International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072

Voltage Controlled Design of a Cycloconverter for Variable Frequency Operation with Harmonics Elimination Technique

Pranjit Kumar Roy[1]

[1]*Assistant Professor, Dept. of Electrical Engineering, Bengal College of Engineering and Technology, West Bengal, India*

---***---

Abstract – *The major findings of this paper are based on realization of a Cycloconverter which is having an immense importance for the frequency controlled drives and various high frequency applications. The deviation of source voltage is controlled simultaneously with the frequency of the output signal which is maintained effectively under desired limit. The positive and negative sequence of switching signals are applied maintaining mathematical modeling and simulation of the proposed model. It is developed using MATLAB/Simulink software. The Model is simulated with resistive and inductive type of loading which incurs harmonic distortions at the output end. The filtering of the harmonic contents are shown in this paper and which lies under the IEEE specified standard limits. Fast Fourier Transform (FFT) is used as a mathematical tool to analyze the limit of harmonics in MATLAB platform. The synchronized operation of generating pulses after calculating the optimum pulse width and time interval result in successful operation of the proposed Cycloconverter model.*

Key Words: Cycloconverter, Controlled-voltage source, Conduction period, Fast Fourier Transformation, Harmonic elimination, Variable frequency.

1. INTRODUCTION

Cycloconverter plays a crucial role for the variable frequency applications by controlling its conduction period. Various a.c. appliances are needed to run with variable speed for different household and industrial applications where Cycloconverter meets the required demand efficiently and cost effectively [1]. It converts the constant frequency to the desired variable frequency in a single stage and losses will be comparatively lower compare to the other existing techniques. There are different applications where standard 50Hz frequency cannot be directly utilized whereas Cycloconverter effectively reduces the frequency (e.g. 1/3rd or 1/4th of the rated/supplied frequency) without any significant stresses or losses. The Cycloconverter consists of two bridges. Bridge 1 indicates the operation of positive half cycle as well as bridge 2 indicates the operation of negative half cycle. The signals are generated maintaining the sequence logic and duration of conduction are also controlled. This methodology is implemented on R-L type of load where the input voltage is controlled continuously [2]. The output voltage and current waveforms are verified for different frequency levels. The basic bridge type Cycloconverter circuit is shown in Fig -1.

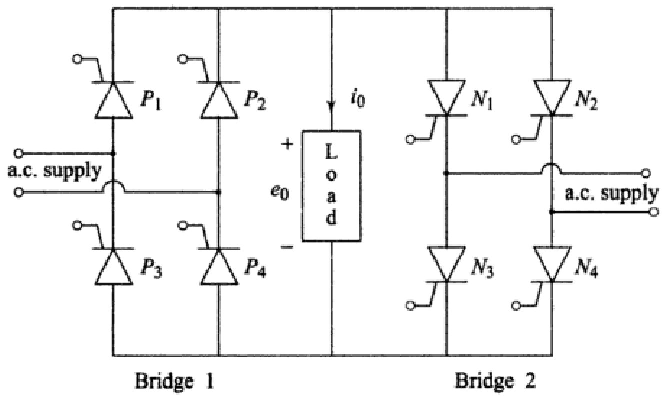

Fig -1: Bridge type configuration of Cycloconverter

P_1, P_2, P_3 and P_4 are four switches which are operated for the conduction of positive half-cycle and N_1, N_2, N_3 and N_4 are four switches for the conduction of negative half-cycle. Pulse-generators are the used to provide necessary firing pulses for each switch.

2. WORKING OF SIMULATED MODEL

The Cycloconverter is operated in two half-cycle i.e. positive half-cycle and negative half-cycle. In positive half-cycle, Thyristors T_1, T_2, T_3 and T_4 are under operating condition while the gate pulses are provided from pulse generator 2. In case of negative half-cycle, Thyristors T_5, T_6, T_7 and T_7 are in working state while gate pulses are fed from pulse generator 3 after applying certain conduction period [3]. Four switches are used here where switch 3 and switch 4 are in phase opposition for maintaining the sequence of negative half-cycle with logical NOT operator and gate pulses are sent from pulse generator 1. The voltage that is acted as input is controlled continually with respect to the voltage at load end.

