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Performance Analysis of Single Phase Inverter

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Abstract: *In this paper performance of Single Phase Inverter is discussed. In this case IGBT & GTO switches are used with Sinusoidal Pulse Width Modulation technique. First of all two models are developed using SIMULINK toolbox of MATLAB software and SIMULATE both models. After the simulation performance of both Inverter is compared. Finally it indicates that IGBT based Inverter is more suitable.*
Keywords: *DC Source, GTO, IGBT, PWM, RLC Load, SIMULINK, SIMULATION.*

I. Introduction

The process of conversion of a DC power into AC power at a desired output voltage and frequency is called inversion. This can be done by a fully controlled converter (using thrusters) connected to ac mains. When a thruster based inverter supplies an ac power to an isolated load forced commutation techniques are required. This makes the inverter bulkier and costlier. Therefore thruster based inverter are used only in high power applications. For low and medium power inverter gate controlled turn OFF device such as Power BJT, Power MOSFET, IGBT, GTO and SIT etc. are used. In addition to being fully controlled these have high switching frequencies. Therefore these devices may be very efficiently employed in inverters. Where the output voltage is to be controlled using the pulse width modulation (PWM) technique.
Inverter can be broadly classified into two types based on their operation.

1. Voltage Source Inverter (VSI)
2. Current Source Inverter (CSI)

1. Voltage Source Inverter (VSI)

Type of inverter is fed by a dc source of small internal impedance. Looking from the ac side terminal voltage remains almost constant irrespective of the load current drawn. Depending on the circuit configurations VSI may be classified as half bridge and full bridge inverters. VSI may further be classified as square wave inverter and pulse width modulation inverter.

2. Insulated Gate Bipolar Transistor (IGBT)

It is used for medium power application. It is developed to remove drawbacks of power BJT and power MOSFET. It is a minority carrier device its switching speed is slightly inferior to that of a power MOSFET. It has many appealing features of both power BJT and MOSFET e.g. low conduction voltage drop ease of drive wide SOA, peak current capability, no turn off saturation time, no second breakdown and ruggedness. It has a high impedance gate (like a MOSFET), low on state voltage drop (like a BJT), and bipolar voltage blocking capability(like a thruster/SCR) .

3. Gate Turn OFF Thruster (GTO)

It is also used for medium power application. It is a member of thruster family. It can turned ON by a positive gate pulse (like a SCR) and turned OFF by a high power negative gate pulse. Since no separate forced commutation circuit is required (as in case of SCR), cost size and weight of controllers reduce where as the efficiency improves. It has high efficiency and high power handling capability. But requires a large gate power source (negative) to turn it OFF $I_G = I_A/3$.

4. Pulse Width Modulation (PWM)

To achieve voltage control with in inverter and to reduce the harmonic contents in the output voltage pulse width modulation techniques are used. In PWM technique width of output pulses are modulated to achieve the voltage control. Among the large number of modulated technique simple modulation techniques are-

a. Single Pulse Width Modulation
b. Multiple or Uniform Pulse Width Modulation
c. Sinusoidal Pulse Width modulation

5. Sinusoidal Pulse Width Modulation

Sinusoidal PWM pulse can be achieved by comparison of high frequency triangular signal with required frequency sinusoidal signal .In this modulation technique width of pulses varies in proportion to the magnitude of a sine wave.

