IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 10, Issue 11, November 2021

ISSN INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.282

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 11, November 2021 ||

DOI:10.15662/IJAREEIE.2021.1011011 |

Derived Topology of Hybridized Three Phase 13 Level Inverter Fed BLDC

Divyashree D[1] , K P Shobha[2]

PG Scholar, Dept. of EEE, University Visveshvaraya College of Engineering, Banglore, Karnataka, India[1]

Associate Professor, Dept. of EEE, University Visveshvaraya College of Engineering, Banglore, Karnataka, India[2]

ABSTRACT: To resolve the power demand problem and scarcity, we have to improve the power extracting methods. A multilevel inverter is utilized to extract power from solar cells, fuel cells, and batteries. It synthesizes ac output from dc. A multilevel inverter, is gaining much attention nowadays and they have been occupied a superior position over the conventional two-level inverter, in their significant advantages. This paper presents the derived three-phase thirteen level hybridized inverter. The proposed thirteen level inverter is a hybrid of H-bridge and flying capacitor inverter. This thirteen level inverter will reduce harmonic content in output voltage and load current. The principle of operation and control schemes with half height and Level-shift Pulse width modulation technique (LS-PWM) has been implemented. The proposed inverter topology is simulated in MATLAB Simulink and its results are validated with RL load and this proposed inverter effectively drives BLDC Motor. Total harmonic distortion for both half height and LS-PWM control technique has been observed and compared.

KEYWORDS: Multilevel hybridized inverter, half height method, equal phase method, LS-PWM, MATLABsimulink

I.INTRODUCTION

The task of reducing harmonic content in the output voltage is addressed by the multilevel inverter which is suitable for high-voltage and high-current applications, thus have reduced Total Harmonic Distortion (THD) in voltage. With an increased number of voltage levels, this can be operated with the lower switching frequency and hence the switching losses are reduced and Electromagnetic Interference (EMI) problem will also be reduced.

Conventional topologies of Multilevel Inverters use more number of power switches. Its output voltage waveform may contain more harmonics. It has been seen that with an increase in the number of output levels, the numbers of clamping diodes in Diode Clamped inverter and Cascaded inverter needs separate dc sources. In this paper, a novel hybrid thirteen level inverter for both single phase and three phase is proposed.

This Inverter uses a reduced number of switches compared to other symmetrical thirteen level topologies. This inverter configuration uses tapped reactors for harmonic current sharing between two parallel legs of H-bridge topology thus reduces the current stress on the switching devices by distributing the compensation current. This also reduces voltage stress across the switches by utilizing a conventional three-level flying capacitor topology. The configuration is capable of producing thirteen distinct voltage levels and thus lower dv/dt is achieved.

II. PROPOSED TOPOLOGY

The proposed topology as ten switches and reactor between two legs of H-bridge. The reactor used in proposed topology has a tapping at its one-third position. The reactor can be divided into two parts, one as L_1, consists of the $1/3^{rd}$ of the turns, that is $N_1 = N$ and corresponding voltage measured is Va_1; part two as L_2, consists of the $2/3^{rd}$ of the turns, that is $N_2 = 2N$ and corresponding voltage measured is Va_2 .The output voltage is measured across tap so that getting six positive and six negative voltage levels with zero, as output voltage levels.

In this circuit there will be one DC source with voltage V_{dc}. C_{dc} is the energy storing capacitor in the circuit, the following table shows the voltage which as to be applied across the Va_1 and Va_2 and the corresponding output voltage.

Output voltage is given by $V_o = \frac{2}{3}(Va_1) + \frac{1}{3}(Va_2)$

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 11, November 2021 ||

DOI:10.15662/IJAREEIE.2021.1011011 |

The proposed three phase thirteen level inverter is a hybrid of H-bridge and flying capacitor inverter.

