CHAPTER 7

FABRICATION AND TESTING OF AC CHOPPER

7.1 INTRODUCTION

To observe the performance of chopper controlled ac voltage controller (ac chopper) with R, RL and RLE (induction machine) load, it is proposed to fabricate an ac chopper. The fabrication of power MOSFET based ac chopper and the associated microprocessor based control circuitry are presented in this chapter. The test results of single phase ac chopper with R, RL and induction motor load are also presented.

7.2 FABRICATION OF SINGLE-PHASE AC CHOPPER

7.2.1 Power Circuitry

Single-phase ac chopper consists of two ac switches, one connected in series with the load and the other one in parallel as shown in fig. 7.1a. The AC switch is realised with a diode bridge and a Power MOSFET as shown in fig. 7.1.b. The configuration of the power circuitry for the ac chopper is shown in fig. 7.2.

The implementation of ac chopper was found to be difficult. The ON/OFF of the semiconductor switch requires finite delay time associated with the storage charge. If there is an overlap between the switching of the series and parallel switches, the supply voltage is short circuited. A finite amount of switching delay between the switches is hence essential. This switching delay results in the interruption of the load current causing voltage spikes in the case of inductive load.

To reduce the spikes, a suitable snubber circuit is designed. The snubber diode selected has a high surge current capability and can withstand the charging current of the capacitor during OFF period of the MOSFET. The value of the snubber resistance chosen is relatively small to ensure that the snubber capacitor is fully discharged during the ON period of the MOSFET (The Snubber resistance and capacitance values chosen are 50Ω and 3μF respectively).
7.2.2 Control Circuitry

Microprocessor based control circuitry is used to generate the trigger pulses for the ac chopper. The configuration of the control circuitry is given in fig. 7.3. The control circuitry generates two sets of trigger pulse trains to control the series and parallel switches. The flow chart of the program used for generating the trigger pulses are given in fig. 7.4. Port A and Port B of 8255, the Programmable Peripheral Interface, are used to link the microprocessor with external devices. The trigger pulses generated at Port A are complimented to obtain the pulses at Port B with some time delay incorporated between them. This time delay ensures that there is no short circuit between the switches. Buffers are used to protect the microprocessors from any external voltage spikes. Zener diodes across the gate source protect the gate of the MOSFET from voltage transients in both the directions. MCT2E opto-isolator is used to provide isolation between the power circuitry and the control circuitry.

7.3 TEST RESULTS

The fabricated ac chopper is tested with R, RL, and RLE (Induction motor) loads. The load voltage waveform for a multiple pulse ac chopper with R load is shown in fig. 7.5. In the case of RL load, voltage spikes are observed due to the time delay between the switchings of the series and parallel switches. The spikes are found to be reducing with the decrease in the time delay between the switches. Load voltage waveforms for different time delays were observed as shown in fig. 7.6. In order to decrease the voltage spikes further, a snubber circuit is connected. The load voltage and current waveforms with and without snubber are shown in fig. 7.7 and 7.8.

The performance of ac chopper is studied for various switchings per half cycle. Fig. 7.9 and 7.10 show the load voltage waveforms and the Harmonic Spectra for different number of pulses per half cycle of the ac chopper.

Finally, the performance of ac chopper with a single phase induction motor is observed. A fan motor is used for this purpose. The load voltage and current waveforms observed are shown in fig. 7.11. The performance of ac chopper with the induction motor load is compared with that of a conventional phase controlled ac voltage controller. Figures 7.12 and 7.13 show the voltage and current waveforms and the harmonics spectra of chopper controlled and phase controlled ac voltage controller. It is found that in the case of ac chopper fed induction motor, the harmonic is much less compared to the conventional controller fed induction motor.
7.4 CONCLUSION

A microprocessor based single phase ac chopper has been fabricated. The developed circuit is tested for R, RL and RLE (Induction Motor) loads. The load voltage and current waveforms are studied with digital storage oscilloscope. The harmonic contents are measured with FFT analyser.

