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MATLAB Simulation of Choppers

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Abstract: MATLAB Simulink is a commercial tool developed by the Math Work Inc. Under the MATLAB family for modelling, simulating and analysing multi domain dynamic systems. In this paper simulation of different chopper circuits are done. Dc Chopper finds tremendous applications indrives and control. The variable resistance is commonly used in series with the armature of the DC motor for speed control can be replaced by a chopper resulting in better efficiency. Therefore it can be utilized in battery-operated vehicles and in applications where saving of energy is a prime consideration. Operation of various choppers in four quadrant had been simulated by using Matlab in this paper.

Keywords: Dc Chopper, Matlab, four quadrant, Simulink.

I. INTRODUCTION

Now a days high power controlled semiconductor switches like thyristor power MOSFETs and IGBTs are available for constructing DC power converters. The converters are of two types – inverter-rectifier system and DC Chopper system. In the inverter-rectifier system, the DC is first converted into AC by using an inverter which is then stepped up or stepped down and then rectified back to DC by a rectifier. As conversion is done in two stages this system is costly bulky and less efficient. The DC chopper system converters directly from DC to DC and is a latest technology with good efficiency. As the conversion is done by switching action the power is lost only in turning the switch ON/OFF.
Chopper circuits are classified according to the polarity of the output voltage and current. They are classified as Type-A or first quadrant, Type B or second quadrant, Type C or two quadrant Type A, Type-D or two quadrant Type B, and Type –E or four quadrant chopper depending on the quadrant in which the output voltage and current of the chopper lie. This has been simulated by using MATLAB SUIMULNK Software.

TYPE –A CHOPPER

In a Type A chopper or first quadrant chopper, the output voltage and current can be zero or positive. So the power delivered to the load is either positive or zero. Thus the power can flow only from the source to the load.

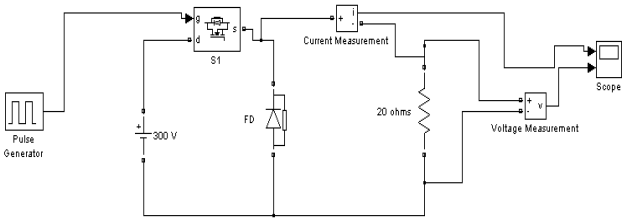

Fig. 1 Type – A Chopper

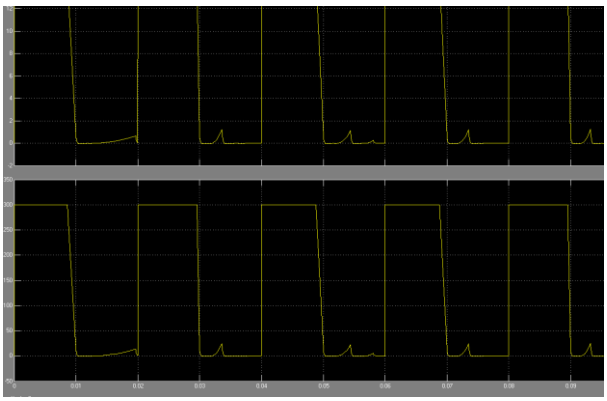

Fig .1.1 output Current and voltage waveforms verses Time.

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The circuit model of a type A chopper containing a dc supply of 300 V, pulse generator, MOSFET switch, freewheeling diode and resistive load. The parameters are set for the pulse generator are as followers: Amplitude- 5, period – 0.02s, Pulse width-50% and phase delay -0 S. The output voltage is 300 V when the switch is closed and is zero when the switch is open. The output voltage and current waveforms obtained after simulating the model are shown in fig 1.1. It can be observed that current and voltage are positive and zero. He peak magnitude of the current is 15A and that of voltage is 300 V. As the output voltage is less than input voltage this chopper is known as step down chopper.

TYPE –B CHOPPER

In a type –B chopper, the output voltage is positive or zero, whereas the output current is zero or negative. The output power is negative in Type – B chopper. It implies that the power is delivered from the load to the source. The load must contain a DC source, that is a battery or a DC motor. The voltage across the load is V out =E+(iRL di/dt), which is always greater than the source voltage. So, this chopper is a step up chopper. Figure 2 shows a model of a Type – B chopper containing 120 V DC source, pulse generator and a diode Mosfet Switch with load inductance of 5mH, resistance 1Ω along with the battery of 50V. The output voltage varies form 0V to 50 KV and the output current varies form 0 to -100A. Thus the power delivered to the load is negative in this chopper circuit. Also, it is clear from the circuit that diode D will allow the current flow only from the load to source. The average output voltage of the chopper depends on the duty cycle of the switch.

