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A Comprehensive review on LLC and LCC Resonant Converters

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ABSTRACT

The most common problems in power switching converter design are to achieve high power density as well as high conversion efficiency. Switching frequency of the converter has to be increased in order to increase the power density. By increasing the switching frequency, we can actually reduce the size of the components and also weight of its reactive component. The conventional converterssuffer from severe switching losses as it approaches to high switching frequency hence resonant converters are also analyzed, designed for various applications.

KEYWORDS: Resonant converter, Efficiency, Switching Frequency.

1. INTRODUCTION

Resonant converters are also type of power converters which includes network of capacitors and inductors these networks of capacitors and inductors are called as resonant tank up which are meant to be turned on at particular frequency these are different types of resident converter series resonant converter parallel resident converter and series parallel resonant converter etc there are numerous benefits of resident converter when we compare with the conventional converters it can regulate the output over where line and load variations with the relatively small variations of switching frequency it can maintain excellence switching frequency and efficiency of switching operations can be achieved over the entire range.The growth of consumer electronics has necessitated tiny package size and great power supply efficiency. The two-stage arrangement of power supplytypically used in applications requiring modest power. Normally, Using power factor correction (PFC), the front-end stage can

implemented with an efficiency of 93–95 percent. meeting theefficiency standards set forth by the EPA. The Climate Saver Computing Initiative (CSCI) andthe power supply unit's circuit efficiency should be greater than90% for the majority of load circumstances. Consequently, the dc-dcsecond-stage converter (with a 95% PFC circuit) shouldbe higher than 95% to satisfy the CSCI criterion. Softswitching strategies have been put forth todc-dc converter with excellent efficiency. On the other hand, high voltage orpresent power constraints.

2. LCC RESONANT CONVERTERS

2.1 LCC RESONANT CONVERTER OPERATING UNDER DISCONTINUOUS RESONANT CURRENT MODE IN HIGH VOLTAGE, HIGH POWER AND HIGH FREQUENCY APPLICATIONS

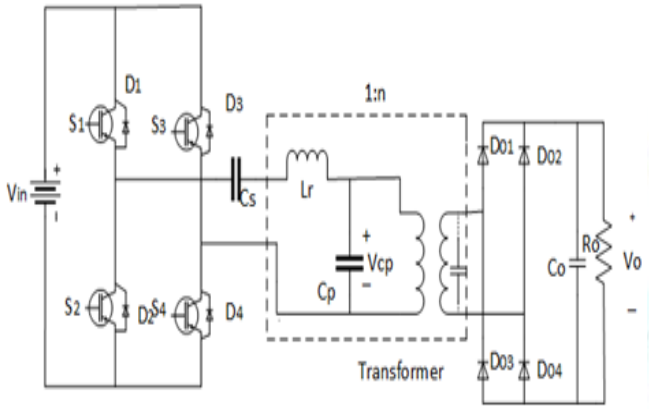

Fig 1:LCC resonanttopologywithcapacitiveoutputfilter

TheFullbridgeseries-parallelLCCresonantconverter withacapacitorasanoutput filterisoperatedata high output voltage (>50kv), high power (>50kw) and high frequency (>20kHz) for electro staticprecipitator power supply applications.leakage inductance and the winding capacitance of thetransformer are used as a Resonantelement there is an additional resonant capacitor is required toform an LCC topology. In this soft switching ZVS turn off and ZCS turn on of switches are obtained byadopting the Discontinuous current mode control method. The LCC resonant topology is shown infigure [1].