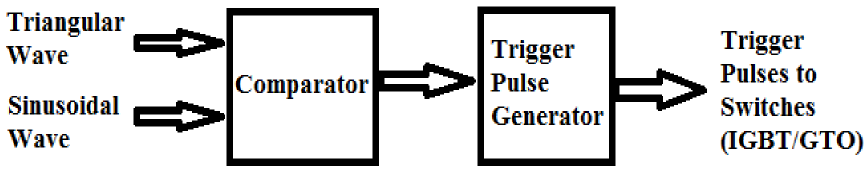

Fig. 1

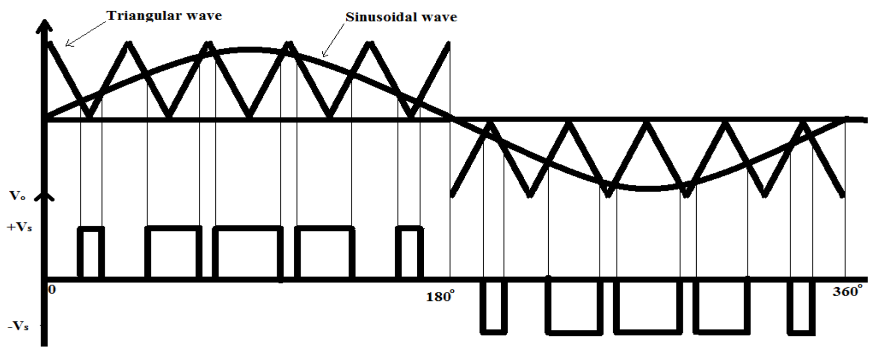

Fig. 2

6. Total Harmonic Distortion (THD)

A total harmonic distortion is a measure of closeness in a shape between the output voltage waveform and its fundamental component.

II. Simulation

In this section basic SIMULINK blocks which are used to make Inverter models are shown. And both IGBT and GTO based SIMULINK models are also shown. Load voltage and load current waveform which are obtained after SIMULATION are also given.

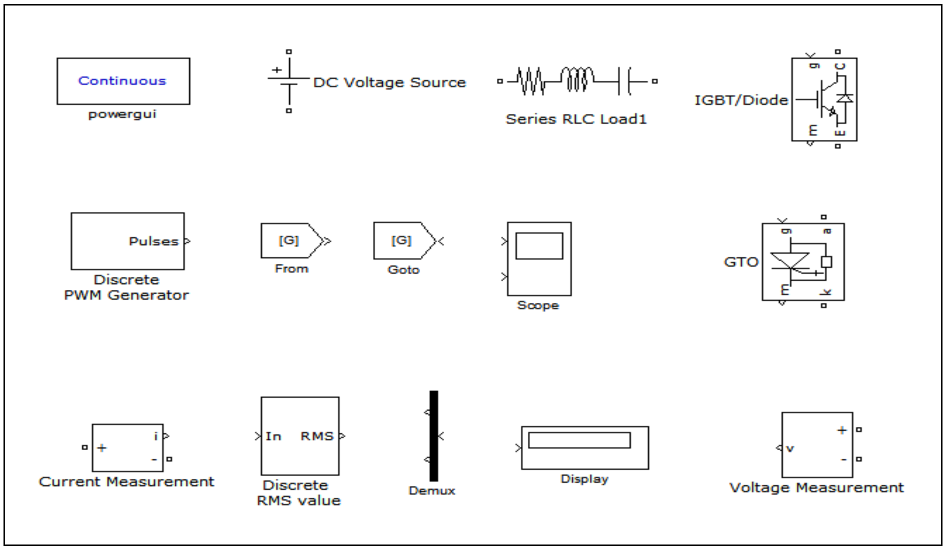

Fig. 3 Simulink Blocks

Block Name	**Details**
D C Voltage Source	400 Volt
Series RLC Load	Nominal Voltage Vn (Vrms) 230V, Nominal frequency f_n 50Hz, Active power (P) 1000W, Inductive Reactive Power (Q_L) 750Var, Capacitive Reactive power (Q_c) 150Var, Capacitor Initial Voltage 0V, Inductor Initial Current 0 A.
IGBT	Internal Resistance (Ron) 0.009 ohms, Snubber Resistance (Rs) 90000ohms, Snubber Capacitance (Cs) 10micro F
GTO	Resistance (Ron) 0.001ohms, Inductance (Lon) 0H, Forward Voltage (Vf) 1V, Current 10% fall time(T_f) 10 micro Sec., Current tail time (Tt) 20micro sec., Snubber Resistance (Rs) 120ohms, Snubber Capacitance (Cs) 10micro F, Initial Current (Ic) 0A.
Discrete PWM Generator	Carrier Frequency 1080Hz, Frequency of Output voltage 50Hz, Sample time 5 micro sec., Modulation index 0.4 to 1, Phase of output voltage(degrees) 0

