Design and Implementation of AC Chopper

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Abstract: *This paper Describes the design and simulate a single phase AC chopper module using IGBT as a power switch and designing and implementing the control circuit used to trigger the power switches. In this paper given that the difference between thyristor and IGBT. The reason for phase delay between main and freewheeling IGBT. In this paper control circuit is designed such that more related to the hardware elements and we can go for hardware implementation. AC Chopper is simulated in MATLAB software.*

Keywords: *AC Chopper, control circuit and MATLAB*

1. Introduction

Converter is defined as converting one form of the source energy to the other form. In general we are having two types of sources i.e. AC and DC sources. The different Converters Rectifiers, Choppers, Inverters, AC Voltage Converters and Cyclo Converters.

Rectifier is a static converter which converts from AC to DC. Chopper is a static converter which converts from fixed DC to variable DC.

Inverter is a static converter which converts from DC to AC. AC Voltage converter is a static converter which converts AC to AC with changing Magnitude and without changing frequency.

Cyclo converter is a static converter which converts AC to AC without changing Magnitude and with changing frequency.

AC Chopper is a static converter which converts AC to AC without changing the frequency and AC choppers have been widely used to control average load power from a fixed ac source.

2. Introduction to AC Chopper Model

AC Chopper is a static converter which converts AC to AC without changing the frequency and AC choppers have been widely used to control average load voltage from a fixed ac source.

Advantages

- Simplicity
- Ability of controlling large amount of power
- High efficiency

Disadvantages

- Protection against detrimental switching voltage transients.
- Negative Temperature coefficient.

Applications

- Industrial heating
- Light dimming
- AC motor speed control

3. About Thyristor and IGBT

Thyristor

- Even though Thyristors have high voltage and current handling capabilities they suffer with commutation problems.
- Continuous gating signal increases the power loss in the gate junction.
- Having lower switching frequencies.

IGBT

- No commutation problem
- It is most versatile, due to its simple gating requirements and fast switching speed
- High-current handling capability
- Operation at high junction temperature is allowed (>100°C)

IGBT have more advantages over thyristor so in this paper we are taking control switch as IGBT.

4. CIRCUIT DESCRIPTION

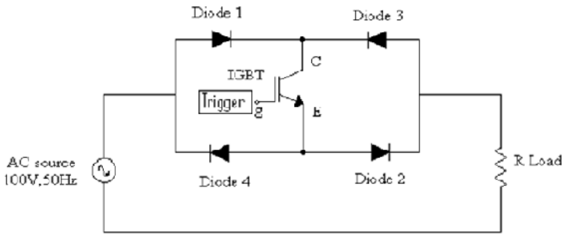

Fig 4.1 *Basic AC Chopper Circuit*

AC Chopper is a static converter which converts AC to AC without changing the frequency. Figure 4.1 represents the basic Ac chopper circuit, it consisting of IGBT connected between load and the source, here pure resistive load is considering . The basic circuit is modified as fig.4.2 because all practical loads are inductive nature. Two freewheeling diodes are connected anti parallel across the load.

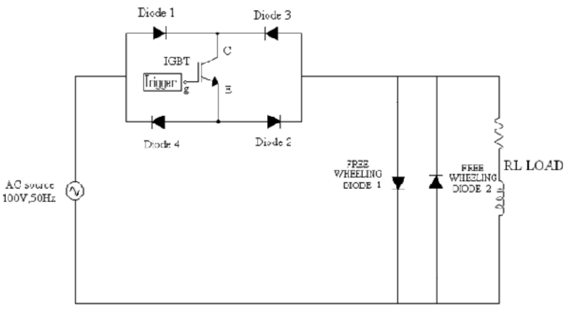

Fig 4.2 *Modified Basic AC Chopper with anti parallel diodes connected across the RL - Load.*

Freewheeling diodes provides the continuity in the circuit but the output voltage is clipped. So this circuit is modified as fig - 4.3.

