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REGULATOR AND CHOPPER FED DC MOTOR

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ABSTRACT

This paper introduces the running of DC motor with AC power supply. The Input power supply is stepped down using a 12V step down transformer and fed to the semi converter. The AC supply is converted into dc by using a rectifier with thyristors and diodes. The Rectified supply is fed into the boost regulator for the amplification process and this amplified DC output is fed for the DC motor. The thyristor and Mosfet are triggered by gate pulses produced by multivibrator. The Semiconverter is turned on by the gate pulses provided by the Astablemultivibrator having transistors while the boost converter is turned on by gate pulses provided by Astablemultivibrator having 555 timer

KEYWORDS: Regulator, Chopper, Thyristor, Astablemultivibrator

INTRODUCTION

In a converter two diodes and two thyristors are used. The switching actions of T1 and T2 can be performed by gate turn off pulses. The characteristics of Gate Turns Off thyristors are such that a Gate Turn Off thyristor can be turned on by applying a short positive pulse to its gate as in the case of normal thyristors and can be turned off by applying a short negative pulse to its gate. An Insulated-gate Bipolar transistors (IGBT's) remains on as long as a gate voltage is applied to its gate terminal. In an extinction angle control thyristor T1 is turned on at wt=0 and is turned off by forced commutation at wt=π-β Thyristor T2 is turned on at wt=π and turned off at wt= (2π-β). The Output voltage is controlled by varying the extinction angle .

The output of the regulator is fed as the input of boost regulator. In the boost regulator, the Mosfet needs a square wave to get triggered and this square wave is provided by the astable multivibrator using 555 timer.

PRINCIPLE OF OPERATION

We have used thyristor to convert ac supply to dc supply and it is fed to the boost regulator to run a DC motor.

A Thyristor is a four junction semiconductor device which acts as a switch. The characteristics of the thyristor are as follows:

Reverse Blocking Thyristor

When the anode is made positive with respect to cathode with the switches being open, the thyristors become reverse biased. In this reverse biased condition the thyristor exhibits a blocking characteristic similar to that of a diode. In this reverse biased condition, the outer junction J1 and J3 are reverse biased and the middle junction J2 is forward biased. Hence a small leakage current flows. This region is known as reverse blocking region.

Forward Blocking Region

In this region the anode is made positive with respect to cathode and hence junctions J1 and J3 are forward biased while the junction J2 remains reverse biased. Hence, the anode current is a small forward leakage current. This region is known as forward blocking region.

Forward Conduction Region

When a gate pulse is applied, the thyristor turns on before breakdown voltage is used. The forward voltage at which the device switches to ON state depends upon the magnitude of the gate current, higher the gate current, lower is the forward biased voltage. Once the SCR is conducting a forward current that is greater than the minimum value called the Latching current, the gate current is no longer required to maintain the device in its ON state.

Removal of the gate current does not affect the forward conducting characteristics of SCR. The SCR will return to its original forward blocking state if the anode current falls below a low level, called the holding current. The latching current is associated with the TURN-ON process while the holding current is associated with the TURN-OFF process.

SEMICONVERTER

The ac supply is converted to dc supply by using a semi converter. The output of the semi converter is fed as input to the boost regulator.

The semi converter is of two types:

- Asymmetrical Configuration
- Symmetrical Configuration.

We have used Symmetrical configuration of semi converter. The gate pulse to this semi converter is fed by astablemultivibrator. Once the gate pulse is provided by the astable multivibrator, the SCR's are turned on and they start to conduct. The semi converter provides dc supply to the boost regulator.

The DC regulator is used to modify the dc signal fed to it.

The different kinds of regulators are:

- Buck regulator
- Boost regulator
- Buck –Boost regulator
- Step-up regulator
- Step-down regulator.

We have used boost regulator. The boost regulator is used to increase the magnitude of DC signal. The gate of MOSFET used in the boost regulator is provided by multivibrator using the 555 timer. A multivibratoris an electronic circuit used to implement a variety of simple two-state systems such as oscillators, timers and flip-flops. It is characterized by two amplifying devices (transistors, electron or other devices) cross-coupled by resistors or capacitors.