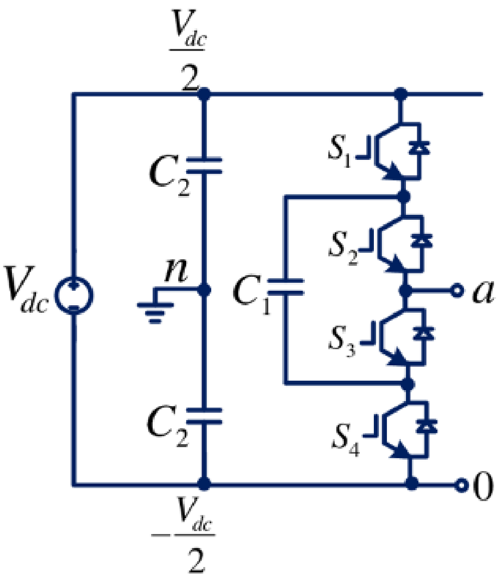


Fig.1Flying capacitor inverter

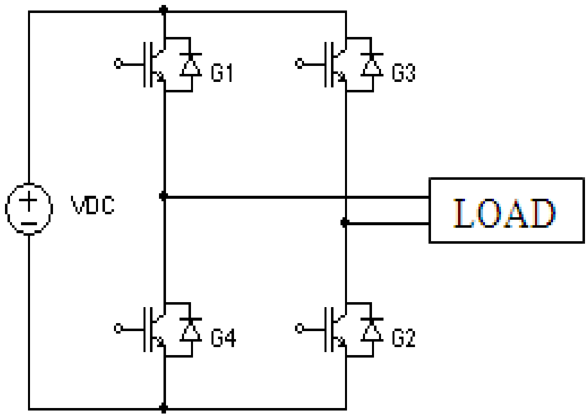
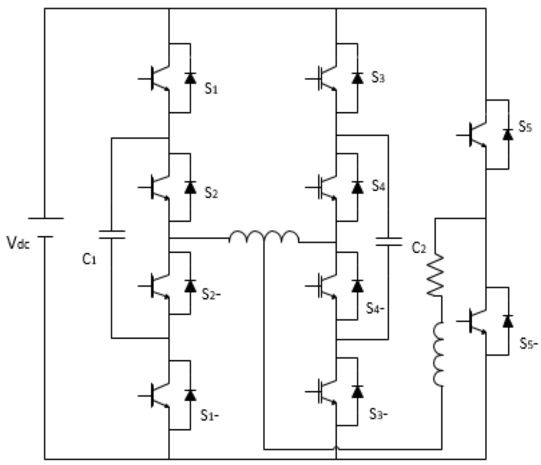


Fig.2 H-bridge inverter



Va1	Va2	Vag
0	0	0
0	Vdc/2	Vdc/6
Vdc/2	0	Vdc/3
Vdc/2	Vdc/2	Vdc/2
Vdc/2	Vdc	2Vdc/3
Vdc	Vdc/2	5dc/6
Vdc	Vdc	Vdc
0	-Vdc/2	-Vdc/6
--Vdc/2	0	-Vdc/3
- Vdc/2	-Vdc/2	-Vdc/2
- Vdc/2	-Vdc	-2Vdc/3
-Vdc	-Vdc/2	-5Vdc/3
-Vdc	-Vdc	-Vdc

Fig3. Circuit diagram of proposed derived topology for phase'a'Table 1

III. DETERMINATION OF SWITCHING ANGLES BY EQUAL PHASE METHOD

In the equal phase method the switching angles are distributed averagely in the range 0- π.The main switching angles are obtained by the formula

$\alpha_i = i * (180^0 / m)$; i=1, 2,… (m-1)/2 ;m=13

IV. DETERMINATION OF SWITCHING ANGLES BY HALF HEIGHT METHOD

In this method the main switching angles of the proposed 13-level inverter are as follows

Main Switching Angles in the first quarter of the sine wave (0^0 to 90^0): $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6.$

Using equation, $\alpha_i = \sin^{-1}\left(\frac{2i-1}{m-1}\right)$

; i=1, 2, 3, 4, 5, 6 and m=13

The switching angles in the second quarter of the sine wave (90^0 to 180^0):

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 11, November 2021 ||

DOI:10.15662/IJAREEIE.2021.1011011 |

$\alpha_7=\pi-\alpha_6$ $\alpha_8=\pi-\alpha_5$, $\alpha_9=\pi-\alpha_4$, $\alpha_{10}=\pi-\alpha_3$, $\alpha_{11}=\pi-\alpha_2$ $\alpha_{12}=\pi-\alpha_1$

The switching angles in third quadrant of the sine wave (180^0 to 270^0):

$\alpha_{13}=\pi+\alpha_1$ $\alpha_{14}=\pi+\alpha_2$ $\alpha_{15}=\pi+\alpha_3$ $\alpha_{16}=\pi+\alpha_4$ $\alpha_{17}=\pi+\alpha_5$ $\alpha_{18}=\pi+\alpha_6$

The switching angles in the fourth quadrant of sine wave (270^0 to 360^0):

$\alpha_{19}=2\pi-\alpha_6$ $\alpha_{20}=2\pi-\alpha_5$ $\alpha_{21}=2\pi-\alpha_4$ $\alpha_{22}=2\pi-\alpha_3$ $\alpha_{23}=2\pi-\alpha_2$ $\alpha_{24}=2\pi-\alpha_1$

	0	$\frac{-Vdc}{6}$	$\frac{-Vdc}{3}$	$\frac{-Vdc}{2}$	$\frac{-2Vdc}{3}$	$\frac{-5Vdc}{6}$	$-Vdc$	$-Vdc$	$\frac{-5Vdc}{6}$	$\frac{-2Vdc}{3}$	$\frac{-Vdc}{2}$	$\frac{-Vdc}{3}$	$\frac{-Vdc}{6}$	0
S_1	1	1	0	0	0	0	0	0	0	0	0	0	1	1
S_2	1	1	1	1	1	0	0	0	0	1	1	1	1	1
S_2^-	0	0	0	0	0	1	1	1	1	0	0	0	0	0
S_1^-	0	0	1	1	1	1	1	1	1	1	1	1	0	0
S_3	1	0	1	0	0	0	0	0	0	0	0	1	0	1
S_4	1	1	1	1	0	1	0	0	1	0	1	1	1	1
S_4^-	0	0	0	0	1	0	1	1	0	1	0	0	0	0
S_3^-	0	1	0	1	1	1	1	1	1	1	1	0	1	0
S_5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S_5^-	0	0	0	0	0	0	0	0	0	0	0	0	0	0

