Effective Controlling of Dc Machine by Using Dual Input Z-source Chopper Converter

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ABSTRACT- effective controlling of dc machine by using dual input z-source chopper converter based. In the proposed converter, the input dc voltage can be controlled, boosted and the input dc sources can be deliver the power to the load individually or simultaneously, so the combination of a battery with one of the new non conventional energy sources like wind turbine, photovoltaic(pv), solar array or fuel cell can be used as input sources. Different states of dual input z-source chopper converter are explained and modeling of separately excited dc motor is explained in detail. Finally, the simulation results are presented to confirm the theoretical analysis.

Keywords: *z-source, controlling of dc machine, chopper converter.*

I.INTRODUCTION

The renewable energy sources like as hydroelectric power stations and wind turbine power stations has created various electrical energy sources with entire different electrical characteristics for the modern group of power generating systems. In order to combine more than one electrical energy sources, such as hydroelectric power stations and wind turbine power stations, solar array, fuel cell (FC) and commercial ac line to get the regulated output voltage, the different types of multi input converters have been explained in recent years.

In generally, two dc voltage sources are connected to two independent chopper power converters to obtain the two stable and equivalent output voltages, which are connected to the load or dc bus, to provide the electrical energy demanded by the loads.

Another method for the dual-input z-source chopper converter is to develop two dc voltage sources in series to form a single voltage source where traditional choppers i.e. dc-dc power converters can be used to transfer power to the load. In order to transfer power simultaneously and individually, each dc voltage source needs a controllable switch to provide a bypass short circuit for the input current of the other dc voltage source to deliver electrical energy continuously.

Another technique is to put pulse width modulation converters in parallel without or with electrical isolation between them by using the coupled transformers.

Because of the voltage amplitude variations between the two dc sources, only one of them can be connected to the input terminal of the dc-dc converter and transfer power to the load at a time.

The objective of this paper is to propose a dc motor fed with double input dc-dc converter which has the following advantages:

The power can be deliver to the load i.e. dc motor individually or simultaneously; the multi winding (mw) transformers are not needed, the magnitude of the input dc current or voltage can be higher or lower than the one of the regulated

.

II. CIRCUIT CONFIGURATION AND PRINCIPLE OF OPERATION

A. Z-Source Converters

Impedance-source i.e. z-source converters are group of power electronic converters which can overcome the problems of traditional converters.

Alternate energy sources such as solar, fuel cells, wind turbines have wide range of voltage variations due to nature. Photovoltaic cell voltage varies with respect to radiation and temperature. Fuel cell stack voltage drops greatly with load current .and wind generator voltage varies with wind speed and control.

The traditional voltage source inverter that has been the power conversion technology for these energy sources cannot cope with the wide voltage change and often requires additional voltage boost by additional dc-dc converter, which increases cost, and power loss.

The Z-source converter/inverter systems can solve this problem. The Z-source inverter is a novel topology that overcomes the conceptual and theoretical barriers and limitations of the traditional voltage-source converter and current-source converter.

B. Circuit Configuration

The circuit diagram of an effective controlling of dc machine by using dual input z-source chopper converter based as shown in fig.1.The circuit consisting of two different input voltage sources, those are voltage source V_{dc1} and voltage source V_{dc2}, and four diodes, D1,D2,D3,D4,.In this proposed paper, permanent connection of input dc sources are considered, so that diode D1 and diode D2 can be replaced with active switches if it's required to connect and disconnect each of sources to input side of converter frequently. Energy receiver, converter and transmitter sections are situated in the middle side of the converter.

C. *Principle and modes of Operation of Dual Input chopper Converter*

In this circuit there are four different types of operating states with respect to active or inactive states of dc sources. Both of the input voltage source V_{dc1} and voltage source V_{dc2} can deliver the power to the load either individually or simultaneously by using multi input converters. When one of the input sources V_{dc1} or voltage source V_{dc2} feeds the multi input converters, it will be transfers the power to the load individually and the MIC will operate as does a PWM converter.

