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Series Operation of Power IGBT's for Gate Drive Circuit for Three Phase Inverter using OrCAD Applicable in Induction Motor Speed Control Drive

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Abstract— *The induction motors are relatively cheap and rugged machines because their construction is realised without slip rings or commutators but its speed control is complex & very expensive. so, for speed control of non- linear operated induction motor by design a IGBT based semiconductor switch for gate turn on for three phase inverter.*
The series operation of power IGBTs for high frequency and high voltage chopper operation introduce higher switching frequency. The design of a semiconductor switch for desired turn on time by chopping up the input voltage via controlling the duty cycle (i.e. ton / T). The isolation between control & gate signal is provided by fiber optic cable.
The circuit simulated in OrCAD, is can used simply as switch in which series operated IGBTs with drive & protection circuit designed for load operated on KV voltage and MHZ frequency by connecting 2.5KV volt ratted five IGBTs in series.

Keywords*: Electrical, Power Electronics, IM speed control drive.*

1. INTRODUCTION

The power IGBTs and MOSFETs are used extremely for operate at higher frequencies, but practically difficult during in switching transition to equal V sharing, because the tiny delay in triggering & small variation in rise & fall time, cause large inequalities, difficult equal voltage sharing, even when individual gate to emitter triggering voltage for each IGBT.[1]

But practically each device have slightly different I-V characteristics, result different gate current (Ig), cause different collector-emitter (Vce), result will not turn on at same rate.
Slightly modifications in above method in which all gate electrode capacitor are connected to ground but the current flowing to each of capacitor are change. The main limitation of power device is their limited hold off voltage (the maximum voltages which can safety applied between drain and source), for higher load voltage application.[1, 2, 3]

(i) Table for Specification Of Devices:

Name	Latching	Non Lacking	Terminal	Dire. Cond.	Forw. Block V	Rev. Block V	Ton	Toff	Field current	Cond drop
BJT	N	y	3	Uni.	600 V	N	1ms	5ms	300A	1.2 V
MOSFET	N	y	3	Bi.	1200 V	N	50ns	150 ns	50A	8V
IGBT	Y	y	3	Uni.	1200 V	50V	0.8 µs	0.5µs	400A	3V

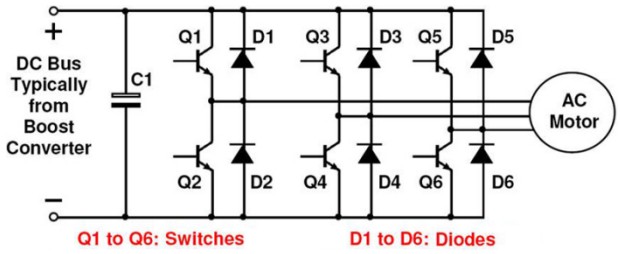
(ii) Comparisons Between BJT, MOSFET & IGBT

Sr. No	BJT	MOSFET	IGBT
1.	1200V, 800A	500V, 140A	1200V, 500A
2.	10 to 30Khz	Above 30Khz	Intermediate bet. BJT & MOSFET
3.	Negative temperature coefficient	Possitive temperature. coefficient	Negative temperature coefficient
4.	Ic controlled by Ib	Id controlled by Vgs	Ic controlled by Vge
5.	Secondary breakdown occur	Secondary breakdown not occur	Secondary breakdown not occur
6.	Low I/P impedance	High I/P impedance (105Ω)	High I/P impedance
7.	Bipolar, I flow by electron & hole.	Unipolar, I flow by movement of majority carrier	Bipolar, I flow by electron & hole.

8.	Have low conduction loss, especially with large blocking V, but have longer switching time especially at turn-off.	Turn-on & turn-off much faster, but on-state conduction loss are large specially when device ratted for higher blocking V (100's or more)	With large blocking V, Have Turn-on & turn-off much faster.

(iii) OrCAD is software, which offers a core design task, in which not just collection of independently developed point tools but a total solution design flow through simulation.

(iv) Digital Drive Circuit**:** The size of "voltage pulse generator" is very large for to generate voltage pulse individually for separate drive circuit. So, here we preferred CMOS logic whose operating voltage is up to 18V (work on +15V)



2. CIRCUIT DESIGN AND SIMULATION ON ORCAD

When the voltage rating of a single device is less than required for the circuit application, devices are operated in series (where I is equal & V are dissimilar). Practically no device is ideal & always has a leakage current, in its blocking states. Leakage resistance is $R_l = V_l/I_l$. Due to the different R_l, some device will share higher voltage then their rating & likely to fail. After one device failing, remaining device will try to share full leading voltage & caused failure of another device.

