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Analysis and Modelling of Nine-Switch Inverter for Three Phase R & R-L Loads

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Abstract— Power Electronics plays a vital role in the indsutrial apllication.Almost all the loads utilizing the three phase supply, to control the three phase loads inverter technology contribute a big role.There are mainly two methods for inverter control. The first method is to provide two inverters to control two loads. The other method is to connect two loads in parallel and driving them with a single inverter. The first method requires a bulky and expensive setup while other method cannot control two loads independently. To overcome these difficulties, nine-switch inverter is proposed that can independently control two three phase loads. This paper introduces the structure of the nine-switch inverter, which is made from nine switches. The validity of the proposed inverter is verified through simulation and experiments.

Key words: Nine-Switch Inverter, Induction Motor, Pulse-width modulation, Driver-circuit, converters

I. INTRODUCTION

Inverters are used as dc/ac converters to control the frequency and the amplitude of the voltage applied to ac loads. The development of electric vehicles (EV) and hybrid electric vehicles (HEV) has offered many challenges to the power electronics industry. In recent decades, much research efforts have been taken directed towards finding an isolated dc-ac converter that effectively processes the energy. In a three phase inverter drives only one load it cannot control more than one load. In many cases there are two or more ac loads, which require independent control. The application such as traction system, hybrid vehicle, helicopters, robotics etc deals with more than one motor. In particular, there are two methods of controlling dual motors: providing two separate inverters to drive each motor and connecting the two motors in parallel and driving them through a single inverter. While designing power electronics circuitry it is focused to reduce the number of active and passive element. The step ahead in this field is by designing a five leg inverter which adopts a sharing configuration, where two three-phase motors are controlled by four independent phase-legs and a fifth shared phase-leg. The number of switches saved here is two as compared to conventional method. Further modification to this topology leads to the invention of Nine Switch Topology for the inverter .This topology has the merits of low cost, easily controlled and high reliability. In this topology, the switch count is reduced by one as compared to previous modification and by three as compared to conventional method. This reduces the components required for the gate driver circuit and cost.

II. STRUCTURE OF NINE SWITCH INVERTER

A. Basic Topology:

The structure of the nine-switch inverter is presented in Fig.1. This consists of two three-phase inverters combined with three common switches (RM, YM and BM). The upper portion in Fig. 1 is called Inv1, and the lower part is called Inv2. The Inv1 consists of switches RH, YH, BH, RM, YM and BM. and Inv2 consists of the switches RM, YM, BM, RL, YL and BL. Thus the switches RM, YM and BM are shared by Inv1 and Inv2.The balanced loads are supplied from these inverters.

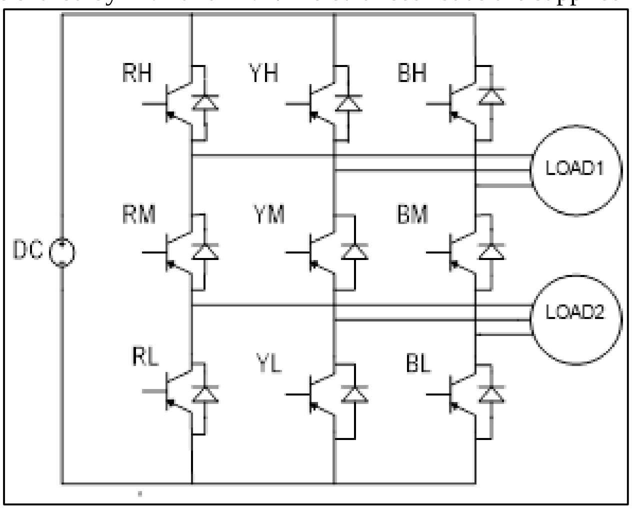

Fig. 1: Main circuit of proposed nine-switch inverter

B. Basic circuit for pulse generation:

Fig.2. shows the basic circuit for pulse generation. The gate signals for upper switches i.e. RH, YH and BH of a leg are generated by comparing the carrier signal and upper reference signal. The gate signals for lower switches i.e. RL, YL and BL are generated from the carrier signal and lower reference signal. The gate signals for mid switches i.e. RM, YM and BM are generated by the logical XOR of the gate signals for upper and lower switches. Only two switches are ON in one leg with this method.