V. POSITIVE SWITCHING SEQUENCE TABLE

	0	$\frac{Vdc}{6}$	$\frac{Vdc}{3}$	$\frac{Vdc}{2}$	$\frac{2Vdc}{3}$	$\frac{5Vdc}{6}$	Vdc	Vdc	$\frac{5Vdc}{6}$	$\frac{2Vdc}{3}$	$\frac{Vdc}{2}$	$\frac{Vdc}{3}$	$\frac{Vdc}{6}$	0
S_1	0	0	1	1	1	1	1	1	1	1	1	1	0	0
S_2	0	0	0	0	0	1	1	1	1	0	0	0	0	0
S_2^-	1	1	1	1	1	0	0	0	0	1	1	1	1	1
S_1^-	1	1	0	0	0	0	0	0	0	0	0	0	1	1
S_3	0	1	0	1	1	1	1	1	1	1	1	0	1	0
S_4	0	0	0	0	1	0	1	1	0	1	0	0	0	0
S_4^-	1	1	1	1	0	1	0	0	1	0	1	1	1	1
S_3^-	1	0	1	0	0	0	0	0	0	0	0	1	0	1
S_5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_5^-	1	1	1	1	1	1	1	1	1	1	1	1	1	1

VI .NEGETIVE SWITCHING SEQUENCE TABLE

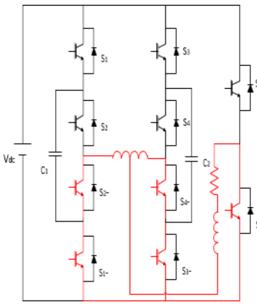
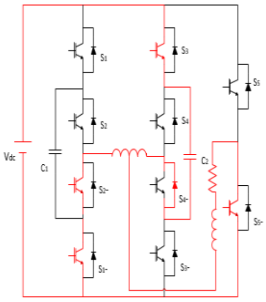
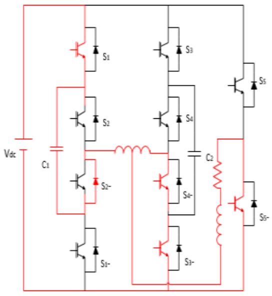
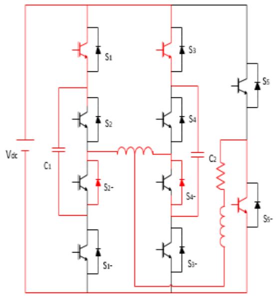
.

Note*: switching angles and switching sequence table are shown for only phase 'a'. same switching sequence will be repeated for other two phase 'b' and 'c' but switching angles will be phase shifted, with 120^o for phase 'b' and with 240^o for phase 'c'.

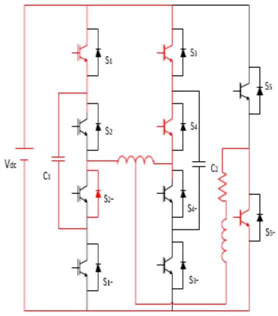
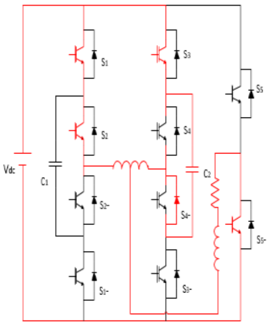
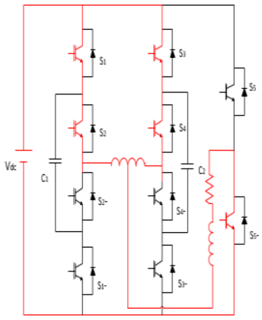
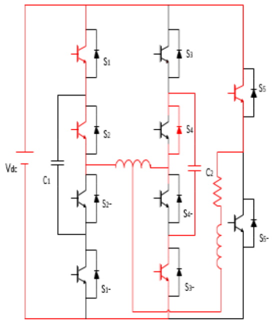
| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 11, November 2021 ||

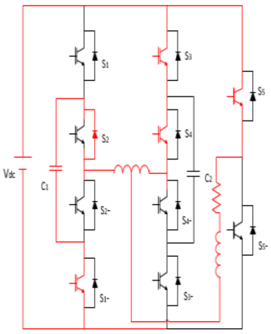
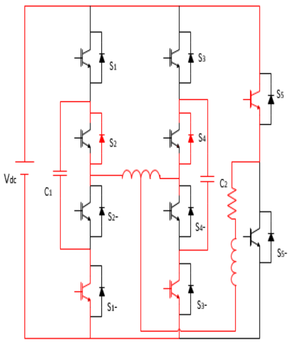
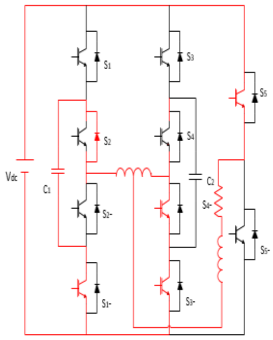
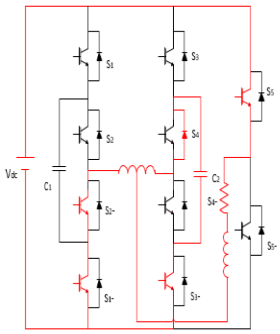
DOI:10.15662/IJAREEIE.2021.1011011 |