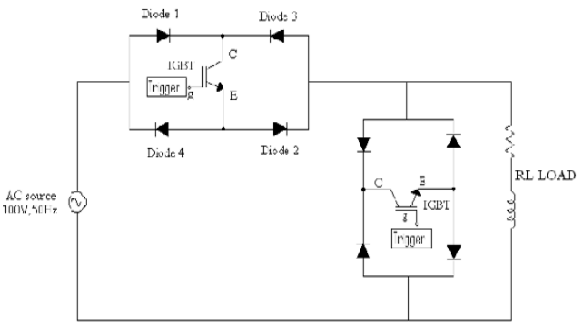

Fig 4.3 *Complete circuit diagram for AC Chopper with RL - Load.*

It consists of two IGBTs. Main IGBT connected between load and source, auxiliary IGBT connected for freewheeling purpose across the load. The IGBTs connected diagonally in a diode bridge circuit. D1, D2 connected for forward protection, and D3,D4 connected for reverse protection. The same circuit fallowed for the freewheeling IGBT. The output is modified than previous circuit. The R.M.S output voltage is given by

$$\frac{V_m}{\sqrt{\pi}} = \sqrt{\pi - 2\alpha - \frac{\sin 2(\pi-\alpha)}{2} + \frac{\sin 2\alpha}{2}}$$

Output R.M.S current is given by

$I_{r.m.s} = V_{r.m.s}/R_{load}$

Out power is

$P_{out} = V_{r.m.s}*I_{r.m.s}$

5. CONTROL CIRCUIT FOR IGBTS

The control circuit is specially designed for these IGBTs, the outputs are pulses and given to the gate terminals of IGBTs. Controlling circuit consisting of two outputs with phase delay of 1800. The designing of the circuit by taking the real components such as logical gates and mono - stable vibrators.

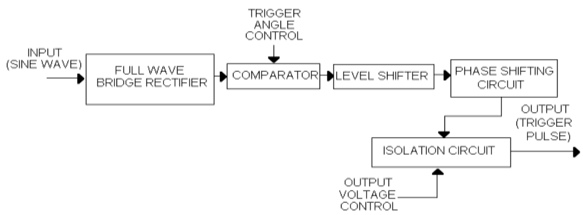

Fig 5.1 *Block diagram for control circuit*

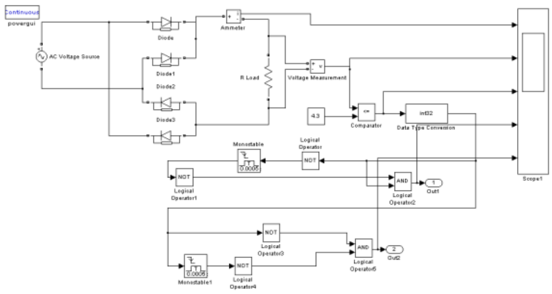

Fig 5.2 *Circuit diagram for Control circuit.*

The control circuit consists of a diode bridge rectifier circuit, the output of this circuit given to the comparator, comparator which compares the output of bridge rectifier circuit to a constant value, if the condition is true it will generate high pulse. This has given to the level shifter. It will increase the magnitude. The output of the level shifter given to the phase shifter it will adjust the phase. For adjustment of the phase shifter we are using mono stable vibrator. The output of the control circuit is given to the IGBT gates. The gate pulses are represented in the results. The IGBT two pulses are in 1800 phase shift. All the outputs are represented in the results.

