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Advanced technique with Nine IGBTs for Three-Phase Three-Leg AC/AC Converter

1. G.Gopal, Assistant Professor, EEE Department, Mahatma Gandhi Institute Of Technology

2. Bojja narsimha Reddy, Assistant Professor, EEE Department, Mahatma Gandhi Institute Of technology

Abstract:

This paper proposes a novel three-stage nine-switch ac/ac converter topology. This converter highlights sinusoidal sources of info and yields, solidarity input power factor, and all the more critically, low assembling cost because of its decreased number of dynamic switches. The working guideline of the converter is expounded; its modulation plans are examined. Mimicked semiconductor misfortune examination and correlation with the consecutive two-level voltage source converter are introduced. At long last, exploratory outcomes from 5-kVA model framework are given to confirm the legitimacy of the proposed topology.

Keywords:

reduced switch count topology , pulsewidth modulation(PWM), AC/AC converter.

Introduction:

3-PHASE ac/dc/ac and ac/ac converters with variable frequency (VF) and variable voltage activity have discovered wide applications in the business. The most famous design utilizes voltage source inverter (VSI) with a diode rectifier as the front end for movable speed drives (ASDs), uninterruptible power supplies (UPS), and other mechanical applications [1]. This setup includes minimal expense and dependable activity because of the utilization of a diode rectifier, however it creates exceptionally contorted info line flows and doesn't have regenerative or dynamic slowing down ability. These issues can be moderated by utilizing a back-toback two-level voltage source converter (B2B 2L-VSC), appeared in Fig. 1, where a pulsewidthmodulation (PWM) voltage source rectifier is utilized to supplant the diode rectifier [2].The B2B 2L-VSC requires a moderately high number (12) of

dynamic switches, for example, protected door bipolar semiconductors (IGBTs).It likewise needs a dc-connect capacitor that is answerable for a restricted life expectancy and expanded expense. To decrease the gadget check and limit/wipe out the dc-capacitor channel, different converter geographies have been

proposed in the writing. The main methodology announced in [3]–[5] places two dc capacitors in course and accepts their midpoint as one of the info yield terminals,whereby a whole phase leg for the rectifier as well as inverter can be saved. It is additionally conceivable to lessen the all out number of switches, as the subsequent methodology recommends [6], [7], by dividing one of the three phase legs among the rectifier and inverter with appropriate control. Moreover, joined utilization of dc midpoint association and phase leg sharing has been proposed in [8], where just four legs are expected to perform three-phase ac to ac change with bidirectional power stream and power factor control.Although every one of the prior references accomplish the objective of diminishing the quantity of switches and subsequently decreasing the expense, they unexceptionable have restricts or include complex control because of their unequal topological design. For unidirectional applications,diodes can be utilized instead of dynamic switches in the rectifier part, for example, the VIENNA rectifier [9], three-phase three-switch buck-type rectifier [10], and three-phase three-switch two-level rectifier [11]. These converters may likewise be viewed as geographies with a saved number of switches, notwithstanding their work of an enormous number of diodes. Not at all like VSCs that definitely require the dc-connect stage, the lattice converter [12] presents an extreme change in topology and straightforwardly changes over a fixed ac input voltage to a flexible ac yield voltage. It highlights sinusoidal info yield, controllable power factor, and is equipped for bidirectional energy move from the stockpile to the heap or the other way around. Since there is no dclink circuit, the dc capacitor in the VSC isn't required here, prompting cost decrease just as improved unwavering quality and life span. Nonetheless, the customary network converter (CMC) ordinarily requires 18 dynamic switches and its switching plan is mind boggling. The high semiconductor cost and complex control have made this topology less alluring. Like the circumstance of VSCs, endeavors to lessen the quantity of dynamic switches for a lattice converter have been made in ongoing distributions [13],[14], several topological variations, for example, the inadequate network converter (SMC) were proposed. The SMC gives identical usefulness to the CMC. It utilizes 15 switches with the semiconductor cost still higher than that of the B2B 2 L-VSC. In this paper, a novel one-stage three-phase ac/ac converter topology is proposed. Not quite the same as any remaining existing geographies, this converter has just three legs with just nine dynamic switches for bidirectional ac/ac power transformation.