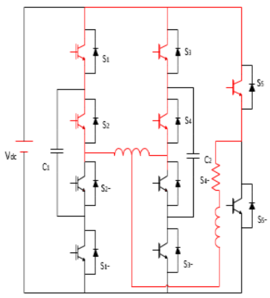
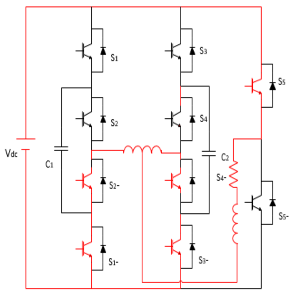
VII.OPERATION OF CIRCUIT AT DIFFERENT VOLTAGE LEVEL FOR PHASE 'a'

a)For Vo=0b) For Vo=Vdc/6c) For Vo=Vdc/3d) For Vo=Vdc/2

e)ForVo=2Vdc/3f)For Vo=5Vdc/6g) For Vo=Vdch) For Vo= -Vdc/6
i) For Vo= -Vdc/3j) For Vo= -Vdc/2k) For Vo= -2Vdc/3l) For Vo= -5Vdc/3

m) For Vo= -Vdcn) For Vo= 0

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 11, November 2021 ||

DOI:10.15662/IJAREEIE.2021.1011011 |

VIII.SIMULATION RESULTS

The simulation is carried out to validate the proposed topology with tapped reactor L=0.3mH and winding resistance = 0.3Ω with capacitor=0.01µF and RL load with R=18.4 Ω and L= 43.92mH. The simulation is carried for three phase circuit with half height and LS-PWM control technique and THD has been observed for both output current and voltage as shown in the figure below.

