OPEN ACCESS

International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-4, November 2019

# A Novel Current Injection Circuit For Adjustable Speed Drives



**A.Kannan, T.Chandrasekar, B. Justus Rabi, S.S. Darly**

***Abstract: An adjustable speed drive creates the harmonics. The novel current injection circuit does not need any additional active devices. With the significant reduction in current harmonics, the AC input line current is sinusoidal. The ZVS technique is used for all the switches operation. The rectifier diodes are by soft switching. The output voltage regulated by fixed duty ratio with varying switching frequency. The advantages of proposed AC-DC-AC systems are low price, compact, high efficiency, and simplicity. Nine level diode clamped inverter produces the voltage harmonics of 8.75%. The Total Harmonic Distortion (THD) of input current is as low as 7.72 % and power factor as high as 0.99. Theoretical results are verified initially through PSIM simulation and validated with an experimental prototype of 2.5Kw.***

***Index Terms: ASD, Three phase rectifiers, THD, Current Injection Technique, high power factor***

## I. INTRODUCTION

The electrical power can be saved around 20% to 30% through adjustable-speed drives (ASDs). ASDs efficiency can be improved because of in it .Normally ASDs consists of rectifier–inverter setup. In such cases, the rectifier drawn waveform of ac input line current contains undesirable harmonics. The system equipment and operations are affected by these harmonics. Due these problems, transformer gets overheated; fuse blowing, motor failures, failure of capacitor, and controls malfunction. With the increasing use of ASDs, techniques of harmonic reduction focused mainly. The basic techniques of harmonic reduction are as follows: 1) active filters; 2) passive filters; 3) harmonic current injection method; and 4) multiples rectifiers. The above techniques have their own merits and demerits. They depends on the source impedance, passive filters will performance, which is not known accurately. The merits of the proposed schemes are: it does not need additional active components for current injection, the switching stresses are minimized to half of the conventional methods because two switches are dividing shunt capacitor voltage, and that makes it good for high-voltage drive applications.

## II. ASD WITH CURRENT INJECTION USING PASSIVE NETWORK

The proposed 3-phase HF current injection topology is depicted in Fig.2.1. It consists of a3-phase diode bridge rectifier ($D_1$-$D_6$), line source inductors ($L_{SR}$-$L_{SB}$) and HF current injection circuit. The HF current injection circuit comprises of DC blocking capacitors ($C_1$-$C_3$), three-phase DC MLI and high-frequency inductors ($L_1$-$L_3$). In the input side, inductors are connected with three-phase rectifier,
The output DC voltage, $V_{dc}$ of the rectifier performs as the input to the inverter through four split capacitors ($C_{dc1}$-$C_{dc4}$). Each leg of the DCMLI consists of eight active switches ($S_1$-$S_8$) and six clamping diodes. One phase-leg of a three-level DCMLI comprises of two clamping diodes and four IGBTs. The other two phase-legs would be joined across the same DC bus, and the clamping diodes joined to the same midpoint of the DC capacitor.

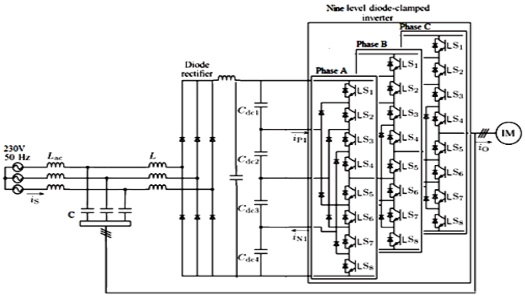


**Fig.2.1 Nine level inverter with passive current injection circuit**

## III. PERFORMANCE ANALYSIS

### 3.1 The Current Injection Circuit Design

#### *3.1.2 Calculations of* Feedback capacitor ($C_1$-$C_3$) and *feedback Inductor ($L_1$-$L_2$)*

With output power, $P_0$=2.2kW, $\sigma$=150° and efficiency of the converter assumed as 92%, the value of the feedback inductor is estimated to $L_1 = \frac{3 v_p 2\sigma T_S}{8\pi P_o}$

Feedback capacitor can be evaluated by using Equation

$$C_1 = \frac{4\sqrt{2}P_0\left(\sqrt{\frac{3\pi - 2\sigma}{\pi}}\right)}{3 V_P 2 f_s \eta} \quad (1)$$

Hence, $C_1$=$C_2$=$C_3$=1$\mu$F (poly propylene capacitor) is chosen.

