch three-stage (B6) inverter. Nonetheless, the equilibrium among the stage flows falls because of the variance of the two dc-connect capacitor voltages; along these lines, its

application is restricted. This paper proposes a prescient force control (PTC) conspire for the B4 inverter-took care of enlistment engine (IM) with the dc-interface voltage offset concealment. Restricted control set-model farsighted force control (FCS-MPTC) has a fast strong response since this computation straightforwardly picks the ideal voltage vector by its cost work for acceptance machine drives dealt with by voltage source inverter (VSI). Regardless, having a spot with open-circle control perspective, the FCS-MPTC has force following slip-up due to unavoidable weight disrupting impact and confused model limits really [6].

A versatile regulator for the speed control of induction motor (IM) drives with mistaken models is planned in this paper. In particular, we expect that each condition in the state-space model of the drive is liable to gradually differing mistake. The proposed regulator is made out of a versatile feedforward control term, which makes up for the nonlinear and dubious elements, and a criticism control term, which ensures the framework security [9].

II. BACKGROUND

P. R. Bhimireddy et al.,[1] presents, a compelling stage reconfiguring idea is proposed for decreasing the dc-interface voltage prerequisite of the proposed MLI. Likewise, every one of the potential outcomes of stage reconfiguring subtleties for proposed MLI-took care of 9-stage IM drive are additionally introduced. A three-stage transporter based space vector pulsewidth regulation is executed for further developing the direct adjustment scope of proposed MLI arrangement further. Interestingly, with existing 9-stage three-level inverters, similar to NPC and FC, the proposed MLI design requires just a single dc interface (with half of the extent) and lesser number of semiconductor gadgets. The proposed MLI-took care of, 5 hp, 9-stage, 4-shaft IM drive is approved by involving Ansys Maxwell FEM recreation and trial model for whole adjustment range.

P. Liu et al.,[2] To fill this hole, this work gives the itemized mode activity examination of the TLFB converter and uncovers the reason for the irregularity. Furthermore, the component of oneself equilibrium capacity given by the flying capacitors is made sense of exhaustively, which gives a profound understanding into the converter. Finally, the impact component of the voltage mistake in consistent state has been dissected, and the particular articulation of the voltage blunder is additionally determined. The practicality of the hypothetical examination is checked by the recreation and test results.

N. Farah et al.,[3] present plan and carry out a straightforward self-tuning fluffy rationale regulator (ST-FLC) for IM drives application. The proposed self-tuning component can change the result scaling variable of the principle FLC speed regulator by working on the exactness of the fresh result. The viability of the proposed regulator was explored by directing a near examination between fixed boundary FLC and ST-FLC in forward and invert speed activities, with and without load aggravations. At long last, the exploratory testing was completed to approve the reenactment results with the guide of an advanced sign regulator board, dSPACE DS1104, with an induction motor drive framework. In view of the outcomes, the ST-FLC showed prevalent execution in transient and consistent state conditions as far as different execution measures, for example, overshoot, rise time, settling time, and recuperation time.

M. K. Metwaly et al.,[4] shows, another control procedure for an induction motor (IM) drive framework took care of from three-stage beat width regulation (PWM) ac chopper is proposed. The fundamental target of the proposed control plot is to accomplish input power factor rectification (PFC) of the IM drive framework under various working circumstances. PFC is accomplished by ceaselessly compelling the real three-stage supply currents with the comparing reference currents, which are produced in stage with the stock voltages, utilizing hysteresis band current control (HBCC) method. The proposed control procedure has two circles: the inward circle and external circle. The result of the external circle is the size of the stockpile reference current coming about because of either speed regulator or startup regulator, though the result of the inward circle is PWM signs of the air conditioner chopper. The proposed ac chopper includes fewer dynamic semiconductor switches, four IGBTs, with just two PWM entryway signals. Accordingly, the proposed framework is straightforward, dependable, exceptionally productive, and practical. Numerical examination of the drive framework is introduced. Parts of the info LC channel are planned utilizing recurrence reaction. The IM drive framework is displayed utilizing MATLAB/SIMULINK and a lab model was constructed and tried. The reenactment and exploratory outcomes affirm the legitimacy and power of the proposed control methodology.
S. R. P. Reddy et al.,[5] proposes a clever control method, which incorporates the power highlights of scalar control and great unique execution of vector control. Assessment of the transient vector is liable for further developing elements in the proposed control. The proposed control strategy utilizes an ideal regulator with a result criticism regulation. The activity of the proposed control is approved tentatively under both consistent state and transient circumstances. At last, the proposed control is contrasted and both the V/f and vector control techniques regarding dynamic execution and boundary responsiveness.