2.2 DESIGN AND IMPLEMENTATION OF ENHANCED RESONANT CONVERTER FOR EV FAST CHARGER

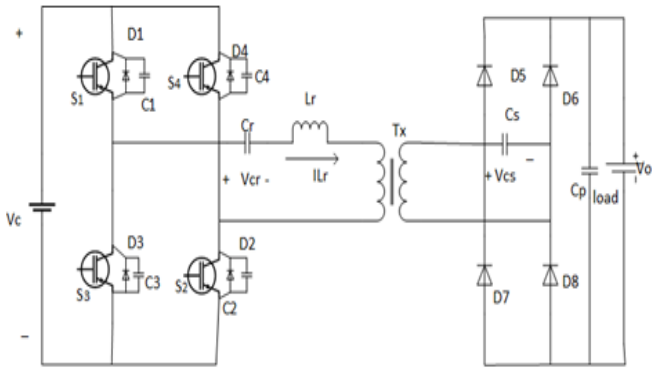

Fig 2:Schemeofenhancedseriesloadedresonantconverter

The enhanced series loaded resonant converter, which is depicted in the figure, has the benefit of high efficiency, particularly at the rated load condition because it can lower conduction and switching losses. Conduction losses can be lowered by optimising the resonance current shape, and switching losses can be lowered by raising snubber capacitance. It is created a straightforward gate drive circuit that actively detects the IGBT's zero voltage status in order to reduce turn on loss. This suggested design was used to create the 60KW Electric Vehicle rapid charger, which has an output range of 50 to 500 volts [2].

2.3 DC POWER SUPPLY BASED ON HALF BRIDGE LCC RESONANT CONVERTER

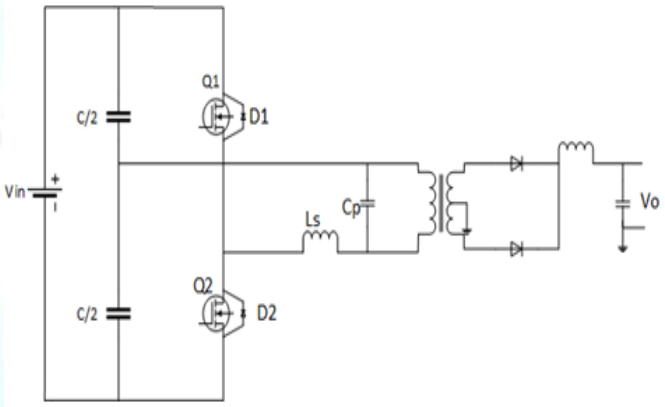

Fig3:Half-bridgeLCCresonantconverter

The half bridge series parallel LCC resonant converter The DC power supply input voltage is DC 24Vand output voltage is DC 3.3V. The voltage gain of LCC converter is modulated by the ratio of theswitchingfrequencyandtheresonantfrequency.The operationiscarriedoutinsteadystateconditionbyvariablefrequencycontrol.Outputpowercanbeadjustedfrom minimalvalues(theoreticallyzero),up to nominal power. Dependences of the maximum voltage and current values in the tank elementsand the efficiency versus the switching frequency have shown that there is only a small area wheretheoperationoftheconverterislimited,specificallythearesurroundingresonancesoftheConverter [3].

2.4 Current-fed Isolated LCC-T Resonant Converter with ZVS and Improved Transformer Utilization

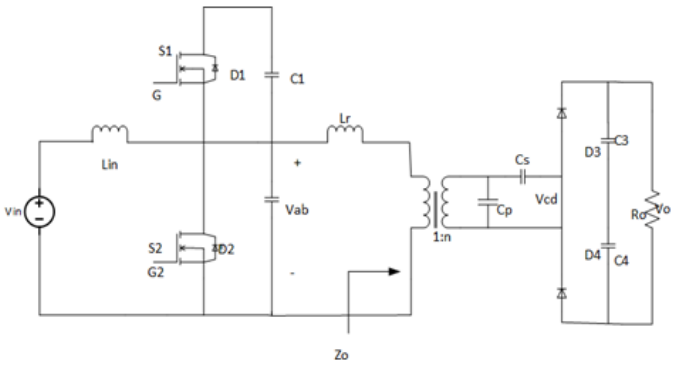

Fig 4:SchematicoftheproposedCurrentfedIsolatedLCC-T ResonantDC/DCconverter

Current fed isolated LCC-T resonant DC/DC converter with capacitive output filter aims at improvingefficiency of the converter byoperating allswitches in ZVS mode,and alldiodesin ZCS modetransformer with continuous current and minimum stress on resonant tank components. current fedisolated LCC-T resonant converter which can provide high efficiency by minimizing conduction andswitchinglosses,minimumstressonresonantcompon entsbyrelocatingseriesandparallelcapacitorsandintrodu cingvoltagedoublar,effectiveutilizationoftransformerby maintainingcontinuoussinusoidalcurrentthroughit [4].

