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# Simulation of SVM based Three Phase Induction Motor Drive with an Improved Charge Pump Circuit

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***Abstract*— This paper proposes a Space Vector Modulation (SVM) based three phase induction motor drive with an improved charge-pump (CP) circuit. In this paper three phase induction motor is fed with the improved charge pump circuit. The proposed circuit replaces the electric double layer capacitor (EDLC) in the conventional circuit with a normal capacitor. The circuit is redesigned with a coupled inductor and a better charging path for the capacitor. The inductor coupled to the CP circuit enables linear variation of DC link voltage. The CP circuit boosts low level voltages to high output voltage. Open loop speed control of motor is achieved using variable frequency control. The inverter is controlled using SVM technique. Simulation of the proposed model was done in MATLAB/SIMULINK.**

***Keywords—Charge Pump(CP), Electric Double Layer Capacitor(EDLC) , Induction motor.***

## I. INTRODUCTION

Induction motors are widely used in most of the industries. Reason for this is the fact that squirrel cage induction motors are cheap and rugged than its competitor, the DC motor. It has been used in constant and variable speed drive applications.

The motor drive systems used in industries require high speed response. This requirement leads to the usage of boosted voltage.

Fig.1 shows a conventional charge pump circuit. For boosting the DC link voltage, the circuit has electric double layer capacitor ($C_{cp}$-Charge pump capacitor), switches $Q_{c1}$ and $Q_{c2,}$ and diodes $D_1$ – $D_4$.[1]. DC voltage supply $V_s$ is connected to electrical capacitor $C_{nc}$ through diode $D_s$. Supply voltage $V_s$ and diode $D_s$ can be replaced by using a rectifier connected to a single phase or three phase AC voltage supply. Capacitor $C_{nc}$ and diode $D_s$ can be removed if regeneration is needed. As Permanent Magnet Synchronous motor (PMSM) is used in the conventional configuration, torque ripple will be high. And also, the circuit cannot provide a proper charging path for the charge pump capacitor.

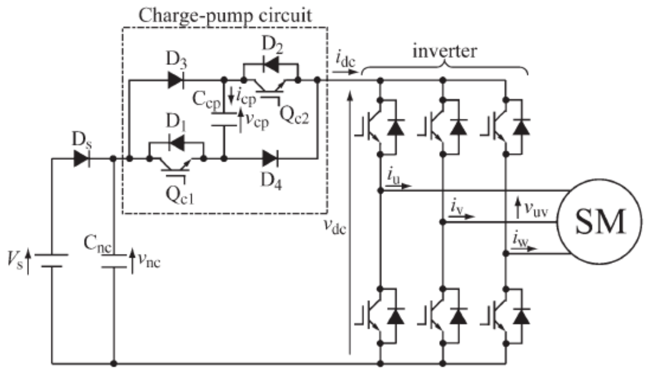


Fig.1: Conventional boost driver with charge pump circuit

In this paper, the conventional circuit is modified in such a way that lesser number of components are used, the EDLC is replaced with ordinary electrolytic capacitor, an inductor is included in the circuit and the charge pump circuit is fed with a three phase induction motor. The boost operation of the proposed circuit is simulated using MATLAB/ SIMULINK.

## II. PROPOSED CONFIGURATION

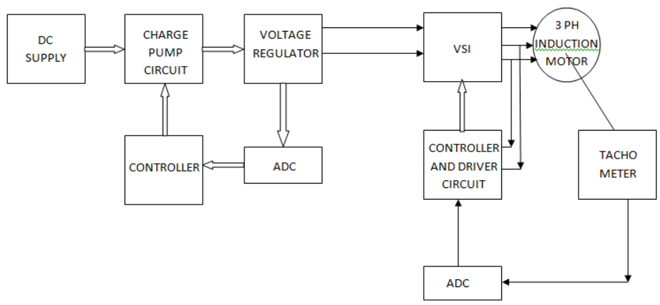


Fig.2: Block diagram of the proposed configuration

Fig. 2 shows the block diagram of the proposed configuration. It consists of a regulated DC supply, a DC-DC converter, which is the improved charge pump circuit to step up the DC link voltage, a voltage regulator to maintained the voltage at a desired value, three phase voltage source inverter (VSI) by which the three phase induction motor is fed, tachometer, which is used to sense the speed of the motor, analog to digital converters (ADCs) to convert analog value to a digital value, and two controllers. The first controller controls the duty ratio of the pulses to the switches of CP circuit and the second controller is for switching the inverter.

