triple active bridge converter. The proposed duty ratio control method, ZVS conditions is achieved over the entire phase shift region. The three port bidirectional converter having the following features, all ports are bidirectional, including load port for application, Centralized control of power flow, reduced switching losses due to soft-switching operation.

High frequency three-winding transformer is proposed to provide the isolation between the three Ports. Due to single-stage power conversion, the converter has a centralized control for regulating the output voltage. The converter naturally yields to bi-directional power flow in all ports. One method of building a single-stage power converter circuit interfacing multiple energy sources and the load is to emulate a multiple bus power system. HF transformers have small size, light weight, and low cost compared to bulky line frequency transformers.

All of these topologies use inductors as the main power transfer and storage element. Another method of building a single stage power converter circuit is to use time-sharing principle i.e., at any time instant only one of the sources will be connected to the load. These converters employ square-wave pulse width modulation to achieve voltage regulation. The average output voltage is varied by varying the duty cycle of the power semiconductor switch.
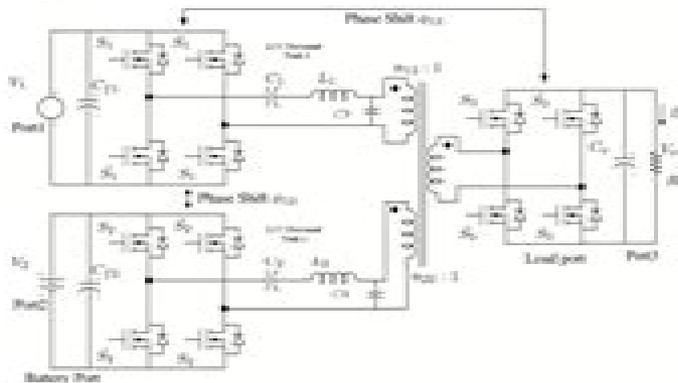

Fig.1 Three-port DC-DC converter

An LCC resonance converter shares the advantages of other resonance converters, when the switching frequency is lower than the resonant frequency [8], and Zero voltage switching suitable for MOSFETs when the switching frequency is higher than the resonant frequency. These characteristics make the LCC resonant converter a potential candidate for high power and high frequency application.

Besides the above features, the LCC resonance converter offers additional merits when compared with series resonant converter (SRCs) and parallel resonance converter (PRCs). First the series capacitor the equivalent at light load end. This is because the tank capacitances smaller, this results in an increase of the characteristics impedance of the resonant tank, and is helpful to limit the circulating current. Secondly, the voltage conversion characteristics allow the converter to operate in a wide load range (from full load to no load),where PRCs may lose regulation at full load end SRCs may lose regulation LCC resonance converter behaves more like a PRCs under light load, and an SRCs under full load. Therefore, the circulating energy at light load is minimized. Thirdly the LCC converter has inherent short circuit protection.

3. DESIGN

The proposed circuit is shown in Fig.1. It has two LCC resonant tanks formed by L1, C1 and C3, L2, C2 and C4, respectively. The input filters capacitor for port 1 and port 2 are Cf1 and Cf2, respectively. Two phase shift variables $\varphi 13$ and $\varphi 12$ are considered as shown in Fig.1. They control the phase shift between the square wave outputs of the bridges. The phase shift $\varphi 13$ and $\varphi 12$ are considered positive.

The transformer is a core component. It provides isolation and voltage matching. The selection of the transformer turns ratio using the formula.
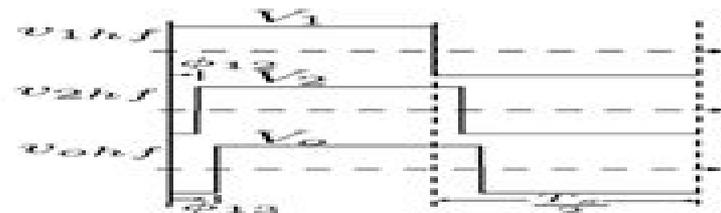

Fig.2 PWM waveform with definitions of phase-shift variables $\varphi 13$ and $\varphi 12$

$$\frac{N_1}{V_1} = \frac{N_2}{V_2} = \text{..........} = \frac{N_N}{V_N} \quad \text{...............(1)}$$

Where N1, N2 are the winding turn's number and V1, V2 are the port voltages. The power throughput of the transformer should be the maximum of all the possible situations. When switching frequency is fixed, the power flow through the