(i) Gate side method**:** It also called AVGC (active gate voltage control). It drives the power devices in series, synchronizing the pulse, and compensates the difference in switching time. The use of high frequency switching devices in power converters, induce high current and voltage variations, which excite oscillation in element of power circuit.

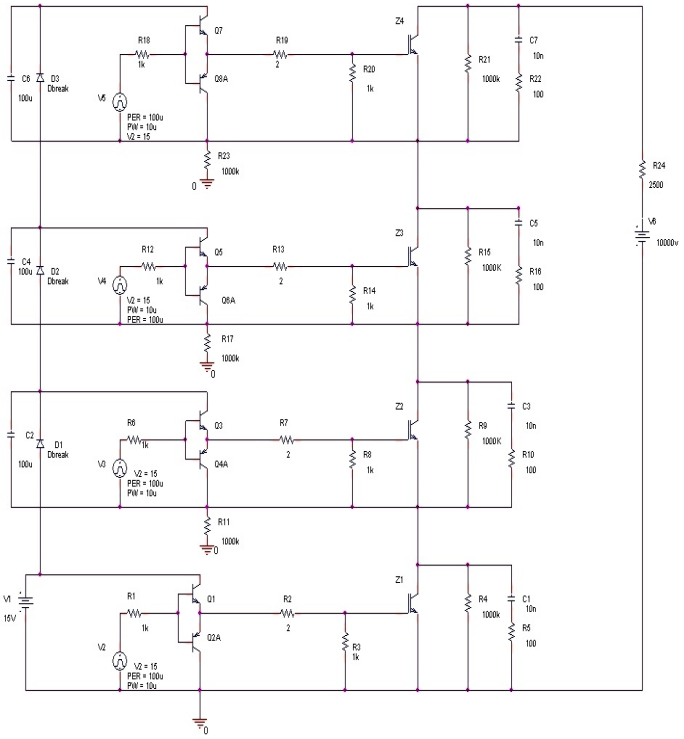
So, generally the gate circuit is fed by a "square wave voltage source" which provide a pulse through which Vge vary +15V to –5V in on and off state.[3,1]

(ii) The Snubber circuit: It used to protect the device against abnormal operating condition, like operating rating exceeds (V and I not exceed the specified rating of the device), or any switching condition (At turn on di/dt will large and at turn off dv/dt rating is large).

(iii) The design series operation of the power IGBTs, at high frequency and high voltage chopper operation for resistive (suitable for laser) load. The design of a 10kV switch, have higher switching frequency of 10 kHz, for fulfill the requirement for power modulation of 25KW RF oscillator. It reduces switching losses with increasing reliability of circuit with its simplicity.

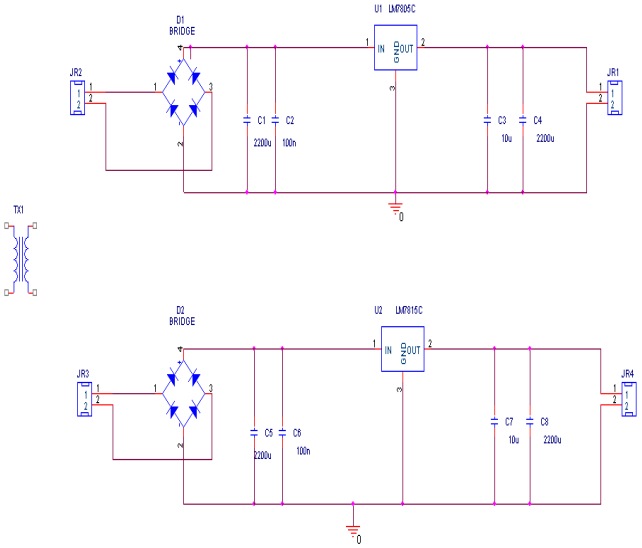
First of all to understand the operation of series connected IGBT's in circuit and then determine assumptions of component's

value of connected in circuit to conform accurate circuit design by using pspice orCAD simulation. We run a simple basic circuit for 300V at 10 KHZ frequency, then run for 10KV at 10KHZ which represent the response, as desired.



