Modelling and Design of Power electronic converter to Drive Electrical Machines

I. History and Motivation:

Recently, the multilevel converter is widely applied in the industries because the demand to operate switching, power converters in high power application has the development continuously. The ability of multilevel converters to operate at high voltages of the AC waveforms has low distortion, high quality and high efficiency. However, the multilevel converter [1] technology has improved efficiency by employing various controls to achieve the high efficiency and maximize to save energy.

Machines are treats as horses to drive the industries. So most of the research work going in this area. Any fault in a machine will have direct and significant impact on the overall plant economy. It is necessary not only to detect a fault (which is the easy part) but also isolate and identify a fault. We seek a framework for machine fault diagnosis that provide a reliable estimate of fault location as well as fault severity.
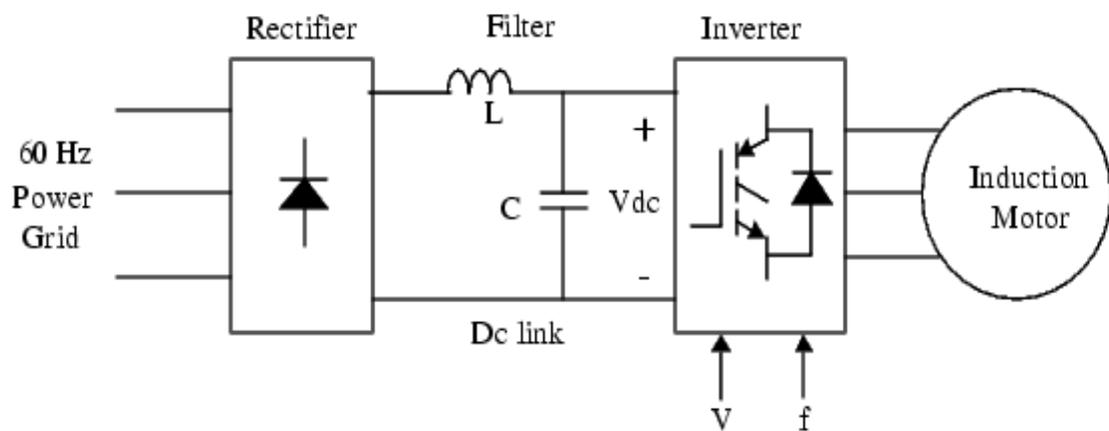

Fig.1. Inverter Based I.M Drive

Now days, Special machines are fulfilling society requirements efficiently in various applications. Those machines are Hysteresis motor, linear induction motor, brush less DC motor, reluctance motor *etc..,* so speed torque control and fault analysis of those machines is really headache for electrical engineers now.

II. Literature Survey:

The advanced power electronic technology, more high frequency switching products has been widely used in home electronic equipment and the industry applications. Generally such systems use a diode bridge rectifier followed by a capacitor filter as the primary unregulated dc voltage. Low power factor and high input current harmonics from the ac mains are the main disadvantages of a diode bridge rectifier.

- Voltage source multilevel inverters have received much attention of researchers and industries, because they 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. For medium voltage inverters, cascaded H-bridge (CHB), neutral point clamped (NPC), and flying capacitor (FC) are the primary topologies. In this NPC works very well compare to other power electronic converter circuits,

- The main features of the NPC converter include reduced *dv/dt and Total Harmonic Distortion (THD) in its AC* output voltages in comparison to the conventional two level converter.

- As in any multilevel converter it can be used in the medium-voltage applications to reach a certain voltage level without series connection of power semiconductors.

- NPC inverter uses diodes to clamp the voltage levels generated at the dc-link capacitors to the output.

- Excessive number of diodes, unbalanced operation of dc-link's voltage divider capacitors, and uneven distribution of loss among switches are major problems of this topology.
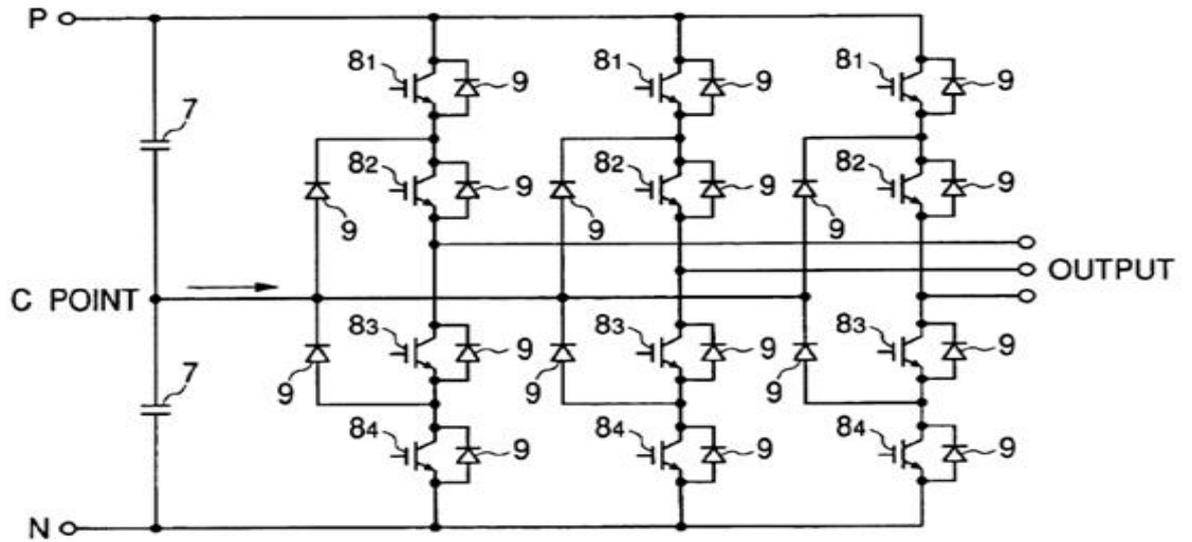
Fig.2. NPC based Inverter to fed I.M.