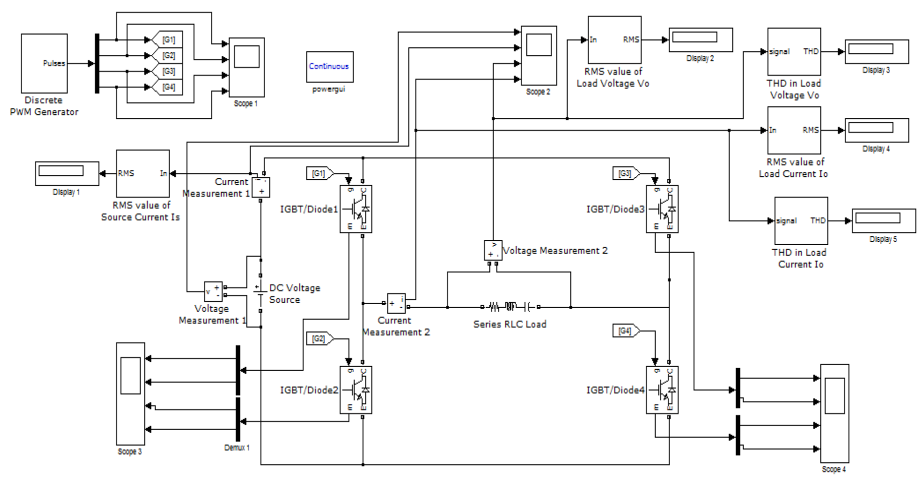

Fig. 4(A) Simulation model for IGBT based Inverter

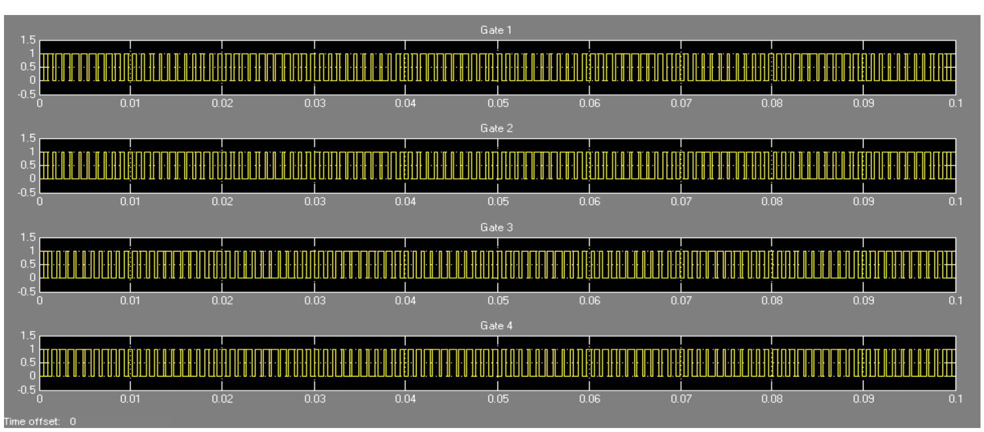

Fig. 4(B) Waveform of PWM Pulses

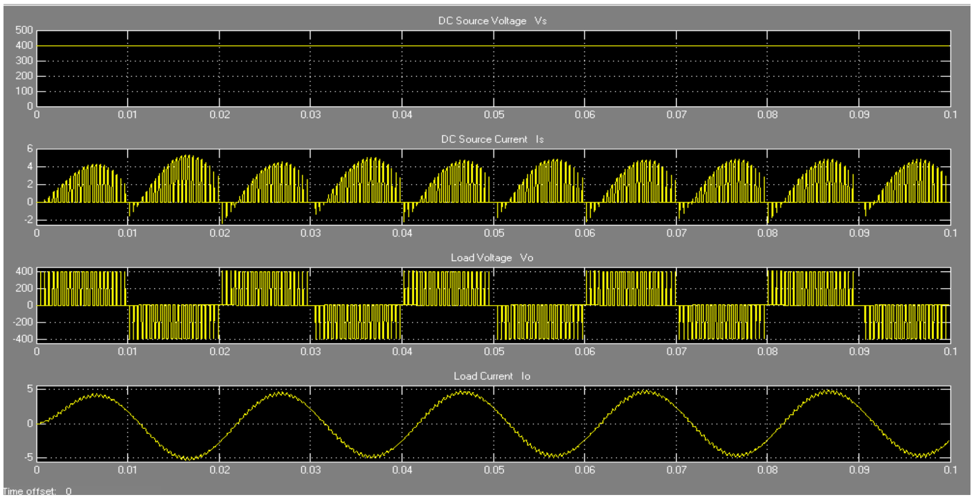

Fig. 4(C) Waveform of Source & Load

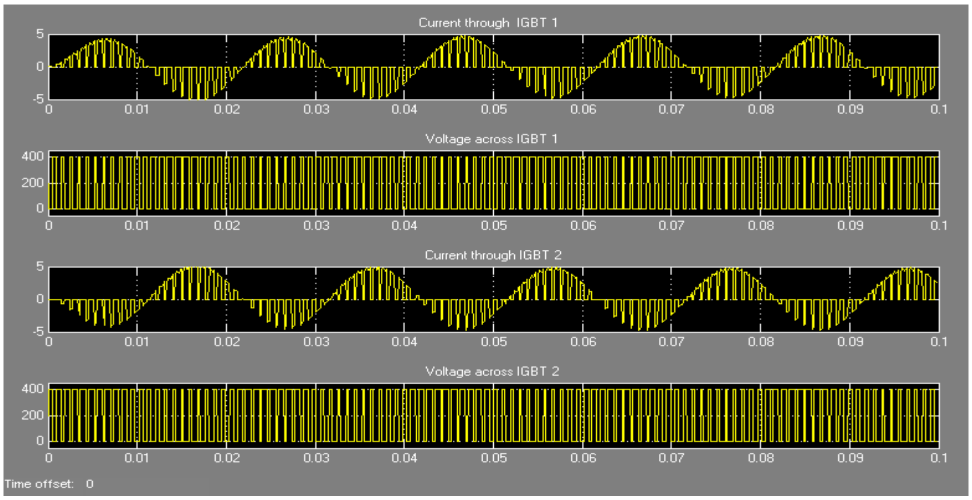

Fig. 4(D) Waveform of IGBT1 & IGBT2

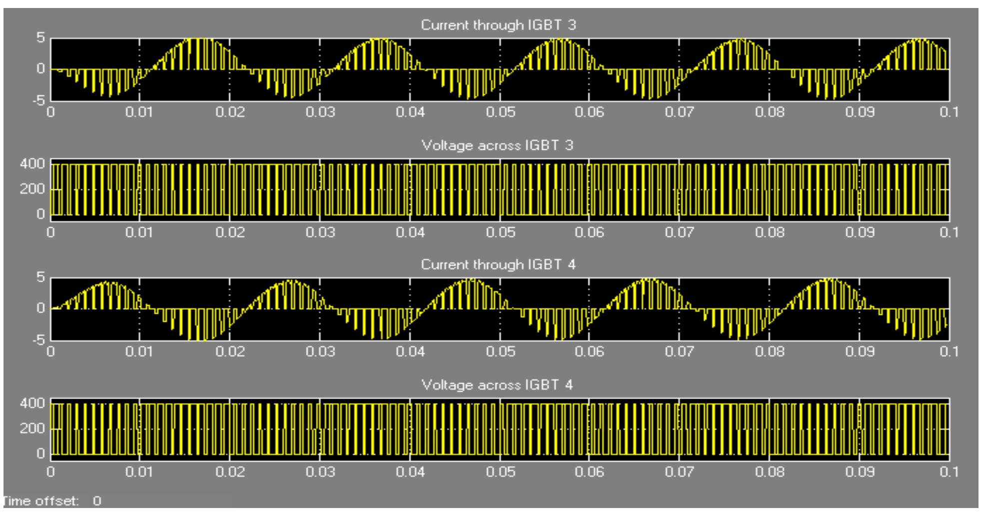

Fig. 4(E) Waveform of IGBT 3 &IGBT 4

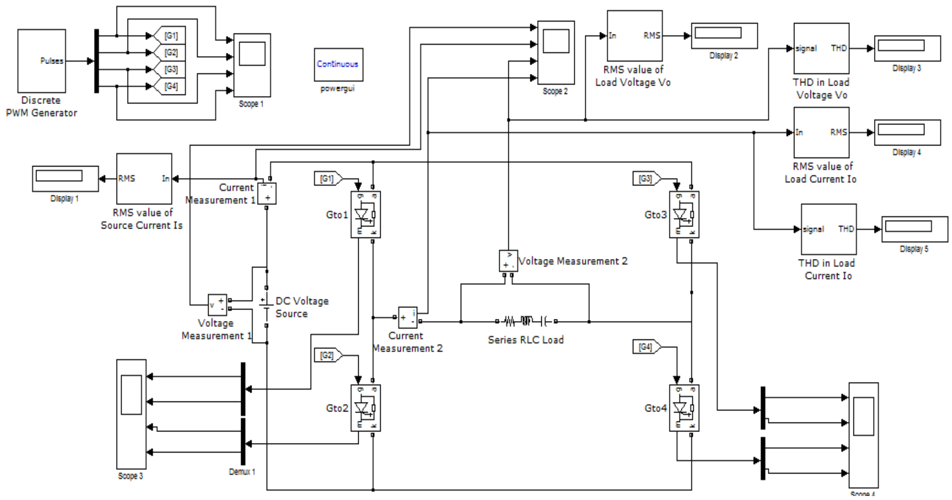

Fig. 5(A) Simulation model for GTO based Inverter

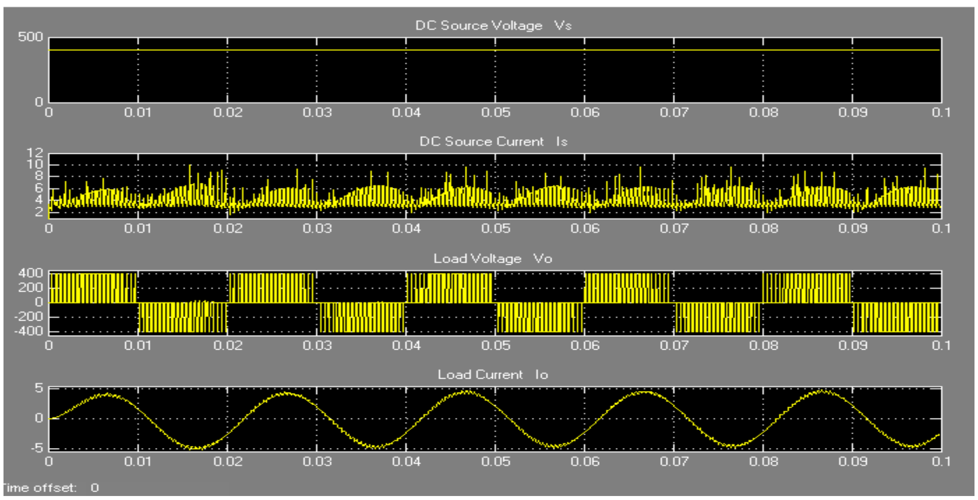

Fig. 5(B) Waveform of Source & Load