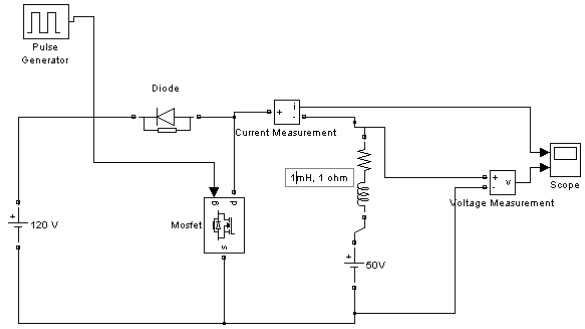

Fig. 1 Type – B Chopper

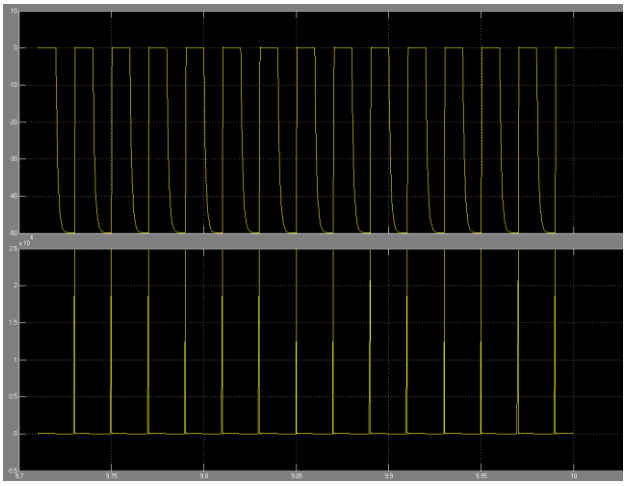

Fig .2.1 output Current and voltage waveforms verses Time.

TYPE – C CHOPPER

The Type – C chopper is a two quadrant chopper. In this chopper the output voltage is positive or zero whereas the output current can be either negative or positive. Type-A and Type – B choppers in parallel. A model of Type – C is shown in figure – 3. For this model, the input supply is 250V; load consists of 1mH inductance, 5Ω resistance, and 125 V battery; and two MOSFET switches S1 and S2 and used along with two diodes as can be observed in fig. 3. The parameters set for the Gate Pulse blocks are as follows For G1: Amplitude-5, period -0.01s, pulsewidth-50%, and phase delay - 0 s; and for G2:Amplitude-5, period -0.01s, pulsewidth-50%, and phase delay - 0.005s.

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In this chopper. In this chopper when switch S1 is on current flows from source to load and when switch S2 is ON, current flows from load through switch S2. Thus load current can be positive or negative but load voltage remains positive. Switches S1 and S2 should not be turned on simultaneously as this would result in short circuit of the input supply. This chopper can be used for DC motor control and regenerative braking. The output voltage varies from 80V – 170V. When the output current is positive, the power delivered to the load is positive and when the output current is negative, the power delivered to the load is negative.

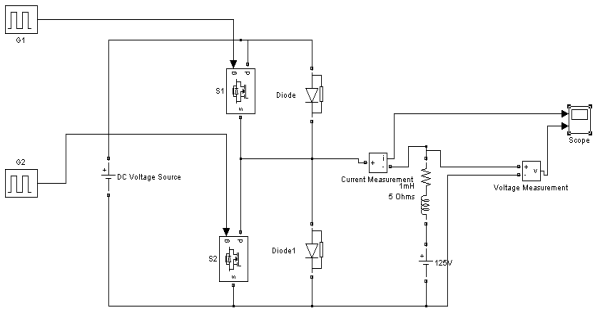

Fig. 3. Type – C Chopper

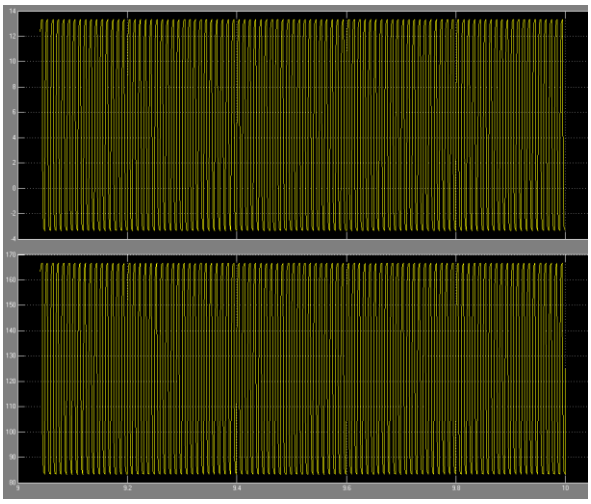

Fig .3.1 output Current and voltage waveforms verses Time.