Manuscript published on November 30, 2019.
* Correspondence Author
**A.Kannan***, Associate Professor, Department of EEE, Dr.M.G.R Educational and Research Institute, Chennai, India.
**T.Chandrasekar**, Professor, Department of EEE, Anna University/ Sri Andal Alagar Engineering College, Chennai, India.
**B.Justus Rabi**, Professor Department of EEE, Anna University/ Sri Andal Alagar Engineering College, Chennai, India.
**S.S.Darly**, Assistant Professor, University College of Engineering, Tindivanam, Tamil nadu

## IV. RESULTS AND DISCUSSION

The 3-phase Nine level diode clamped MLI fed induction motor with passive current injection is analysed. The passive current injection network is consists of resonating components. The absence of active switches is the advantage of this network. It makes the system simple and cost effective. Fig. 4.2 demonstrates the injected current waveform to make the compensation on the distorted input current of diode rectifier. The passive compensation network is added to inject the harmonic component in the input current of diode rectifier. As a result, the distortion available in the input current is decreased.

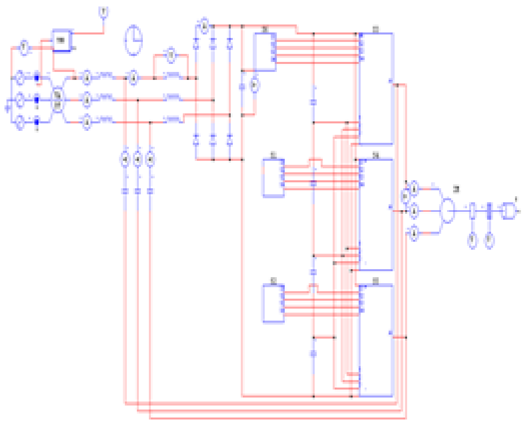

**Fig.4.1 PSIM model of nine level diode clamped MLI fed induction motor with passive current injection circuit**

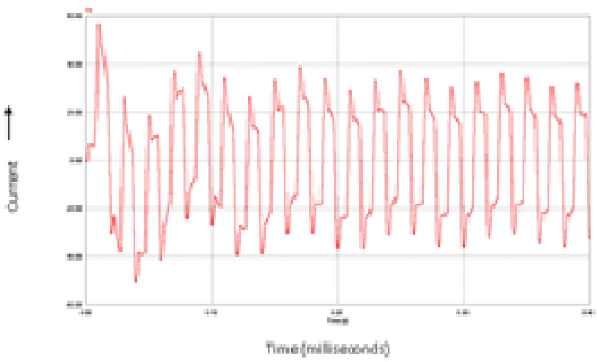


**Fig.4.2 Injected current Ira: 20A/div Time: 0.10msec/div**

The Fig. 4.3 demonstrates the per phase compensated input current of six-pulse diode rectifier. It is nearly sinusoidal when compared with an uncompensated waveform.

The PF and THD of supply current obtained from simulation are shown in Figure4.4. The compensated supply current THD is 7.72 %and power factor is 0.99.

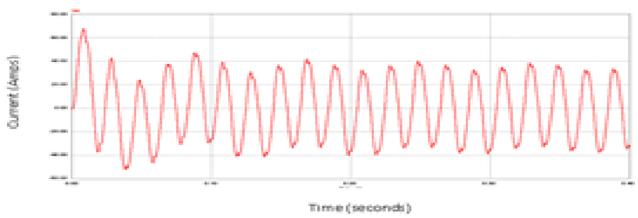


**Fig.4.3 Source current with compensation20A/div. Time: 0.1s/div**

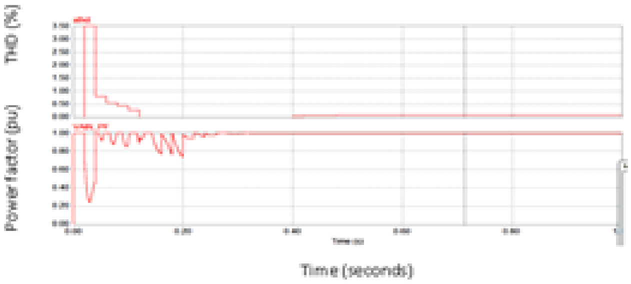


**Fig.4.4 THD and PF; a thd (THD): 0.5pu/div. $V_A$IN_PF(PF):0.2pu/div. Time: 0.2s/div**

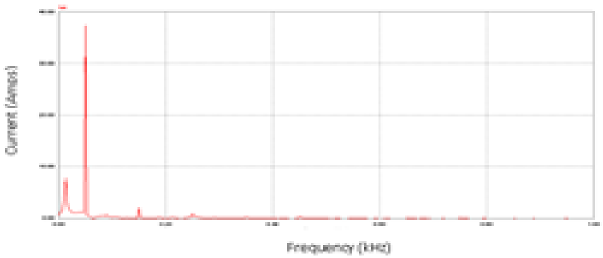


**Fig.4.5 FFT spectrum 10A/div. Frequency: 0.2 kHz/div**

The Fig..4. 5 displays the FFT spectrum of the supply current is obtained from simulation. It explains the order of harmonics. Waveform clearly shows the absence of harmonic current.