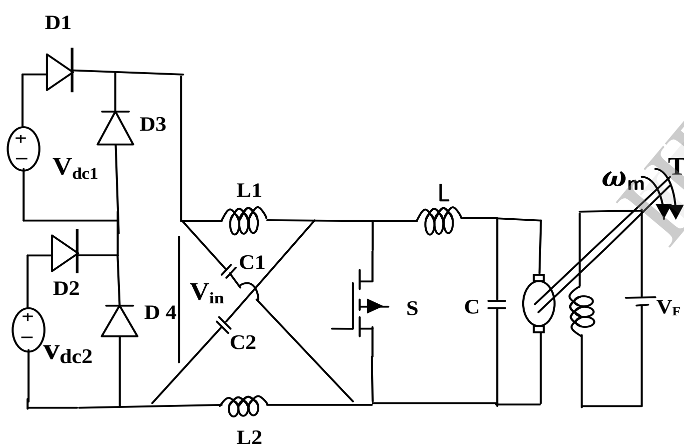

Fig1.DC Machine fed with dual input Z-source chopper converter

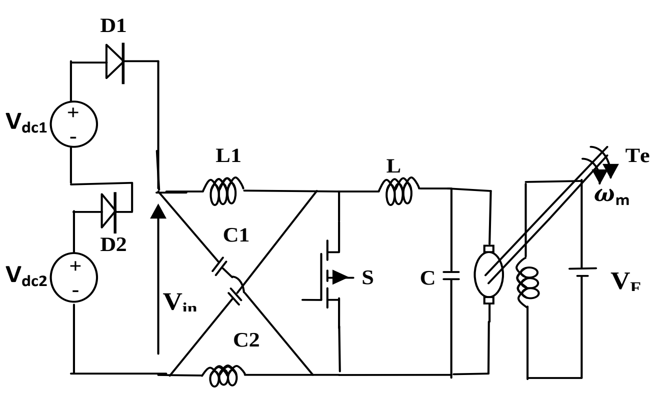

Fig2. Dual input chopper converter mode1

1) Mode 1, both Vdc1 *and Vdc2 are in active state*

Fig. 2 shows equivalent circuit of this mode. *Both* Vdc1 *and Vdc2 are in active state*, the converter input dc voltage is sum of the voltage of two series dc voltage sources, by Fig. 3 and 1 illustrates that.

$$V_{input} = V_{dc1} + V_{dc2} \quad \dots\dots\dots (1)$$

In this mode, because both two sources are active, the diode D1 and the diode D2 are forward biased and the diode D3 and the diode D4 are reverse biased. Thus, the sources current enters in to the Z-network through diode D1 and diode D2 and after passing through the load impedance and comes back into the negative polarity to the source.

2) Mode 2, Vdc1 *is active and Vdc2 is inactive*

In this mode, source *Vdc*1 is active, so that only this source provides the energy to the load. Because of the Vdc1 is active then diode D1 is forward biased and diode D3 is reverse biased, so current follows from diode D1 to Z-network to the load.

State modes	Voltage Sources States		Switching mode				V_{input}
	V_{dc1}	V_{dc2}	D1	D2	D3	D4	
1	ACTIVE	ACTIVE	ON	ON	OFF	OFF	$V_{dc1}+V_{dc2}$
2	ACTIVE	INACTIVE	ON	OFF	OFF	ON	V_{dc1}
3	INACTIVE	ACTIVE	OFF	ON	ON	OFF	V_{dc2}
4	INACTIVE	INACTIVE	OFF	OFF	ON	ON	0

TABLE I. MODES OF DUAL INPUT CHOPPER CONVERTER

In reverse path from load to the source, current can't pass through source 2 and D2, so D4 is forcedly turned on and conduct current to source 1. In this state, converter input dc voltage is only provided by source 1, as (2) shows.