In the case of inductive loads, to avoid short circuit, the necessary time delay is introduced between the series and parallel switches. The resulting voltage spikes were reduced by introducing an appropriate snubber circuit. The load voltage and current waveforms are observed for different time delays and for different number of pulses per half cycle.

The performance of ac chopper is compared with that of a conventional ac voltage controller with induction motor load. The lower order harmonics are found to be much less in the case of ac chopper.

Three phase ac chopper is yet to be fabricated.
FIGURE 7.1 SINGLE-PHASE AC CHOPPER

(a) BASIC CONFIGURATION

(b) REALISATION OF AC SWITCH
FIGURE 7.2 POWER CIRCUITRY FOR SINGLE-PHASE AC CHOPPER
FIGURE 7.3 CONTROL CIRCUITRY FOR SINGLE-PHASE AC CHOPPER
FIGURE 7.4. FLOW CHART OF THE PROGRAM FOR GENERATING THE TRIGGER PULSES
FIGURE 7.4. FLOW CHART OF THE PROGRAM FOR GENERATING THE TRIGGER PULSES

2
Set Acc = 0

Send Accumulator value to Port B

After some delay Complement the Accumulator Value and Send to Port B

Decrement counter C

Is C = 0 ?

No

Yes

Reinitialize the Value of H and L register to 0 and 1 respectively.

3
Set Acc = 0

Send Accumulator value to Port A

After some delay Complement the Accumulator Value and Send to Port A

Decrement counter B

Is B = 0 ?

No

Yes

Reinitialize the Value of H and L register to 1 and 0 respectively.

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FIGURE 7.4. FLOW CHART OF THE PROGRAM FOR GENERATING THE TRIGGER PULSES
FIGURE 7.5 LOAD VOLTAGE WAVEFORM OF MULTIPLE PULSE AC CHOPPER WITH R LOAD
FIGURE 7.6 LOAD VOLTAGE WAVEFORM OF AC CHOPPER WITH RL LOAD FOR DIFFERENT TIME DELAYS

(a) WITH 12 MICRO SECONDS TIME DELAY BETWEEN SWITCHES

(b) WITH 24 MICRO SECONDS TIME DELAY BETWEEN SWITCHES
FIGURE 7.7 EFFECT OF SNUBBER IN THE LOAD VOLTAGE WAVEFORM OF AC CHOPPER WITH RL LOAD
FIGURE 7.8 EFFECT OF SNUBBER IN THE LOAD CURRENT WAVEFORM OF AC CHOPPER WITH RL LOAD
(a) 3 PULSES PER HALF CYCLE

(b) 5 PULSES PER HALF CYCLE

FIGURE. 7.9. LOAD VOLTAGE WAVEFORMS AND HARMONICS OF AC CHOPPER WITH RL LOAD FOR DIFFERENT NUMBER OF PULSES
FIGURE 7.9. LOAD VOLTAGE WAVEFORMS AND HARMONICS OF AC CHOPPER WITH RL LOAD FOR DIFFERENT NUMBER OF PULSES

(c) 7 PULSES PER HALF CYCLE

(d) 9 PULSES PER HALF CYCLE
FIGURE 7.10 HARMONIC SPECTRUM OF AC CHOPPER FOR DIFFERENT NUMBER OF PULSES
FIGURE 7.11 WAVEFORMS OF AC CHOPPER WITH INDUCTION MOTOR (FAN MOTOR) LOAD
(a) LOAD VOLTAGE WAVEFORM AND HARMONIC SPECTRUM

(b) LOAD CURRENT WAVEFORM AND HARMONIC SPECTRUM

FIGURE 7.12. PHASE CONTROLLED AC VOLTAGE CONTROLLER WITH INDUCTION MOTOR LOAD
(a) LOAD VOLTAGE WAVEFORM AND HARMONIC SPECTRUM

(b) LOAD CURRENT WAVEFORM AND HARMONIC SPECTRUM

FIGURE 7.13. CHOPPER CONTROLLED AC VOLTAGE CONTROLLER WITH INDUCTION MOTOR LOAD