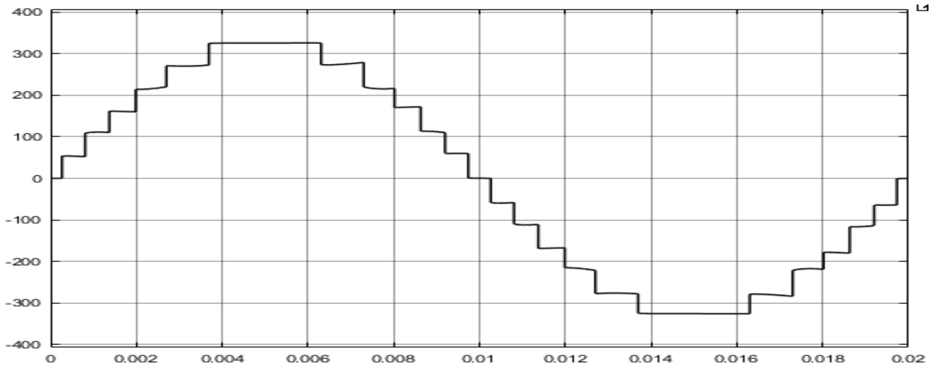


Fig 4.Simulation result for phase 'a' with half height control technique

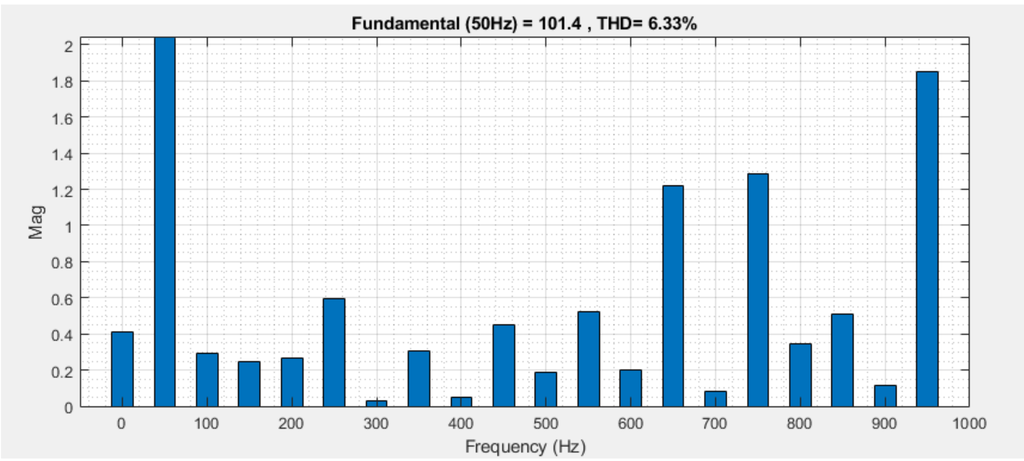


Fig5.Voltage THD for phase 'a' with half height control technique

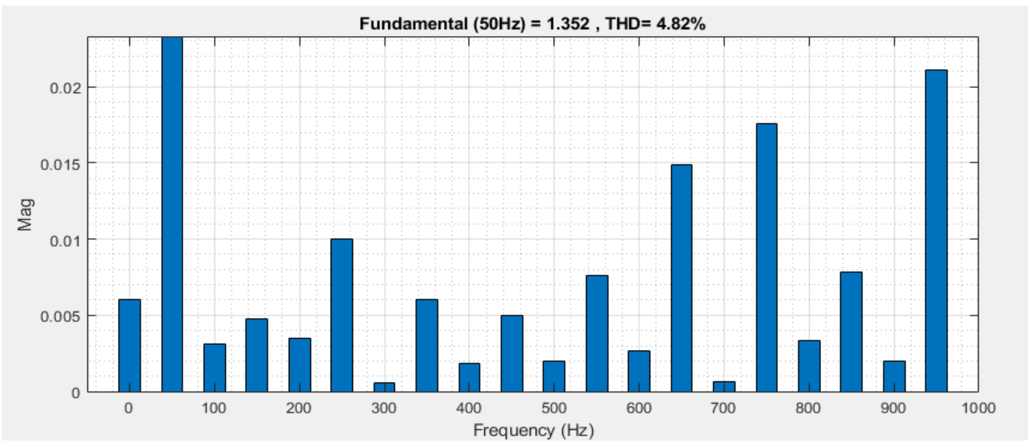


Fig 6.Current THD for phase 'a' with half height control technique

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 11, November 2021 ||

DOI:10.15662/IJAREEIE.2021.1011011 |

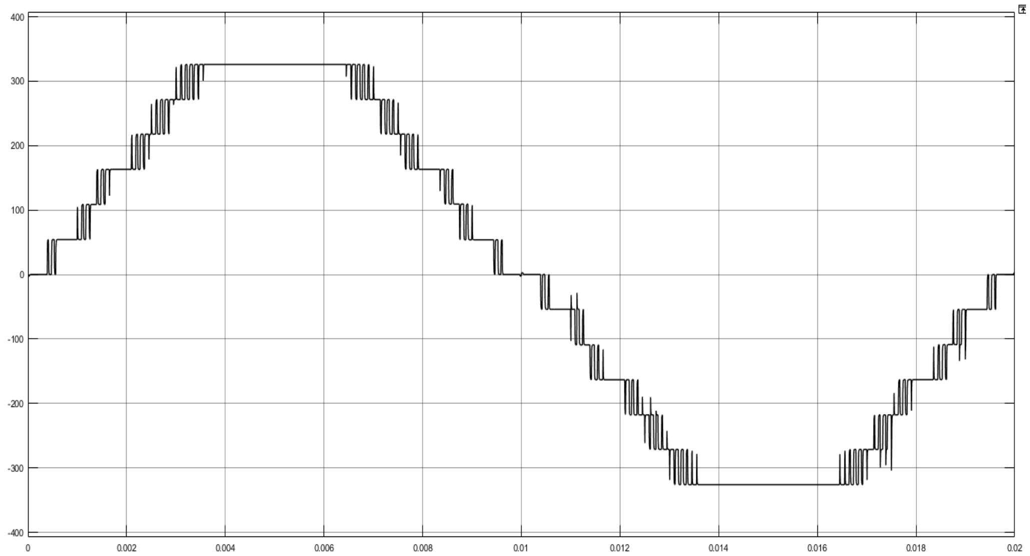


Fig7.Simulation result for phase 'a' with LS-PWM technique

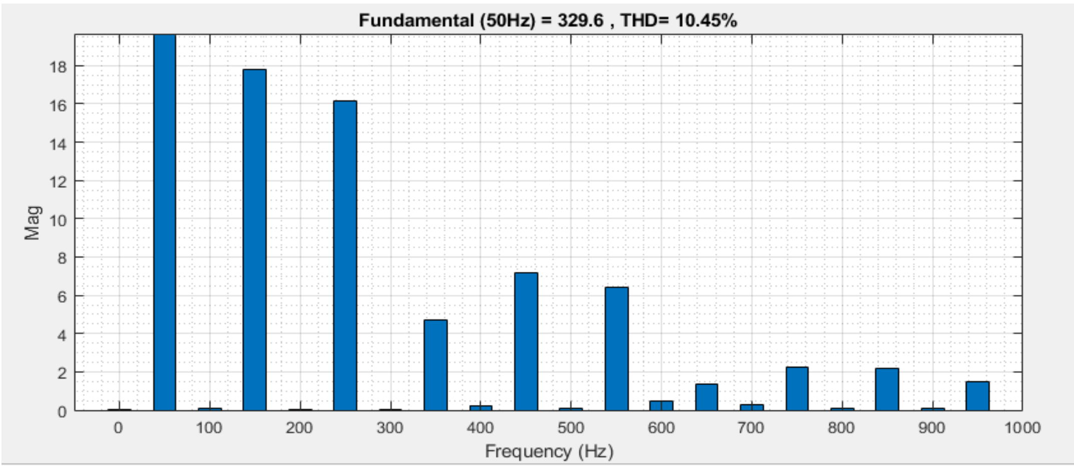


Fig8.Voltage THD for phase 'a' with LS-PWM technique

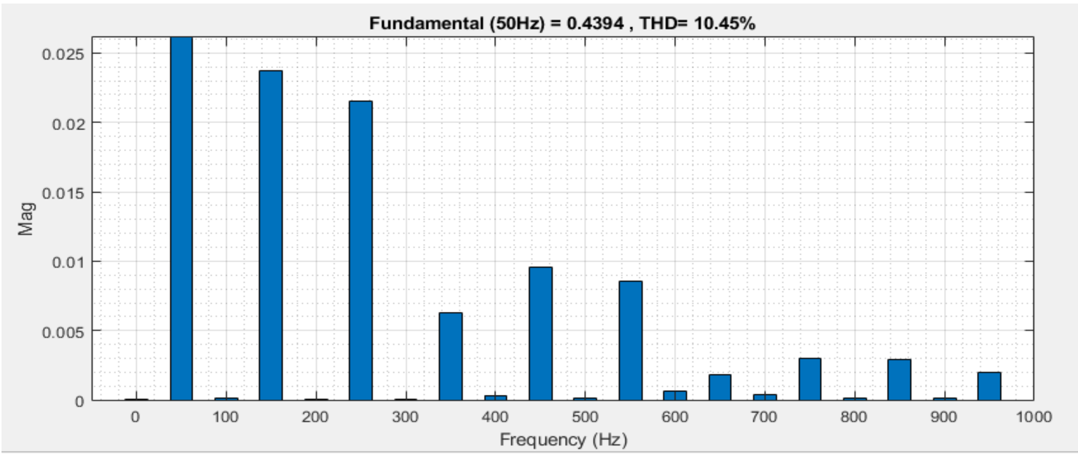


Fig 9.Current THD for phase 'a' with LS-PWM technique

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 11, November 2021 ||

DOI:10.15662/IJAREEIE.2021.1011011 |

