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Performance Comparison of LCL Half bridge and LCL Push Pull Resonant Converter for 5G Communication

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Abstract: ***In recent communication technology DC-DC converters are widely used for different applications. Here two converters LCL half bridge resonant and LCL push pull resonant converters are designed for 5G communication application. In both the converters, the switching devices operates at zero voltage switching (ZVS). The proposed technique eliminates switching loss, reduce stress on switching devices and increase efficiency. Here the capacitor act as resonating component as well as tune filter at load side this will reduce number of components. The proposed circuits are designed at 240V input, 48V output voltage and the circuits are designed and simulated results are verified.***

Keywords: DC-DC Converters, LCL Resonant Elements, Soft Switching.

I. INTRODUCTION

In modern technology smart power supplies are required for DC-DC conversion. In 5G communication networks low voltage and high power is used for transmission in remote site communication equipment's. The resonant power supplies are very essential for conversion of DC-DC, these power gives high efficiency, low power loss and zero voltage switching across switching. The LCL topology is applied for different basic converters like half bridge circuit, full bridge circuit and push pull converter circuit to accomplish ZVS (zero voltage switching) for different applications [2], [4], [7], [8]. In resonant converters the different topologies used depending on input/output voltage, current and power for different applications. The LLC topology is more efficient for battery charging applications [15], [16]. The proposed LCL topology output side of rectifier C and L act as tuned filter as well as resonating components, it require minimum components. These converters are more suitable for automotive LED drivers, solar battery charging and DC grids [10]-[14]. In LCL topology, two inductor and one capacitor are connected in different fashion to accomplish ZVS [1]-[9]. The LCL is connected secondary side of transformer, L is series with C, L and C act as filter at output side as well as resonating elements [3], during turn off and turn on the switching device voltage becomes zero, minimum transition losses and minimum stress on switches. The DC-DC resonant converter block diagram is as shown in figure1. In switch network half bridge/push pull converter connected with coaxial transformer, here coaxial transformer is used to step up or step down the input voltage. The resonating tank circuit consist of resonating element. The resonating components (L and C) are connected after rectifier circuit which provides current turn off at primary side switches. The capacitor in low pass filter act as tuned filter. The half bridge and push pull resonant converters are designed for same voltage and current ratings. The LCL half bridge and LCL push pull converters are simulated and compared the results, a comparative performance is presented.

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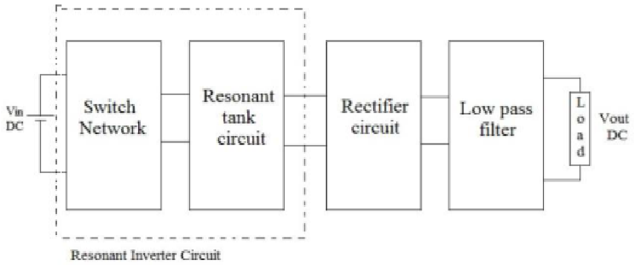

Fig.1. Block Diagram of dc-dc Converter with Resonant Tank Circuit

II. ZERO VOLTAGE SWITCHING LCL TOPOLOGY

The LCL topology the capacitor act as filter at side of load as well as resonating component. In parallel LCL resonant circuit, the capacitor and inductor are connected parallel. The switches 'S_1' and 'S_2' operates at 50% obligation cycle, with 180^0 phase shift, S_1 and S_2 shares equal current, the transformer magnetizing current flows through the MOSFET body diodes, it leads to zero voltage across MOSFET switch during turn on and turn off. The LC components resonates twice the switching frequency and switching frequency remains constant. The circuit operates at high switching frequency hence it reduce transformer size and small values of LC components are required.

III. BASIC MODES OF OPERATION

The circuit operates in four fundamental modes, for each operation mode one switching device conducts [3]. In normal operation, mode 1 and mode 3 operates short switching transitions due to transformer magnetizing current. The maximum power flow occurs in mode 2 and mode 4.

The inductor positive current and negative current flows through the diodes of body MOSFETs.

IV. DESIGN CONSIDERATION

The transformer is designed with input 240 V and output 48 V, 50 KHz switching frequency. The L and C components are calculated with desired switching frequency. The optimum values of inductor and capacitor selected, the high value of capacitor reduce voltage stress on rectifier circuit diode and high value of inductor reduce current ripples, hence optimum values of inductor and capacitor values selected for ripple free output values.

