Cascaded H-Bridge Inverter Configuration For Transformer Less Traction System

Sanghvi Shukla[1], P.Yadav[2]
[1]*M.Tech Student, Electrical &Electronics Engineering, OCT, Bhopal, India*
[2]*Professor, Electrical & Electronics Engineering, OCT, Bhopal, India*

Abstract – This paper represents the application of inverters in the railway traction system without the use of transformers. The proposed system is designed by replacing transformer with a cascaded rectifier inverter circuit. The output of this configuration is fed to induction motor which helps in the movement of the tractive system. The PWM technique is used in the inverters to provide the gate pulses to the inverter. The overall system is simulated using MATLAB/Simulink software to get the desired output.

Keywords – Inverters, Induction motor, Rectifier, Transformer, Traction system, PWM technique.

1. INTRODUCTION

Due to improvement of fast switching, power electronic inverters are becoming popular for various industrial drive applications. In the recent years, high power and medium voltage drive applications have been installed. To overcome the problem of limited semiconductor voltage and current ratings, some kind of special series and/or parallel connections are necessary. Due to their ability to synthesize waveforms with a better spectrum and attain higher voltages, multilevel inverters are receiving attention in the past few years. The multilevel inverters were introduced as a solution to raise the converter output voltage above the voltage limits of the semiconductors that were used earlier. The multilevel voltage source inverters are recently used in many industrial applications such as AC power supplies, static VAR compensators, drive systems etc. One of the major advantage of multilevel configuration is the harmonic reduction in the output waveforms without increasing switching frequency or decreasing the inverter power output.

Electric Railway Traction System

Electric railway traction drive system has been introduced as a solution to environmental problem that are caused by the use of diesel or steam engines. Generally, an AC electrified railway system is supplied with 25kV, 50Hz AC supply. It is fed to the traction motor after stepping down it to three phase, 415 V, 50 Hz with the help of a transformer. This transformer leads to high weight, several losses and reduced efficiency. The railway electric traction drive system requires high voltage operation. This is achieved with the help of multilevel inverters. Among all the multilevel inverters, cascaded multilevel inverters are best suited for railway traction applications because of its modular structure and the use of low rating devices. The three phase induction motors are widely used in the railway traction drive system because of its low cost, less weight, better torque characteristics, high reliability and less maintenance due to the absence of the brushes.

2. SYSTEM MODEL

The block diagram of traction system using inverter and rectifier configuration is shown in fig.1. It consists of 25kV AC supply, rectifier and inverter configuration circuit, induction motor. The 25kV AC supply from the pantograph is initially fed to the rectifier, where the 25kV AC gets converted to 415 volts DC. Then this DC this passed to inverter, which further converts this 415 volts DC to 400 volts AC.

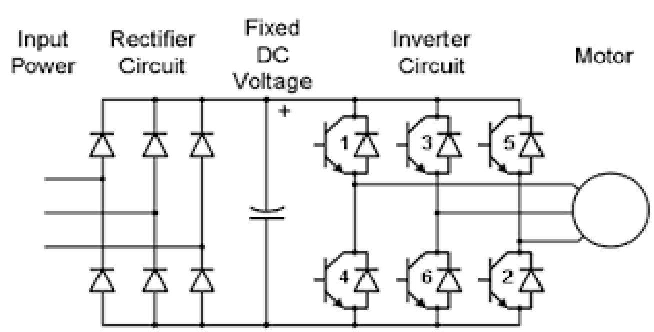

Fig.1. Block diagram of railway traction system using rectifier inverter configuration.

The AC output voltage from the rectifier inverter circuit is further passed to filter circuit to remove the unwanted signals and the output voltage waveforms of the inverter circuit that is further fed to the induction motor. This induction motor further helps in operation of the traction system. The inverter circuit used here is a three phase two level inverter. The gate pulses to IGBT based inverter circuit is provided using PWM generator i.e. the PWM control technique is used to generate the gate signals which are further fed to the two level inverter. The induction motor is used in the traction system, since it is advantageous over DC motor which was used from the past few decades.

3. PROPOSED METHODOLOGY

The proposed transformer less traction system used in the railways using cascaded rectifier inverter configuration is shown in fig.2. A 50Hz , inverter source feeds a 50 Hz, 3730 VA load through an AC-DC-AC converter. The 415 volts, 50 Hz voltage is first rectified by a six pulse diode bridge. The filtered DC voltage is applied to an IGBT two level inverter generating 50 Hz. The IGBT inverter uses PWM (pulse width modulation) technique at a 2 kHz carrier frequency. The circuit is discretised at a sample of 2 μs.