## *A. Improved charge pump circuit*

Fig. 3 shows the circuit configuration of the proposed charge pump. The modified charge pump circuit consists of diode D, capacitors $C_1$ and $C_2$, semiconductor switches $Q_1$ and $Q_2$ and a resistor R. The switches used are N channel MOSFETs.

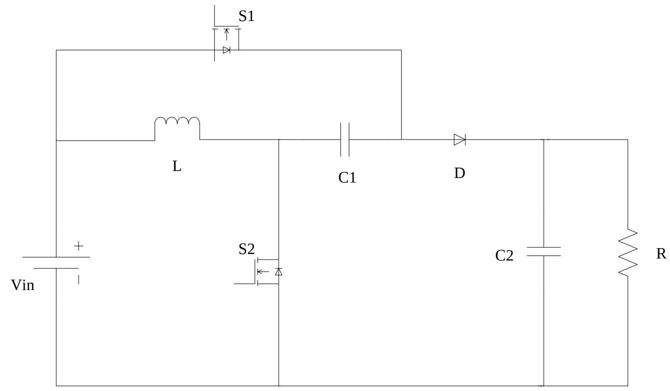


Fig. 3: Configuration of proposed charge pump circuit

The circuit is supplied with a DC voltage of 24V. An inductor is connected in series with the charge pump circuit. The advantage of providing an inductor in series is that, the output voltage of the charge pump (DC-DC converter) can be varied linearly unlike the other charge pumps. The switches are controlled simultaneously. Only a common pulse is needed for the switching of modes. The induction motor speed is controlled by variable frequency control technique. The diode $D_1$ is provided in the simulation model (Fig. 6), in order to prevent back feeding from the induction motor. The induction motor speed is controlled by variable frequency control technique.

There are two operating modes for the proposed improved charge pump circuit. In one mode, the capacitor gets charged and in the other mode, it discharges. In mode one, the switches $Q_1$ and $Q_2$ are kept on till the capacitor $C_1$ charges to $V_{in}$ ; and the inductor L gets energized, following the path shown in Fig. 4.

During mode 2 operation, both the switches are turned on, and the capacitor starts to discharge through the path shown in Fig. 5.

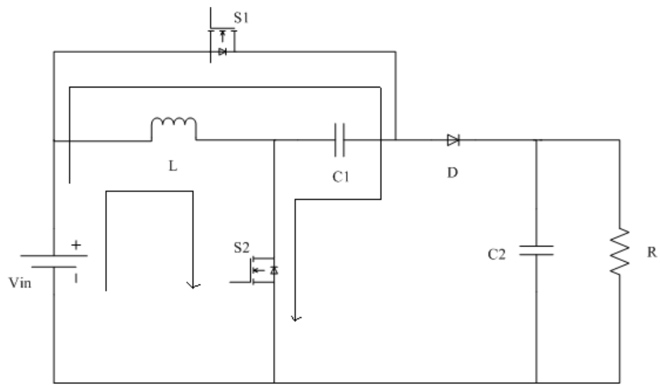


Fig. 4: Mode 1

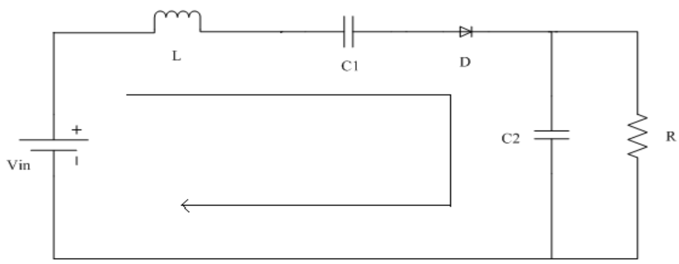


Fig. 5: Mode 2

At this instant, the output voltage will be the sum of input voltage ($V_{in}$), inductor voltage ($V_L$) and the capacitor voltage ($V_{C1}$). ie., the output voltage is given by,

