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Push Pull Converter With PMDC Motor For Servo Applications

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Abstract : In this paper, Push Pull converter with PMDC motor is proposed. Push Pull converter procures idiosyncratic characteristics such as intent input current, good higher power density in low cost. Push Pull converter is connected to an ideal DC voltage source, which supplies constant voltage supply to the converter. The linear transformer is commonly connected for both the switches of the circuit. A PMDC motor is connected as the load for this converter. Speed and Torque are analysed for this circuit for two different voltages, initially for 100 V and for 240 V. The output obtained from this converter is used for certain applications of PMDC motor such as air conditioners, starters for automobile, small robots and servo applications which includes solar racking system, robotic vehicles. Since here the continuous DC motor type is used, the application of powering robots could be easily curbed through electronic switches, relays in computers which overcomes the poor performance of other motor type such as stepper motor under varying loads.The proposed Push Pull converter with PMDC motor compares the output power obtained from the two different voltages of 100 Volts and 240 Volts respectively.

Keywords: Push Pull converter, PMDC motor, Speed and Torque.

1. INTRODUCTION

The push pull converter topology utilises the core of the transformer efficiently with the drive winding duality fostered [1].A push pull boost PFC proposed by Yu-Kang Lo,et.al [2] reduces the switches conduction losses and the inductor windings turns and diameter. The current fed push pull topology is most commonly used for medium power applications [3]. The proximity effect is reduced using the push pull topology [4].

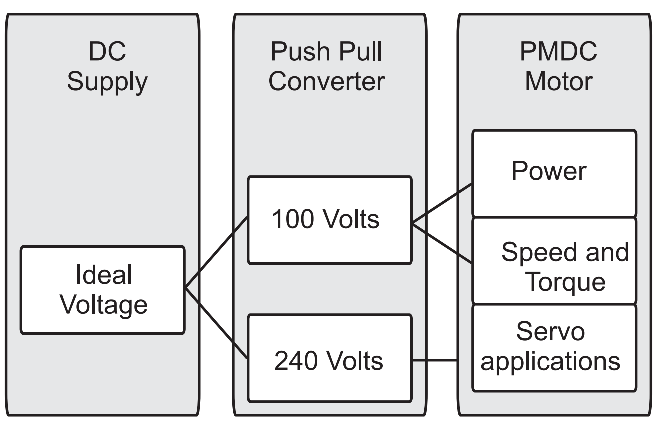

Figure 1: Working of PMDC Motor in 100 V and 240V of Push Pull converter- Process

The push pull converter proposed here basically uses the switches based on the MOSFET type which possess dielectric properties is forge on SiC [5]. This SiC Mosfet is to be used in hardware for future scope due to reduction in size, improving breakdown voltage and switching losses is less. For factories, Electric

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vehicles driven by small batteries a DC motor is most appropriate [6]. Here for push pull converter, the load connected is the PMDC motor, this circuit is operated in two different voltages 100 Volts and 240 Volts. Hence the output voltages, along with power and speed and torque analysis is done respectively out of which the efficient output produced is used for servo applications such as conveyor belts, antenna positioning and printing presses. Here the push pull topology used with PMDC motor produces an efficient output of 11.39hp used for higher applications with reduced size when compared with the two module dual inductor fed push-pull converter which produces 400-1200 W for 18-30 Vdc [7].