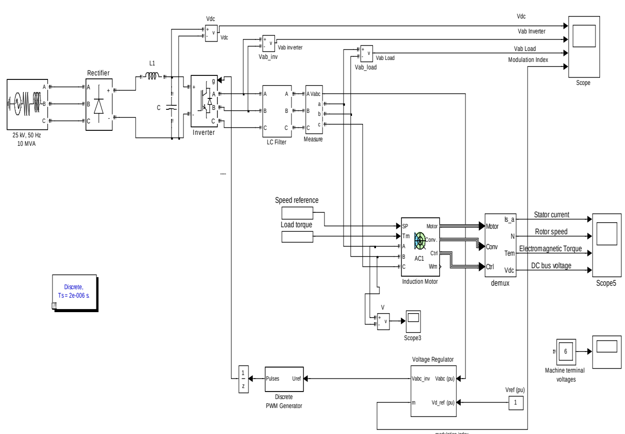

Fig.2. Proposed simulink model of transformerless traction system using rectifier inverter configuration.

The load voltage is regulated at 1pu by a PI voltage regulator using abc_to_dq and dq_to_abc transformations. The first output of the voltage regulator contains the three modulating signals used by the PWM generator to generate the 6 IGBT pulses. The second output produces the modulating index. The output waveforms of this circuit is shown in the following figures. A positive current indicates a current flowing in the IGBT, whereas a negative current indicates a current flowing in the anti-parallel diode.

4. SIMULATION/EXPERIMENTAL RESULTS

It can be seen that the supply voltage of 25kV has been reduced to 400V which is the rated voltage of motor. When supply is cut off, the voltage gradually becomes zero and during braking a constant DC supply is used. The electromagnetic torque developed by the induction motor drive can be seen in Fig.3. At starting, a high torque was developed. After sometime, the supply is cut off, hence torque approaches zero and after that a negative value when DC dynamic braking is applied and the torque became negative and this is the braking torque

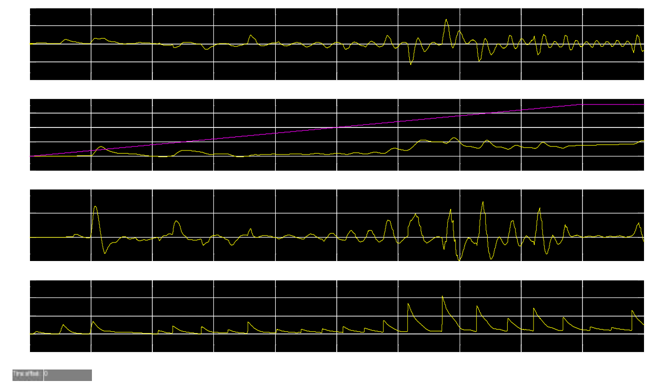

Fig.3. Output waveforms of speed, torque, current of induction motor.

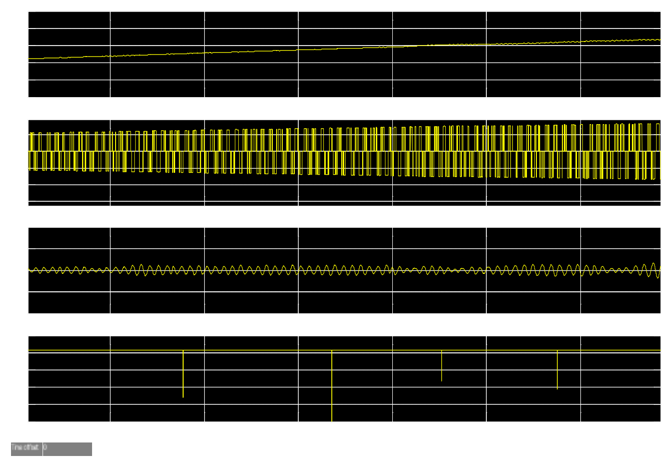

Fig.4. Output waveforms of inverter circuit used in the traction system.

Fig.4 shows the output rms current of the inverter that is supplied to the induction motor. Fig.3 shows the stator current of the induction motor. It can be seen that when a DC supply is given to the IMs, the stator current is also a DC.

5. CONCLUSION

It is found that the cascaded multilevel rectifier and inverter can be used in the traction drive of the railway system. It can step down the supply voltage to the rated voltage of the induction motor. Hence, it eliminates the need of the transformer. This leads to a transformer less railway traction drive. This further improves efficiency, causes reduction in floor area, reduction in losses.

6. FUTURE SCOPES

The levels of the inverters can be further increased in order to improve the efficiency of the system. The inverter that is used in the traction system can be used using various other modulation techniques. Direct torque flux control strategy, Vector control technique can be used in the induction motor of the traction system.

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AUTHOR'S PROFILE

Sanghvi Shukla has received her Bachelor of Engineering degree in Electrical & Electronics Engineering from Oriental College Of Technology, Bhopal in the year 2013. At present she is pursuing M.Tech. with the specialization of Power Electronics in Oriental College Of Technology, Bhopal. Her area of interest are Power electronics, Power Systems, Transformers.

P.Yadav is working as a Head Of The Electrical And Electronics Department at Oriental College Of Technology, Bhopal. His areas of interests are Power electronics, Electrical Drives, Power Systems.