The name multivibrator was initially applied to the free-running oscillator version of the circuit because its output waveform was rich in harmonics. There are three types of multivibrator circuits depending on the circuit operation:

- Astable, in which the circuit is not stable in either state —it continuously switches from one state to another. It functions as a relaxation oscillator.
- Monostable, in which one of the states is stable, but the other state is unstable (transient). A trigger pulse causes the circuit to enter the unstable state. After entering the unstable state, the circuit will return to the stable state

after a set time. Such a circuit is useful for creating a timing period of fixed duration in response to some external event. This circuit is also known as a one shot.

- Multivibrators find applications in a variety of systems where square waves or timed intervals are required.

SIMULATION PROCESS

The regulator and chopper is simulated using mat lab. The L and C values of chopper are found using Mat lab simulation.

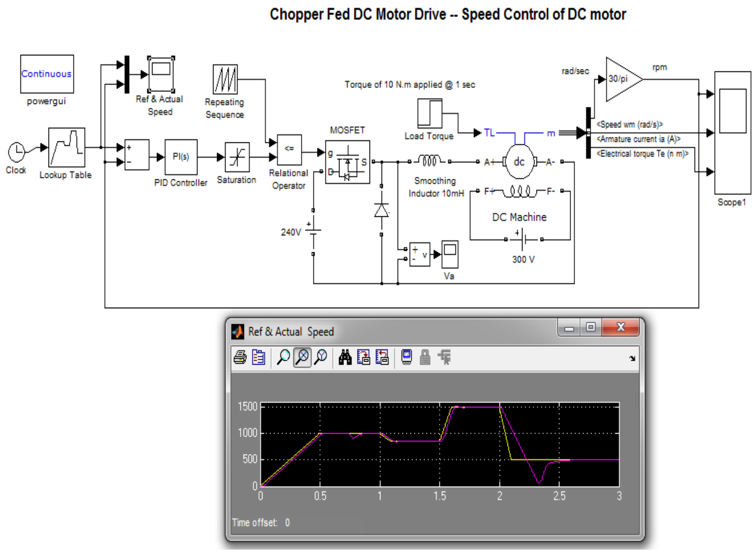

Figure 1: Simulink of Chopper Fed DC Motor

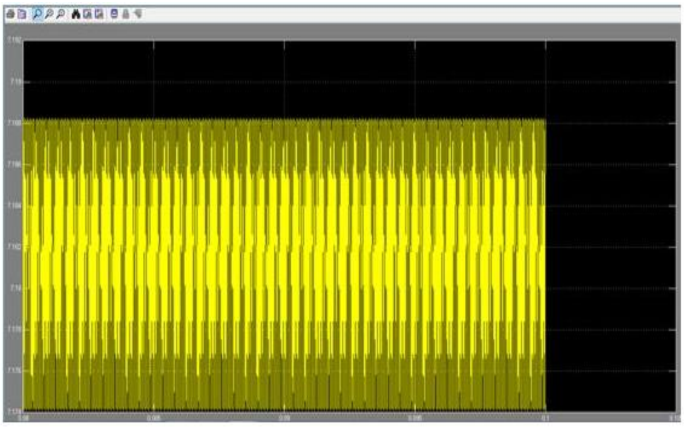

Figure 2: Simulation Result of the Boost Regulator

The boost converter amplifies the magnitude of input dc supply. Initially 3V dc supply is fed into the boost regulator and this is amplified into a 7V dc output. The values of the inductor and capacitor values are found using Mat lab software and implemented in the boost regulator hardware experiment.

HARDWARE IMPLEMENTATION

We have used a regulator which contains bridge configuration of 2 diodes and 2 thyristors. This regulator rectifies ac power supply to dc. AC power supply is fed between the junction of thyristor and diode to trigger the thyristor we have set up a multivibrator.

When triggered by an input pulse, a monostable multivibrator will switch to its unstable position for a period of time, and then return to its stable state. The time period of Monostable multivibrator remains in unstable state which is given by t = ln(2)R2C1. If repeated application of the input pulse maintains the circuit in the unstable state, it is called a retriggerable monostable. If further trigger pulses do not affect the period, the circuit is a non-retriggerable multivibrator.