V. SIMULATION RESULTS

A. LCL Half Bridge Resonant Circuit

The LCL half bridge circuit is simulated using PSIM software, the converter designed with input 240V and 48 V output voltage and simulated. Fig.2 represents simulated circuit.

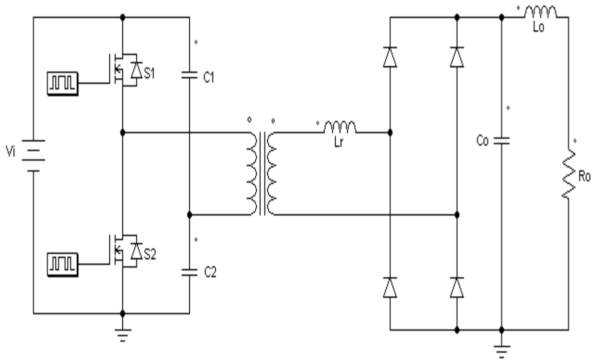

Fig.2. LCL half bridge resonant circuit

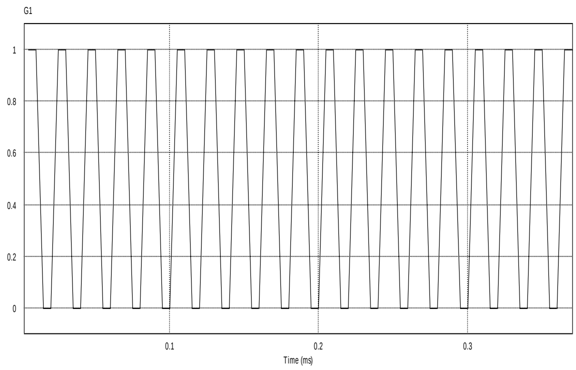

Fig.3. The switching device MOSFET1 (S1) gate pulse

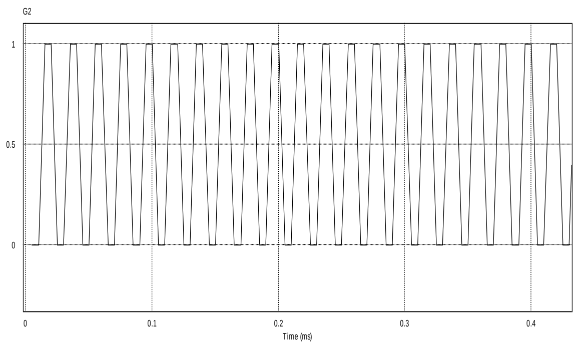

Fig.4 The gate pulse of MOSFET2 (S2)

The switching devices S_1 and S_2 gate pulses as shown in fig.3 and fig.4.

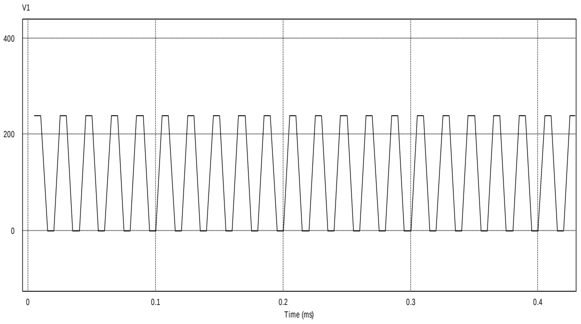

Fig.5. The transformer primary side voltage

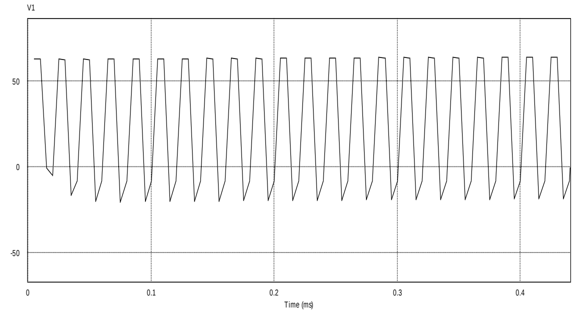

Fig.6. The transformer secondary side voltage

Here, fig.5 and fig.6 shows primary and secondary voltages of transformer.