2.5 A Wide-ZVS RangeLCCResonantConverter

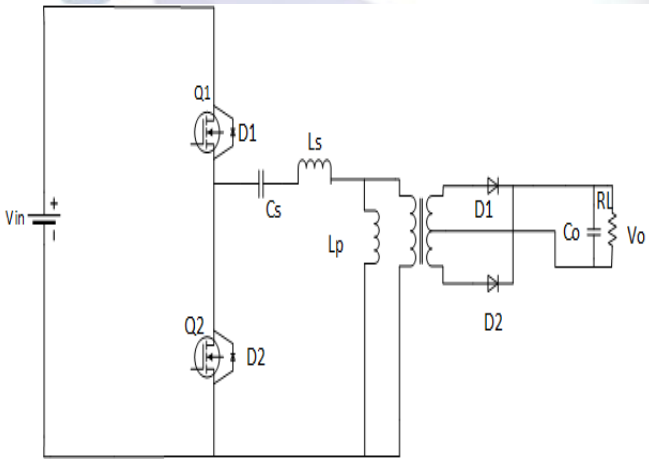

Fig 5:LCCresonantconvertertopology

By continuously operating all switches in ZVS mode and all diodes in ZCS mode transformer, the current fed isolated LCC-T resonant DC/DC converter with capacitive output filter aims to increase the efficiency of the converter while putting the least amount of strain on the components of the resonant tank. A current-fed, isolated LCC-T resonant converter can achieve high efficiency by reducing conduction and switching losses, placing series and parallel capacitors away from resonant components, adding voltage doublar, and maintaining a constant sinusoidal current through the transformer [5].

3. LLC RESONANT CONVERTERS

3.1 Designing an LLC Resonant Half-Bridge Power Converter

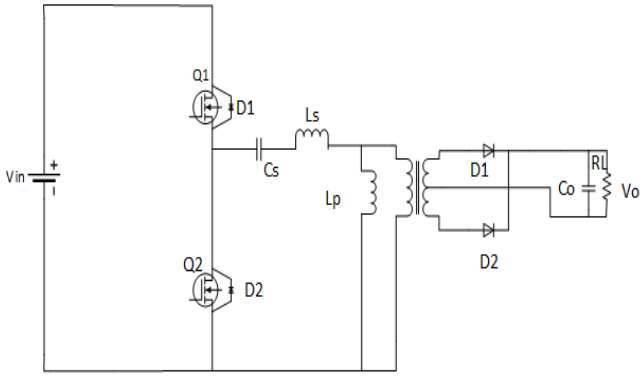

Fig.6: LLC resonant half-bridge converter

It is an example for series-parallel resonant converter the choice of present converter over the conventional converter is based on the reduction in the switching losses, the power MOSFETs are used to generate the square wave voltage by giving 50% alternating duty cycle and also small dead time is also provided between the consecutive transition of operation as they are turned on turned off alternatively. This technique is in taken in order to prevent the cross conduction of the power MOSFETs. The resonant tank consists of one resonant capacitance Cs and two inductors that is series resonant inductance Ls and Transformer's magnetizing inductance Lp. The Transformers trans ratio the resonant network includes Ls, Lp and Cs circulates the current in the circuit hence energy circulated and it is delivered to the load through the transformer. The transformer is used for isolation purpose as well as providing turns ratio for required voltage. The primary winding of the transformer collects bipolar square wave and the secondary side of the transformer consists of diodes for rectification purpose sometimes output capacitance is also included in this circuit in order to smoothening of output voltage and output current [6].