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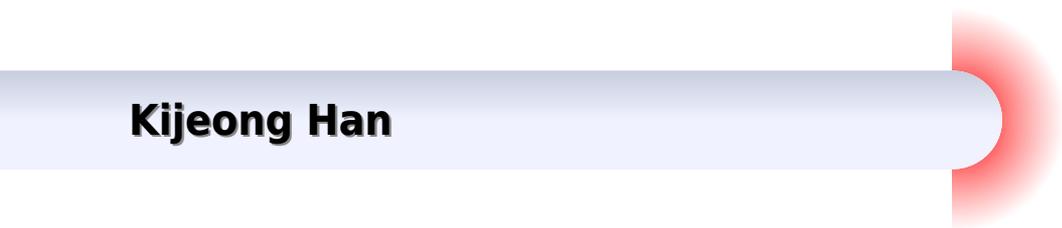
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Proceedings ,1969 **Government Reports Announcements & Index** ,1990-09 *Science Citation Index* ,1992 Vols for 1964 have guides and journal lists *Power MOSFETs* Duncan A. Grant,John Gowar,1989-04-25 Details the theory of power MOSFETs and their applications Explains the basis of MOSFET characteristics and the features that determine MOSFET behavior Examines the interaction of the MOSFET device with other elements in the circuit and how device characteristics influence circuit design Describes several circuits at length to highlight the practical details of power MOSFET use High Speed, High Current Switching Using Power MOSFETs Ethan Petersen (F.),1995 Low Voltage Power MOSFETs Jacek Korec,2011-03-30 Low Voltage Power MOSFETs focuses on the design of low voltage power MOSFETs and the relation between the device structure and the performance of a power MOSFET used as a switch in power management applications This SpringerBriefs close the gap between detailed engineering reference books and the numerous technical papers on the subject of power MOSFETs The material presented covers low voltage applications extending from battery operated portable electronics through point of load converters internet infrastructure automotive applications to personal computers and server computers The issues treated in this volume are explained qualitatively using schematic illustrations making the discussion easy to follow for all prospective readers **Switching Characteristics of Power MOSFETS Under Different Load Conditions** Kok Foo Leong,2000 Improving Switching Performance of Power MOSFETs Used in High Rep-Rate, Short Pulse, High-Power Pulsers E. G. Cook,2006 As their switching and power handling characteristics improve solid state devices are finding new applications in pulsed power This is particularly true of applications that require fast trains of short duration pulses High voltage 600 1200V MOSFETs are especially well suited for use in these systems as they can switch at significant peak power levels and are easily gated on and off very quickly MOSFET operation at the shortest pulse durations is not constrained by the intrinsic capabilities of the MOSFET but rather by the capabilities of the gate drive circuit and the system physical layout This project sought to improve MOSFET operation in a pulsed power context by addressing these issues The primary goal of this project is to improve the switching performance of power MOSFETs for use in high rep rate short pulse high power applications by improving the design of the gate drive circuits and the circuit layouts used in these systems This requires evaluation of new commercial gate drive circuits and upgrading the designs of LLNL developed circuits In addition these circuits must be tested with the fastest available high voltage power MOSFETs **Analysis of the Ultra-fast Switching Dynamics in a Hybrid MOSFET/Driver** ,2011 The turn on dynamics of a power MOSFET during ultra fast ns switching are discussed in this paper The testing was performed using a custom hybrid MOSFET Driver module which was fabricated by directly assembling die form components power MOSFET and drivers on a printed circuit board By using die form components the hybrid approach substantially reduces parasitic inductance which facilitates ultra fast switching The measured turn on time of the hybrid module with a resistive

load is 1 2 ns with an applied voltage of 1000 V and drain current of 33 A Detailed analysis of the switching waveforms reveals that switching behavior must be interpreted differently in the ultra fast regime For example the gate threshold voltage to turn on the device is observed to increase as the switching time decreases Further analysis and simulation of MOSFET switching behavior shows that the minimum turn on time scales with the product of the drain source on resistance and drain source capacitance R sub DS on C sub OSS This information will be useful in power MOSFET selection and gate driver design for ultra fast switching applications

The Use of MOSFET as Synchronous Rectifier in Switching Power Supplies Chi Keung Mak,University of California, Berkeley. Department of Electrical Engineering and Computer Sciences,1982   **The MOSFET as a Synchronous Rectifier in Switching Power Supply Circuits** Richard S. Kagan,University of California, Berkeley. Department of Electrical Engineering and Computer Sciences,1981   *High Frequency Switching with Power MOSFETs* Robert John Leedham,1996   **Advantages of Power MOSFETs Over BJTs in Switching Power Supplies** William D. Serjeantson,1986   *Design, Analysis, and Optimization of 1.2 KV 4H-SiC Planar-Gate Power MOSFETs for Improved High Frequency Switching* Kijeong Han,2019

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