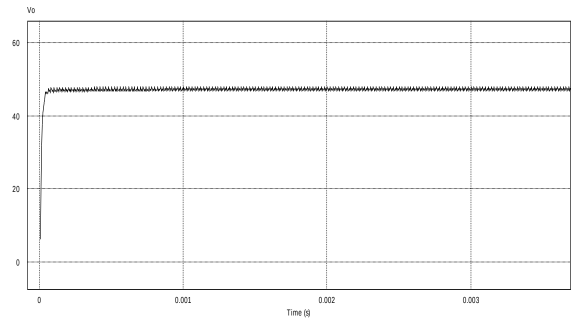

Fig.7.The output voltage of LCL half bridge resonant converter

Here, Fig.7 presents output voltage and fig.8 presents output current of half bridge resonant converter.

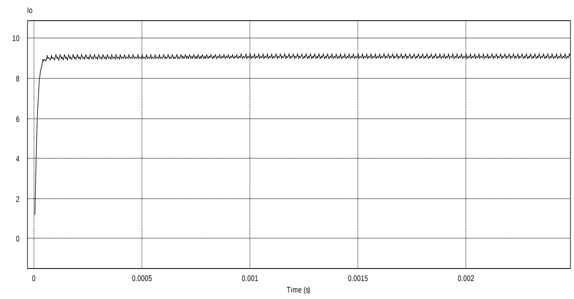

Fig.8.The output current of LCL half bridge resonant converter

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B. LCL Push-Pull Resonant Converter

The LCL push-pull resonant circuit has been simulated with same input voltage 240 V and 48 V output voltage. Fig.9 shows the converter simulated circuit.