$$V_o = V_L + V_{in} + V_{C1} \qquad (1)$$

where, $V_o$ is the output voltage; $V_L$ is the inductor voltage; and $V_{C1}$ is the capacitor voltage. After mode 1, $V_{C1}$ is equal to $V_{in}$. Therefore,

$$V_o = V_L + 2V_{in} \qquad (2)$$

The inductor voltage varies with the load current. The proposed circuit requires less number of components compared to the conventional charge pumps circuits, and this circuit is very simple.

## *B. Induction motor drive*

The three phase induction motor is fed from a three phase voltage source inverter (VSI). The DC link voltage to the inverter is taken from the output of the charge pump circuit. The inverter switches are controlled using space vector modulation technique.

The induction motor speed is sensed using a tachometer. For speed control applications, the tachometer value gives the actual value of speed and it can be compared with the reference speed value to achieve the required speed. Control pulses to the inverter switches are generated by the controller circuit, and it depends on the desired speed. Variable frequency control technique is used in the simulation to perform open loop speed control.

## III. SIMULATION

Simulation model for the proposed system is shown in Fig 6. The switches of charge pump circuits are turned on and off simultaneously. Therefore, only a single pulse generator is needed to provide the switching pulses for the charge pump switches.

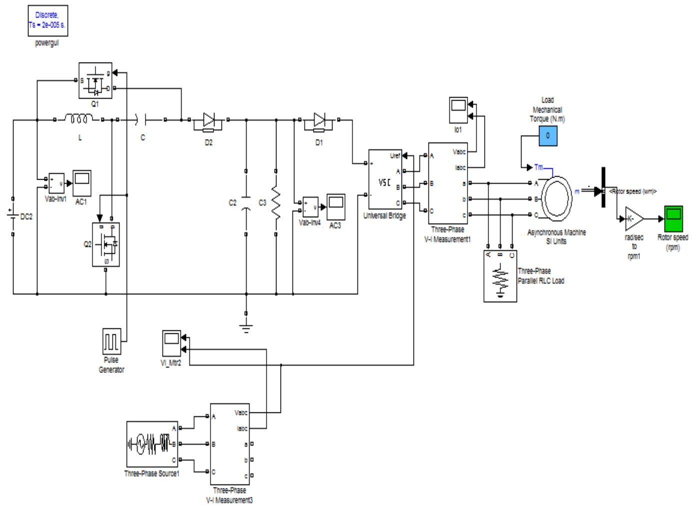


Fig. 6: Simulation diagram of SVM based three phase induction motor drive with the improved charge pump circuit

The charge pump is supplied with a 24V DC supply. The output voltage of the charge pump circuit varies with the duty ratio of the pulses given to the switches. The boosted voltage is given to the VSI which feeds the three phase induction motor. Open loop speed control of the motor is achieved using variable frequency control technique.

## IV. RESULTS

The output voltage waveform of the CP circuit for input voltage 24 V and different duty ratios are shown.