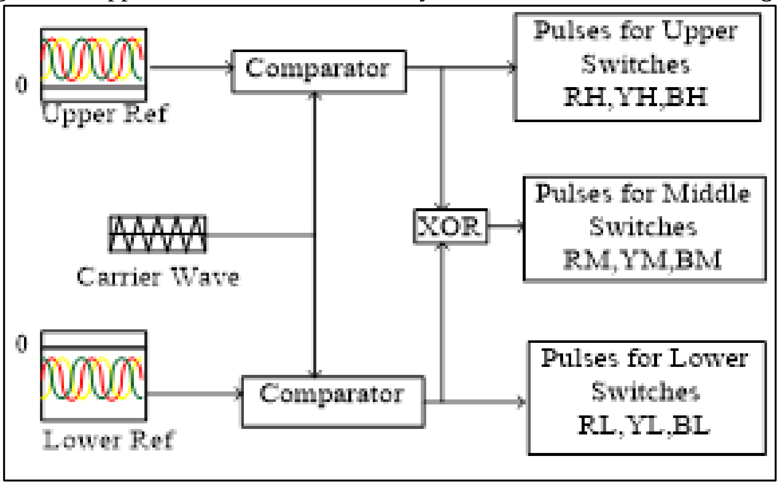

Fig. 2: Basic circuit for pulse generation

C. Principle Of Operation:

The two sinusoidal reference signals are required for controlling the output voltages of nine switch inverter. The pulse width modulation of *Inv1* is obtained at the upper part of a triangular wave, and the pulse width modulation of *Inv2* is calculated at its lower part, as shown in Fig. 3. Let voltage reference for *Inv1* is V_U^{ref} and voltage reference for *Inv2* is V_L^{ref}. Assume that V_U^{ref} and V_L^{ref} are given by

$$V_U^{ref} = A_1 \sin(2\pi f_U + \phi_1)$$

$$V_L^{ref} = A_2 \sin(2\pi f_L + \phi_2)$$

where A1 and A2 are the amplitudes, f_U and f_L are frequencies and Φ_1 and Φ_2 are phases

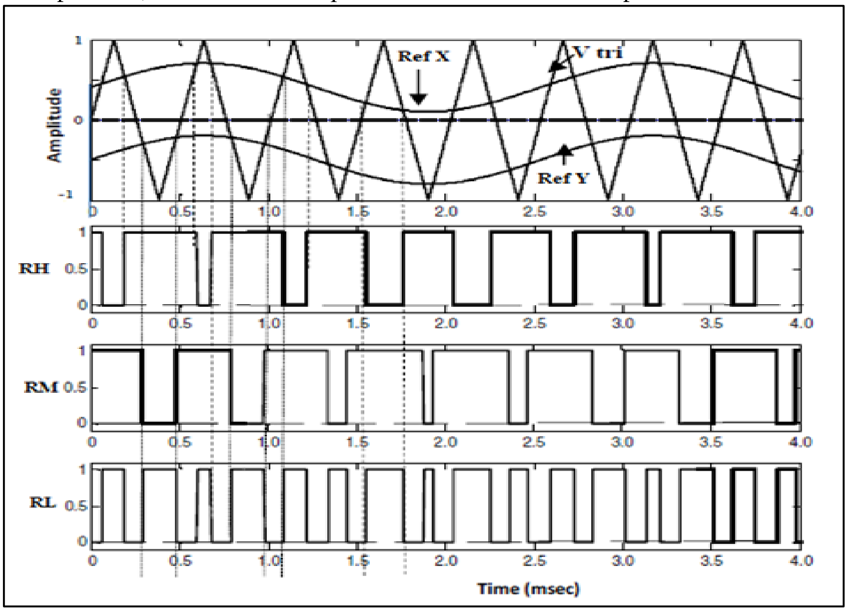

Fig. 3: Reference signal for Inv1 (Ref X), Reference Signal for Inv2 (Ref) and carrier signal (VTri)

The gating signal for the switch RH is generated by comparing reference signal (VUref) with the upper half of the triangular waveform. Similarly, by comparing lower reference signal (VLref) with lower half of the triangular waveform to get the pulse for switch RL. The gating signal for the middle switches is obtained by XORing the signal obtained for upper and lower switch. For e.g. Gating pulse for switch RM is the XOR for the gating pulse for RH & RL.