Flying Capacitor inverter uses capacitors to generate output voltage levels. The availability of intra-phasal redundant states in this topology can provide both capacitor voltage balancing and power loss distribution among switches. However, increased number of flying capacitors at higher levels that increases the initial cost and maintenance surcharges and decreases the reliability of the inverter along with the capacitor precharge in some applications are the main drawbacks of this topology.
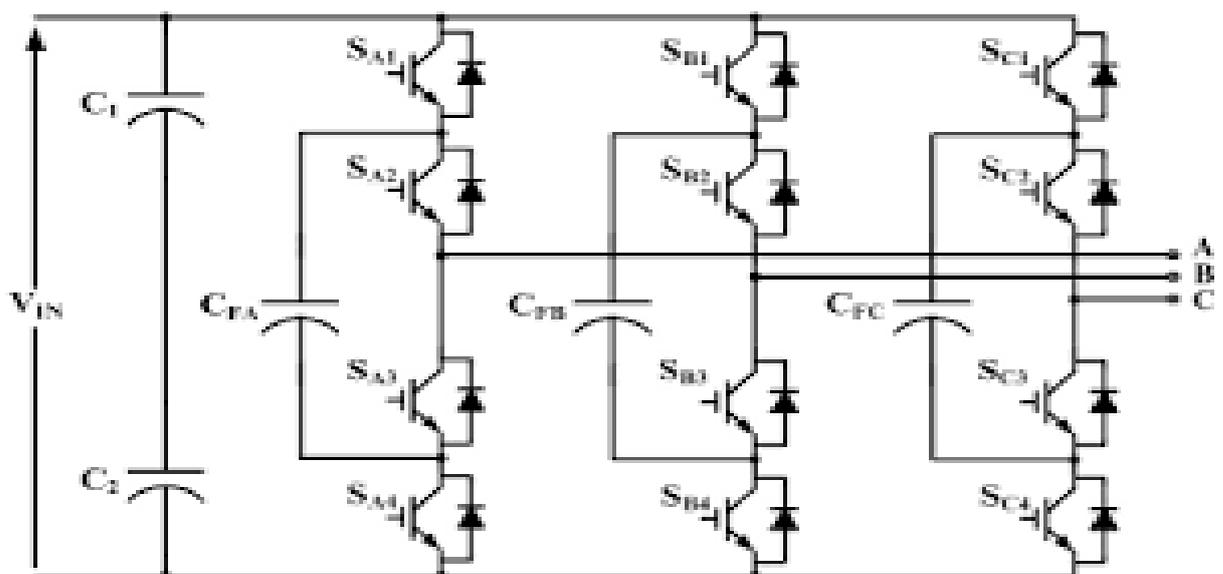
Fig.3. FC based Inverter to fed I.M.