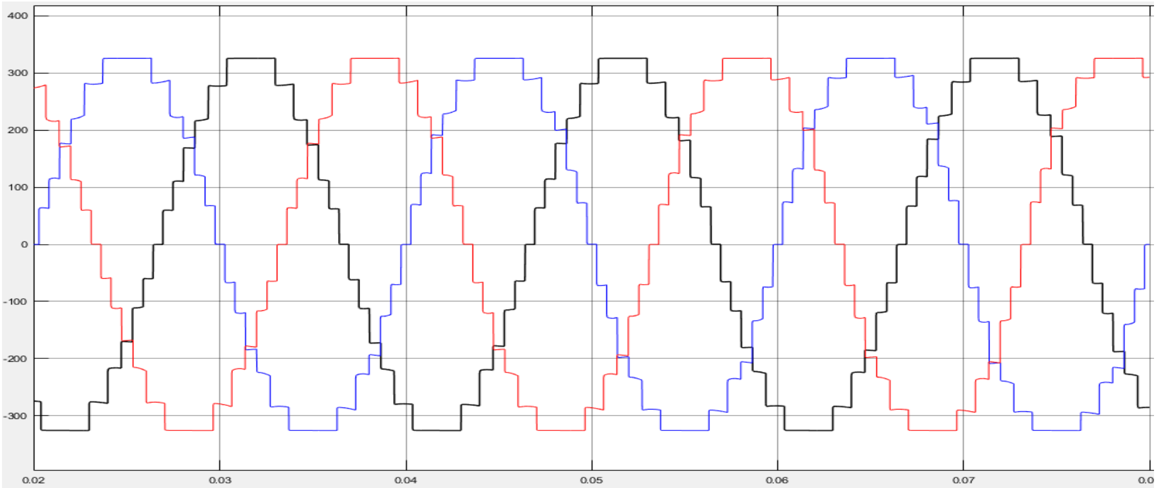


Fig 10.Simulation result for three phase with half height control technique

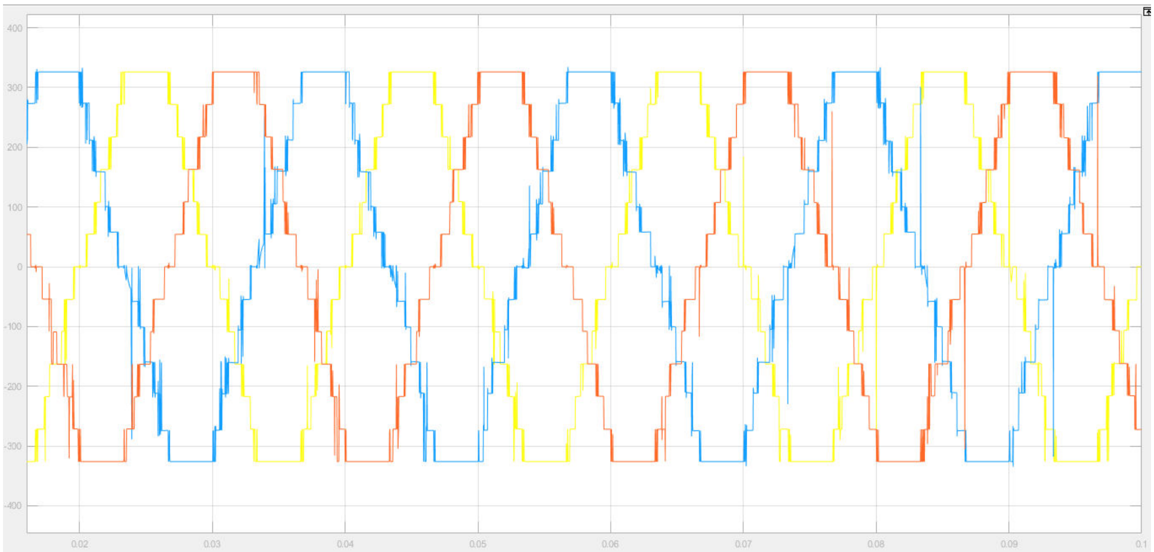


Fig 11.Simulation result for three phase with LS-PWM technique

IX. BLDC MOTOR AND ITS SIMULATION RESULTS

Brushless dc (BLDC) motors are preferred as small horsepower control motors due to their high efficiency, silent operation, compact form, reliability, and low maintenance. However, the problems are encountered in these motor for variable speed operation over last decades continuing technology development in power semiconductors, microprocessors, adjustable speed drivers control schemes and permanent-magnet brushless electric motor production have been combined to enable reliable, cost-effective solution for a broad range of adjustable speed applications.