$$V_{input} = V_{dc1} \quad \dots\dots\dots\dots (2)$$

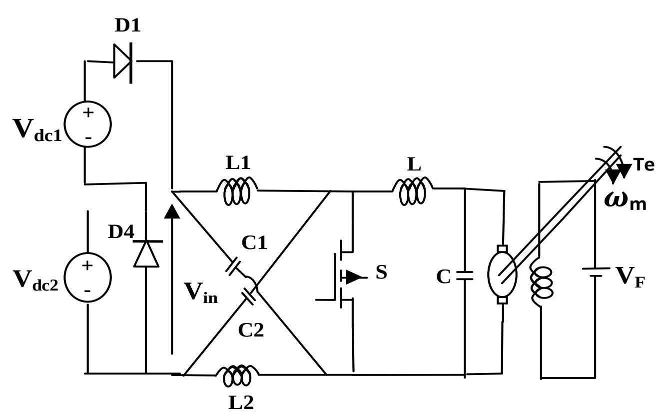

Fig3. Dual input chopper converter mode 2

3) Mode 3, Vdc*1 is inactive and Vdc2 is active*

If Vdc1 is switched off mode for each reason and *Vdc*2 is active mode, the chopper converter can operate normally without effect of *Vdc*1. Fig. 4 shows the equivalent circuit for this mode. In mode3, the *Vdc2* only that supplies power to the converter and load. *Vdc*2 activation causes forward bias of diode D2 and reverse bias of diode D4. Because of source 1 disconnection, current passes through D3 and indeed, current turns it on forcedly to complete current path. In this state, converter input dc voltage is only provided by source 2, as (3) shows.

$$V_{input} = V_{dc2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

4) Mode 4, Vdc*1 and Vdc2 are inactive*

In generally, this mode4 is to be only following one of the previously mentioned 3 modes. why Because in this mode the two sources Vdc*1 and Vdc2 are inactive* and sources are disconnected from the converter, diode D1 And diode D2 are forcedly switched off ,then the only existing path for remain current, from previous mode, is to be provided by diode D3 and diode D4. In this mode4 diode D3 and diode D4 are switched on. Fig.5 shows the equivalent circuit of this mode. The Input voltage is zero in this mode as shown in (4).

$$V_{input} = 0 \qquad \ldots\ldots\ldots \quad (4)$$

Because of both Vdc1 *and Vdc2 are inactive modes so that* dc sources are disconnected from the converter, duration of this mode is very short time period and when the current descends to zero, whole of the converter will be inactive mode.

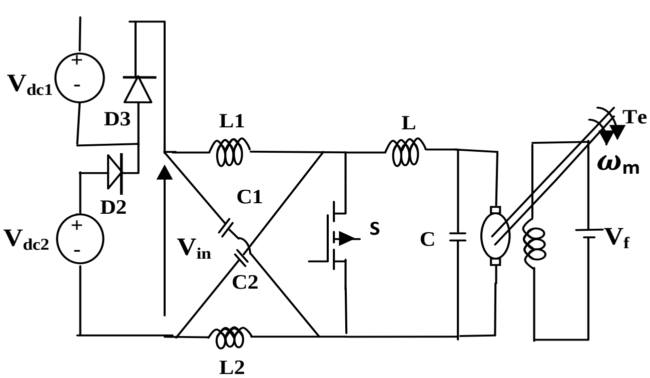

Fig4. Dual input chopper converter mode3

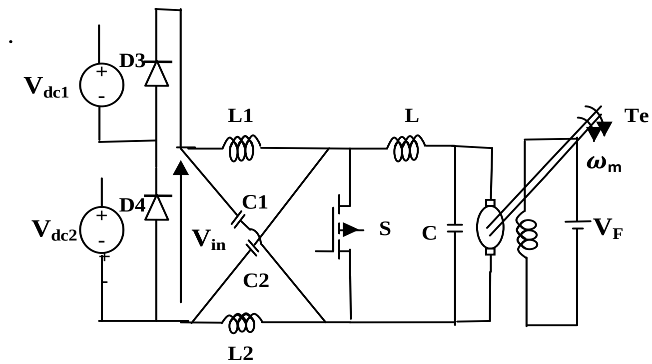

Fig5. Dual input chopper converter mode 4

III. STEADY STATE ANALYSIS OF DC MACHINE BY USING DUAL INPUT Z-SOURCE CHOPPER CONVERTER

All 4 modes of dual input Z-source chopper converter can be analyzed, but in this section only first mode is analyzed which is to be applied to the other modes of chopper converter. Fig. 3 is considered for the steady state analysis of dual input z-source chopper converter.