The Cycloconverter model is simulated with resistive and inductive type of loading environment. The inductive type loading induces harmonics in the voltage and current at the output side which are beyond the standard limits. The harmonic contents are mitigated using capacitors C_1, C_2 and internal inductor with controlled voltage utilization. After the implementation of Fast Fourier Transform (FFT), Total Harmonic Distortion (THD) is analyzed and elimination of harmonics in the output parameters are shown [4].

For various industrial drives, variable frequency is an essential parameter [5] which is verified and depicted after successful simulation of the described Cycloconverter. The model of Cycloconverter developed in MATLAB platform is shown Fig -2.

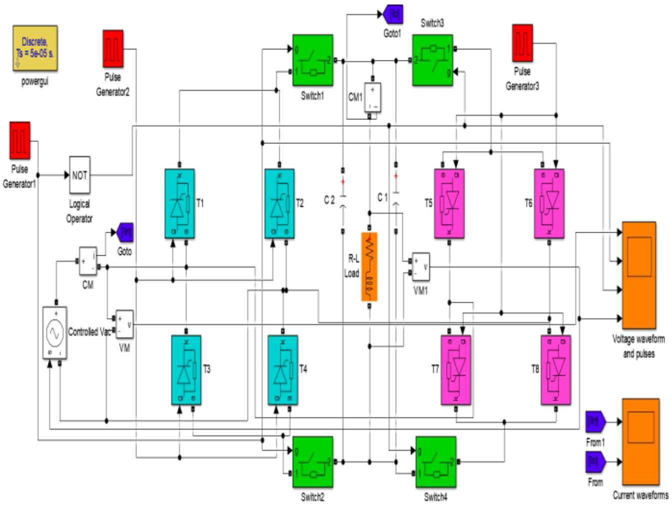

Fig -2: Working model of Cycloconverter after simulation

Two scope blocks are used where in the first scope block, gate pulses from pulse generators and voltage from the input end and output end are depicted. The voltage and current waveforms are shown for different levels of frequency which are of required for domestic and industrial applications [6].

3. OBSERAVATIONS

The source voltage is shown for 230V, 50Hz (f) in Fig -3 whereas gate pulses for the mode of operation in positive and negative half cycles are visualized in Fig -4 and Fig -5.

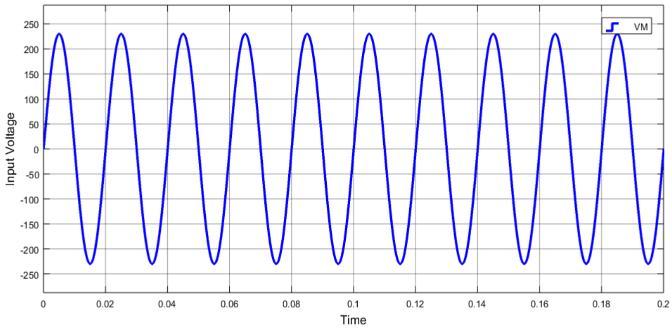

Fig -3: Controlled Voltage at the input side

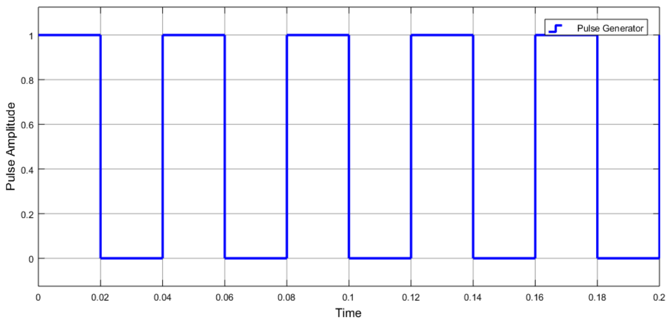

Fig -4: Gate pulse for positive half-cycle

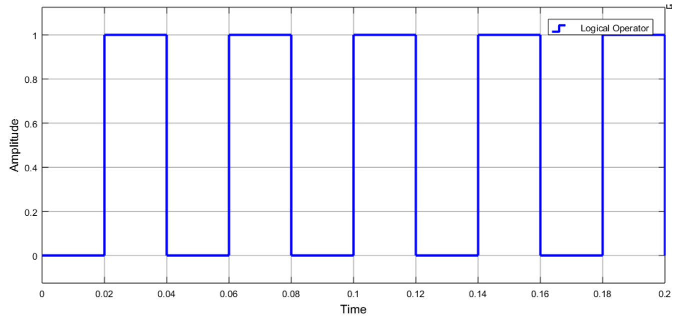

Fig -5: Gate pulse for negative half-cycle

The different level of frequency i.e. 1/2nd, 1/3rd and 1/4th of the supply frequency, voltage and current waveforms are constructed and verified under 120Ω, 60 mH loading in the following figures. Voltage waveform across the load at the output end for f/2, f/3 and f/4 are shown in Fig -6 Fig -7 and Fig -8 respectively.

