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Performance Analysis of Flying Capacitor Multilevel Inverter

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***Abstract*— This Paper Proposes A Simulation Study Of Phase-Disposition (PD-PWM) Pulse Width Modulation Strategies In 3 Phases, Seven Level Flying Capacitor Multilevel Inverter (FCI) In MATLAB Simulink. The Simulation Model Is Developed And Analyzed For Induction Motor Using PD-PWM. Harmonics Analysis Of The Waveform Can Be Carried On Output Waveform Of Inverter Voltage, Inverter Current Of Flying Capacitor Multilevel Inverter.**

Keywords*— PD-PWM, flying capacitor multilevel inverter(FCI), Thermal harmonic distortion (THD)

I.INTRODUCTION .

A multilevel inverter (MLI) is an electrical device that converts a dc power supply into an ac power supply. MLI are capable of handling high voltage with minimum voltage stress on switching devices, generate output voltage with minimum harmonic content, and generate low dv/dt and have a lower common mode voltage, which result in reduced stress on motor bearing in drive applications

Three types of multilevel inverter

1. Diode-clamped multilevel inverter.
2. Flying-capacitor multilevel inverter.
3. Cascaded-multi level inverters[1].

Meynard and Foch introduced a flying-capacitor-multilevel inverter in 1992. The structure of this inverter is similar to that of the diode-clamped inverter except that instead of using clamping diodes, the inverter uses capacitors in their place. The property to naturally maintain the cell capacitor voltages at their target operating levels is called natural balancing, and allows in principle the construction of such inverters with a large number of voltage levels.

II. FLYING CAPACITOR MULTILEVEL INVERTER

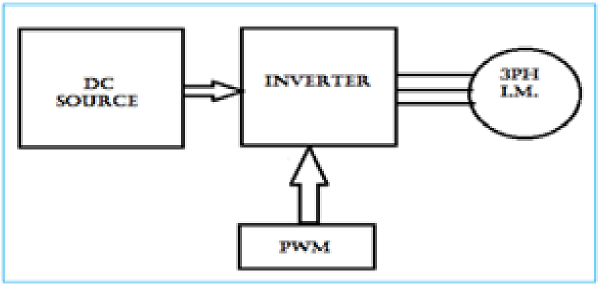

Fig.1 Block diagram

A. *Operating principles of 7l FCI*

Each phase leg requires a minimum of 12 is switches (S1 to S6 and S’1 to S’6) and 5 p capacitors (C1 to C5) clamped in between the modular cells depending on the device voltage ratings considered during the design of the converter The difference would be even obvious when the converter is designed for three-phase systems. Since 6 pairs of active switches are used in the proposed SIX-cell 7L-MFCI .Two redundant states are produced for zero output level and three redundant states for each ±Vdc/2 ,±Vdc/3 and ±Vdc/6 output levels. It should be noted that all positive output levels are achieved when S1 conducts, whereas all negative output levels are obtained when S’1 conducts. Therefore, the two switches S1 and S’1 in Cell 1 are always performing at fundamental frequency of 50 Hz. During steady-state operation, the flying capacitor voltages VC1, VC2, VC3, VC4 and VC5 of SIX-cell 7L-RFCI are maintained at Vdc/6, Vdc/3, and Vdc/2, respectively.[2]

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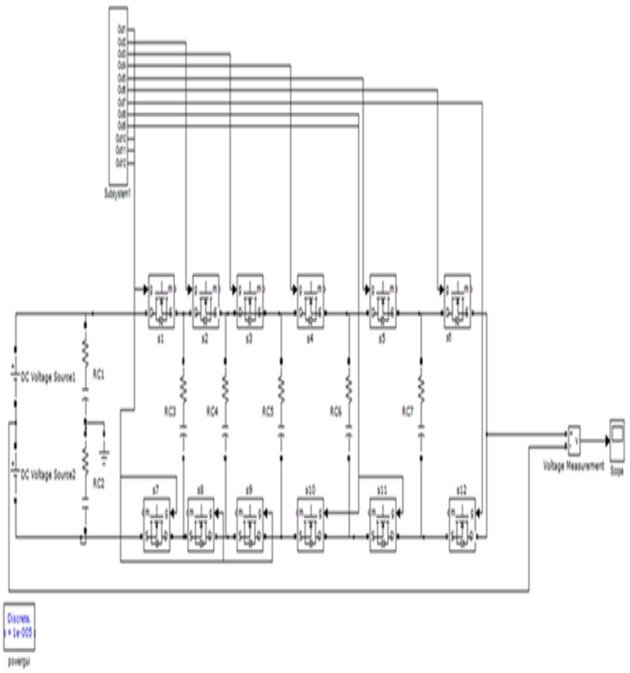