The circuit diagram for astable multivibrator is shown in Figure 3:

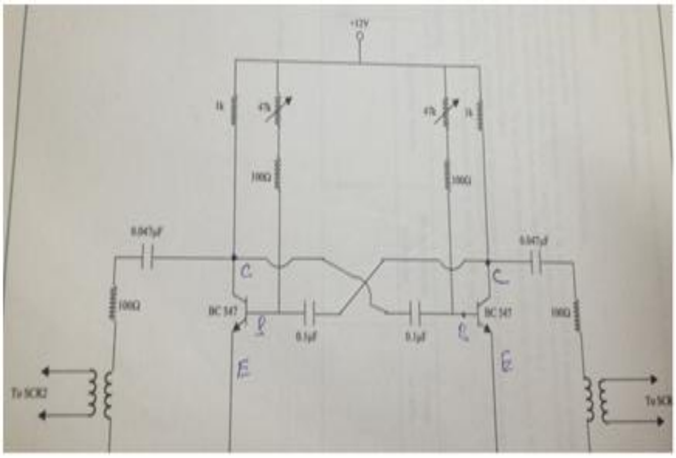

Figure 3: Astable Multivibrator

CIRCUIT OPERATION

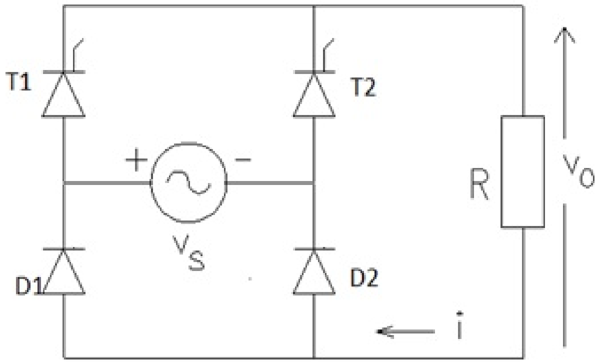

Figure 4: Semiconverter

Initially the thyristers T1 and T2 used in the regulator are reverse biased. In our circuit, separate triggering gate pulses are given to the thyristor using astable multivibrator. This type of configuration is known as asymmetrical configurationof half controlled Bridge rectifier. During the positive half cycle of the ac supply, the thyristor T1 and Diode D1 are forward biased and are in forward blocking mode. When the SCR T1 is triggered at a firing angle, the current flow through the path L-T1-R-D1-N.During the negative half cycle of the ac supply, thyristor T2 and diode D2 are forward biased. When SCR T2 is triggered, the current flow through the path N-T2-A-R-B-D2-L.This current is continuous, when the SCR T2 is turned off till angle 2π.

The voltage and current relations are derived as follows:

- Average DC load-voltage:

$E_{dc}=1/\pi \int_{\alpha}^{\pi} E_m \sin wtd(wt)$

$=1/\pi\ E_m\ [1+\cos \alpha]$

- Average load-current:

$I_d = E_M/\pi R[1+\cos \alpha]$

- RMS load voltage:

$$E_{rms} = [E^2_m/\pi \int_{\alpha}^{\pi} \sin wt d(wt)]^{1/2}$$

$$= E_m[(\pi - \alpha/2\pi) + (\sin\ 2\alpha/4\pi)]^{1/2}$$

The ac input supply is converted into dc output and then it is fed using Semi converter and the output of this semi converter is fed as input to the boost regulator. The Boost regulator is used to amplify the DC signal to DC signal with higher magnitude. The boost regulator is turned on by Gate pulse and this gate pulse is provided by the 555 timer. The circuit diagram for the astable multivibrator using IC 555 is shown here. The astable multivibrator generates a square wave, the period of which is determined by the circuit external to IC 555. The astable multivibrator does not require any external trigger to change the state of the output. Hence the name free running oscillator. The time during which the output is either high or low is determined by the two resistors and a capacitor which are externally connected to the 555 timer. The above figure shows the 555 timer connected as an astable multivibrator. Initially when the output is high capacitor C starts charging towards V_{cc} through R_A and R_B.

The circuit diagram of astable multivibrator using 555 Timer is shown below in Figure 5:

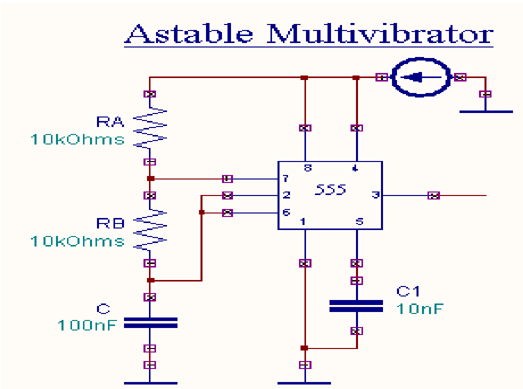

Figure 5: Astable Multivibrator Using 555 Timer

A boost converter (step-up converter) is a DC-to-DC power converter with an output voltage greater than its input voltage. It is a class of switched-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element, a capacitor, inductor, or the two in combination. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple.