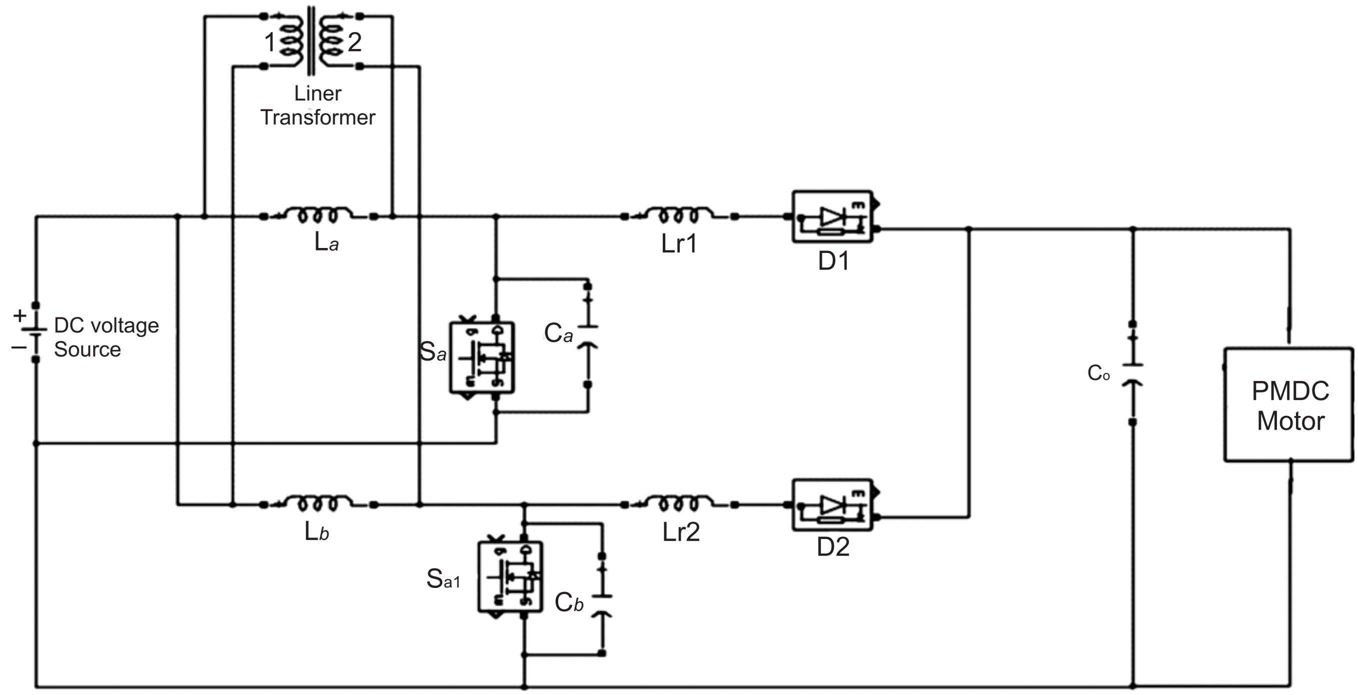

Figure 2: Circuit Diagram of Push Pull converter with PMDC Motor

2. CIRCUIT MODEL – MODES OF OPERATION

Figure 2 shows the circuit diagram of push pull converter with PMDC motor. The module consists of two switches S_a, S_b, inductors L_a, L_b, L_{r1}, L_{r2}. A linear transformer, diodes D_1, D_2, Capacitors C_a and C_b, a PMDC motor as load and a common output capacitor C_o are also present in this module.

Mode 1

Initially when the ideal voltage is supplied, switch S_a starts conducting, while the diode D_1 becomes reversed biased, switch S_{a1} is switched off, hence D_2 is also reverse biased. The input voltage V_i flows across the linear transformer couplings, hence the energy is stored in the inductor L_a, since L_b is also connected to the transformer it also stores energy. On the load side, the output capacitor C_o supplies energy to the motor. Whereas the inductor current across the switch is given by:

$$iL_a(t) = \frac{V_i}{L_a}(t_1 - t_2) + iL_a(t_1) \tag{1}$$

$$VD_1S_a(t) = 0 \tag{2}$$

$$iL_b(t) = \frac{V_i}{L_b}(t_1 - t_2) + iL_b(t_1) \tag{3}$$

$$VD_2S_{a1}(t) = 0 \tag{4}$$

Where iL_a is the current flowing through the inductor L_a, iL_b is the current flowing through the inductor L_b.

Mode 2

Here, now the switch S_a is turned off, whereas the inductor current iL_a starts flowing unceasingly with the diode D_1 conducting, the output capacitor C_o and the PMDC motor load stores the energy released by inductor L_a, on the other side of the transformer inductor L_b also stores energy flowing, hence inductor current, iL_b flows through the forward biased D_2. The equations are given as follows:

$$iL_a(t) = \frac{V_i - V_0}{L_a}\,(t_1 - t_2) + iL_a(t_2) \qquad (5)$$

$$VD_1S_a(t) = V_0 \qquad (6)$$

$$iL_b(t) = \frac{V_i - V_0}{L_b}\,(t_1 - t_2) + iL_b(t_2) \qquad (7)$$

$$VD_2S_{a1}(t) = V_0 \qquad (8)$$

Where V_0 is the output voltage.

Mode 3

Both the switches S_a and S_{a1} are switched off, whereas diodes the diodes D_1 and D_2 are also turned off. With the input voltage of V_i and parallel connection of L_a and L_b, the series resonant loop is formed, hence C_a the output capacitance of S_a and L_{r1} starts to resonate, similar on the other side through the same parallel connection and series resonant loop, output capacitor of S_{a1}, C_b and L_{r2} starts to resonate.

3. SIMULATION CIRCUIT DIAGRAM

Figure 3 below shows the simulation of the circuit of push pull converter with motor load. As mentioned above this proposed model is operated for different ideal voltages (*a*) 100 Volts and (*b*) 240 Volts respectively. The simulation results obtained for both the voltages are compared.