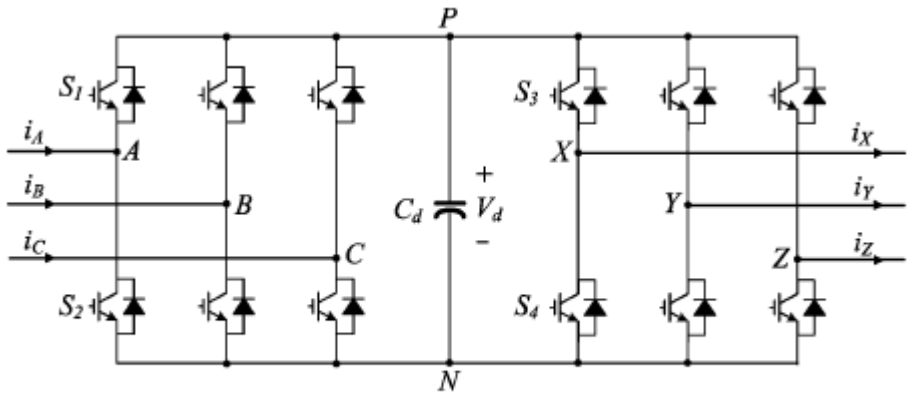

Fig. 1. B2B 2L-VSC.

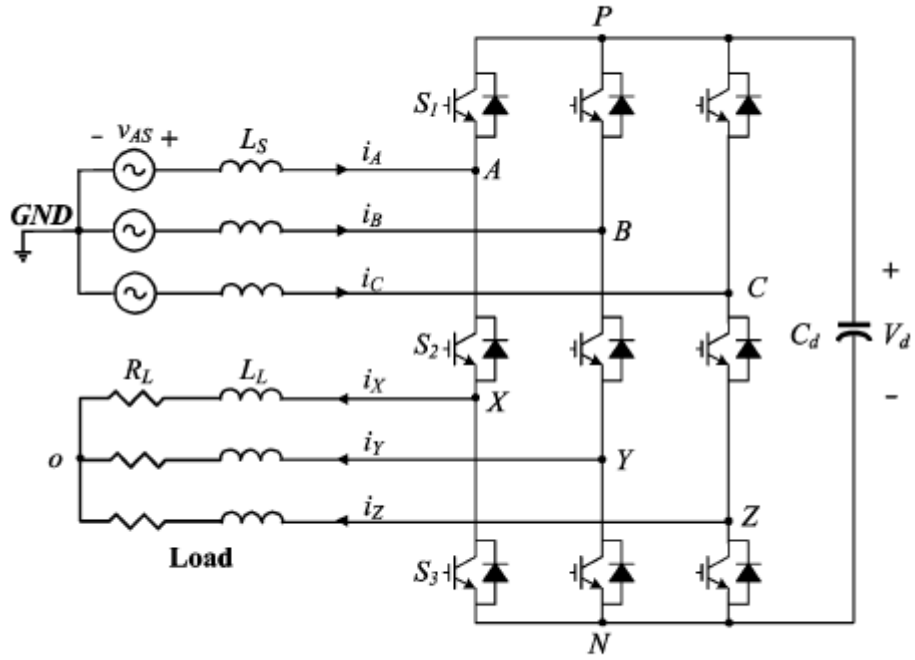

Fig. 2. Proposed nine-switch ac/ac converter with a quasi-dc link.