TYPE D CHOPPER

In Type –D or two quadrant Type – B chopper, the output current is positive or zero whereas the output voltage can be either positive or negative depending upon the duty cycle of the chopper.

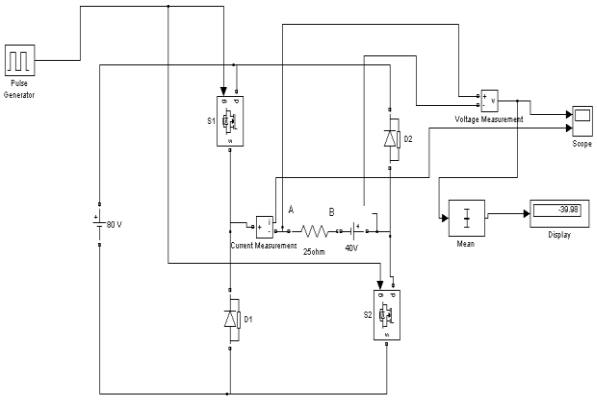

Fig. 4. Type - D Chopper

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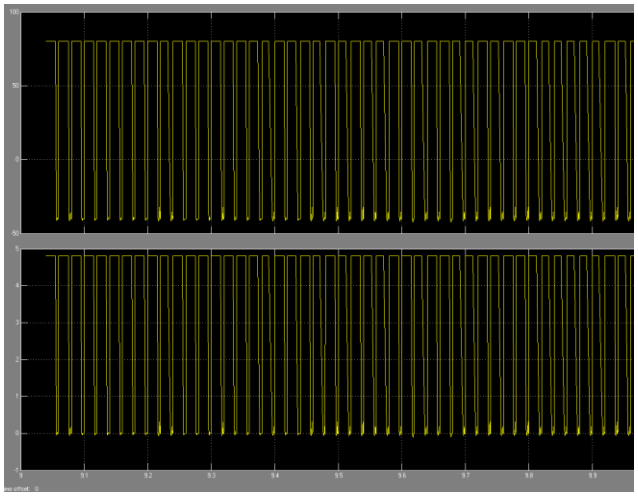
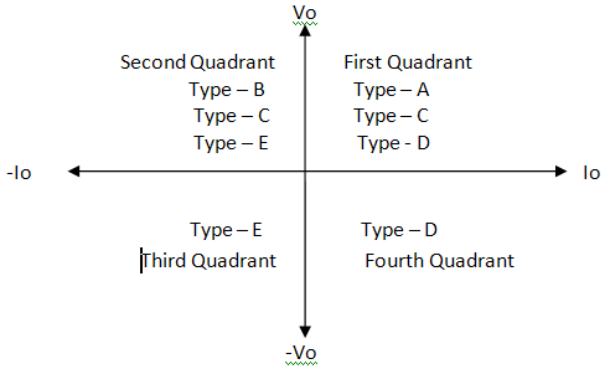


Fig .4.1 output Current and voltage waveforms verses Time.

The model of a type – D chopper contain a DC source of 80V, MOSFET switches S1 and S2, diodes D1 and D2, a load of 25Ω,40V, pulse generator and measurement blocks is shown in Fig. 4. The paramaters set for Gate Pulse block are as follows: Amplitude – 5, perod-0.02s, pulse width – 80%, and phase delay 0s. When switch S1 and S2 are On, current flows from A to B as be seen from figure 4.1.