A. Design of regulated power supply 5V (IC7805) and 15V (IC7815) DC

The need of IC based power supply design for to obtained isolation between logic circuit & power device (or control & gate signal), because both devices are connected a common ground.



B. Design of Digital Circuit for simultaneous gate pulses for all connected IGBT's

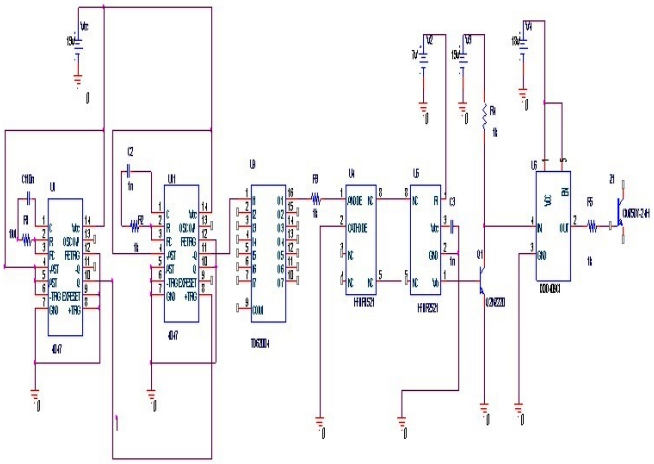
It is CMOS logic based circuit, work on +15V & +5V.

a) Astable multi-vibrator: In astable mode no stable state, hence it is useful for providing clock signal.fig(i)

b) Mono-stable multi-vibrator: Commonly knows as one shot or single shot has only one stable state and other is quasi-stable state (high state). It produces a pulse of predetermined width. fig(ii)

c) Two transistor Darlington**:** It is a very popular connection on two BJT for operation as a one "super beta" transistor, called Darlington, in which composite transistor act a a single unit, providing large current gain.

d) Transmitter & receiver: the transmitter & receiver are used for isolation.



e) Transmitter logic as inverter: BJT are used as inverting switch. Here NPN transistor are used, when Vcc=15V, output voltage, across collector terminal [Vce(sat)] is negligible. So, we assume it equals to zero volt (0V) as the input of IN of digital driver circuit.

f) Driver: it is "IXDD409, hex non-inverting, 9 ampere, low side, ultra fast MOSFET" driver. If the I/P is high, V0=15V at gate of IGBT. Vice versa, If I/P is low, V0=0V at gate of IGBT