NINE-SWITCH CONVERTER TOPOLOGY

Fig. 2 shows the proposed three-phase nine-switch converter topology. This converter has just three legs with three switches introduced on every one of them. The oddity in this is that the center switch in every individual leg is shared by both the rectifier and the inverter, consequently diminishing the switch tally by 33% and half in contrast with the B2B 2L-VSC and CMC, individually. The information power is conveyed to the yield mostly through the center three switches and mostly through a semi dc-interface circuit. For the accommodation of conversation, we can think about that the rectifier of the nine-switch converter is made out of the top three and center three switches, though the inverter comprises of the center three and base three switches. The converter has two methods of activity: 1) consistent frequency (CF) mode, where the yield frequency of the inverter is consistent and furthermore equivalent to that of the utility inventory, while the inverter yield voltage is movable; and 2) VF mode, where both size and frequency of the inverter yield voltage are customizable. The CF-mode activity is especially reasonable for applications in UPS, though the VF mode can be applied to variable-speed drives.

MODULATION SCHEMES

The decrease of the quantity of switches in the proposed converter topology forces certain switching limitations for the switching design plan. In the B2B 2L-VSC appeared in Fig. 1, the rectifier leg voltage vAN , which is the voltage at hub A regarding the negative dc transport N, can be constrained by switches S1 and S2 in the rectifier, while the inverter leg voltage vXN can be constrained by S3 and S4 in the inverter. This implies that the rectifier and inverter leg voltages can be controlled freely. The B2B 2L-VSC has four switching states for every phase, as characterized in Table I.For the nine-switch topology, the control of the information and yield voltages must be refined through the three switches on every

leg. Since the center switches are shared by the rectifier and inverter, the proposed converter has just three switching states for each phase, as recorded in Table I. It tends to be seen that switching state 4 for the B2B 2L-VSC doesn't exist in the nine-switch converter, which infers that the inverter leg voltage vXN can't be higher than the rectifier leg voltage vAN at any moment. This is, indeed, the fundamental limitation for the switching plan of the nine-switch converter.Carrier-based ceaseless PWM plans for tweaking the 2L-VSC, like sinusoidalPWM(SPWM), space vectorPWM (SVPWM), and third-consonant infusion PWM(THIPWM), are grounded in the writing [15]. The standards of these techniques would all be able to be applied to the nine-switch converter however a little change would be important, on the grounds that when planning the switching design for the nine-switch converter, the switching imperative examined before should be satisfied.Fig. 3 delineates the summed up transporter based modulation conspire in a solitary switching period for the nine-switch converter.The rectifier tweaking wave vmr and the inverter adjusting wave vmi are organized with the end goal that vmr isn't lower than vmi at any moment of time. These two tweaking waveforms are contrasted and a typical three-sided transporter vc . The created rectifier and inverter leg voltages vAN and vXN are additionally appeared in the figure. This course of action ensures that switch state 4 in the B2B 2L-VSC is disposed of here for the nine-switch converter.Taking SPWM for instance, Fig. 4 outlines the adjusted plot for CF-mode activity, where mr and mi are the rectifier and inverter modulation lists (characterized as the top to-top extent of the sinusoid isolated by the top to-top size of the transporter), separately. The contrast between this plan and the conventional SPWM for 2L-VSC is that here the regulating rushes of the rectifier (strong line) and the inverter (ran line) are put in a solitary dc plane and contrasted with a typical three-sided transporter wave. The door signals are produced at the waveforms' crossing points with the transporter. To forestall the tweaking waves from crossing each other, the rectifier's balancing waves are lifted to the highest point of the dc plane while the inverter's are moved to the base by adding legitimate dc balances. Thusly, the switching requirement of the nine-switch converter can be fulfilled. By and by, the rectifier side modulation can be synchronized to the matrix by means of a phase-bolted circle (PLL). The opportunities of picking its modulation file mr and terminating point α between the regulating wave and the network can be utilized to control the dc voltage and the information power factor. The inverter-side modulation file mi can be uninhibitedly chosen to change the yield size. In the event that the inverter's balancing wave is set in phase with the rectifier's,as for the situation appeared in