Fig 2 Simulink circuit for 7 level single phase MFCI

In fig 2 PD-PWM switching method are used for gate signals given to the 1 ph 7 level FCI circuit. In subsystem1 switching logic circuit is designed for triggering the switches

B. *Output voltage waveform for single phase MFCI*

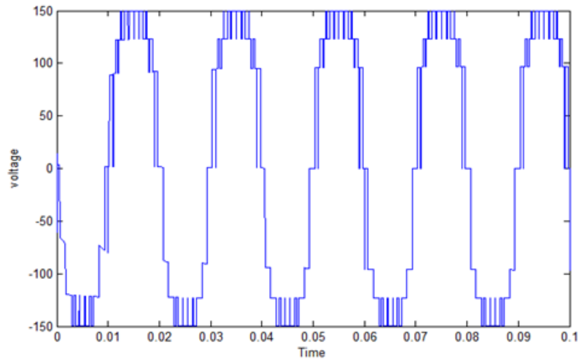

Fig.3 waveform of 1 ph MFCI

III. 3 PH MFCI CIRCUIT

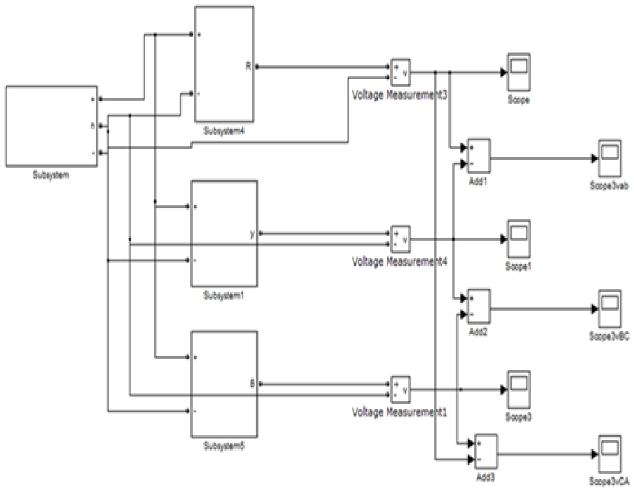

Fig4. 3 ph flying capacitor multilevel inverter

C. *Explanation about the selection of carrier frequency and value of capacitor*

The value of carrier frequency should be in such a way that the reconstructed sinusoidal signal from dc source should be even in nature meaning if the frequency is less than the reconstructed signal will be a sinusoidal signal and the it has more percentage of square wave at output side so it will be called as modified sine wave inverter. So, one should select The value of carrier frequency such that pure sinusoidal waveform should be available at output using low pass filter. One more important thing is value of capacitor should selected in such way that the capacitor should not discharge in switch off period of MOSFET and the magnitude of voltage level in each switching instant should be maintained Because discharging rate of the capacitor during switching off instance of time t_0 is given by

$$V\_c=V\_max\ e^{(t\_0/R\_c)}$$

Where R is load resistance and C is the value of capacitor

So for V_c=V_max

The value of t_0/R_c should be approximately zero

Either have less value of numerator or high value of denominator. We cannot increase the value of R, because if we do so, the efficiency of the system will determinate sine I^2R loss will be there. So reduce the value of t_0 and increase the value C, means reduction in value of capacitance will introduce the more discharging of capacitor so, then same results as that of modified wave we will get .so, choose higher value of capacitance and less time period of carrier frequency (more than 10K_HZ) but then switching losses will increase and efficiency will further decrease. So optimized value of carrier frequency should be in range of 3K_HZ to10K_HZ and capacitor value should be in the range of 2200uf to 4700uf .because if you further increase the value of capacitor than it will be heavy on packets.