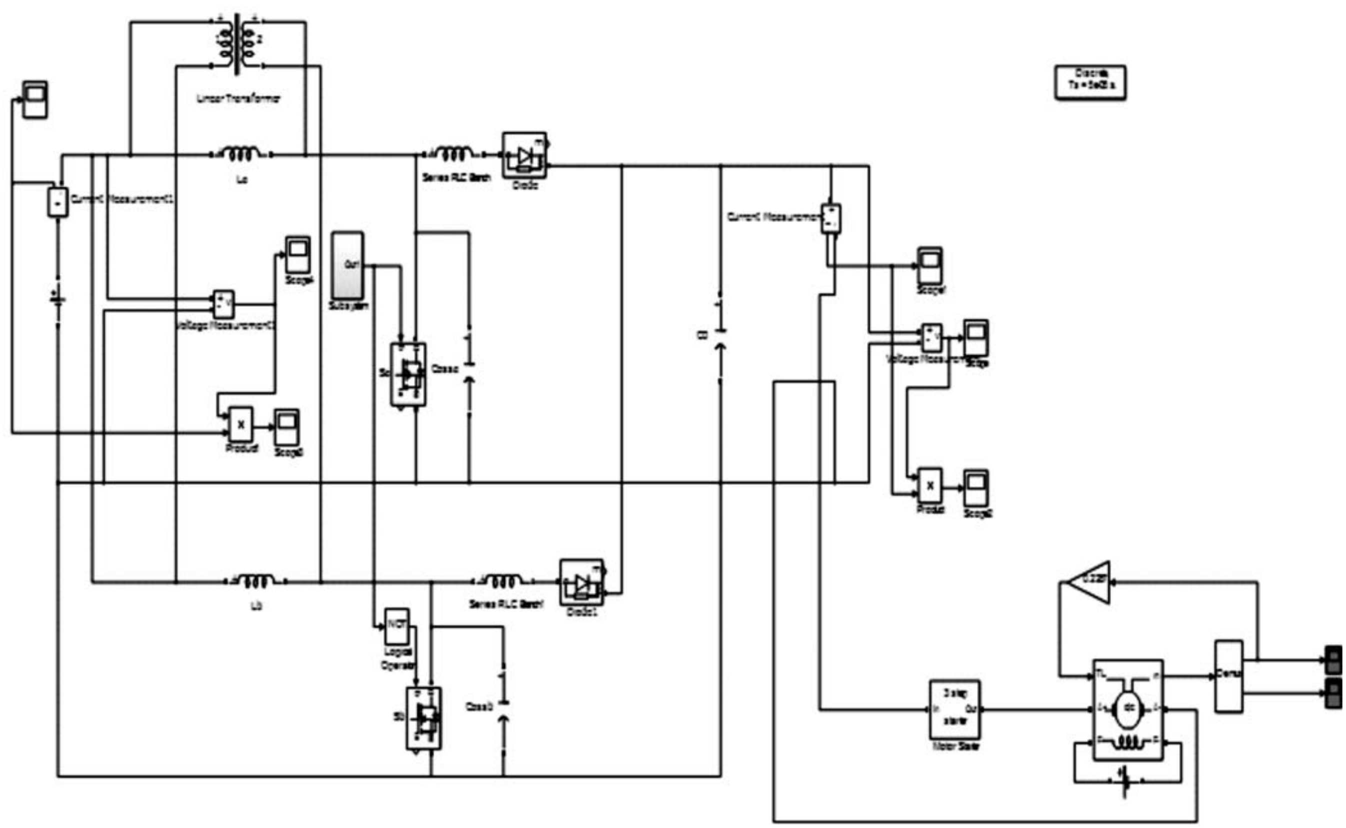

Figure 3: Simulation of Push Pull converter with PMDC Motor

Table 1
Conduction of switches and Diodes

Modes	*Switches*		*Diode Biasing*	
	S_a	S_{a1}	D_1	D_2
1.	1	0	Reverse biased	Reverse biased
2.	0	1	Forward biased	Forward biased
3.	0	0	Reverse biased	Reverse biased