Similar way the other Z-source converter modes can be analyzed, the inductors L1, inductor L2 and capacitors C1 , capacitor C2 have the same value of inductance (L) and capacitance (C). From the symmetry and the equivalent circuits, the inductor (L) and capacitor (C) voltages have following relations.

$$V_{C1}= V_{C2}= V_C, \quad V_{L1} = V_{L2} = V_L \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

There are two states of operations are there for steady state analysis of chopper converter circuit. In state1 diodes D1 and diode D2 are switched on and the switch S is switched off. In the converter circuit Z-network capacitors are charged, while Z-network inductors are discharged and transfer the energy to the load. Converter operating interval in this state is (1-a) T, where as "a" is the duty ratio of switch S, and switching cycle is the T. The Fig. 7 shows the equivalent circuit of state1. Thus in this interval the following equations are can be analyzed.

$$V_{input} = V_{dc1} + V_{dc2} \qquad \ldots\ldots\ldots (6)$$

$$V_C = V_{input} - V_L \qquad \ldots\ldots\ldots\ldots\ldots (7)$$

$$V_o = V_{input} - 2V_L \qquad \ldots\ldots\ldots\ldots\ldots (8)$$

In state 2, the switch S to be turned on and diode D1 and diode D2 are turned off. The Z-network capacitors C1, C2 discharge, while inductorsL1, L2 charge and store the energy and it transfer to the load next interval. Converter operating interval in this mode is aT.

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Following equation expresses the voltage V_C , V_o and V_L

$$V_C = V_L , V_o = 0 \qquad \dots\dots\dots\dots\dots\dots.. \qquad (9)$$

The average voltage of the inductors over one switching period (T) in steady state should be zero, so (6)-(9) result:

$$V_L = \int \mathrm{V_C}.\mathrm{aT} + (\mathrm{V_{in}} - \mathrm{V_C})(1 - \mathrm{a})\mathrm{T}]dt \qquad (10)$$

Considering (10) equal to zero, results following equation:

$$\frac{V_c}{V_{in}} = \frac{1-a}{1-2a} \qquad (11)$$

Similarly, the peak output voltage of converter in a Switching cycle can be expressed as follows:

$$V_L = 2V_c - V_{in} = \frac{\mathrm{V_{in}}}{1-2\mathrm{a}} \qquad (12)$$

The average output voltage can be expressed as:

$$V_o = V_c = \frac{1-\mathrm{a}}{1-2\mathrm{a}}\mathrm{V_{in}} \qquad (13)$$

$$V_o = \frac{1-\mathrm{a}}{1-2\mathrm{a}}(\mathrm{V_{dc\,1}} + \mathrm{V_{dc\,2}}) \qquad (14)$$

The output voltage V_o is given to the input of separately excited DC motor.

Modeling of a separately excited dc motor:

$$V_a(t) = R_a i_a(t) + L_a \frac{di_a(t)}{dt} + e_b(t) \qquad (15)$$

$$e_b(t) = K_b.w(t) \qquad (16)$$

$$T_m(t) = K_T i_a(t) \qquad (17)$$

$$T_m(t) = J_m.\frac{dw(t)}{dt} + B_m.w(t) \qquad (18)$$

Here V_a = armature voltage, R_a =armature resistance, L_a =armature inductance, i_a = armature current, e_b =back emf, w (t) =angular speed, T_m =motor torque, J_m =rotor inertia. B_m=viscous friction coefficient, K_T=torque constant and K_b=back emf constant.