L. Yan et al.,[6] In customary FCS-MPTC, the external circle, i.e., speed circle, takes on an exemplary corresponding fundamental (PI) regulator, abridged as PI-MPTC. The lumped unsettling influence is just stifled by a PI regulator. In any case, post situation of the PI regulator is typically planned by cut-and-preliminary, which is challenging to all the while accomplish ideal powerful execution and ideal concealment of lumped aggravation. In this work, the FCS-MPTC with befuddled boundaries is first broke down. Second, the lacks of the conventional PI regulator are presented. Third, aggravation feedforward remuneration

based-model prescient torque control (DFCB-MPTC) of induction machine is proposed to repay lumped unsettling influence and work on the presentation of the framework. Moreover, an improved on stator motion eyewitness is proposed, whose gain network is autonomous of rotor speed. Test results confirm the possibility of the proposed DFCB-MPTC. Contrasted and conventional PI-MPTC, the proposed DFCB-MPTC has better unique execution, consistent execution, and more grounded heartiness.

M. A. Hannan et al.,[7] The principle objective of this study is to foster a quantum-acted easing up search calculation (QLSA) to further develop the indirect field-arranged fluffy relative fundamental (PI) regulator method to control a three-stage induction motor (TIM) drive. The created versatile PI current control boundaries and fluffy participation capacities are conveyed to plan induction motor drive speed regulator to limit the wellness work formed by QLSA. An ideal QLSA-based indirect field-situated control (QLSA-IFOC) wellness work is utilized to lessen the mean outright blunder of the rotor speed to work on the exhibition of the TIM with fluctuating velocity and mechanical burden. Results acquired from the QLSA-IFOC are contrasted and those got through easing up search calculation, gravitational pursuit calculation, backtracking search calculation, and molecule swarm enhancement to approve the created regulator. The enhancement aftereffects of goal capacities as far as box plots and emphasess show that the QLSA calculation outflanks the other improvement calculations. Also, the QLSA-IFOC regulator performed well in all tests regarding transient reaction. The created regulator additionally limits overshoot, increments damping capacity, and r

J. Peter et al.,[8] A consistent exchanging recurrence hysteresis regulator in view of current blunder space vector (CESV) for two-level voltage source inverter took care of induction motor (IM) drive is proposed in this work. Here the stator voltages along the α-and β-tomahawks are assessed utilizing current mistake data and consistent state model of IM. Assessed stator voltages, exchanging abide times, and prompt voltage blunder vectors are utilized in the web-based hysteresis limit calculations. The consistent state CESV limits and the stage voltage standardized symphonious range of the proposed hysteresis regulator at various velocities looks like that of a steady exchanging recurrence voltage-controlled transport bracing heartbeat width tweak based drive. The proposed regulator displays contiguous voltage vector exchanging, quick powerful reaction under transient circumstances, and has a straightforward regulator execution. The prevalent presentation of the proposed regulator is recreated utilizing MATLAB/Simulink stage and tentatively confirmed on a three-stage 2.2 kW IM drive.

J. Talla, et al.,[9] The proposed conspire isn't simply basic and simple to carry out, yet additionally it ensures an exact and quick speed following. Dependability of the proposed speed regulator is affirmed utilizing the Lyapunov hypothesis and a connected lemma. The planned control calculation is contrasted with a regulator in view of nonadaptive input linearization control (FLC), regular field arranged control (FOC), and versatile backstepping sliding mode control (ABSMC). Probes a created IM drive model of evaluated power of 4 kW affirm great control execution [better vigor, more modest mean square, and most extreme outright blunders (MAEs)] contrasted with the contenders, particularly on account of serious boundary befuddle between the genuine drive and model utilized for regulator plan.

M. A. Hannan et al.,[10] This work presents a quantum lightning search calculation (QLSA) - based improvement procedure for controlling velocity of the induction motor (IM) drive. The created QLSA is executed in fluffy rationale regulator to produce appropriate information and result fluffy participation work for IM drive speed regulator. The principle objective of this work is to foster QLSA-based fluffy (QLSAF) speed regulator to limit the mean outright mistake to work on the presentation of the IM drive with changes in speed and mechanical burden. The QLSAF-based speed regulator is carried out in reproduction model in the MATLAB/Simulink climate and the model is manufactured and tentatively tried in a completely incorporated DSP for controlling the IM drive framework. The trial consequences of the created QLSAF speed regulator are contrasted and the recreation results under various execution conditions. A few test results show that there are great arrangement of the regulator boundaries, SVPWM signals, and various kinds of speed reactions and stator currents with the reenactment results, which are checked and approved the presentation of the proposed QLSAF speed regulator. Additionally, the proposed QLSAF speed regulator beats different examinations with settling time in reenactment and in test execution, which approves the regulator execution too.