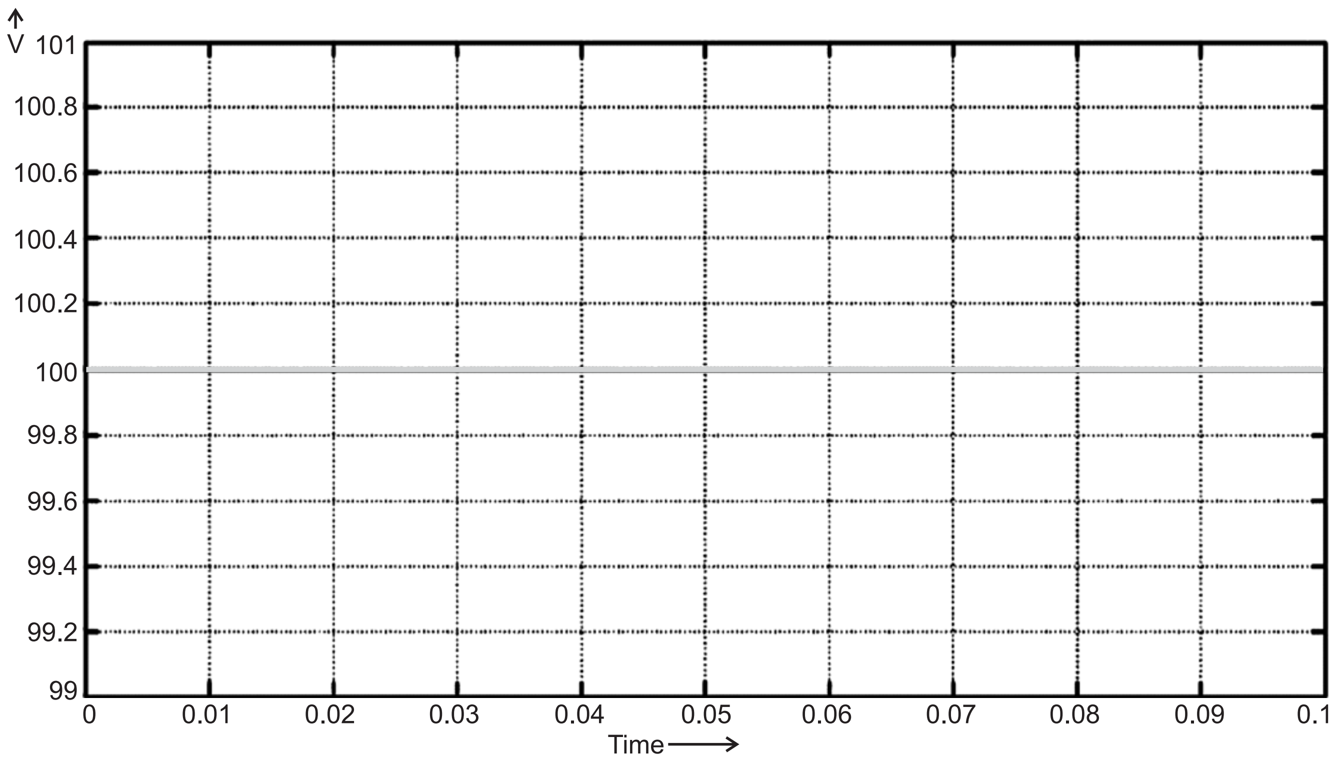

Figure 4: Linear Input voltage – 100 Volts

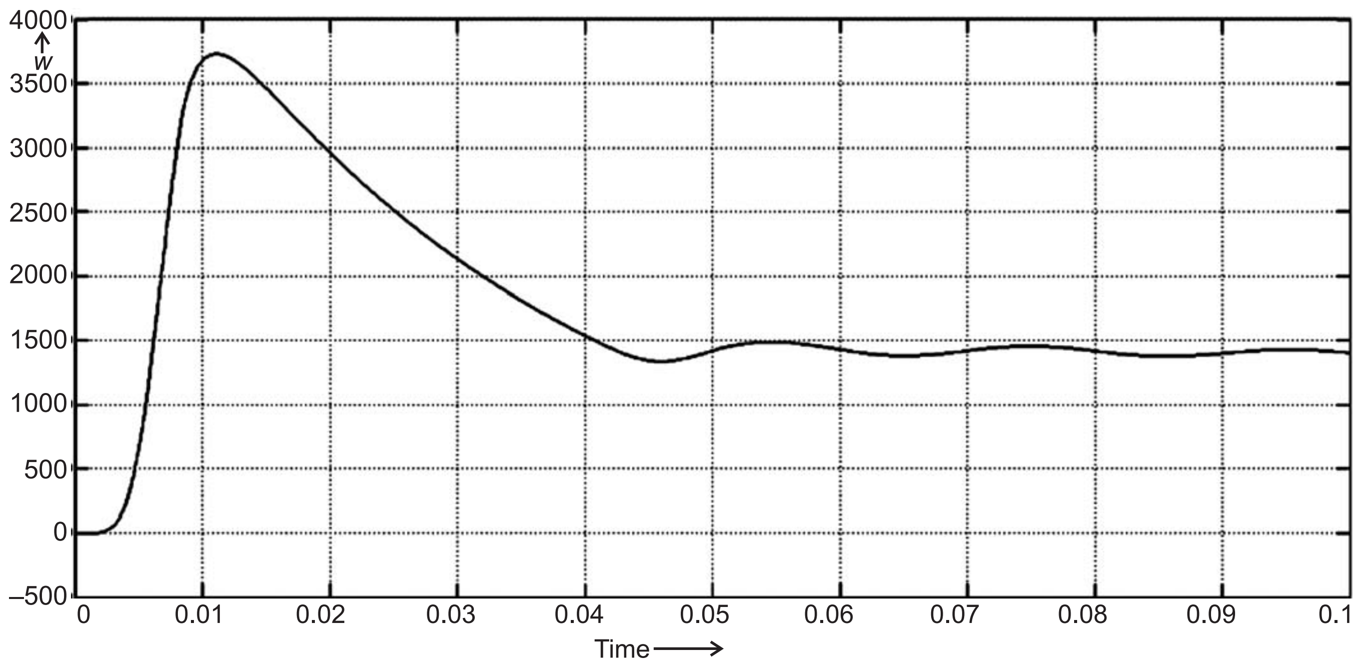

Figure 5: Output Power –3600 W

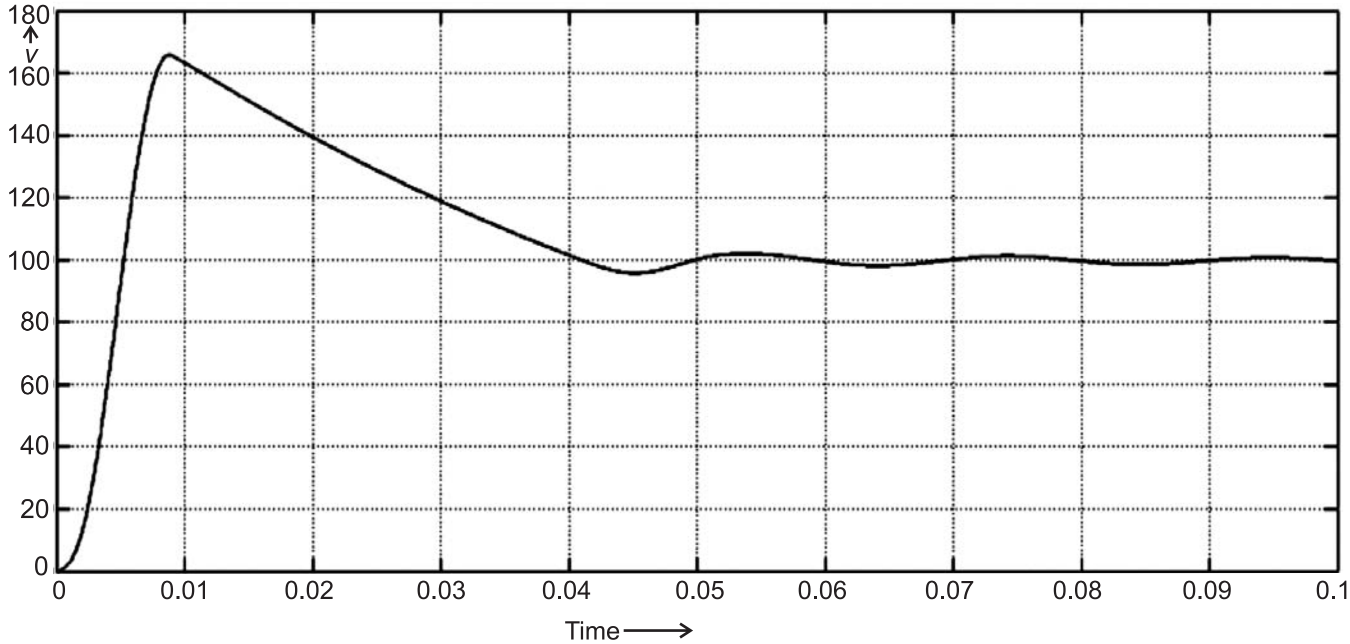

Figure 6: Output Voltage –165 V

In the linear voltage DC supply of 100 Volts , the output voltage obtained is 165 Volts and the output power as 3600 Watts (4.82hp). Through the output obtained of both voltage and power, spike is generated after a linear peak. Hence this becomes a drawback for circuit operated with the input voltage to be used for higher voltage applications.Quantized speed measurements are done [10] in order to estimate the PMDC model parameters.