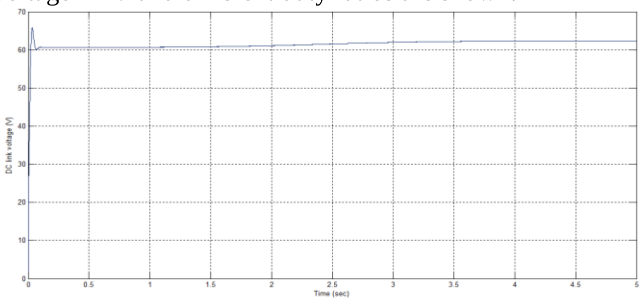


Fig. 7: DC link voltage (CP Output) at duty ratio 40 %

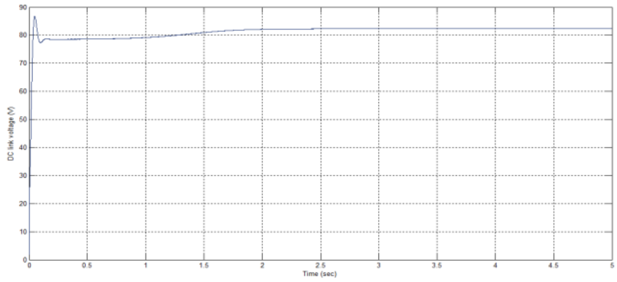


Fig. 8: DC link voltage (CP Output) at duty ratio 60 %

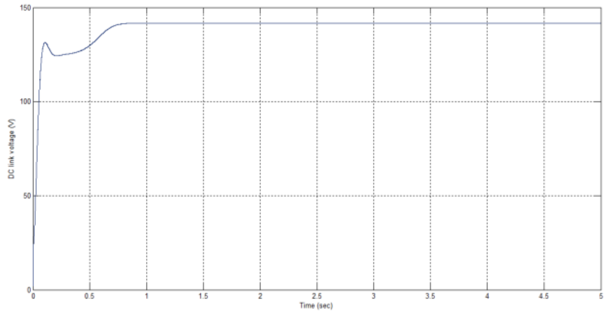


Fig. 9: DC link voltage (CP Output) at duty ratio 70 %

The output voltage obtained from the charge pump circuit at 40 % duty ratio was 62 V. For a duty ratio of 60 % the output voltage obtained was 82 V. When 70 % duty ratio was set, 140V was obtained at the charge pump output.

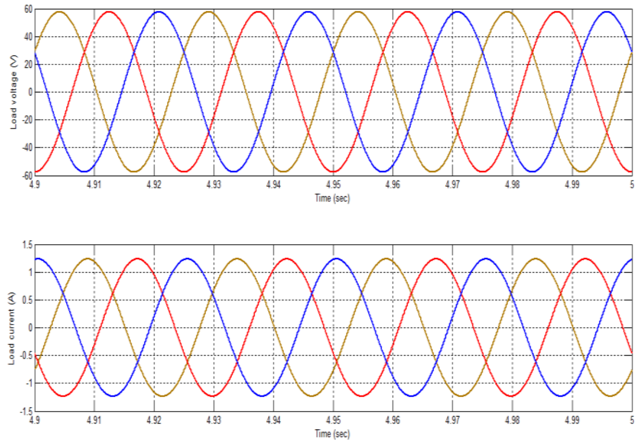


Fig. 10: Load voltage and current at set duty ratio 50%

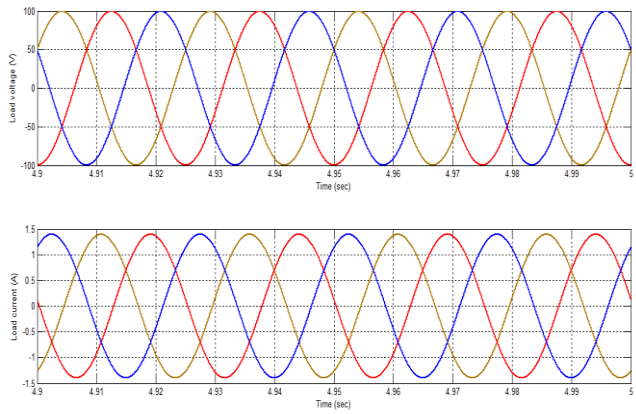


Fig. 11: Load voltage and current at set duty ratio 70%

From the wave forms of voltage and current it can be concluded that the output power of the motor can be controlled by varying the duty ratio of the switches of the converter (CP circuit). When duty ratio of the pulses to the CP circuit switches is 50 %, load voltage is found to be 60 V and the load current is 1.25 A. When the duty ratio is 70%, load voltage is 100V and load current is 1.4A.