Fig. 4, both the rectifier and inverter's modulation lists can all the while arrive at a limit of unity.Fig. 5 shows the SPWM modulation conspire for the VF method of activity. For this situation, the inverter's modulation file and phase point can both be changed autonomously from the rectifier's.In request to fulfill the switching requirement examined before, the amount of the two modulation files mr and mi of the rectifier and inverter should not surpass 1. For coordinating with the information and yield appraisals, we limit both of their maximums to 0.5. It tends to be seen from the figure that both the rectifier and inverter's regulating waves must be changed inside portion of the transporter's size (which addresses the dc voltage);therefore, the dc voltage vd of the converter is twice just about as high as the appraised dc voltage of a B2B 2L-VSC with similar ca appraisals. This is not quite the same as the circumstance of the CF mode with indistinguishable info and yield phases, in which the dc voltage of the converter can be firmly controlled and kept up at around its appraised value.It ought to be called attention to that albeit the additional dc counterbalances ensure that the moment worth of vmr is consistently higher than that of vmi , they are of zero arrangement in the three phases and have no impact on the information/yield ac extents. Truth be told, if the inverter's modulation file is chosen to be higher than the rectifier's, e.g., mi = 0.5 and mr = 0.2, the basic part of the inverter yield voltage vXY will be higher than that of the rectifier input voltage vAB .

TABLE I
SWITCHING STATES AND CONVERTER LEG VOLTAGES

(a) Back-to-back converter						
Switching State	S_1	S_2	S_3	S_4	v_{AN}	v_{XN}
1	On	Off	On	Off	V_d	V_d
2	Off	On	Off	On	0	0
3	On	Off	Off	On	V_d	0
4	Off	On	On	Off	0	V_d

(b) Proposed nine-switch converter					
Switching State	S_1	S_2	S_3	v_{AN}	v_{XN}
1	On	On	Off	V_d	V_d
2	Off	On	On	0	0
3	On	Off	On	V_d	0

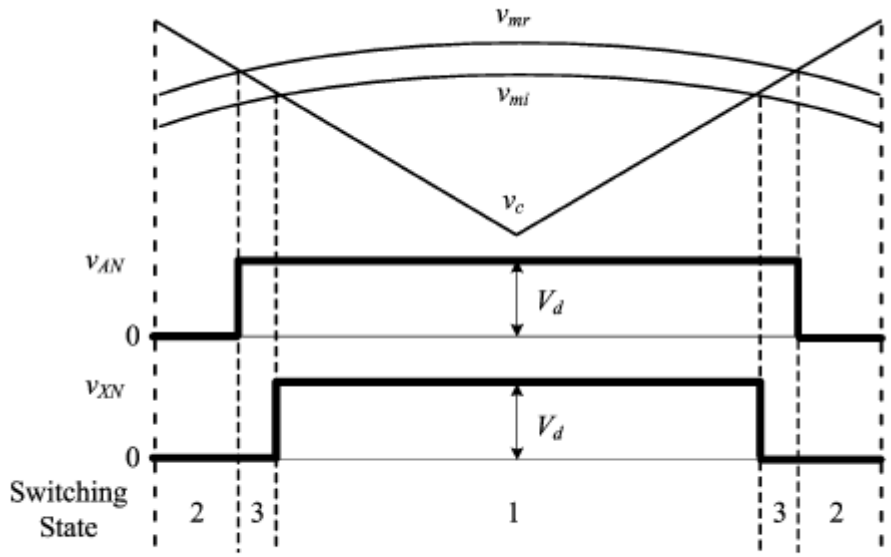

Fig. 3. PWM waveform generation, where switching state 4 of the B2B 2L-VSC is eliminated.