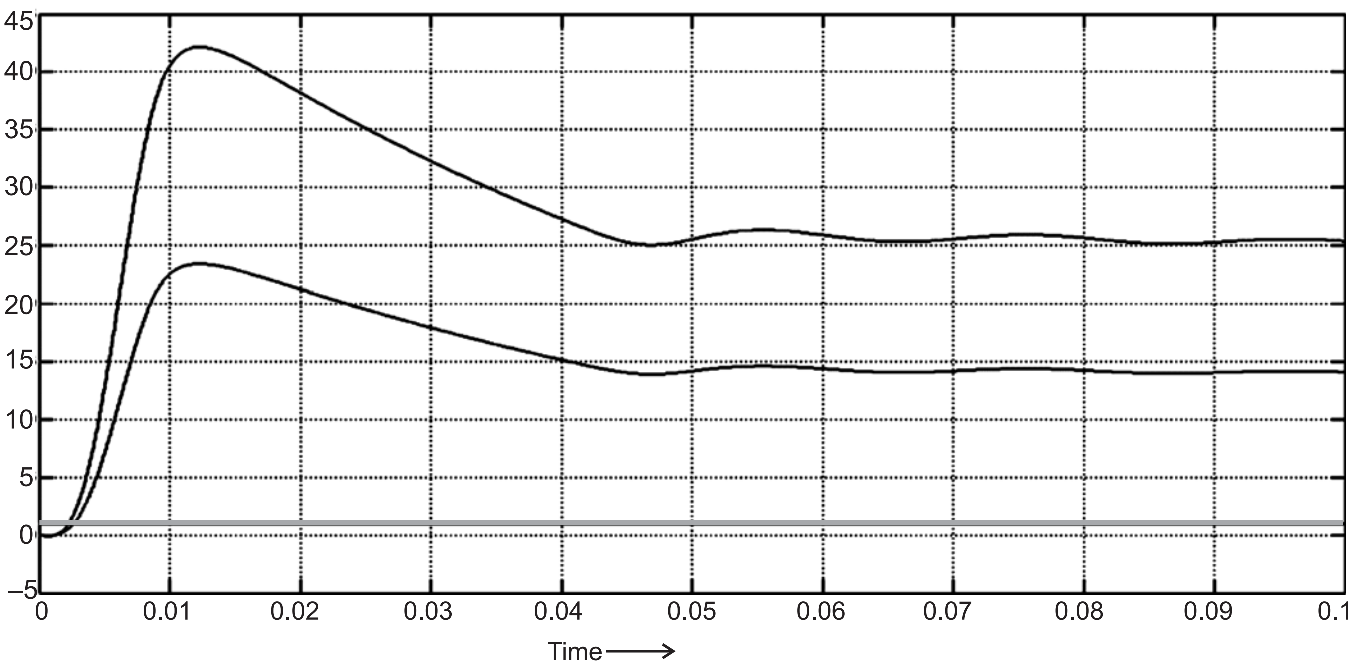

Figure 7: Speed and Torque obtained for 100 V

In the above figures output voltage obtained for the linear voltage supply of 240 Volts obtained is 230 Volts, output power is 8500 Watts which is equivalent to 11.39hp, hence it could be used for servo applications efficiently as there are no spikes produced unlike that of the input supply of 100 Volts and the linearity in the output is maintained after the peak. In small power drives such as door locker, automobile water pump, seat belt adjuster a 2 pole and 3 slot configuration PMDC motors are employed [8].An advantage of push pull converter is it’s ascendancy in high current low voltage situation [9].