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A. OUTPUT VOLTAGE VA, VB, VC

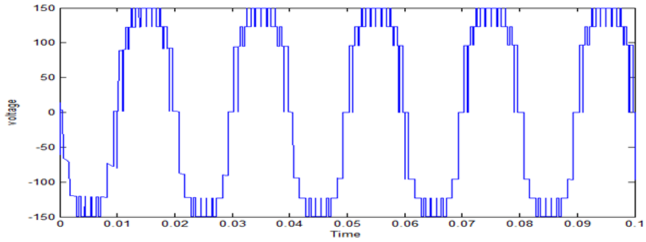

Fig.5 waveform of Va

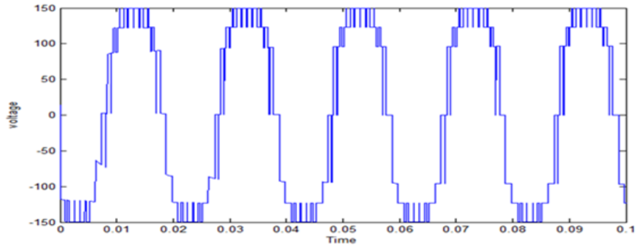

Fig.6 waveform Vb

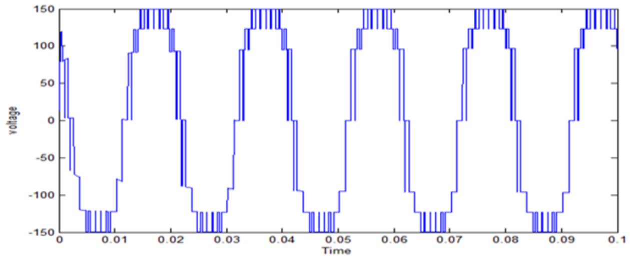

Fig.7 waveform Vc

B. OUTPUT VOLTAGE Vab ,Vbc , Vca

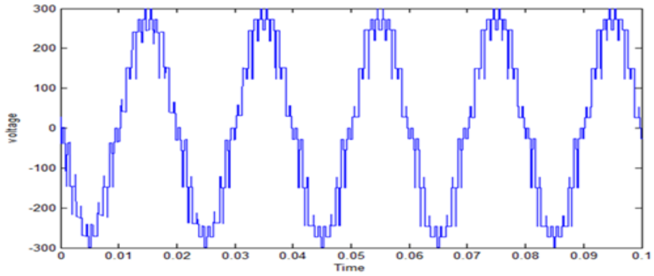

Fig.8 waveform of Vab

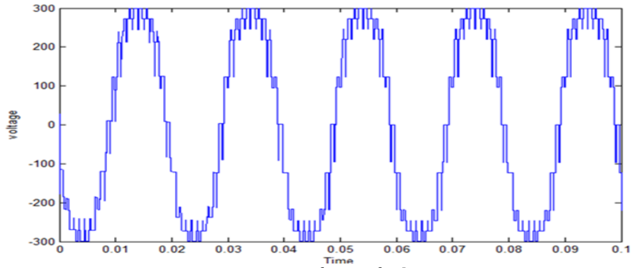

Fig. 9 waveform of Vbc

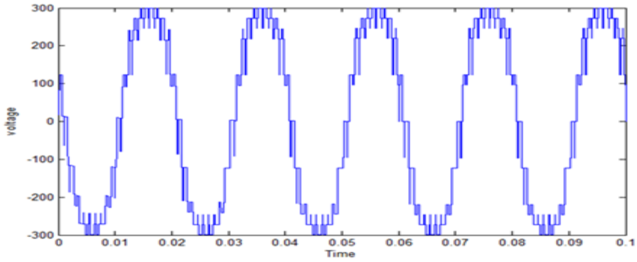

Fig.10 waveform of Vca

IV. INVERTER VOLTAGE, CURRENT

A. Inverter voltage

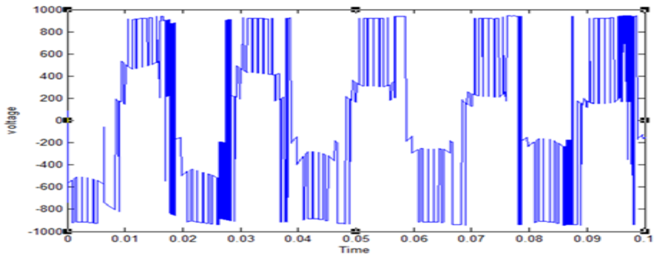

Fig.11 waveform of inverter voltage

B. FFT analysis of inverter voltage

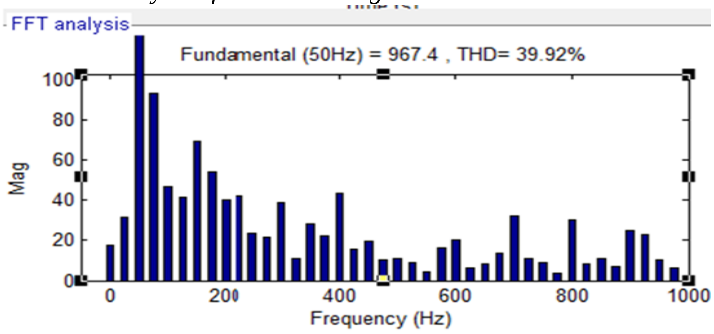

Fig 12.FFT voltage

C. Inverter current

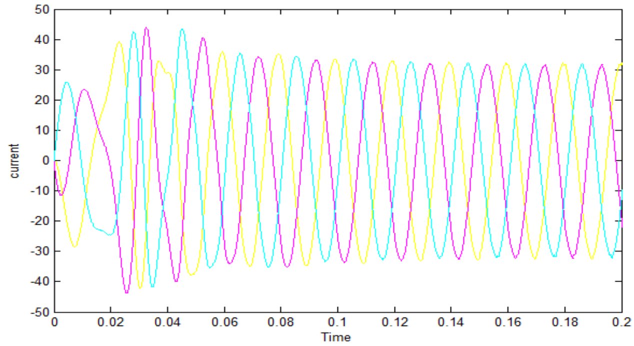

