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High Frequency driver circuit for MOSFET full bridge Resonant Converter

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ABSTRACT: *As the industry pushes for higher power levels and higher switching frequencies, power supplies which use MOSFETs for power conversion, are being designed to attain high efficiency, smaller size and eight. The subject of driving MOSFETs to their highest possible frequencies at the highest possible power level also deals with protection provided by driving circuit. Many topologies in high voltage converter and inverter plications require special techniques to drive MOSFETs. The paper deals with the subject how to drive MOSFETs with minimum attainable switching losses.*

Keywords - *Driver circuit, MOSFET, IC Driver, Pulse Transformer.*

I. INTRODUCTION

Power MOSFETs are used in high switching applications switching applications such as switch mode power supplies (SMPS), brushless DC motor (BLDM) drives Solid state relay, Automobile applications etc. Resonant converter is modern technology in which MOSFETs are conveniently employed along with resonating elements. MOSFET driver circuit has to satisfy some basic considerations for high frequency applications. IC drive has advantage of compactness. But in case of MOSFET bridge converter upper MOSFETS cannot be triggered by IC driver. Isolation of power supply is required in such case. Pulse transformer and Optocouper can be employed for role of isolation. In presented paper MOSFET full bridge is triggered using IC3525 and pulse transformer is used for isolation

II. RESONANT SWITCH CONVERTER

Resonant switch converters are a broad class of converter in which the PWM switch network of conventional buck, boost or other converter is replace with a switch cell containing the resonant elements. These resonant elements are positioned such that semiconductor devices operate with zero current or zero voltage switching and such that one or more switching loss mechanisms are reduced or eliminated.

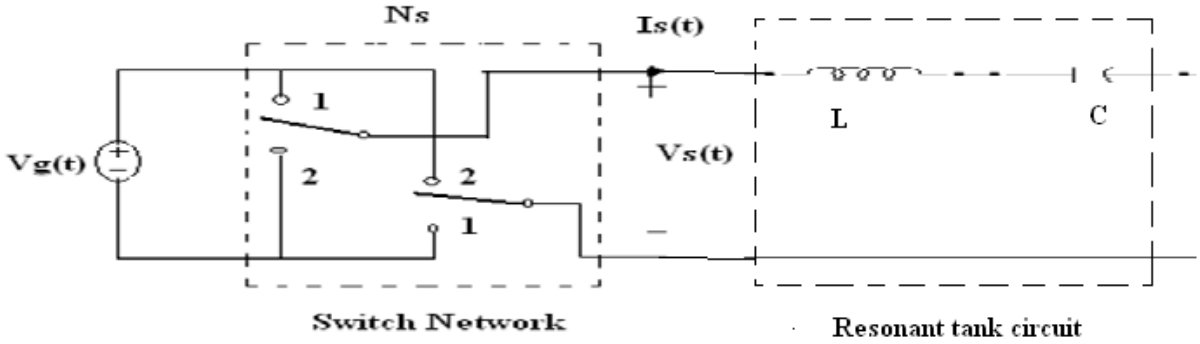

Fig. 1 switch network with resonant tank circuit

Resonant converters are specifically designed for high frequency application. Power MOSFET is extremely popular and most preferable device for high frequency applications. Power MOSFET has advantages suc aspositive temperature coefficient of resistance, majority carrier device, voltage controlled device etc. MOSFET driver circuit designer have to face some problems [6].

III. DESIGN CONSIDERATIONS OF DRIVER CIRCUIT FOR MOSFET

The gate of MOSFET is isolated from the body of device and hence steady state gate-source circuit exhibits infinite input impedance. However, under dynamic conditions, the gate source circuit exhibit gate-source self apacitance. During gate control process, gate current flows only for the short periods, needed to charge and discharge the self-capacitance. While designing driving circuit following factors are considered:

1. The driving circuit must be able to supply current pulses of sufficient magnitude for rapid switching.
2. The driving circuit should be designed to offer low impedance during charging and discharging.
3. Excessive voltage applied to gate may cause breakdown of oxide layer. Therefore, the driving circuit should be designed not to cause any excessive voltage and voltage transient.
4. The driving circuit must offer high impedance to voltage transients in drain circuit.
5. The gate-drive circuit must be able to sense and control fault current [5].