6. RESULTS

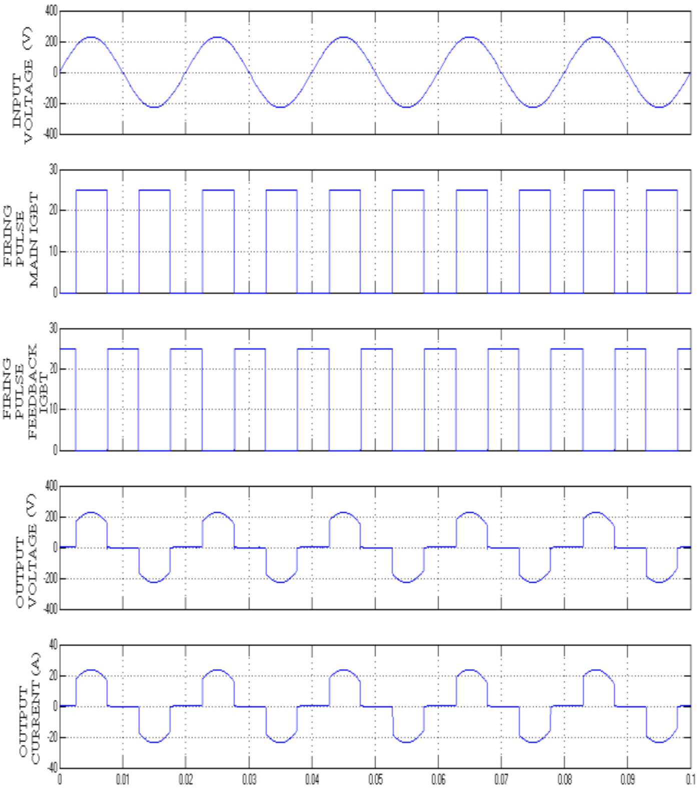

Fig 6.1 *Simulation output wave forms for AC Chopper.*

7. HARD WARE IMPLEMENTATION

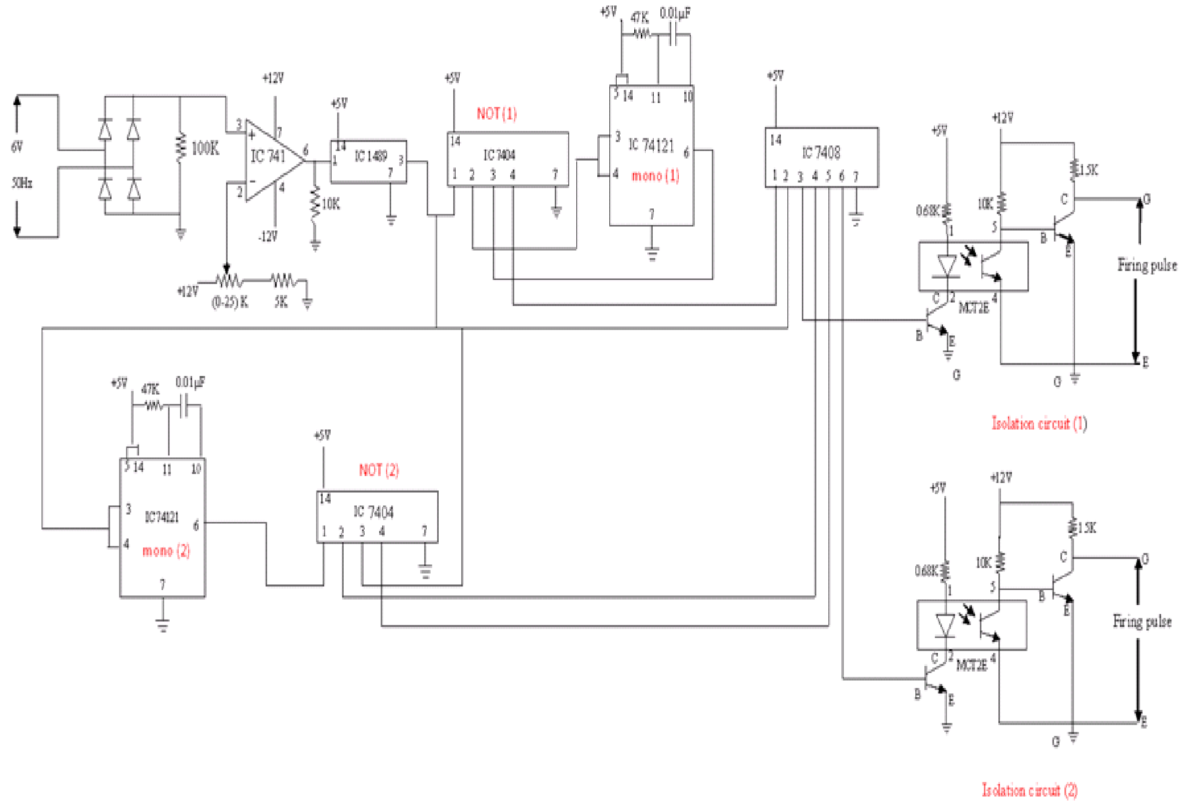

Fig 7.1 *Hard ware control circuit diagram*

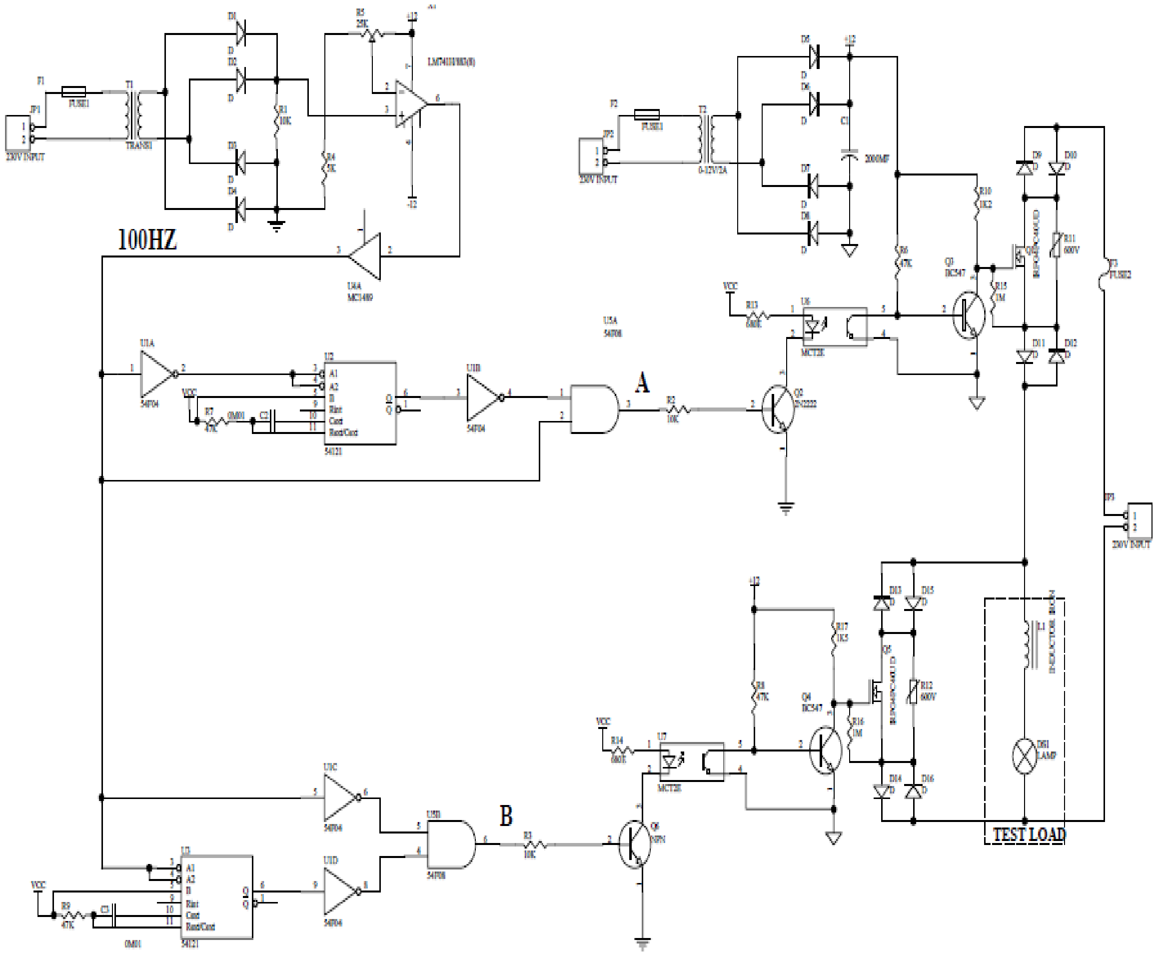

Fig 7.2 *Hard ware connection of control circuit*

In this circuit diagram consist of comparator IC 741, Level Shifter IC 1489, logical gate IC 7404 and mono stable vibrator IC 74121.By using these hard ware connections we are generating the pulses, these pulses giving to the two IGBTs through isolation circuit i.e. MCT2E.