III. SIMULATION

A simulation performed to verify the validity of the proposed inverter. In this simulation, we impose a different reference on each inverter. The reference for Inv1is a three phase sine wave with an amplitude of 4[V] and a frequency of 50Hz, the reference for Inv2 is a three-phase sine wave with an amplitude of4[V] and a frequency of 100Hz. A three phase R-L load is connected to each inverter. Table I shows the simulation parameters. These results indicate that the nine-switch inverter can independently control amplitude and frequency for two loads.

DC Source Voltage	40 V
Frequency of Carrier	10 kHz
Resistance	47 Ω
Inductance	15000 µH

TABLE 1: PARAMETERS OF SIMULATION

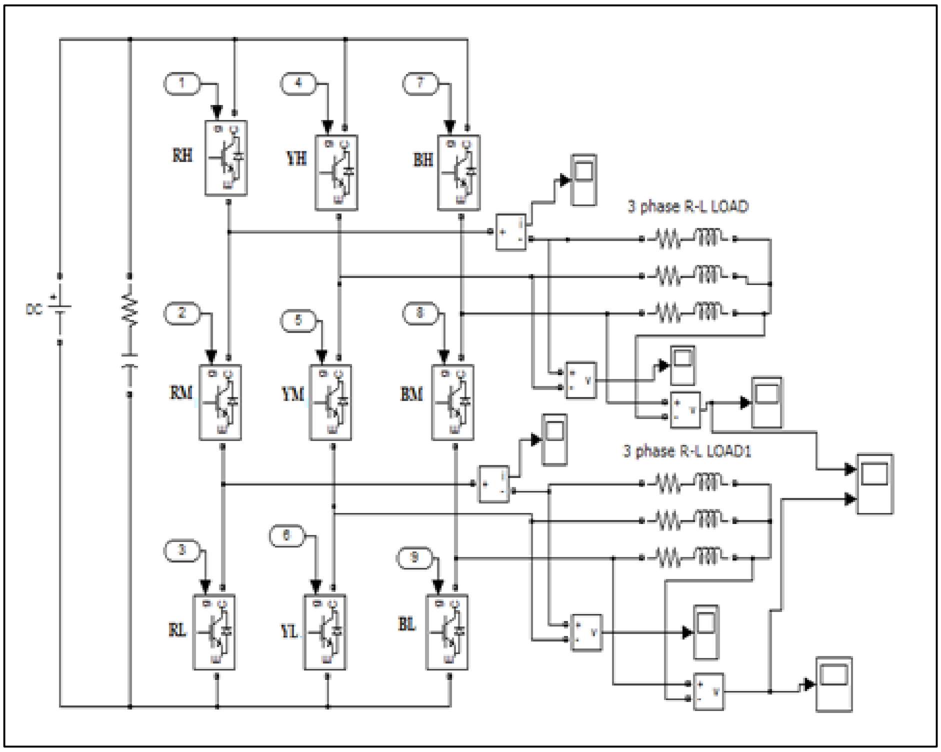

Fig. 4: MATLAB/simulink block of Nine switch Inverter

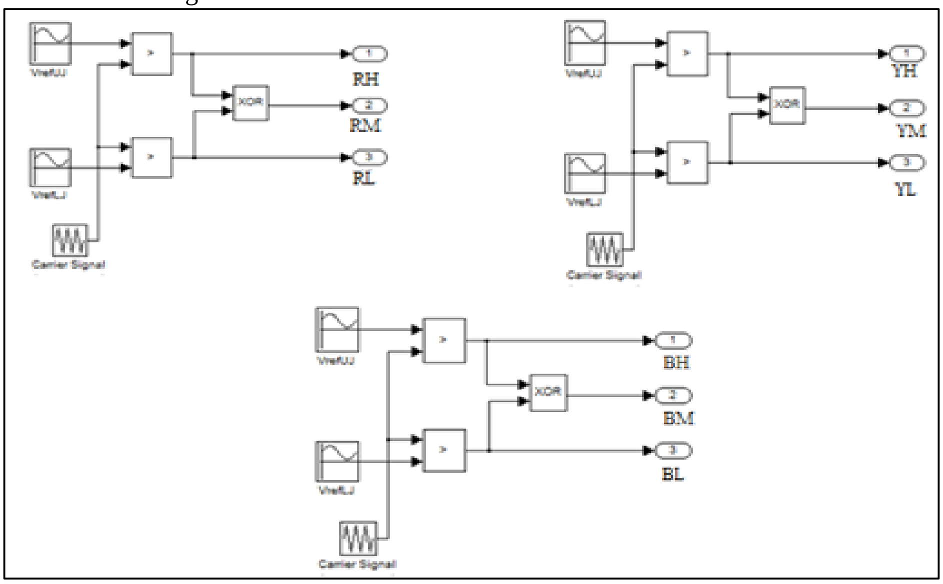

Fig. 5: MATLAB/simulink block of PWM scheme employed in Nine switch Inverter

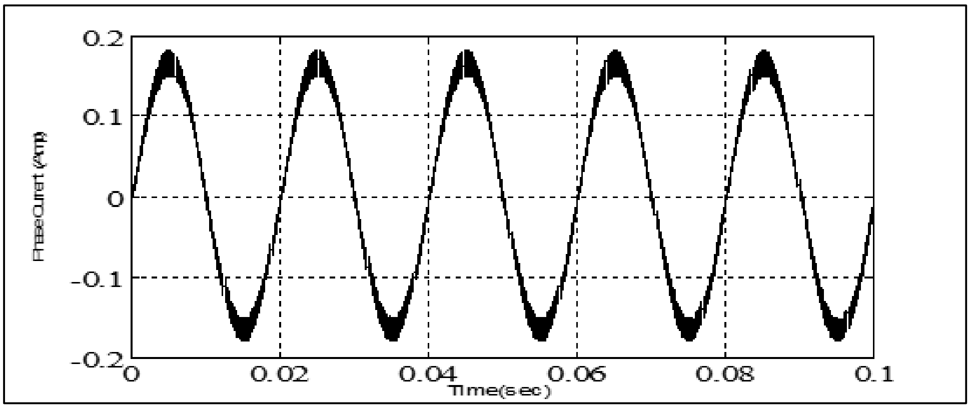

Fig. 6: Simulated phase current of Inv1 (R-phase).The reference for Inv1 is a three-phase sine wave with an amplitude of 4 [V] and a frequency of 50 [Hz].