The transfer function between angular w(s) speed and armature voltage V(s) at no load is given by

$$\frac{w(s)}{V(s)} = \frac{K_b}{s^2 J_m L_a + s(B_m L_a + R_a J_m) + \left(B_m R_a + {K_b}^2\right)} \quad (19)$$

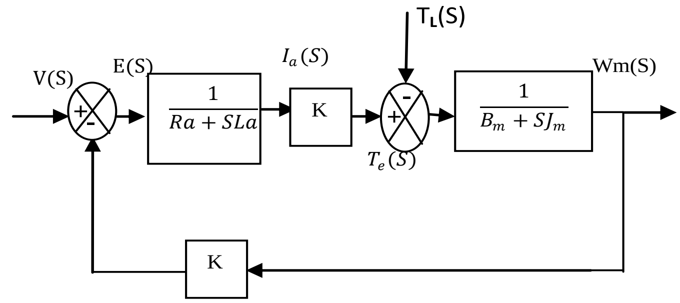

Fig.6 DC motor drive Block diagram

IV.SIMULATION RESULTS

The Simulation result of dual input Z-source chopper converter was performed by using MATLAB SIMULINK to confirm the above result and analysis. The Simulation consists of 4 sections and each section of converter. The Converter parameters are as shown in Table 2.

TABLE 2.SIMULATION PARAMETERS OF THE CONVERETR

parameter	value
Vdc1	100
Vdc2	40
C1=C2	1000μF
C	500μF
L1=L2=L	0.5mH
switching frequency	10KHZ
duty ratio	30%
Ra	0.5 Ω
La	0.01 mH
J_m	0.05kg.m^2
B_m	0.02N.m.s

Dual input Z-source chopper converter with dc machine is to be controlled by using PWM technique. So that by adjusting the duty cycle, converter speed and output voltage of this dc motor is to be regulated.

Dc sources can supply the power to the converter individually or simultaneously. In the simulation results the independence of dc sources from each other are shown in four different states.

1) Mode 1, both Vdc1 *and Vdc2 are in active state*

In this mode 1, that both dc sources were active during simulation time, converter produced 244V by 30% duty cycle in boosting mode. Fig. 7 shows converter output voltage. Fig. 8 shows the electromagnetic torque and Fig. 9 shows the angular speed of the motor. Input current passed through D1 and D2 because these switches were forward biased and turned on. D3 and D4 were reverse biased, thus their currents were zero.