8. Hardware Results

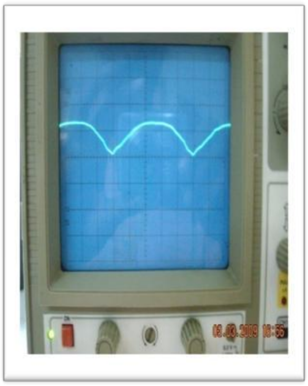

Fig. 8.1. *Bridge rectifier output*

Fig 8.2. *Comparator output*

Fig 8.3 *Level Shifter output*

Fig.8.4 *Level Shifter input & output*

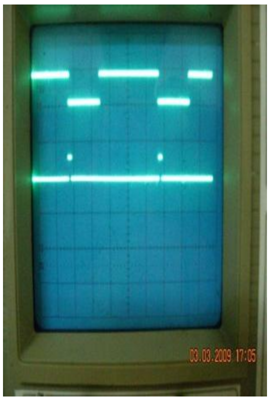

Fig.8.5 *Multivibrator1 in/output*

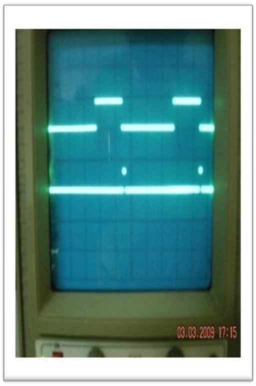

Fig.8.6 *Multivibrator2 in /output*

Fig.8.7 *input and isolation circuit1*

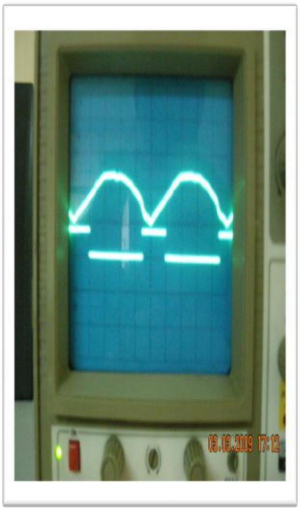

Fig.8.8 *input and isolation circuit2*

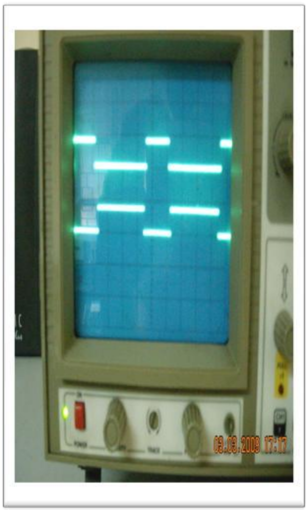

Fig.8.9 *outputs of Isolation circuits 1 & 2*

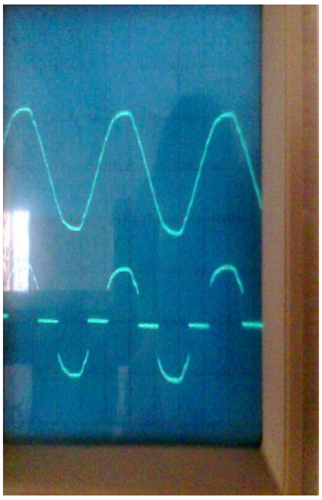

Fig 8.10 *output of AC Chopper*

9. Comparison between Practical and Theoretical Output Values

Table 7.1 *comparison table between Practical and theoretical values*

Firing Angle	Theoretical Output Voltage	Practical Output Voltage	Practical Output Current	Theoretical Output Current	Practical Output Power	Theoretical Output Power
36 deg	84.458 V	80 V	0.090 A	0.0854 A	7.2 W	7.21W
45 deg	77.099 V	70 V	0.085 A	0.0779 A	5.95 W	5.93W
60 deg	64.867 V	55 V	0.060 A	0.0648 A	3.30W	4.20W
75 deg	45.485 V	40 V	0.040 A	0.0454 A	1.60 W	2.04W
89 deg	11.550 V	10 V	0.020 A	0.0115 A	0.20 W	0.12W

10. Conclusion

The proposed scheme is good for applications Industrial Heating, Light dimming and AC motor speed control.

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