3.2 Asymmetric PWM Control Scheme During Hold-Up Time for LLC Resonant Converter

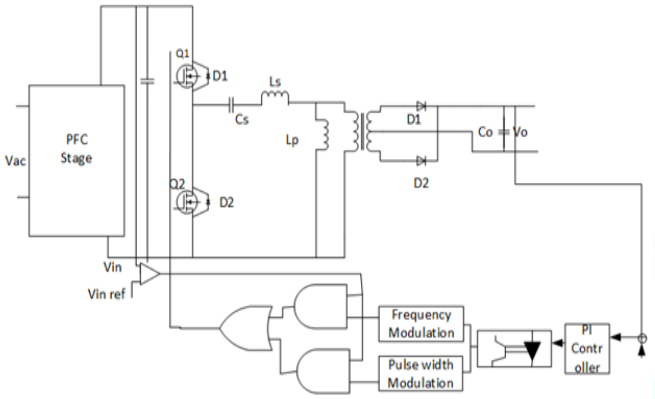

Fig.7: Proposed LLC resonant converter.

The main advantage of using LLC converter resident converter is to operate at present frequency for high efficiency to get constants which in frequency and LLC residence converter operation the frequency modulation is changed to asimit asymmetric pwm technique to get higher gain as well as to reduce the switching frequency variation hence output voltage with narrows which in frequency is regulated which reduces the size of the magnetic components and conduction loss [7].

3.3 Analysis and Design of Two-Phase Interleaved LLC Resonant Converter Considering Load Sharing

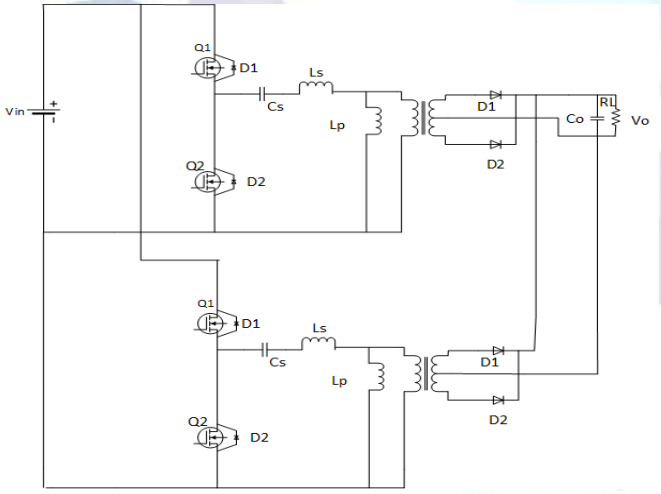

Fig 8: Two-phase interleaved LLC-SRC.

Due to its numerous benefits over other power converters, the LLC series resonant converter (LLC-SRC) is being employed extensively in a variety of applications. The output capacitor experiences extremely high current ripple stress, making it challenging to employ this topology in high current applications. However, by using the interleaved approach, the output current ripple can be significantly reduced. However, multiphase interleaved LLC-SRC, which consists of magnetising inductance (Lp), resonant inductance (Lr), and resonant capacitance, makes it challenging to design resonant tanks to ensure output current sharing (Cs). This work proposes design considerations for multiphase interleaved LLC-SRC output current sharing [8].

2.4 LLC Resonant Converter Topologies and Industrial Applications

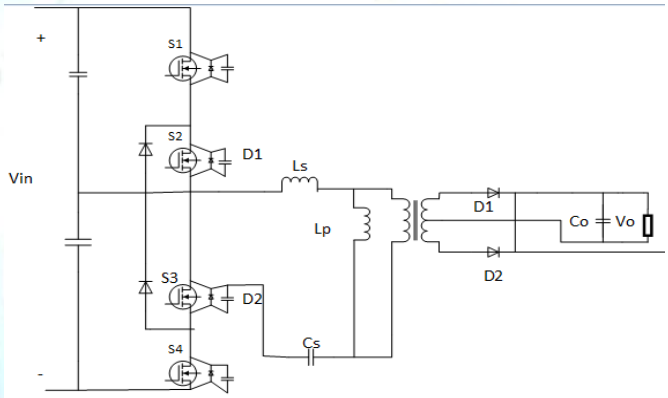

Fig.9 The TL-LLC resonant converter topology

The LLC resonant converters are extensively used in a variety of electronics-based industries due to their benefits of high efficiency, high energy density, electrical isolation, low electromagnetic interference (EMI) and harmonic pollution, magnetic integration, wide output ranges, low voltage stress, and high operation frequency. Three of the most prominent LLC resonant converter topologies are explored along with thorough analyses of their merits and disadvantages. The history and development of LLC resonant converters are also discussed. A significant amount of research is also being done on the industrial uses of LLC resonant converters, namely for the charging of electric vehicles (EVs), solar systems, light emitting diode (LED) lighting drivers, and liquid crystal display (LCD) TV power supply [9].