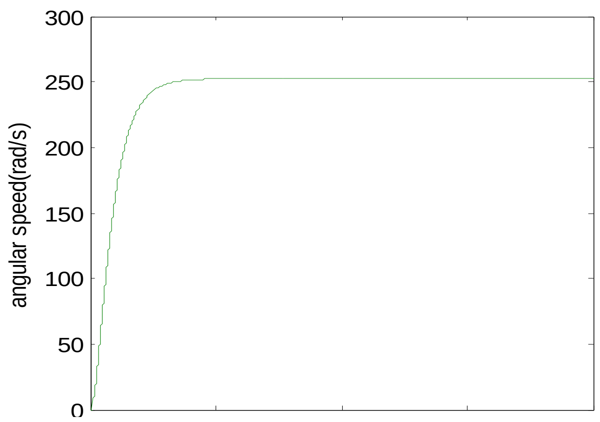

Fig7. Double input chopper converter output speed in mode1

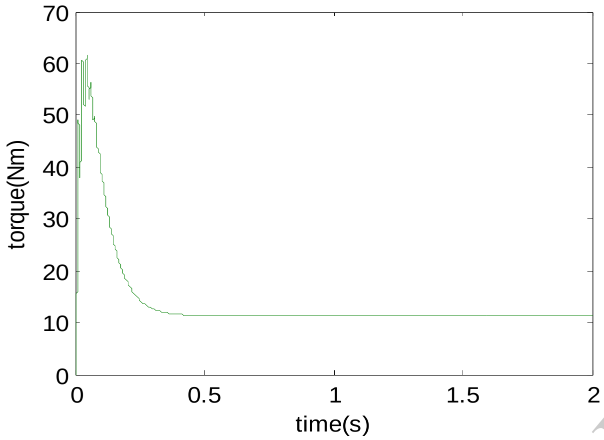

Fig8.electromagnetic torque of the dc motor in state 1

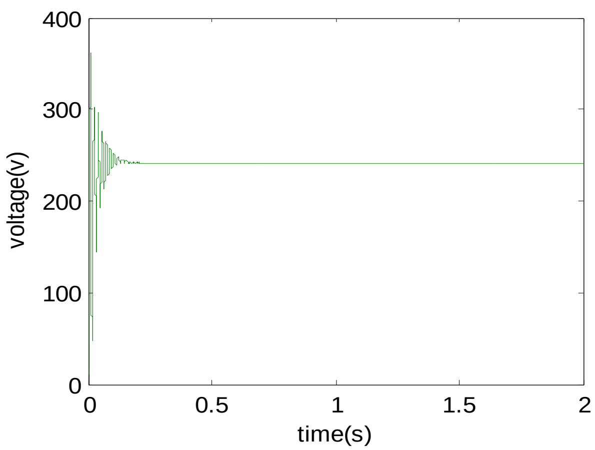

Fig9. Dual input chopper converter output voltage

2) Mode 2, Vdc1 *is active and Vdc2 is inactive*

For this mode 2, the Vdc1 became inactive and it is disconnected.fig.10 shows output speed of the machine for mode 2 and this shows output voltage decreased to 69V which is only Vdc2 stepped up dc the voltage. Thus only the source Vdc2 supplied to the converters and independent of source 1. The converter produced to 69V by the 30% duty cycle in the boosting mode. Fig. 10 shows converter output speed. Fig. 11 shows the output voltage and Fig. 12 shows the torque of the motor. The Input current is passed through the diode D2 and diode D3 because of these switches are forward biased and turned on and diode D1 and diode D4 are reverse biased, thus the currents is to be zero.