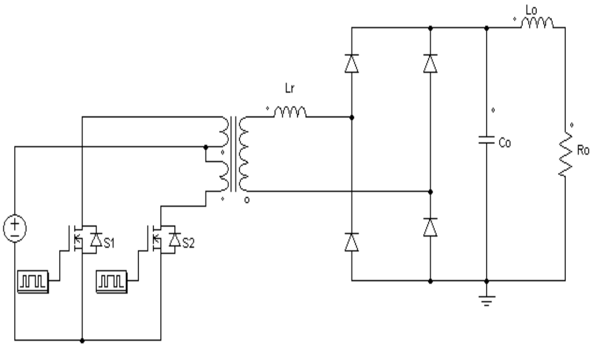

Fig.9.The LCL push pull resonant converter

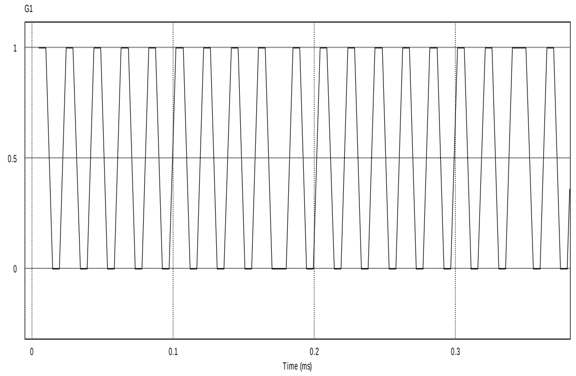

Fig.10.The gate pulse of switching device S1

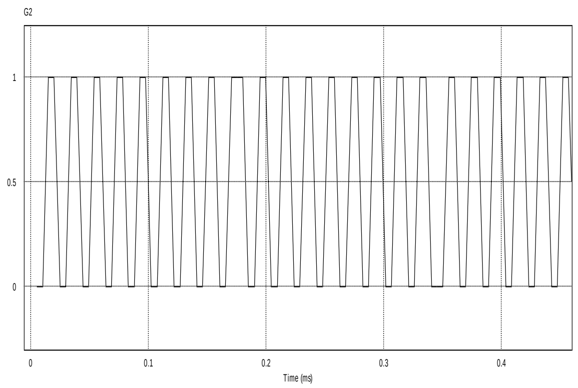

Fig.11.The gate pulse of switching device S2

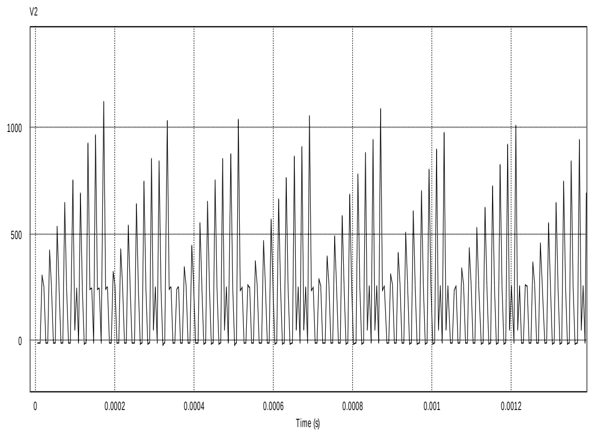

Fig.12.The Voltage at Primary Side of Transformer

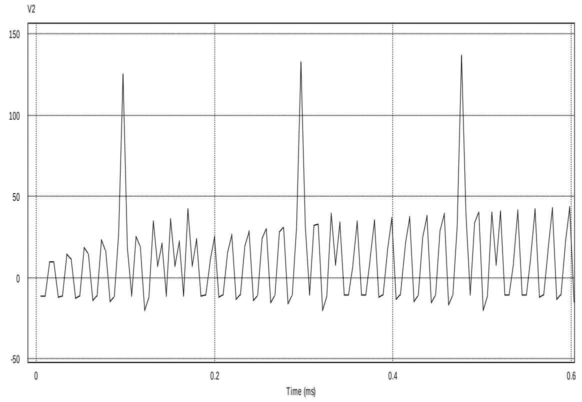

Fig.13.The Voltage at Secondary Winding of Transformer

Here, fig.10 shows gate pulses of S_1 and fig.11 shows the gate pulses of S_2. Fig.12 shows voltage of primary side of transformer and fig.13 shows voltage at secondary winding of transformer.

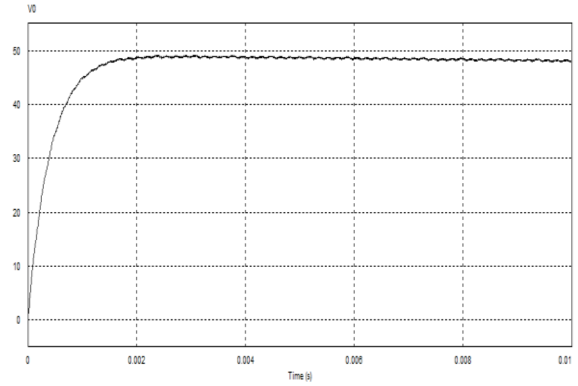

Fig.14. The LCL push pull resonant converter output voltage

Fig14 and fig.15 shows the output voltage, output current of push-pull resonant converter respectively.

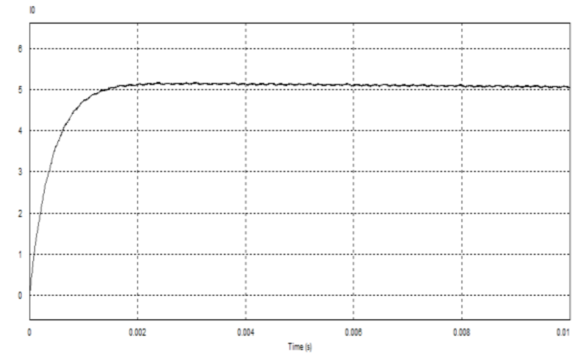

Fig.15.The output Current of LCL Push-Pull Resonant Converter

The circuit modules of two converters simulated. The output voltage, current and power performances are compared by circuit simulations. The maximum ripple voltage and ripple current present in half bridge converter compare to push pull converter, it will effect the loads. The power conversion efficiency of both the converters evaluated.

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The table I represents the performance comparison of both the converters. From this table performance of push pull converter is best suitable compared to half bridge resonant converter.

Table I. Comparison Results

Sl. No.	Converters	Output current ripple(I)	Output voltage ripple(V)	Efficiency
1	Half bridge converter	0.68	0.13	91
2	Push pull converter	0.05	0.005	97

VI. CONCLUSION

The circuit models of LCL half bridge and LCL push pull resonant DC-DC converters are designed and simulated with same input and output voltage. LCL resonance achieves ZVS for the MOSFET switches for both the converters. The performance comparison of two converters results are verified. The LCL push pull converter exhibits better performance compared to the LCL half bridge converter. Scope of future, design and simulation of closed loop LCL push pull converter. Compare results of closed loop and open loop.

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