In a BLDC motor, the electromagnets do not move; instead, the permanent magnets rotate and the armature remains static. This gets around the problem of how to transfer current to a moving armature. In order to do this, the commutator assembly is replaced by an intelligent electronic controller.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 11, November 2021 ||

DOI:10.15662/IJAREEIE.2021.1011011 |

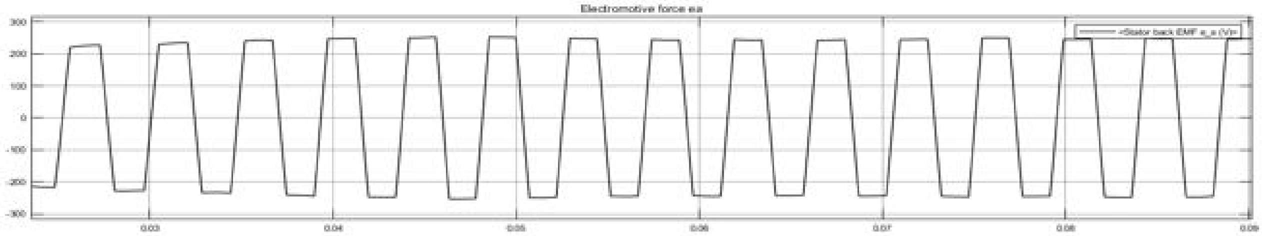


Fig 12.Back EMF of BLDC Motor

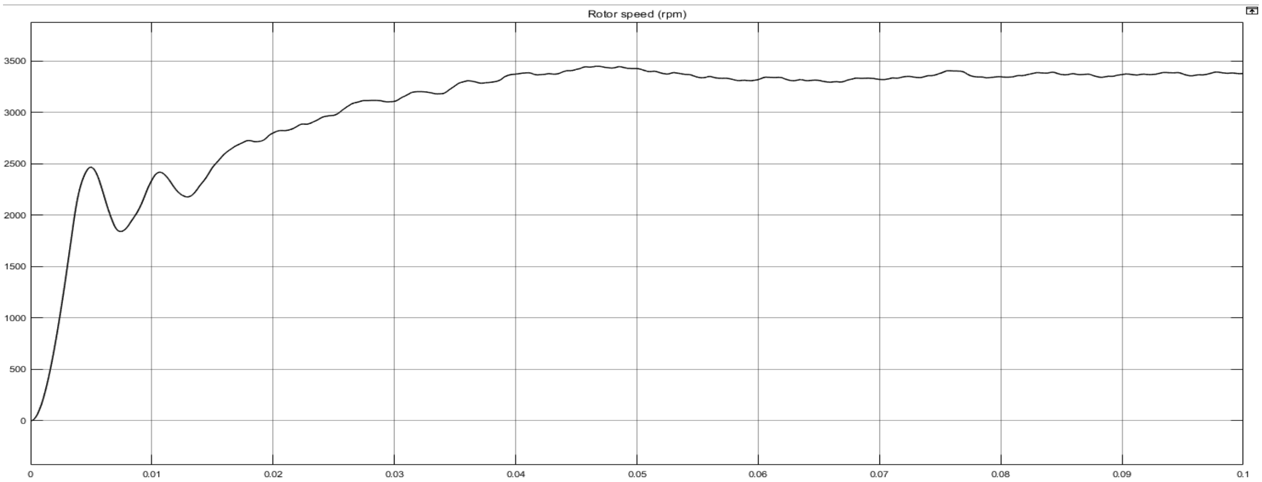


Fig13.Rotor speed

X.CONCLUSION

A derived three phase thirteen level inverter topology has been proposed. Proposed inverter is able to provide output voltage of enhanced quality with reduced harmonic content. Inverter requires less number of components i.e 10 per phase which is turn reduces cost, dv/dt stress, power losses of the switches. Half height and LS-PWM technique has been implemented as the modulation scheme for generating switching signals. This three phase inverter circuit effectively drives the BLDC motor. THD for two different modulation scheme has been observed.

REFERENCES

[1] J .Rodriguez, S. Bernet, P.K Steimer, and I. E Lizama, “A survey on neutral-point-lamped inverters” IEEE Trans ind electron., vol.57, no.7, pp,2219, jul. 2010

[2] J. Huang and K.A Corzine, “extended operation of flying capacitor multi level inverters” IEEE Trans ind electron., vol.56, no.1, pp,140-147, jan. 2006

[3] E. Villanueva, P.correa, J. Rodriguez, “Control a three phase multilevel inverters for grid connected photovoltaic systems” IEEE Trans ind electron., vol.56, no.1, pp.4399-4406, nov. 2009

[4] B. Singh, K. Al-Haddad, and A. Chandra, “A review of active filters for power quality improvement,” IEEE Trans. Ind. Electron., vol. 46, no. 5, pp. 960–971, Oct. 1999.