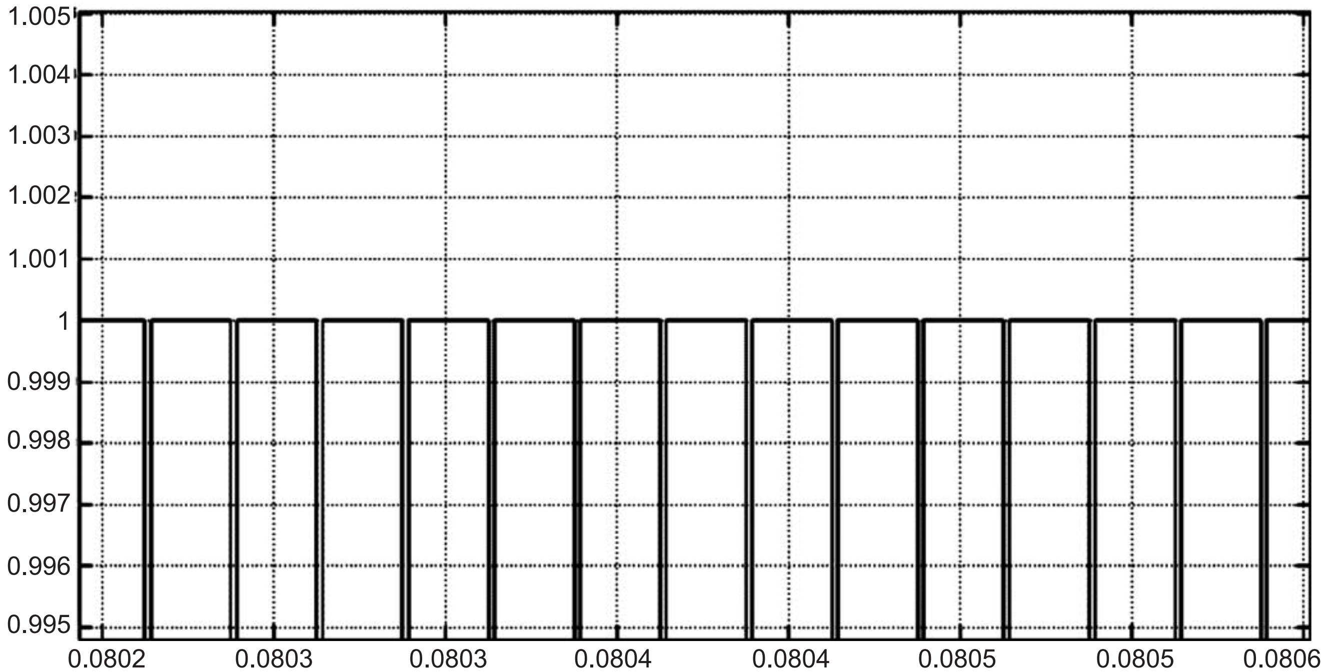

Figure 8: The input pulses given to Switch S_a for 240V

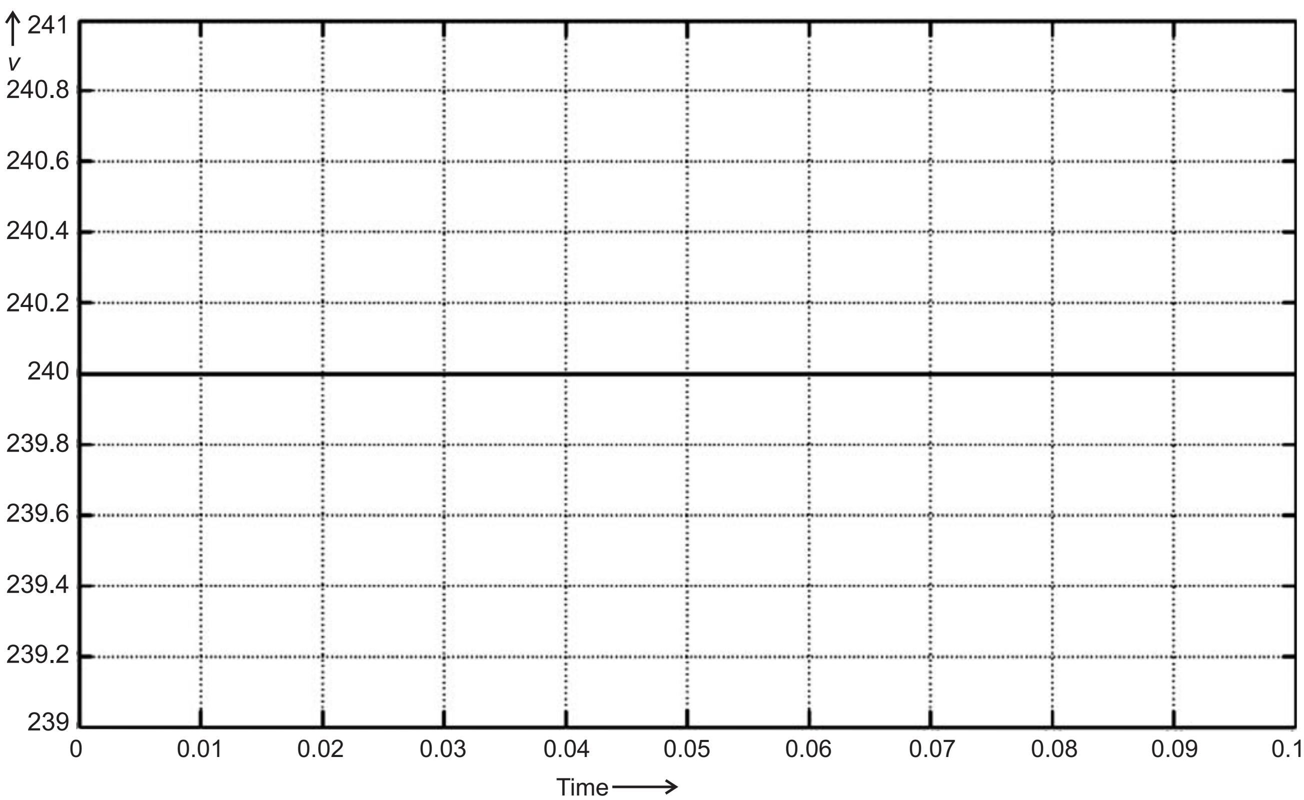

Figure 9: Linear Input voltage – 240 Volts

4. CONCLUSION

The PMDC motor with push pull converter proposed here is simulated for two ideal voltages (*a*) 100 V and (*b*) 240 V. The output parameters of both the voltages are compared. The simulation model has been done in MATLAB. According to the simulation results, it is found that if the circuit is supplied with 240 V, it produces higher and efficient output 8500 W and also it further rectifies the spikes produced in the output power with consistency, when compared with the 100 V which produces 3600 W. Hence this push pull converter with PMDC motor can be used for the servo applications.