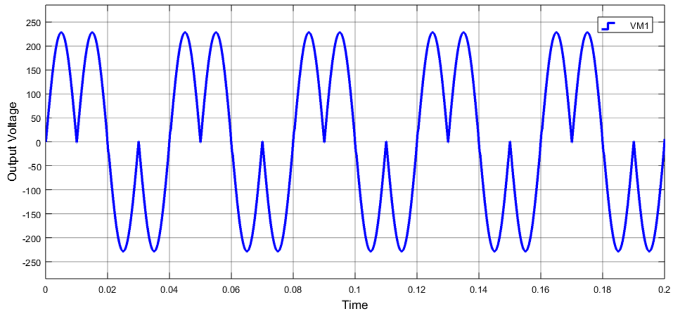

Fig -6: Voltage at the output for f/2 frequency

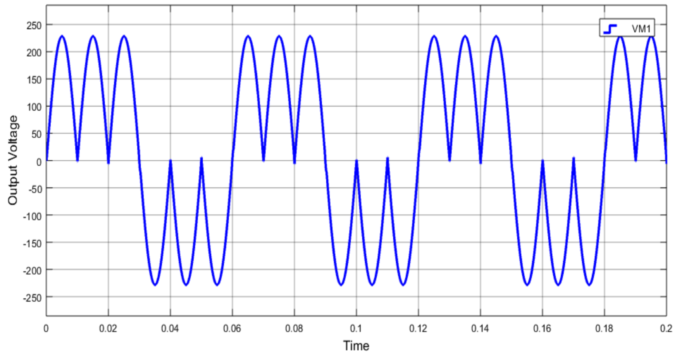

Fig -7: Voltage at the output for f/3 frequency

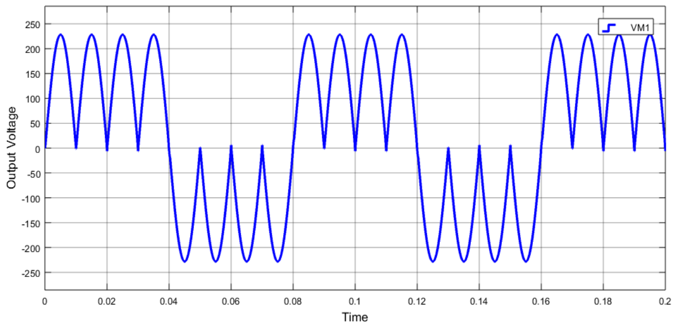

Fig -8: Voltage at the output for f/3 frequency

Current waveforms at the output end for f/2, f/3 and f/4 are simulated and depicted in Fig -9 Fig -10 and Fig -11 respectively.