IV. TYPES OF DRIVER CIRCUITS

4.1 IC drivers

Although there are many ways to drive MOSFET using hard-wired electronic circuits, IC Drivers offer convenience and features that attract designers. The foremost advantage is compactness. IC Drivers intrinsically offer lower propagation delay. As all important parameters are specified in an IC Driver, designers need not go through time consuming process of defining, designing and testing circuits to drive MOSFET. Another advantage is repeatability and predictability of performance, which can't be easily achieved in hardwired driver circuits. In low power applications MOSFETs are turned on directly by pulse output from IC. For driving the upper MOSFET in a phase leg employed in a bridge topology, low side drivers cannot be used directly. This is because the source of upper MOSFET is not sitting at ground potential. This condition needed isolation of gate drive power supplies [1].

4.2 Achieving galvanic isolation by using opto-couplers to drive upper mosfet:

For driving high side MOSFET/IGBT in any topology, opto-couplers can be used with following advantages:

1. They can be used to give a very high isolation voltage; 2500 to 5000 Volts of isolation is achievable by use of properly certified opto-couplers.
2. Signals from DC to several MHz can be handled by opto-couplers.
3. They can be easily interfaced to Microcomputers, DSPs or other controller ICs or any PWM IC.

One disadvantage is that the opto-coupler adds its own propagation delay. Another disadvantage of using an opto-coupler is that separate isolated power supply is required to feed the output side of the opto-coupler and the driver connected to it [1].

4.3 Use of transformers to obtain galvanic isolation in driving upper mosfet:

Using transformers to achieve galvanic isolation is a frequently used technique. Depending on the range of frequencies being handled and power rating (voltage and current ratings and ratios), transformers can be esigned to be quite efficient. The gate drive transformer carries very small average power but delivers high peak currents at turn-on and turn-off of MOSFET.

Advantages of employing transformers for Gate Drive are:

1. There is no need for any isolated DC-to-DC Converter for driving an upper MOSFET.
2. There is practically no propagation delay in a transformer to carry signals from primary side to the secondary side.
3. Several thousand volts of isolation can be built in between windings by proper design and layouts [1].

V. DRIVER CIRCUIT OF MOSFET FOR FULL BRIDGE CONVERTER

5.1 Block Diagram:

Driver circuit of MOSFET full bridge converter is shown in fig 2. Single phase ac supply is rectified and givento IC7812 which supplies 12V to oscillator IC 3525. Oscillator generates PWM pulses to pulse transformer.Two pulse transformers are employed for generation of pulses for upper two M1, M2 and lower two M3, M4 MOSFETs. Experimental hardware setup is shown in fig. 3. Gate pulses generated by pulse transformer are shown in fig.4.