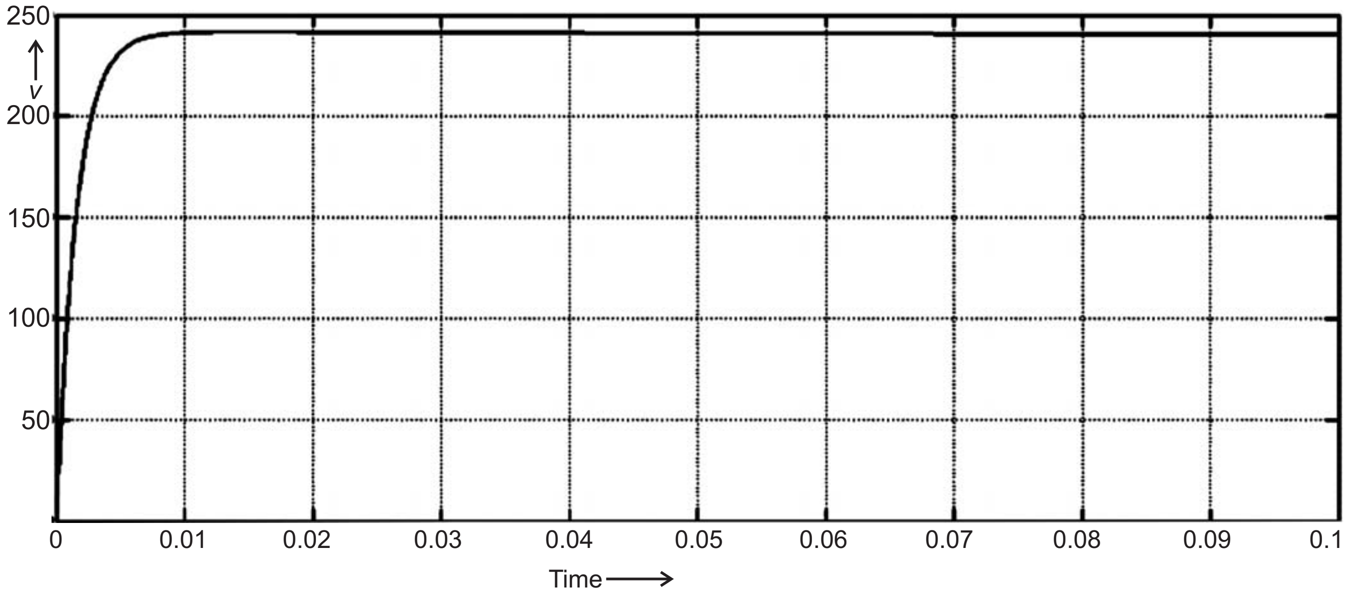

Figure 10: Output Voltage –230 V

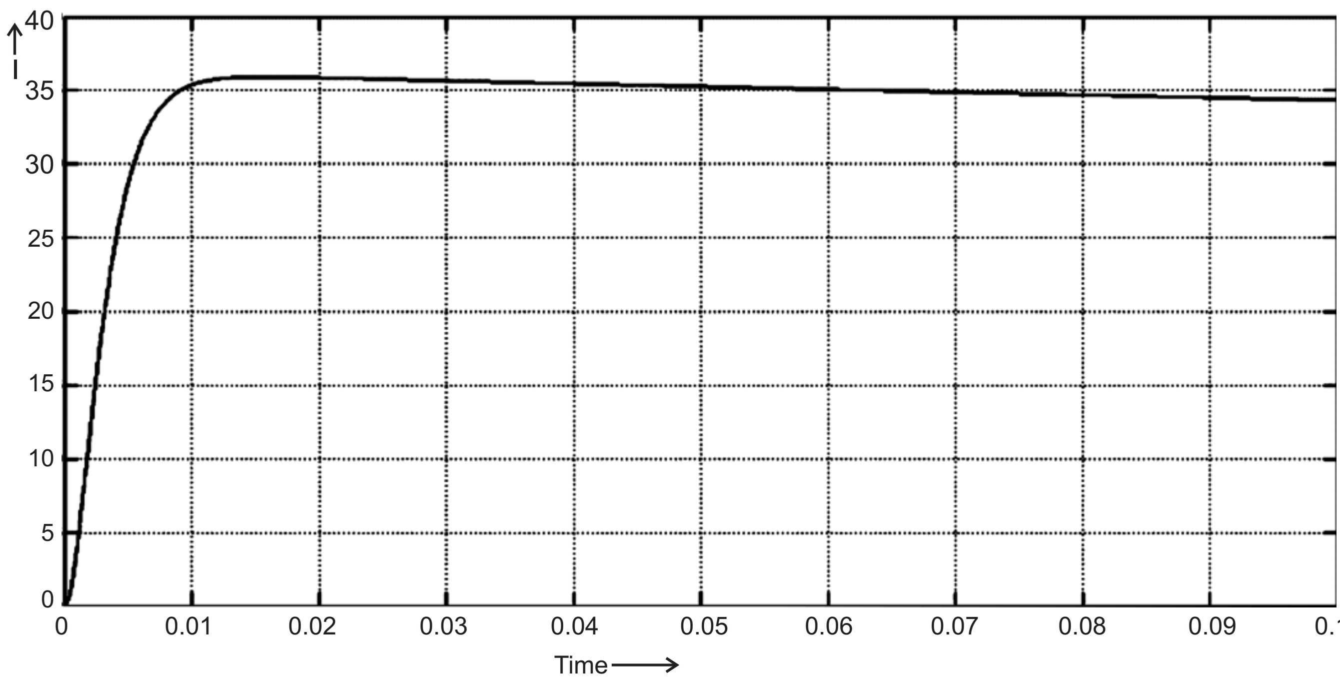

Figure 11: Output Current – 37 A

5. TABULATION

Table 2

Key parameters of PMDC Motor

Parameters	*Values*
Armature resistance R_a	0.06 Ω
Armature inductance L_a	0.012 H