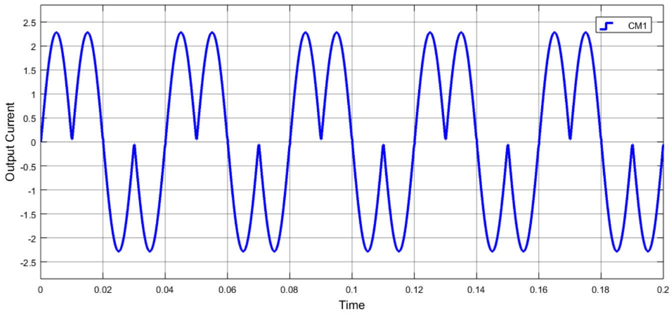

Fig -9: Current at the output for f/2 frequency

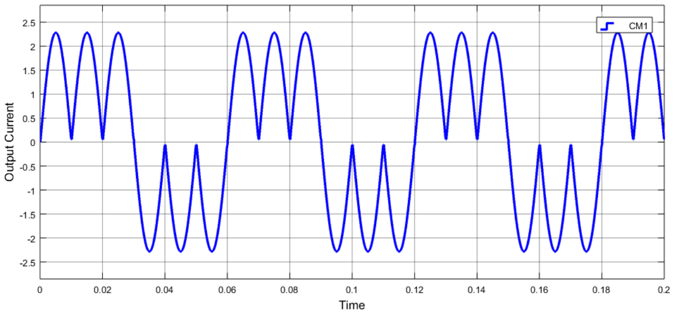

Fig -10: Current at the output for f/3 frequency

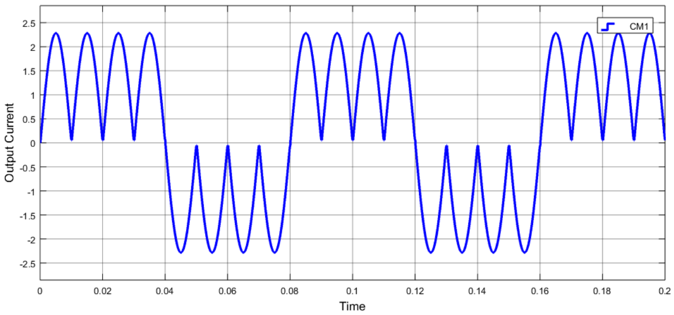

Fig -11: Current at the output for f/4 frequency

The output voltage and current with harmonic distortions for resistive and inductive type (120Ω, 60 mH) loading are graphically visualized in Fig -12 and Fig -13.

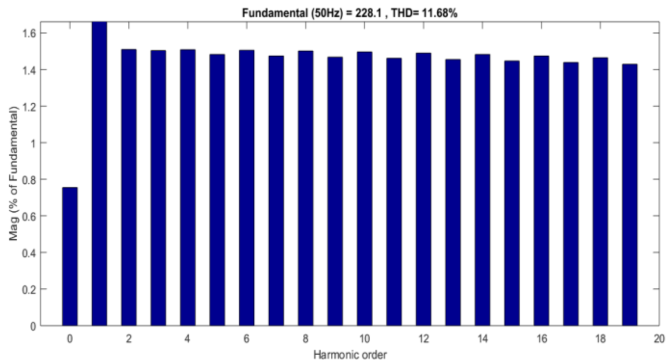

Fig -12: Greater Voltage harmonics graphical presentation

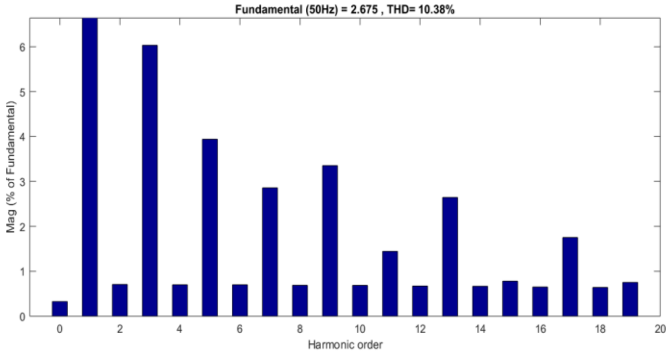

Fig -13: Greater Current harmonics graphical presentation

The harmonics present in voltage and current signals are beyond permissible limit which are 11.68% and 10.38% respectively. After significant amount of harmonics reduction [7] graphical presentation of Voltage and current waveforms can be verified under FFT analysis with THD content in Fig -14 and Fig -15.