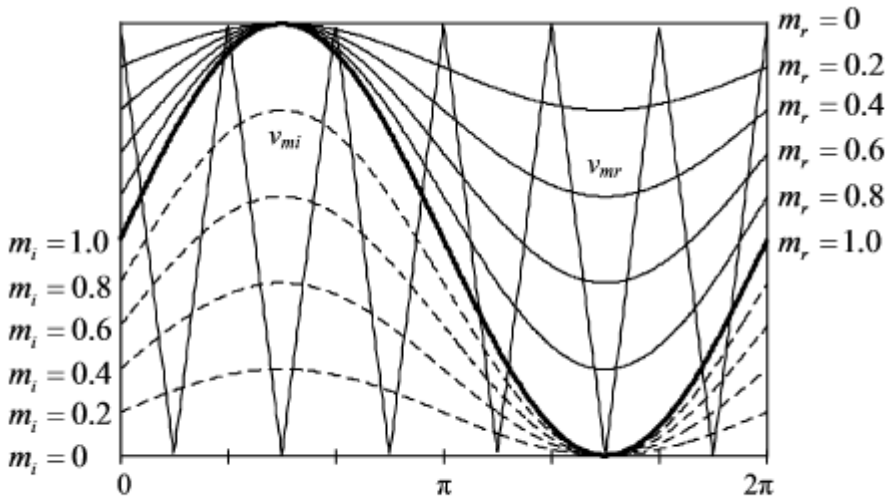

Fig. 4. SPWM scheme for CF-mode operation.

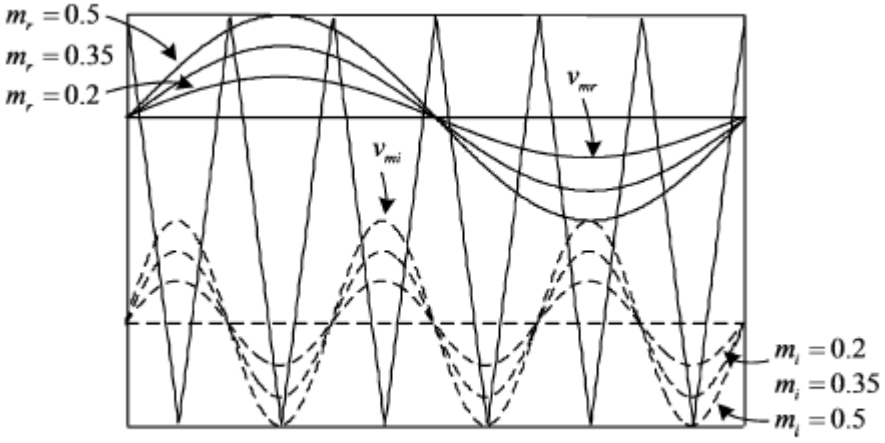

Fig. 5. SPWM scheme for VF-mode operation.