The boost regulator using a MOSFET is shown in the diagram:

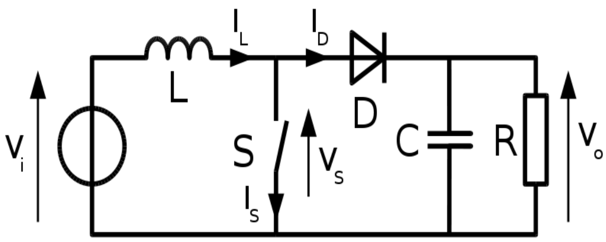

Figure 6: Boost Regulator Using Mosfet

The boost regulator operates on 2 Modes. Mode 1 begins when transistor M1 is switched on at t =0.The input current flows through inductor L and transistor Q1.Mode 2 begins when Transistor M1 is switched off at t=t1.The current that wasflowing through the transistor would now flow through L,C and Load and diode. The inductor current falls until transistor M1 is turned on again in the next cycle. The energy stored in the inductor L is transferred to the load.

The values of L and C are assigned by the following equations:

If I_L is the average inductor current, the inductor ripple current $\Delta I = 2I_L$.We know that,

$$kV_s/fL=2I_L=2I_a=2V_s/(1-k)R$$

This gives the critical value of inductor Lc as

$$L_c=L=k(1-k)R/2f$$

If V_c is the average capacitor ripple voltage $\Delta V_c=2V_a$.We know that

$$I_ak/Cf=2V_a=2I_aR$$

This gives the critical value of capacitor as

$$C_c=C=k/2fR$$

A boost regulator can step up the output voltage without a transformer. Due to a single transistor, it has high efficiency. The input current is continuous. However a high peak current has to flow through the power transistor. The output voltage is very sensitive to changes in duty cycle k and it might be difficult to stabilize the regulator. The average output current is less than the average inductor current by the factor of (1-k). and a much higher RMS current would flow through the filter capacitor, resulting in the use of a larger filter capacitor and a large inductor than those of a buck regulator.

Figure 7: Experimental Setup

Figure 8: Output of Boost Regulator - The 3V DC Supply Fed to the Chopper Circuit is Converted Into 10.15V by the Boost Regulator

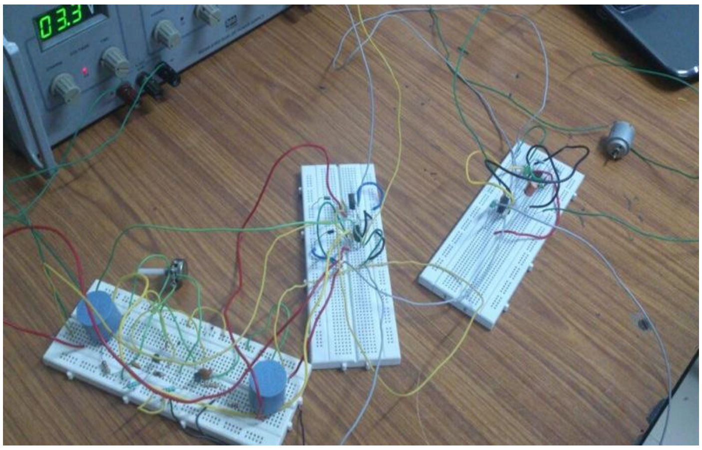

Figure 9: Experimental Setup with DC Motor in Running Condition

CONCLUSIONS

This paper describes the running of DC motor using Regulator and Chopper. The regulator rectifies AC power supply to DC power supply. The Astable Multivibrator provides gate pulses to turn on thyristor in the regulator circuit. We have used Boost regulator (DC-DC converter) which amplifies the magnitude of the given DC supply. The Mosfet in Boost regulator is triggered using 555 timer. Hence, with the complete setup the motor is in the running condition.

ACKNOWLEDGEMENTS

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