3. WAVEFORM'S

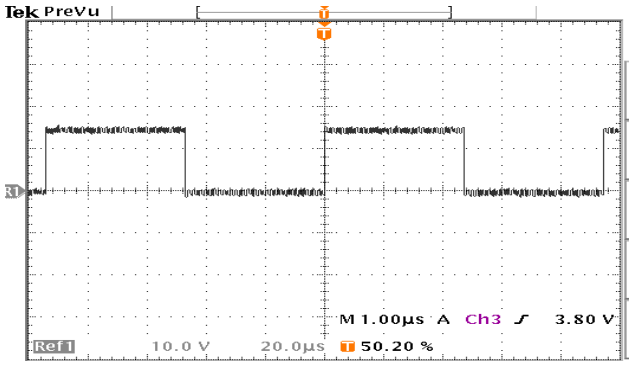


Fig.(i) O/P Waveform of Astable Multivibratore

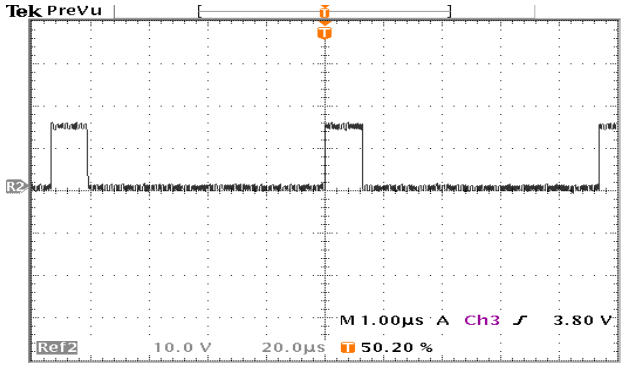


Fig.(ii) O/P Waveform of Mono-stable Multi-vibrator

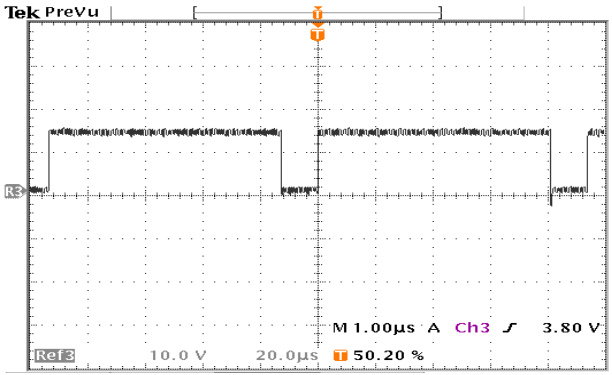


Fig.(iii) O/P Waveform of Darlington Array

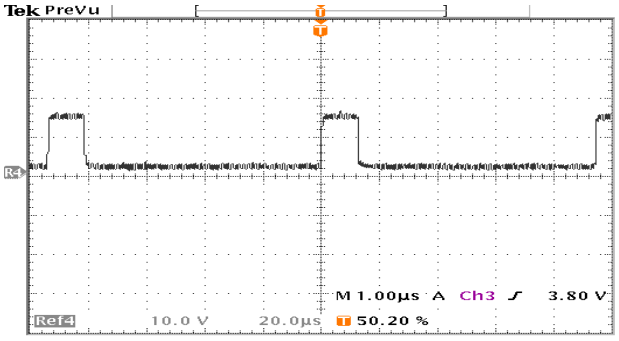


Fig.(iv) O/P Waveform of transistor (as inverter)

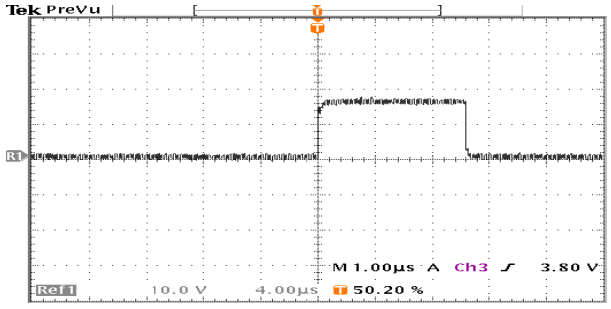


Fig.(v) O/P Waveform of Drive Circuit

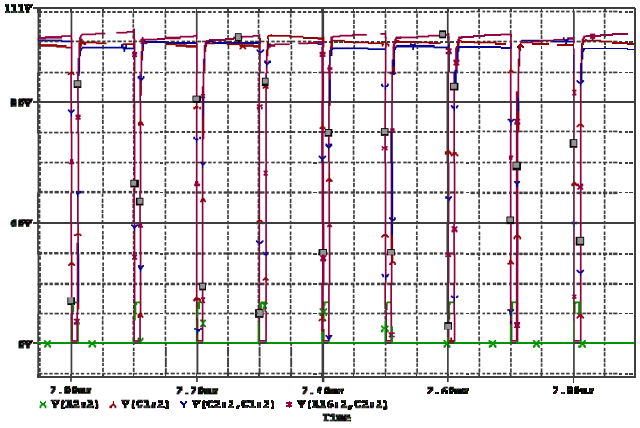


Fig.(vi) O/P Waveform of Simulated Circuit

4. RESULT

The circuit designed and simulated for to evaluate the performance of a "10kV" operated switch, having series connected IGBT's for high frequency, high voltage chopper operation. Simulation results shows that all the IGBT's share equal amount of voltage during transient and steady state conditions.

Then the designed Regulated power supply circuit by using IC provide out-put is 5V and 15V for circuit.

It reliable then totem pole drive circuit. As we desired, got 15V output pulse whose ton time is 10µs.

5. CONCLUSION

First of all circuit operating at 300V using three numbers of series connected IGBT's was simulated then simulates four IGBT's at 10KV volt. Each IGBT shares equal voltage. The sharing of voltages during transient and steady state conditions are also equally shared.

Then design regulated power supply circuit, provide proper 5V and 15V as input for drive circuit. Digital drive circuit, which provide as we desired, input gate pulse for IGBT. Here we required 15V high pulse for 10 µs.

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