Z. M. Elbarbary et al.,[11] proposed a fluffy rationale regulator (FLC) to alleviate the adverse consequences of motor boundary variety impact on indirect rotor field arranged control (IRFOC) without proposing a tuning strategy. Notwithstanding, neither rotor nor it were examined to polarize inductances. All things considered, the variety in stator obstruction and burden idleness which affect the direction calculation is illustrated. This correspondence presents a normal framework model with comparative reenactment stage and boundaries. With indistinguishable tests, two mistakes to the first work have been found. To start with, the announced speed which is in fire up/min ought to be in rad/s. Second, the motor speed reaction to it is inverse to increment idleness. The got results from the assessment model affirm the asserted issues which struggle with the translations of the remarked work results.

M. A. Hannan et al.,[12] This work presents an arbitrary backwoods (RF) relapse based execution of room vector beat width regulation (SVPWM) for a two-level inverter to work on the presentation of the three-stage induction motor (TIM) drive. The RF conspire offers the upside of quick execution and further developed expectation for the SVPWM calculation to work on the exhibition of an ordinary space

vector balance plot. To show the prevalence of the proposed RF strategy over different procedures, a versatile neuro fluffy induction framework (ANFIS) and fake brain organization (ANN) based SVPWM plans are additionally utilized and thought about. The proposed speed regulator utilizes a backtracking search calculation to look for the best qualities for the relative vital regulator boundaries. The power of the RF-based SVPWM is tracked down better than the ANFIS and ANN regulators in completely tried cases as far as damping capacity, settling time, consistent state mistake, and transient reaction under various working circumstances. The model of the ideal RF-based SVPWM inverter regulator of induction motor drive is manufactured and tried. A few trial results show that there is a decent understanding of the speed reaction and stator current with the reenactment results which are checked and approved the presentation of the proposed RF-based SVPWM inverter regulator.

III. FOUR SWITCH THREE-PHASE INVERTER

Photovoltaic a four switch based three stage inverter is proposed for lattice associated applications. The quantity of force electronic switches required for a traditional three stage inverter geography is six during the general effort. To upgrade the general power circuit of the miniature framework, a practical answer for the power circuit is to supplant the conventional six switch based three stage inverter with a four switch based three stage inverter geography.

The four-switch inverter, having a lower number of switches has been read up for the chance of diminishing the inverter cost. In examination with ordinary three stage inverter with six switches, the primary elements of this converter are the accompanying:
(i) Reduced number of switches and freewheeling diode
(ii) Low cost
(iii) Less complex gate driving circuitry
(iv) Reduction in conduction losses.

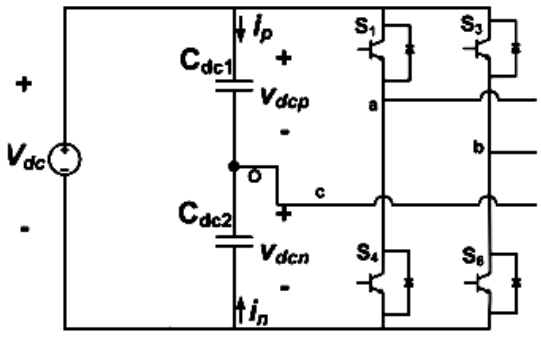

Figure 2: Three Phase Four Switch Inverter

A standard three stage voltage source inverter uses three legs with a couple of correlative power switches per stage. A diminished switch count voltage source inverter involves just two legs with four switches as displayed in Fig. 2.

The circuit comprises of 4 switches S1, S3, S4, S6, and two split capacitors Cdc1 and Cdc2. The dc voltage source Vdc is thought to be framed by the sustainable power sources. The power circuit is the three stage four switch inverter. Two stages "a" and "b" are associated with the two legs of the inverter, while the third stage "c" is associated with the middle mark of the dc interface capacitors, Cdc1 and Cdc2. The 4 power switches are signified by the parallel factors, where the paired "1" compares to an ON state and the double "0" relates to an OFF state. The conditions of the upper switches (S1, S3) and lower switches (S4, S6) of a leg are correlative that is S4 =1− S1 and S6 =1− S3.