TYPE E CHOPPER

The Type –E chopper is a four quadrant chopper in which the output voltage as wel as current can be either positive or negative. The chopper can operate in all four quadrants. For the first quadrant operation Switch S1 is operated, S4 is kept ONand S3 and S2 are kept OFF. When S1is ON, The output voltage is equal to the supply voltage and the load current increases. If S1 is OFF, then the load current decreases gradually due to the inductive load. For the second quadrant operation,Switch S2 is operated with all other switches, i.e., S2,S3, and S4, kept OFF. When S2 in ON, the current in the load flows in negative direction and the load inductor stores energy and when it is OFF, the energy stored in the load inductor is discharged through diodes D1 and D4. As the load voltage is positive and the current is negative the chopper operates in the second quadrant. Also in this case, the load voltage is higher than the supply voltage.For the third- quadrant operation switch S3 is operated, S1 and S4 are kept OFF, and S2 is kept ON and the polarity of the load battery is reversed. When S3 is ON load s connected to the source leading to negative load voltage and current. When switch S3 is OFF, the negative current flows negative current flows through switch S2 and diode D4. For the fourth quadrant load battery is reversed. When S4 is ON, positive current flows through the load and when it is OFF,the load discharges the current through diodes D2 and D3. In this case the load voltage is negative and the load current is positive. Therefore any type of chopper can be realized by Type – E chopper. Figure 5 shows the four quadrants and operation



A Model of Type –E chopper containing four Mosfet switches(S1, S2, S3, and S4), Four diodes (D1, D2, D3, and D4), 230 V DC Supply, pulse generators(G1,G2), R-L-E load for 5Ω, 5H and -190V, and measurement blocks is shown in the figure 6. In order to operate this chopper in the fourth quadrant, S1 and S3 are turned OFF by setting the amplitude

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of G1 equal to zero. Also, S2 is turned OFF by applying a constant value of zero at the gate terminal. Now , only S4 is operated through G2. The parameters set for Pulse Generator G2 are as follows: Amplitude – 5, period – 0.02s, pulse width - 60% and phase delay is - 0s. Voltage terminals of the load battery are reversed by setting the amplitude equal to -190 V. Now when S4 is ON, positive current flows through S4, D2, L,and E and the energy is stored in the load inductor. When S4 is ON, positive current flows through S4, D2, L,and E and energy is stored in the load inductor. When S4 is OFF, inductive current is fed back to the source through D2 and D3. Output voltage and current waveforms obtained after simulating the model is shown in fig.7.1 it can be observed that output voltage varies from -184 to -195V and current varies from 0 to 3 A Also, there is a sudden variation in the output voltage and current and power delivered to the load is negative.

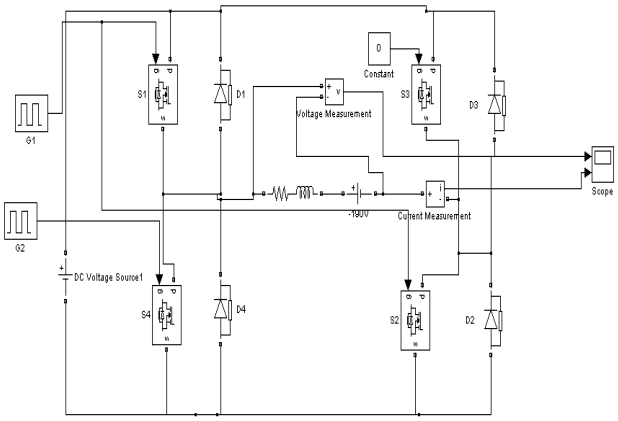

Fig.7. Type - E Chopper

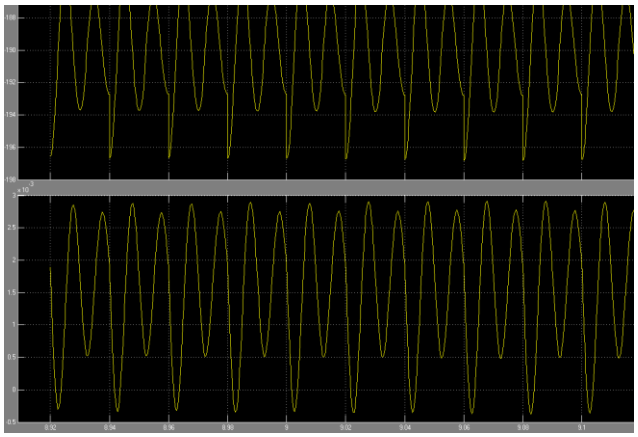

Fig. 7.1 output current and voltage waveforms of class E Chopper.

II. CONCLUSION

This paper provides a plat form for beginners to learn more about electrical simulation using MATLAB. This had been demonstrated with chopper circuits. After Design of any electrical or electronic circuit it is easy to simulate a then find the nearest result and rig up the circuit.

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