Fig.13 waveform of inverter current

D. FFT analysis of inverter current

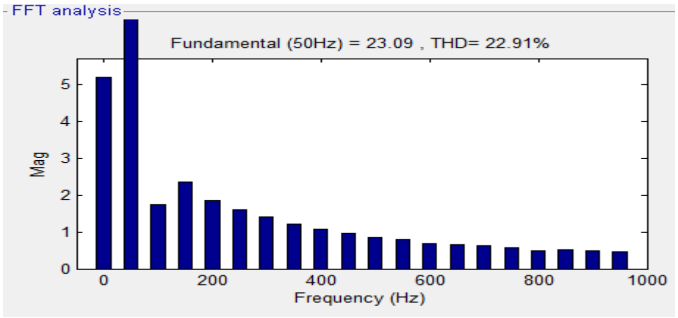

Fig. 14 FFT current

V. MOTOR CIRCUIT

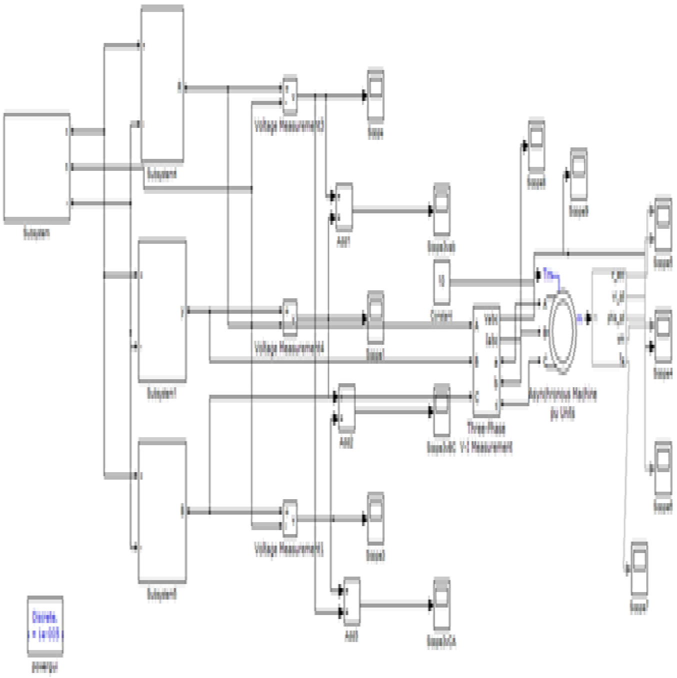

Fig 14. 3 ph. flying capacitor multilevel inverter connected motor circuit

VI. CONCLUSION

This project simulates and implements single phase and three phase flying capacitor MLI. A brief view of the operating principles of single phase and three-phase flying are provided and experimental modules are shown. The single phase and the three phase flying capacitor MLI configurations were individually modeled by MATLAB. Waveforms for the voltage-source inverters, either Single phase or three phase configurations, were figured out in off time by MATLAB

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