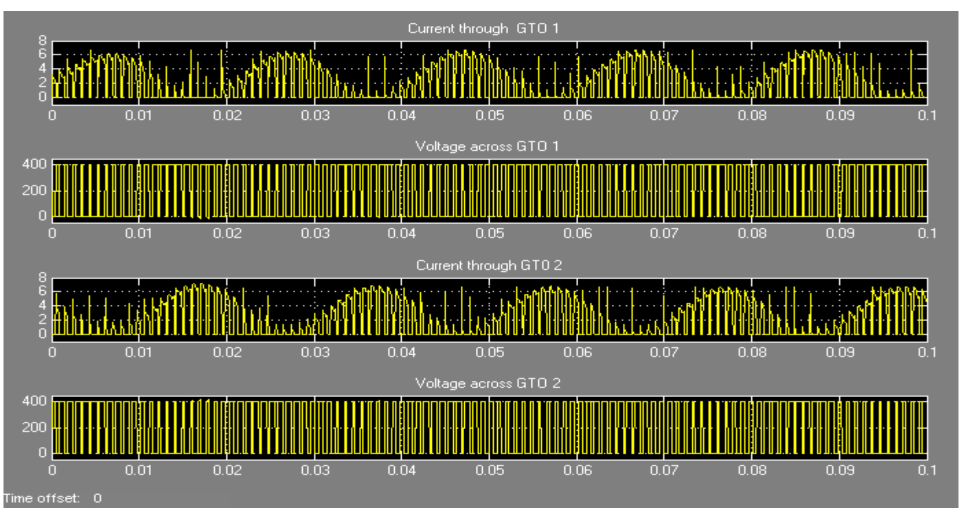

Fig. 5(C) Waveform of GTO 1 & GTO 2

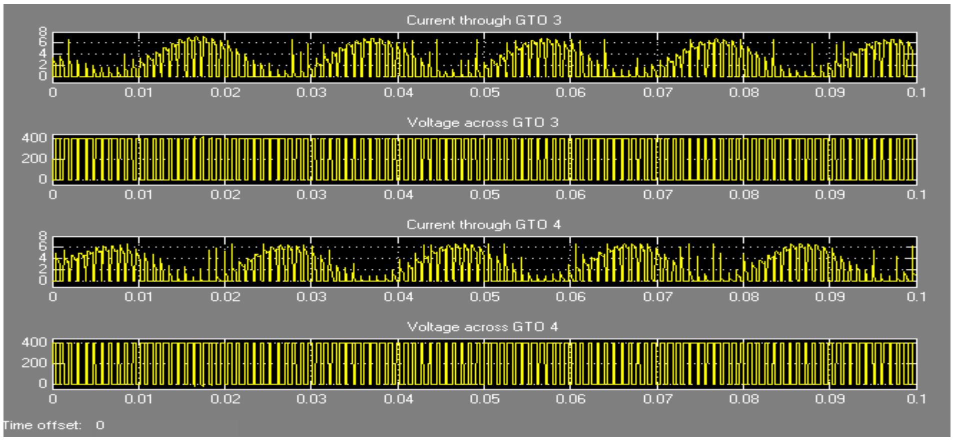

Fig. 5(D) Waveform of GTO 3 & GTO 4

III. Tables

By increasing modulation index (0.4 to 1) we find various value of load voltage and load current with the help of simulation. Here power factor in all these case becomes 0.8.

DC Source Voltage Vs Volt	Modulation Index m	Load Voltage Vo Volt	THD Vo %	Load Current Io Amp	THD Io %	Power Factor
400	0.4	203	147	2.494	4.347	0.8
	0.5	228	122.4	3.117	3.793	
	0.523	229.8	121.3	3.26	3.67	
	0.55	234.9	115.3	3.428	3.53	