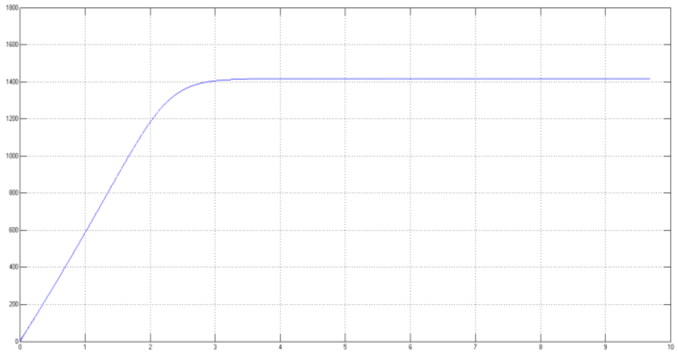

Fig. 12: Speed of motor at 50 Hz (1440 rpm)

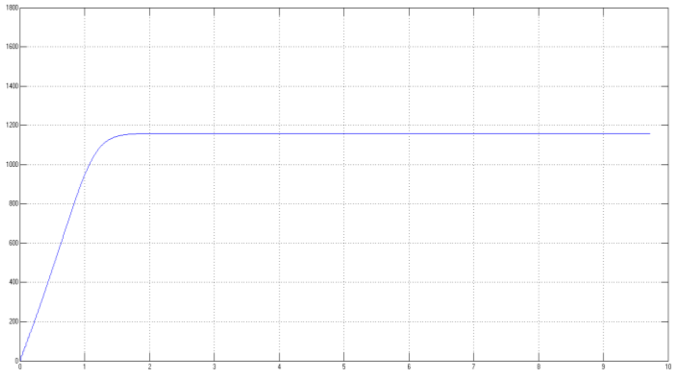

Fig. 13: Speed of motor at 40 Hz (1150 rpm)

Fig. 12 and 13 shows the speed curve of the when different frequencies are set. The motor speed increases with increase in frequency and vice versa with in a particular limit. For a frequency of 40 Hz, the motor attained a speed of 1150 rpm, and for a frequency of 50 Hz, the motor attained a speed of 1440 rpm.

## V. CONCLUSION

SVM based three phase induction motor employing an improved charge pump circuit was simulated in MATLAB/Simulink and high step up voltage of the proposed charge pump circuit was observed. The obtained output voltage was more than 5 times the input voltage. The use of inductor in series enables linear variation of the output voltage
of the CP circuit, unlike the inductor less charge pumps. The main advantage of the improved charge pump with series inductance is high DC voltage gain. High step up ratio is obtained with the improved charge pump circuit. As SVM technique is used to give the switching pulses to the inverter, and also due to lesser number of components in the proposed circuit, compared to the conventional, losses will be less. Motor speed is controlled in open loop using variable frequency method. Duty ratio of the pulses to the CP circuit can be varied to control the output power of the motor. This circuit can be implemented in industries where high voltage supplies are required.

## REFERENCES

[1] Hirokazu Matsumoto and Yasuhiko Neba, "A boost driver with an improved charge-pump circuit",IEEE Transactions on Industrial Electronics, volume 61, no.7, pp.3178-3191, July 2014.
[2] K. I. Hwu and Y. T. Yau, "A novel voltage-boosting converter: KY converter", in Proceedings IEEE Applied Power Electronics Conference, volume 1, pp. 368372, 2007.
[3] Wensong Yu, Member et.al, "High E_ciency Converter with Charge Pump and Coupled Inductor for Wide Input Photovoltaic AC Module Applications", IEEE Transactions On Industrial Electronics, pp. 3895-3900, 2011.
[4] Istiaque Islam et.al"Charge Pump Capacitor Based High Voltage Gain DC-DC Step-Up Converter",3rd International Conference On Informatics, Electronics Vision, 2014.
[5] Kuo-Ing Hwu and Tso-Jen Peng,"High-voltage-boosting converter with charge pump capacitor and coupling inductor combined with buckboost converter",IET Power Electronics,Volume 7, Issue 1, pp. 177188, 2014.
[6] K. I. Hwu and Y. T. Yau, "Voltage-Boosting Converter Based on Charge Pump and Coupling Inductor With Passive Voltage Clamping", IEEE Transactions On Industrial Electronics, Volume 57, No. 5, MAY 2010.