2.5 Analysis of LLC Converter with Series-Parallel Connection

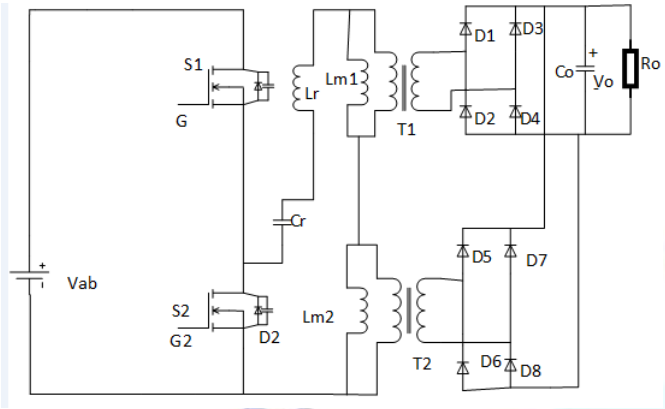

Fig 10. Proposed series-connection in primary and parallel-connection in secondary LLC converter.

To achieve ZVS turn-on for power switches and ZCS turn-off for rectifier diodes, this study offers a parallel LLC resonant converter with series and parallel connections on the secondary sideto become aware of the balanced secondary winding currents and tothe power semiconductor switching losses. This uses a basic harmonic analysis technique.To calculate the converter voltage ratiothe output voltage of a series resonant converter cannot beproperly regulated when there is no load. At the output, a load must be connected so that at low load, circuit efficiency is quite low [10].

III. COMPARISON OF DIFFERENT RESONANT CONVERTERS.

Table 1: Comparison Table for LLC and LCC resonant converter.

Paper	Resonant converter type	Efficiency	No. of Diodes	No. of Switches	Applications	Source	Software	Advantages	Disadvantages
[1]	LCC	----	8	4	Electrostatic precipitation (Power supply application s)	DC supply	--	It can be operated at High voltage, High Power and High Frequency Applications	----
[2]	Series loaded LCC	98.5%	8	4	Electric vehicle battery charging application	DC source	PSpice	increasing the efficiency by decreasing conduction and switching losses	voltage gain is less
[3]	LCC-T	96%	4	2	Electric vehicle battery charging application	DC source	PSpice	minimum stress in Resonant components by relocating series and parallel capacitors	efficiency is high only at light loads
[4]	Half bridge LLC	higher	4	2	Power supply	DC source	PSpice	Efficiency is improved	efficiency versus switching frequency shows that operation of Converter is limited for

									small area
[5]	LLC	---	10	6	Wide range input applications	DC source	--	it can achieve full load ZVS conduction and improved efficiency Good dynamic response	lose of ZVS in wide load changing applications
[6]	LLC	98%	2	2	Power supply design applications	DC suppl y	Matla b	Higher power density, lower electromagnetic interference.	Mosfet's conduction loss
[7]	LLC	Higher	2	2	EV charging station	DC suppl y	PSIM	High gain, reduced switching frequency	Increased size of magnetic components
[8]	LLC-SRC	----	4	4	Power motor drives	DC suppl y	Matla b	Output current sharing, reduced output current ripple	Low effeiciency difficult design
[9]	TL-LLC	Lower	4	2	LED lighting drives, LCD TV power supplies	DC suppl y	Matla b	Low harmonic output voltage	Large stress and complexity of converter
[10]	Parallel LLC	93.5%	8	2	Server and data storage systems	DC suppl y	PSIM	Reduced current stress and switching loss	high component count, increased cost and complexity

4. CONCLUSION

This paper presented a review and comparison of different resonant converters. Series-parallel resonant converter demonstrates that the key benefit is that it exhibits excellent efficiency for large power transfer and greater efficiency for light loads. Conceptualization and research are done on a full-bridge, current-fed partial resonance, series resonant tank dc/dc converter.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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