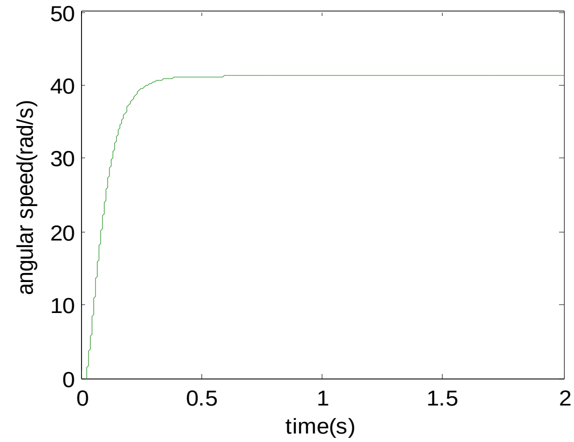

Fig10.converter output speed in state 2

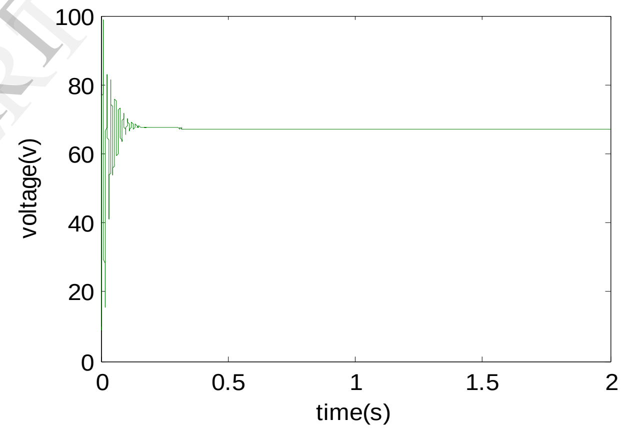

Fig11.converter output voltage in state 2

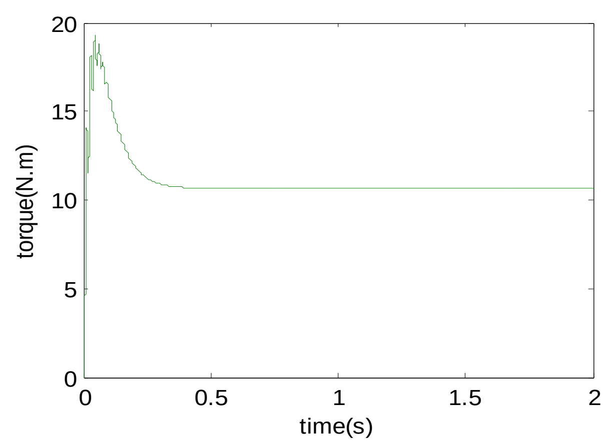

Fig12.electro magnetic torque in state 2

3) Mode 3, Vdc*1 is inactive and Vdc2 is active*

In the mode2 and mode3 *Vdc2* became inactive and it is to be disconnected from converter.fig.13 shows angular speed of the machine for mode 3. The output voltage is to be decreased to 175Volts. So that only source 1 in active mode and converter dependent of source 1 only. The chopper converter produced 175Volts by 30% duty ratio is in boosting mode. Fig. 13 shows the speed of the machine and the Fig. 14 shows the output voltage and Fig. 15 shows the electromagnetic torque of the motor. The Input current is passed through diode D1 and diode D4. Because of these switches are forward biased and the diodes are turned on. The diode D2 and diode D3 were reverse biased, thus their currents is to be zero.

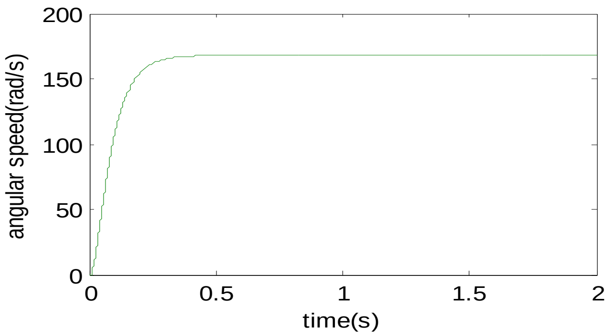

Fig13.angular speed state 3

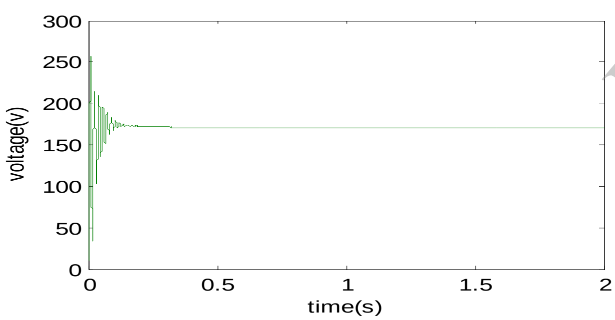

Fig14. Output voltage of the dc motor state 3

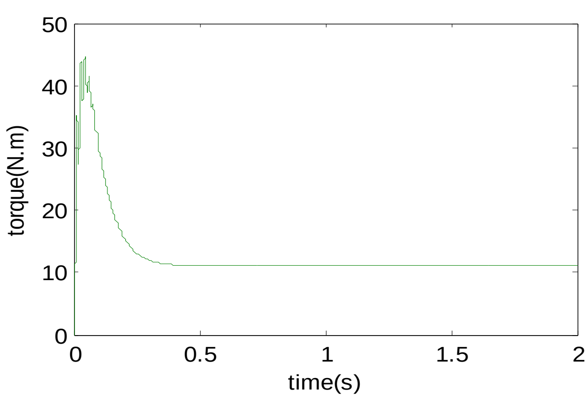

Fig15.electromagnatic torque of the dc motor state 3

4) Mode 4, Vdc*1 and Vdc2 are inactive*

In generally this mode of operation is not considered because both Vdc*1 and Vdc2* are in become inactive and it is not needed, there is no any source to supply the power to the converter or load. In this mode the diode D1 and diode D2 are turned off, and switched to diode D3 and diode D4.

V. CONCLUSION

This paper has proposed an effective controlling of a dc machine by using dual input Z-source chopper converter.The total system controlling, configaration and operating principles are analyzed in detail. And the output responses , equivalent circuits and mathematical expressions are analyzed by using mat lab simulink.

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