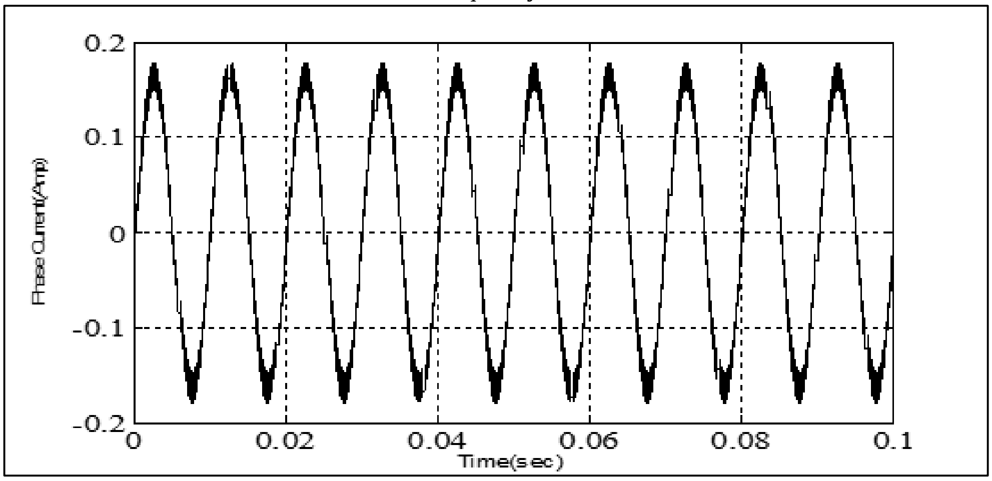

Fig. 7: Simulated phase current of Inv2 (R-phase).The reference for Inv2 is a three-phase sine wave with an amplitude of 4 [V] and a frequency of 100 [Hz].

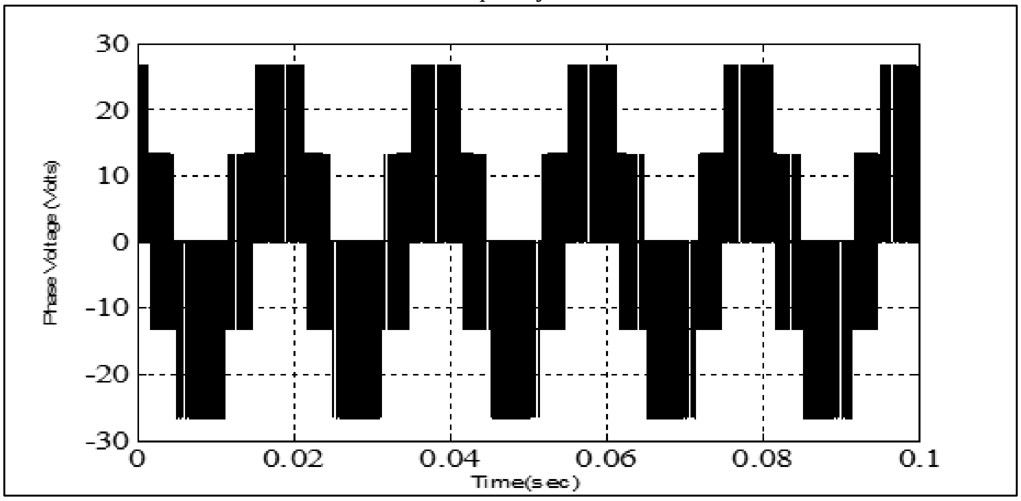

Fig. 8: Simulated phase voltage of Inv1 (R-phase).The reference for Inv1 is a three-phase sine wave with an amplitude of 4 [V] and a frequency of 50 [Hz].

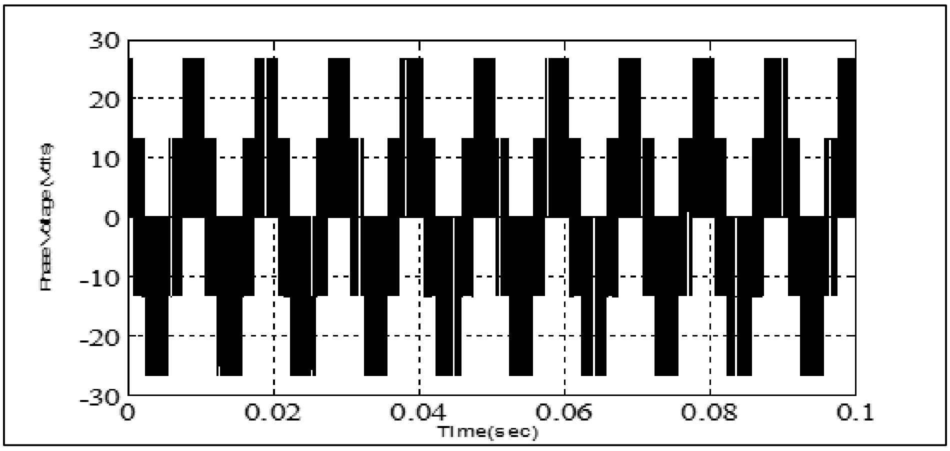

Fig. 9: Simulated phase voltage of Inv2 (R-phase).The reference for Inv2 is a three-phase sine wave with an amplitude of 4 [V] and a frequency of 100 [Hz].