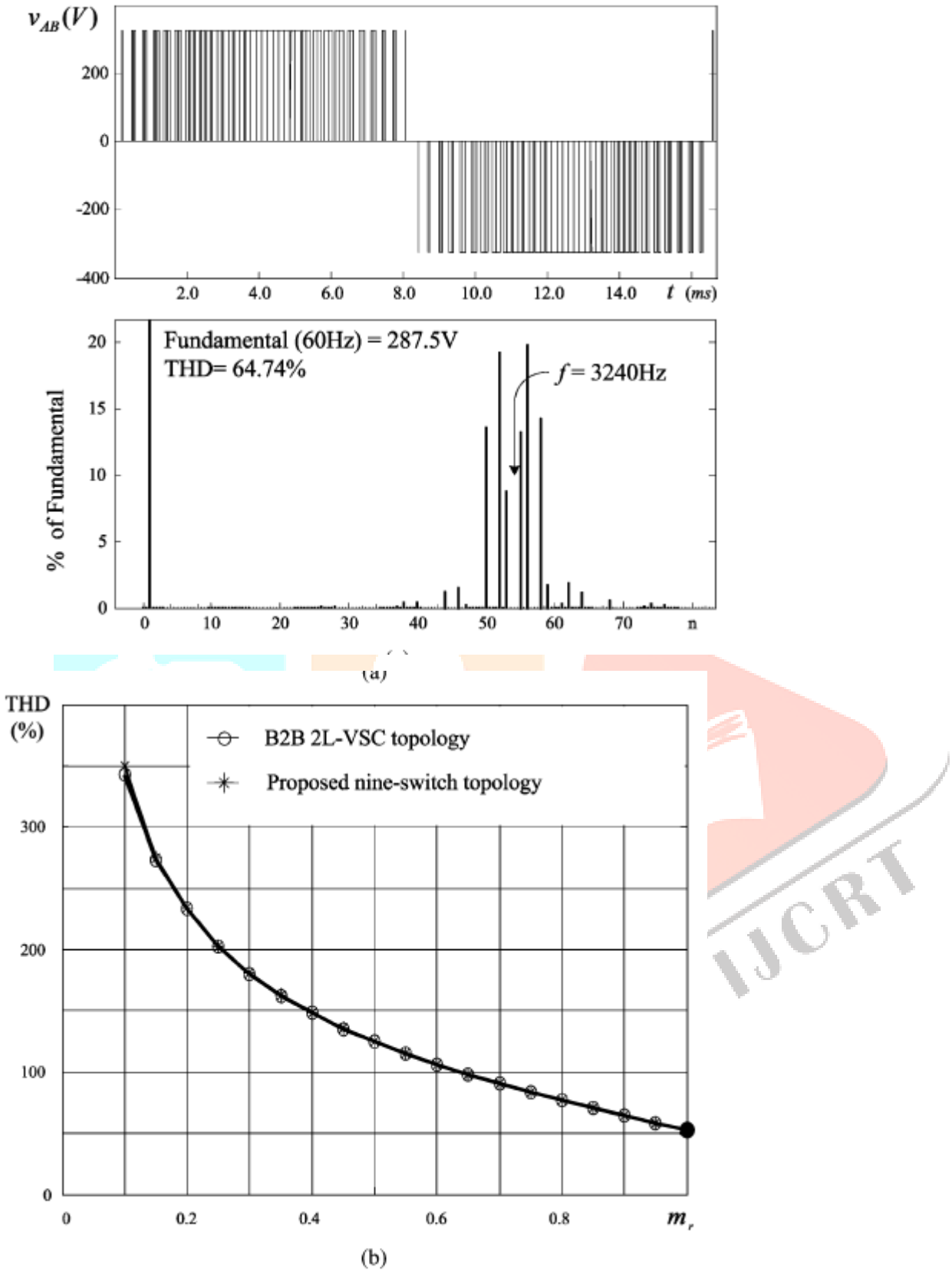

Fig. 6. Rectifier input voltage waveform, spectrum, and THD (CF-mode operation). (a) Rectifier input voltage waveform and spectrum. (b) THD comparison.

EXPERIMENTAL VERIFICATION

A 5-kVA model framework was assembled and tried. The upsides of the stock voltage, source inductance Ls , dc capacitor Cd , and RL load boundaries are equivalent to those given in the simulation.The input power factor of the converter can be driving, lagging,or solidarity. Fig. 12 shows the deliberate inventory phase voltage vA and line current iA of

the converter with solidarity power factor activity. During the test, the dc voltage was kept up at 320 V by the rectifier, and the converter modulation record was mr = mi =0.9. It ought to be noticed that the control of the rectifier and inverter is decoupled, and subsequently, the inverter activity won't influence the activity of the rectifier. estimated voltage and current waveforms when the inverter works with the very frequency as that for the rectifier. The modulation file of the rectifier and inverter was 0.9,while the dc voltage of the converter was 320 V.

CONCLUSION

A tale nine-switch PWMac/ac converter topology was proposed in this paper. The topology utilizes just nine IGBT gadgets for ac to ac change through a semi dc-connect circuit. Contrasted with the ordinary back-with back PWM VSC utilizing 12 switches and the framework converter that utilizations 18, the quantity of switches in the proposed converter is decreased by 33% and half, separately. The proposed converter highlights sinusoidal data sources and yields, solidarity input power factor, and low assembling cost. The working standard of the converter was expounded, and modulation plans for steady and VF tasks were created. Reenactment results including a semiconductor misfortune examination and correlation were given, which uncover that the proposed converter, while working in CF mode, has an in general higher proficiency than the B2B 2L-VSC to the detriment of lopsided misfortune circulation. In any case, the VF-mode adaptation requires IGBT gadgets with higher appraisals and scatters essentially higher misfortunes, and along these lines, isn't just about as appealing as its partner. Exploratory confirmation is done on a 5-kVA model framework.

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