	0.6	244.9	105.8	3.74	3.279	
	0.7	266.8	89.57	4.363	2.774	
	0.8	283.5	76.03	4.985	2.28	
	0.9	299.9	63.96	5.607	1.848	
	1	315.5	50.15	6.235	1.511	

Table 1. for IGBT

DC Source Voltage Vs Volt	Modulation Index m	Load Voltage Vo Volt	THD Vo %	Load Current Io Amp	THD Io %	Power Factor
400	0.4	202	147	2.483	4.345	0.8
	0.5	226.9	122.3	3.102	3.792	
	0.523	228.6	121.3	3.245	3.67	
	0.55	233.8	115.4	3.41	3.533	
	0.6	243.7	106.9	3.7	3.337	
	0.7	265.8	94.2	4.244	3.136	
	0.8	282.9	83.57	4.797	2.936	
	0.9	299.8	72.58	5.386	2.783	
	1	315.9	58.73	6.021	2.84	

Table 2. for GTO

IV. Conclusion

From the tables we see that value of Load voltage and Load current in case of IGBT based inverter is more as comparison to GTO based inverter and also value of Total Harmonic Distortion (both Load voltage and current) in case of IGBT based inverter is less as comparison to GTO based inverter. After these comparison we can say that IGBT is more suitable for inverter as compared to GTO. This paper will help to select proper switch for designing inverter. In future many other switch's performance may be discussed.

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