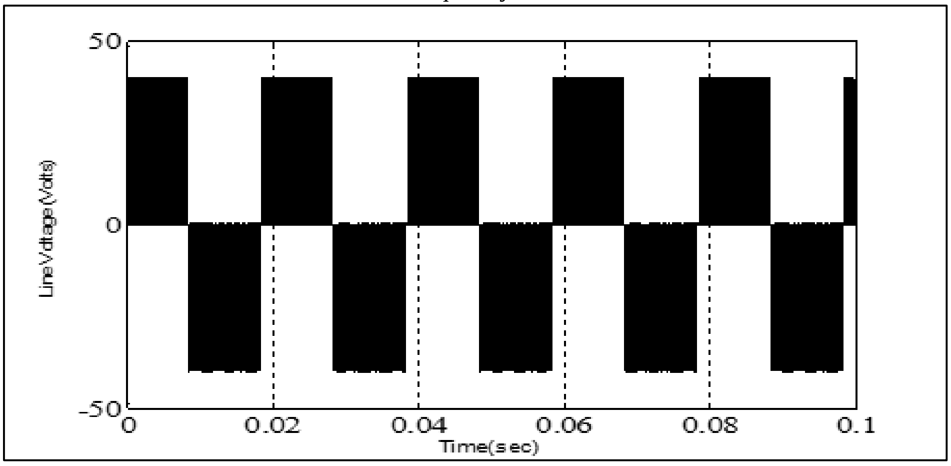

Fig. 10: Simulated line voltage of Inv1.The reference for Inv1 is a three-phase sine wave with an amplitude of 4 [V] and a frequency of 50 [Hz]

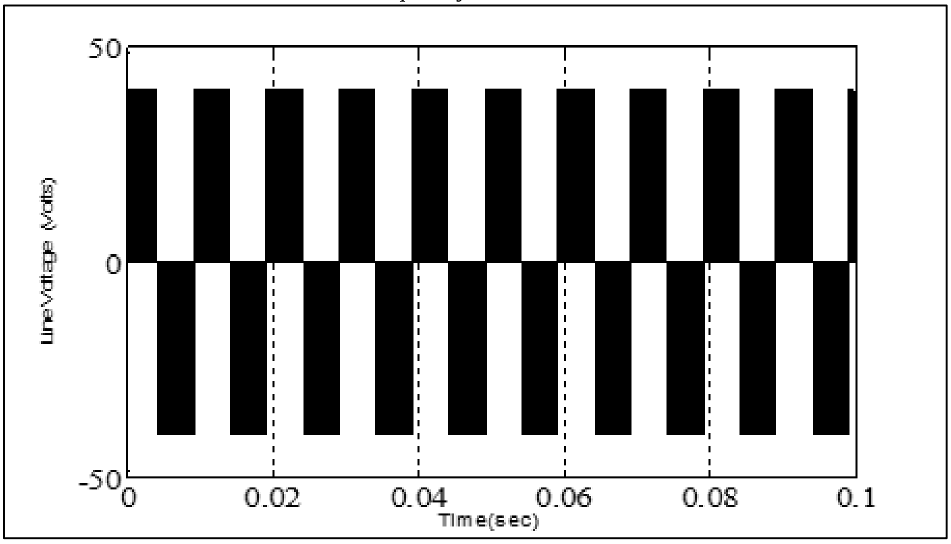

Fig. 11: Simulated line voltage of Inv2.The reference for Inv2 is a three-phase sine wave with an amplitude of 4 [V] and a frequency of 100 [Hz].

IV. CONCLUSION

This paper proposes a nine switch inverter and a PWM method that can independently control two three-phase loads. The simulation has been performed to verify the validity of the proposed inverter. The results confirmed that the nine-switch inverter can independently control amplitude and frequency for two three-phase loads.

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