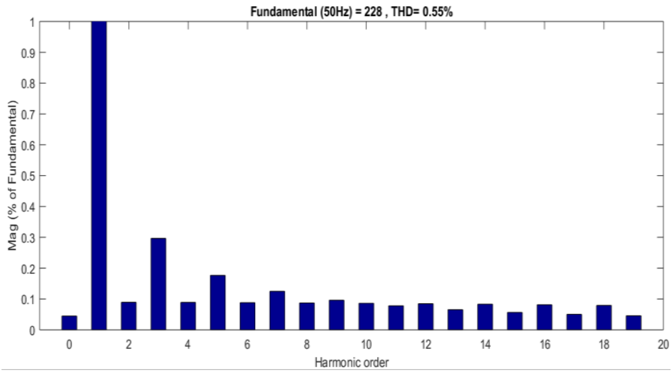

Fig -14: Lower Voltage harmonics graphical visualization

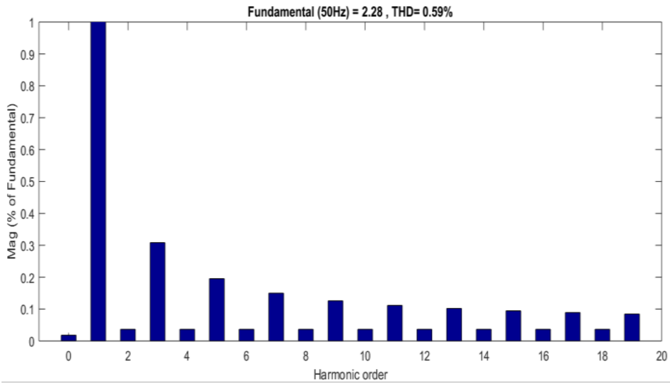

Fig -15: Lower Current harmonics graphical visualization

The voltage and current waveforms are visualized after significant reduction of harmonics which are 0.55 % and 0.59%. This is very much under permissible limit and for efficient operation it is necessary. Performance of various variable frequency drives will be improved as a result in major industrial applications for multiple functional approach. The dynamics of the pulses and signals are continuously monitored for enhancement of exposure in power, energy and control fields.

4. CONCLUSION

This paper ensures the successful working of a Cycloconverter with controlled voltage source for different range of frequencies. The sequential operations of switches are controlled and output parameters are verified for resistive-inductive loading with least switching stresses and losses. The effective harmonics elimination is also implemented here for efficient and sustainable operation with V/F control in variable frequency drives profoundly induction motors. Voltage and current signals are verified for different frequency ranges within optimum operational limit. Further, hardware implementation with active filter design and space vector control can be developed. Thus this paper realizes a significant contribution towards cost-effective, reliable, less complex and efficient Cycloconverter for major industrial appliances under power electronics and drives domain.

REFERENCES

[1] M. H. Mondol, M. S. Uddin, E. Hossain and S. P. Biswas, "A Compact and Cost Efficient Multiconverter for Multipurpose Applications," in IEEE Access, vol. 8, pp. 86810-86823, 2020, doi: 10.1109/ACCESS.2020.2992986.

[2] P. K. Roy, "Design of Closed-loop Inverter Using High Gain Converter," 2020 4th International Conference on Electronics, Communication and Aerospace Technology (ICECA), 2020, pp. 362-367, doi: 10.1109/ICECA49313.2020.9297588.

[3] X. Zhou, J. Xu, and S. Zhong, "Single-stage soft-switching low-distortion bipolar PWM modulation high-frequency-link DC–AC converter with clamping circuits," IEEE Trans. Ind. Electron., vol. 65, no. 10, pp. 7719–7729, Oct. 2018.

[4] W. Ahmed, N. Ali, S. Nazir, and A. Khan, "Power quality improving based harmonical studies of a single phase step down bridge-cycloconverter," J. Electr. Syst, vol. 15, no. 1, pp. 109–122, 2019.

[5] K. H. Reddy, "PSO supported dual matrix converter for doubly fed induction generated driven by variable speed wind turbine system," Int. J. Renew. Energy Res., vol. 10, no. 1, pp. 131–142, 2020.

[6] Ayebatonye Marttyns Epemu, Kingsley Okeoghene Enalume, Speed Control of a Single Phase Induction Motor Using Step-down Cycloconverter, International Journal of Industrial and Manufacturing Systems Engineering. Vol. 3, No. 1, 2018, pp. 6-10. doi: 10.11648/j.ijimse.20180301.12.

[7] Muhammad H. Rashid, "Power electronics: circuits, devices, and applications", Third Edition. 2004, Pearson/Prentice Hall.

[8] Y. Liu, J. He, B. Ge, X. Li, Y. Xue, and F. Blaabjerg, "A simple space vector modulation of high-frequency AC linked three-phase-to-single-phase/DC converter," IEEE Access, vol. 8, pp. 59278–59289, 2020.

BIOGRAPHIES

Mr. Pranjit Kumar Roy received M.Tech degree from JALPAIGURI GOVERNMENT ENGINEERING COLLEGE in Electrical Engineering (Power Electronics and Drives). He is currently working as an Assistant Professor in Electrical Engineering Department at BENGAL COLLEGE OF ENGINEERING AND TECHNOLOGY. His research interests include Power Electronics, Electrical Machine, Power System etc.