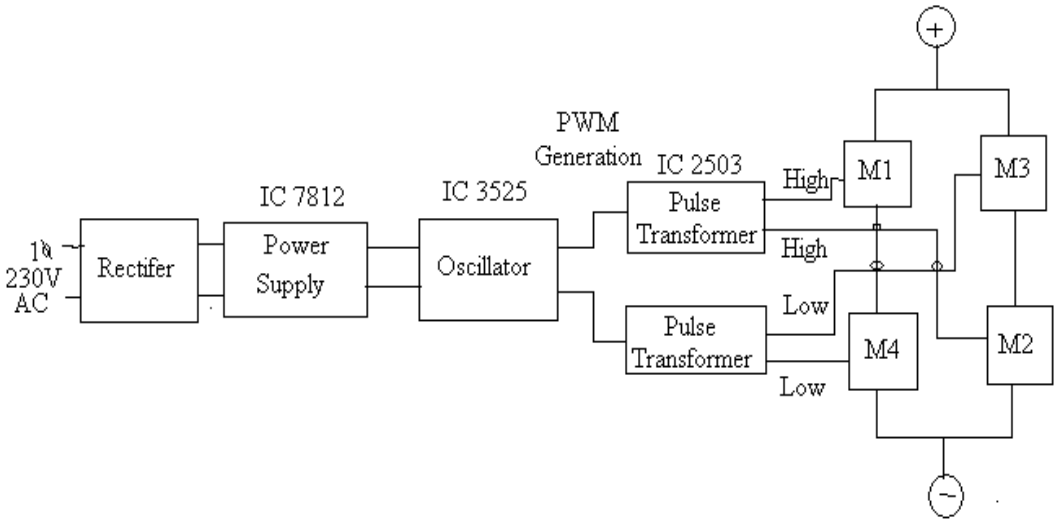

Fig. 2 Block diagram for full bridge MOSFET driver circuit

5.1 Experimental setup:

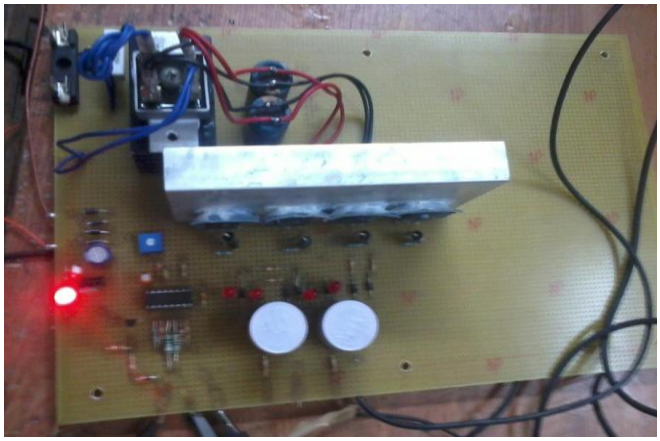

Fig. 3 switch network with resonant tank circuit

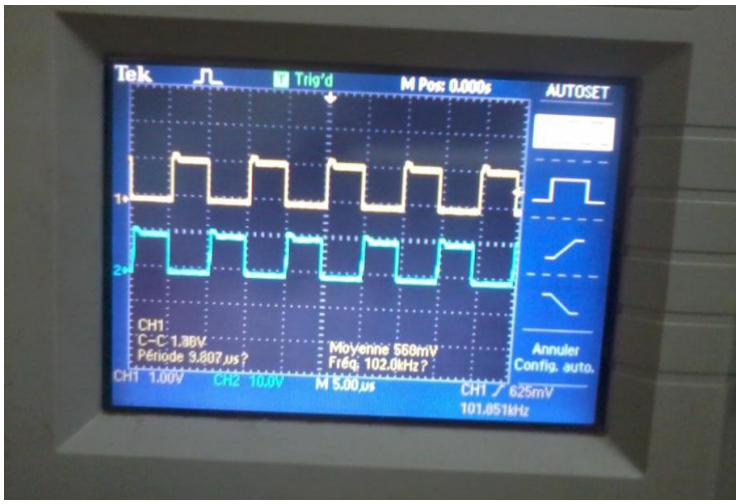

Fig. 4 switch network with resonant tank circuit

VI. CONCLUSION

Pulse transformer isolates gate drive supply from MOSFET which protects MOSFET from false triggering due to transients created by driver power supply. Power MOSFET switching at higher frequencies introduces harmonics in drain current than can be minimized using pulse transformer. Resonant converter itself complicated circuit Implementation of ICs gives advantages of compactness and simplicity. Driver circuit for full bridge MOSFET bridge can be used for various applications such as harmonic reduction, DC motor drive, telecommunication, aerospace applications.

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