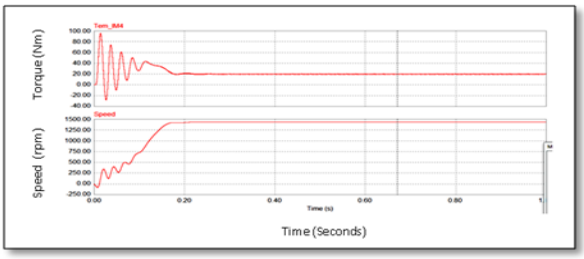


**Fig.4.6 Torque and Speed at full load (Simulation) Tem_IM4 (Torque): 20Nm/div. Speed: 250rpm/div**

The mechanical characteristics of torque and speed of an induction motor obtained from simulation are shown in Figure. 4.6. The inverter fed induction motor has smooth speed – torque characteristics. The speed of an induction motor is around 1350 rpm, and its torque developed in the motor is 20 Nm. The torque pulsation is almost zero. The settling time of the given motor drive is about 0.18 Sec. The results are summarized in the table1.

**Table 1 Performance of ASD after current injection**

| THD | P.F | Speed (rpm) | Torque (N-m) | Settling time(sec) |
|---|---|---|---|---|
| 7.72 | 0.99 | 1350 | 20 | 0.18 |

*Retrieval Number: F2608037619/2019©BEIESP*
*DOI:10.35940/ijrte.F2608.118419*
*Journal Website: www.ijrte.org*



*Published By:*
*Blue Eyes Intelligence Engineering*
*& Sciences Publication*

## V. CONCLUSION

The harmonic performance of high input PF with ASD has been analyzed. The PF of the 3-phase AC input line current is enhanced by injecting the HF current. In this approach, any additional active components are not required for HF current injection. Due to the high frequency current injection, capacitor $C_f$ and inductors $L_f$ value is decreased. Various results are obtained. The obtained value of PF and THD are 0.99 (lagging) and7.72%, respectively, which is more desirable. The simulation results of multilevel inverter show improved the harmonic profile of output voltage waveform. It is about 9%. The high-quality voltage used to drive the induction motor. It causes good torque-speed characteristics of the induction motor.

## REFERENCES

1. E. Embriz-Santander and, A. Domijan (1992) "A summary and evaluation of recent developments on harmonic mitigation techniques useful to adjustable speed drives," IEEE Trans.
2. N. Mohan, et.al(1993), "Analysis of a new power electronics interface with approximately sinusoidal 3-phase utility currents and a regulated DC output," IEEE Trans. Power Del., vol. 8, no. 2, pp. 540–546,..
3. Z. Janda and P. Pejovic, "Optimal current programming in 3phaseHigh PF rectifier based on two boost converters,"IEEE Trans. Power Electron., Vol. 13, no. 6, pp. 1152–1162,Nov. 1998.
4. P. N. Enjeti and S. Kim, "A new approach to improve PF and reduce harmonics in a three-phase diode rectifier type utility interface," IEEE Trans. Ind. Appl., vol. 30, no. 6, pp. 1557–1563, 1994.
5. A. M. A. Amin, (1997) "Line current harmonic reduction in ASD by harmonic current injection," in Proc. IEEEISIE, Vol. 2, pp. 312–317.
6. Blejis. J. A. M, (2005) "Continuous conduction mode operation of 3 phase diode bridge rectifier with constant load voltage," Proc. Inst. Electr. Eng.—Electric Power Appl., Vol. 152, pp. 359–368.
7. G.-S. Kim and S. Choi, C.-Y. Won(2005), , "A new 3-phase harmonic-free rectification scheme based on zero-sequence current injection," IEEE Trans. Ind. Appl., Vol. 41, no. 2, pp. 627–633,
8. Aswini.K., et.al (2017.) "Simulation and Analysis of ASCAD Multilevel Inverter with SPWM for PV System" ,International Journal of Innovative Studies in Sciences and Engineering Technology, Vol.3, No.4,
9. Chandrasekar, T and Rabi, B. Justus, "Harmonics Reduction in 3 Phase System Using Current Injection Technique for Adjustable Speed Drive", Australian Journal of Basic and Applied Sciences, Vol.8, No.16, pp.132-137, 2014.
10. L. C. Gomes de Freitas, et.al (2005) "Programmable PFC based hybrid multipulse power rectifier for utility interface of power electronic converters," in Proc. IEEE PESC, pp. 2237–2243.
11. L. C. Gomes de Freitas, et .al (2006), "Programmable PFC based hybrid multi pulse power rectifier for ultraclean power application," IEEE Trans. Power Electron., vol. 21, no. 4,pp. 959–966,.
12. Chandrasekar,T. Rabi,B. Justus, and A. kannan "Harmonics reduction in front end rectifier of uninterruptible power supplies with active current injection ", American journal of applied Sciences, 11(4),564,2014
13. A.Arther jain, T.Chandrasekar, B. Justus rabi, "Modeling of Nine Level Diode Clamped Multilevel Inverter Fed Induction Motor with front end Rectifier", International Journal of Engineering and Advanced Technology,2019 ,pg. 1415-1419.