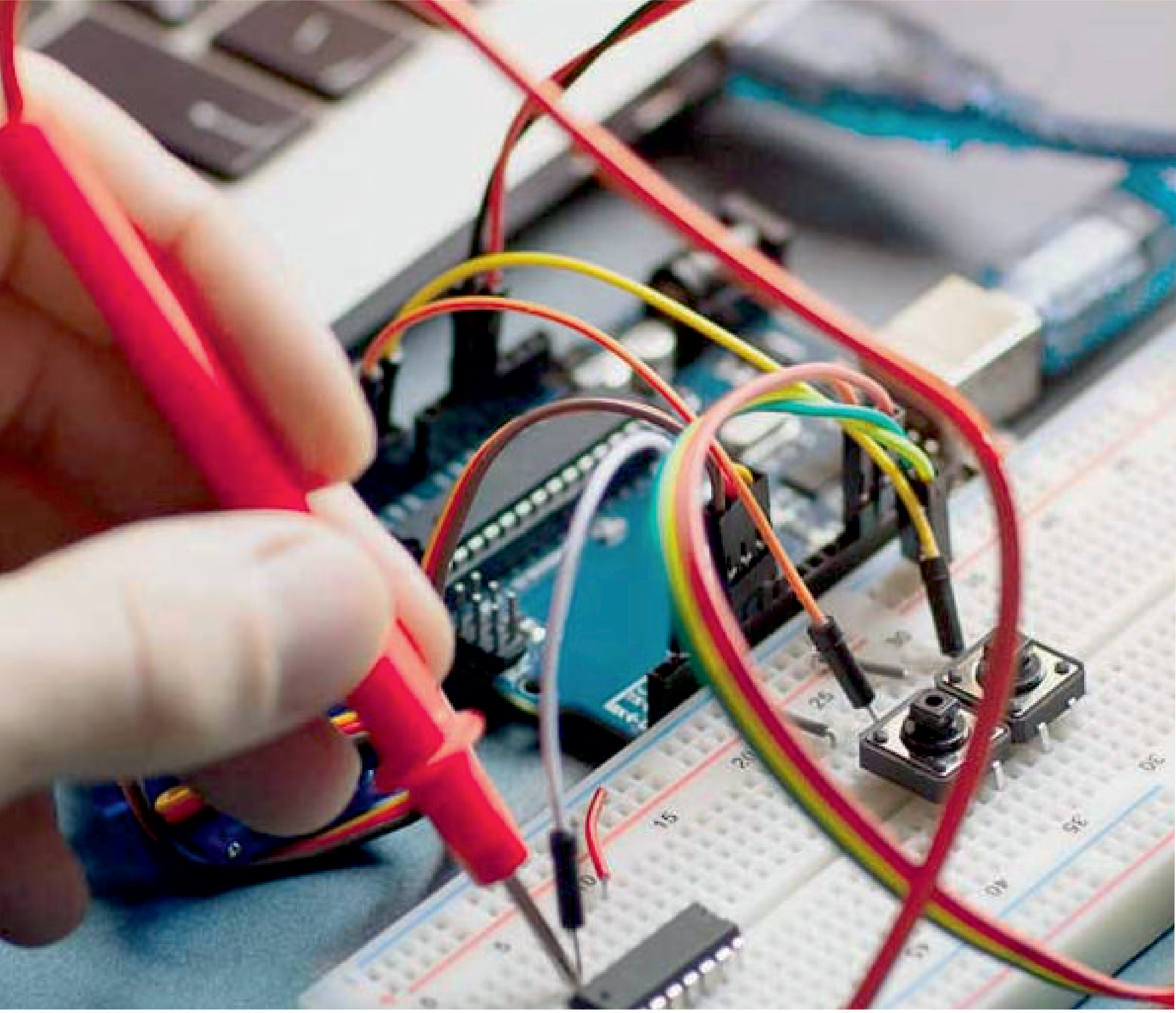
[5] S. Bhattacharya, T. M. Frank, D. M. Divan, and B. Banerjee, “Active filter system implementation,” IEEE Ind. Appl. Mag., vol. 4, no. 5, pp. 47–63, Sep. 1998.

[6] Z. Du, L. M. Tolbert, and J. N. Chiasson, “Active harmonic elimination for multilevel converters,” IEEE Trans. Power Electron., vol. 21, no. 2, pp. 459–469, Mar. 2006

[7] Md. Tariqul Islam, Md. Shahidul Islam, Arnob Kumar Bairagi. "A New Single Phase 21 Level Inverter Topology with Reduced Number of Switches and Sources for Renewable Energy Applications" , 2018 4th International Conference on Electrical Engineering and Information & Communication Technology (iCEEiCT), 2018

[8] Jun Zeng, Weijie Lin, Dehai Cen, Junfeng Liu. "Novel K-Type Multilevel Inverter With Reduced Components and Self-Balance" , IEEE 30

[9] Ki-Mok Kim, Jung-Kyu Han, Gun-Woo Moon. "A High Step-Up Switched-Capacitor 13-Level Inverter with Reduced Number of Switches" , IEEE Transactions on Power Electronics, 2020



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 7.282

doi crossref

ISSN INTERNATIONAL STANDARD SERIAL NUMBER INDIA

निस्केयर NISCAIR

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

9940 572 462 6381 907 438 ijareeie@gmail.com