IV. CONCLUSION

In this paper, use of four power semiconductor switch based three stage inverter has been contemplated. A basic SPWM is utilized to control the exchanging of the four switches. The present control of the inverter guarantees appropriate dynamic and receptive power stream from the network alongside framework current THD control within the sight of the nonlinear burden at the lattice. The reproduction results are assessed and confirmed. A three stage four switch inverter utilizes just four switches. It replaces the two switches with two capacitors and came as a cost effective solution for interfacing renewable sources and micro grid.

REFERENCES

1. P. R. Bhimireddy, S. Keerthipati and A. Iqbal, "Phase Reconfiguring Technique for Enhancing the Modulation Index of Multilevel Inverter Fed Nine-Phase IM Drive," in IEEE Transactions on Industrial Electronics, vol. 68, no. 4, pp. 2898-2906, April 2021, doi: 10.1109/TIE.2020.2979565.
2. P. Liu and S. Duan, "Analysis of the Neutral-Point Voltage Self-Balance Mechanism in the Three-Level Full-Bridge DC−DC Converter by Introduction of Flying Capacitors," in IEEE Transactions on Power Electronics, vol. 34, no. 12, pp. 11736-11747, Dec. 2019, doi: 10.1109/TPEL.2019.2908825.
3. N. Farah et al., "A Novel Self-Tuning Fuzzy Logic Controller Based Induction Motor Drive System: An Experimental Approach," in IEEE Access, vol. 7, pp. 68172-68184, 2019, doi: 10.1109/ACCESS.2019.2916087.
4. M. K. Metwaly, H. Z. Azazi, S. A. Deraz, M. E. Dessouki and M. S. Zaky, "Power Factor Correction of Three-Phase PWM AC Chopper Fed Induction Motor Drive System Using HBCC Technique," in IEEE Access, vol. 7, pp. 43438-43452, 2019, doi: 10.1109/ACCESS.2019.2907791.
5. S. R. P. Reddy and U. Loganathan, "Robust and High-Dynamic-Performance Control of Induction Motor Drive Using Transient Vector Estimator," in IEEE Transactions on Industrial Electronics, vol. 66, no. 10, pp. 7529-7538, Oct. 2019, doi: 10.1109/TIE.2018.2883265.

6. L. Yan, M. Dou, Z. Hua, H. Zhang and J. Yang, "Robustness Improvement of FCS-MPTC for Induction Machine Drives Using Disturbance Feedforward Compensation Technique," in IEEE Transactions on Power Electronics, vol. 34, no. 3, pp. 2874-2886, March 2019, doi: 10.1109/TPEL.2018.2842743.
7. M. A. Hannan, J. A. Ali, A. Mohamed, U. A. U. Amirulddin, N. M. L. Tan and M. N. Uddin, "Quantum-Behaved Lightning Search Algorithm to Improve Indirect Field-Oriented Fuzzy-PI Control for IM Drive," in IEEE Transactions on Industry Applications, vol. 54, no. 4, pp. 3793-3805, July-Aug. 2018, doi: 10.1109/TIA.2018.2821644.
8. J. Peter, M. Shafi K.P., R. Lakshmi and R. Ramchand, "Nearly Constant Switching Space Vector Based Hysteresis Controller for VSI Fed IM Drive," in IEEE Transactions on Industry Applications, vol. 54, no. 4, pp. 3360-3371, July-Aug. 2018, doi: 10.1109/TIA.2018.2816561.
9. J. Talla, V. Q. Leu, V. Šmídl and Z. Peroutka, "Adaptive Speed Control of Induction Motor Drive With Inaccurate Model," in IEEE Transactions on Industrial Electronics, vol. 65, no. 11, pp. 8532-8542, Nov. 2018, doi: 10.1109/TIE.2018.2811362.
10. M. A. Hannan et al., "A Quantum Lightning Search Algorithm-Based Fuzzy Speed Controller for Induction Motor Drive," in IEEE Access, vol. 6, pp. 1214-1223, 2018, doi: 10.1109/ACCESS.2017.2778081.
11. Z. M. Elbarbary, H. A. Hamed and E. E. El-Kholy, "Comments on “A Performance Investigation of a Four-Switch Three-Phase Inverter-Fed IM Drives at Low Speeds Using Fuzzy Logic and PI Controllers”," in IEEE Transactions on Power Electronics, vol. 33, no. 9, pp. 8187-8188, Sept. 2018, doi: 10.1109/TPEL.2017.2743681.
12. M. A. Hannan, J. A. Ali, A. Mohamed and M. N. Uddin, "A Random Forest Regression Based Space Vector PWM Inverter Controller for the Induction Motor Drive," in IEEE Transactions on Industrial Electronics, vol. 64, no. 4, pp. 2689-2699, April 2017, doi: 10.1109/TIE.2016.2631121.