As the name suggests this multilevel inverter uses full H-Bridges connected is series to produce inverted AC from separate DC sources. These DC sources can be any natural resource such as sunlight or wind energy or anything. It does not need any capacitors or diodes for clamping. The wave is quite sinusoidal in nature even if you don't filter it. This was all about cascaded H-Bridge multi -level inverters. Due to their advantages they are often used now-a-days. More of the inverters types are still there which are extensively used and will be discussed in the upcoming tutorials. So keep visiting to know more about them and their uses and advantages as well.
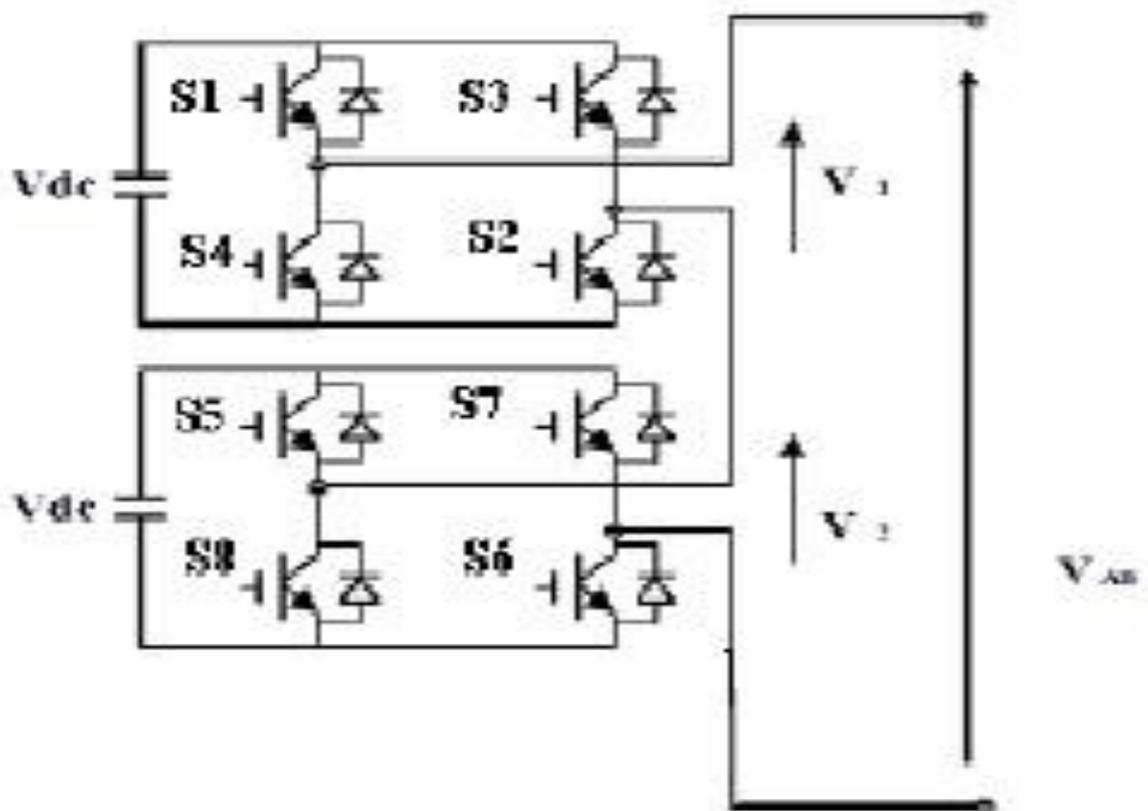
Fig.4. Cascade H Bridge based Inverter

Hybrid topologies are viable solutions where higher number of levels is required. Combining the advantages of CHB, FC, and NPC, hybrid inverters can provide loss and voltage balancing while keeping the number of components low.

III. Proposed Method:

a) Increasing No. of inverter levels:

    i)   Fault Analysis of Induction motor with 11 Level cascaded H bridge inverter

    ii)   Fault Analysis of Induction motor with 11 Level NPC based inverter

    iii)   Fault Analysis of Induction motor with 11 Level Diode Clamped based inverter

b) Increasing No. of phases of Machines:

    i) CHB based 45 phase induction motor

    ii) NPC based 45 phase induction motor

    iii) Diode clamed 9 phase induction motor

c) Design of control unit:

PWM control tuning strategies

    i)   Genetic algorithm

    ii)   Real coded Genetic algorithm

    iii)   Neural and Fuzzy Logic

References:

[1] Leon M. Tolbert, Fang Zheng Peng, and Thomas G Habetler, "Multilevel Converter for Large Electric Drives," IEEE Trans. On Ind Applications, vol.35, No.1 January/February 1999,pp. 36-44.

[2] Leon M. Tolbert, John N. Chiasson, Zhong Du, Keith J. McKenzie, "Elimination of Harmonics in a Multilevel Converter Eith Nonequal DC Source," IEEE Trans. On Ind. Application, vol. 41, No. 2, January/February 2005, pp.75-82.

[3] Bor-Ren Lin Hsin-Hung Lu, "Implementation of Three-level AC/DC/AC converter with power factor correction and harmonic reduction" IEEE 1998, 1-3 Dec. 1998, pp. 768-773.

[4] S. Sirisukprasert, J.S. Lai and T.H. Liu, "Optimum Harmonic Reduction with a Wide Range of Modulation Indexes for Multilevel Converter," CPES. pp. 212-217.

[5] S. Sirisukprasert, J.S. Lai and T.H. Liu, "Optimum Harmonic Reduction with a Wide Range of Modulation Indexes for Multilevel Converter," IEEE Trans. On Ind. Electronics, vol. 49, No. 4, August 2002, pp. 875-881.

[6] Leon M. Tolbert, John N. Chiasson, Zhong Du, Keith J. McKenzie," Elimination of Harmonics in a Multilevel Converter With Nonequal DC Sources," IEEE Trans On Ind. Application, Vol.41 No. 1, January/February 2005, pp. 75-82.

[7] P.C.SEN., Principles of Electrical Machines Power Electronic, 2nd ed., John Wiley&Sons, Inc. New York 1994.

[8] Bor-Ren Lin Hsin-Hung Lu, "A novel Multilevel PWM Control Scheme of the AC/DC/AC Converter for AC Drives," Vol2, pp. 795-800 Industrial Electronics, 1999. ISIE99. 12-16 July 1999.