Field resistance R_f	240 Ω
Field inductance L_f	120 H
Field-armature mutual inductance L_{af}	1.8 H
Total inertia J	1(kg.m^2)

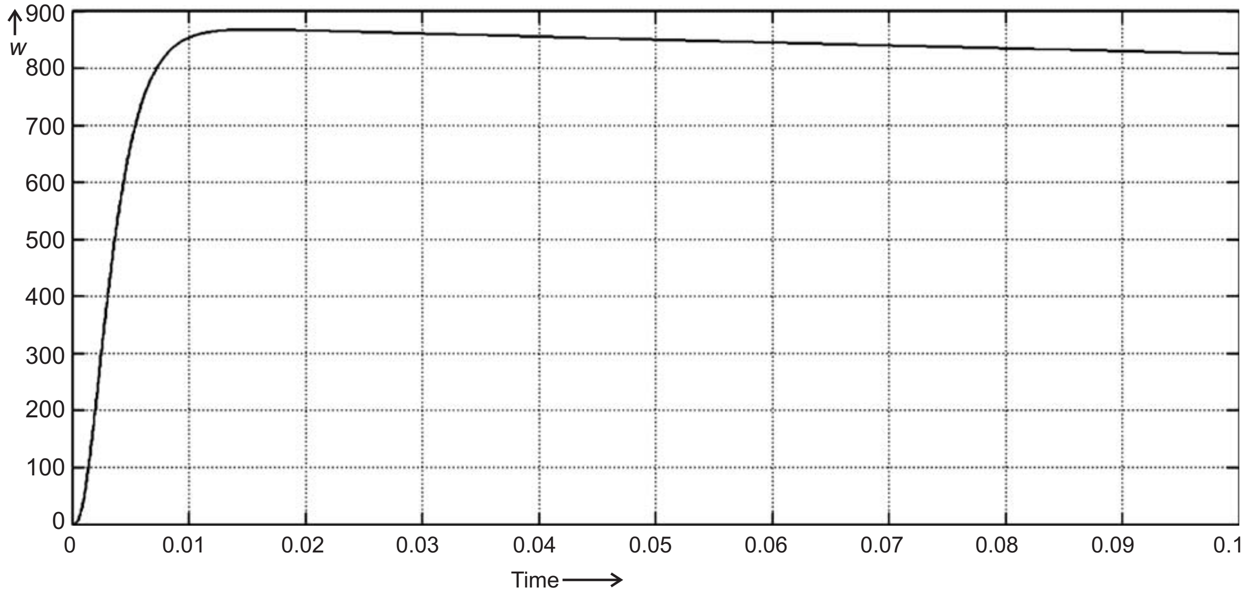

Figure 12: Output Power – 8500 W

Given below is the speed and torque characteristics obtained for 240 Volts .

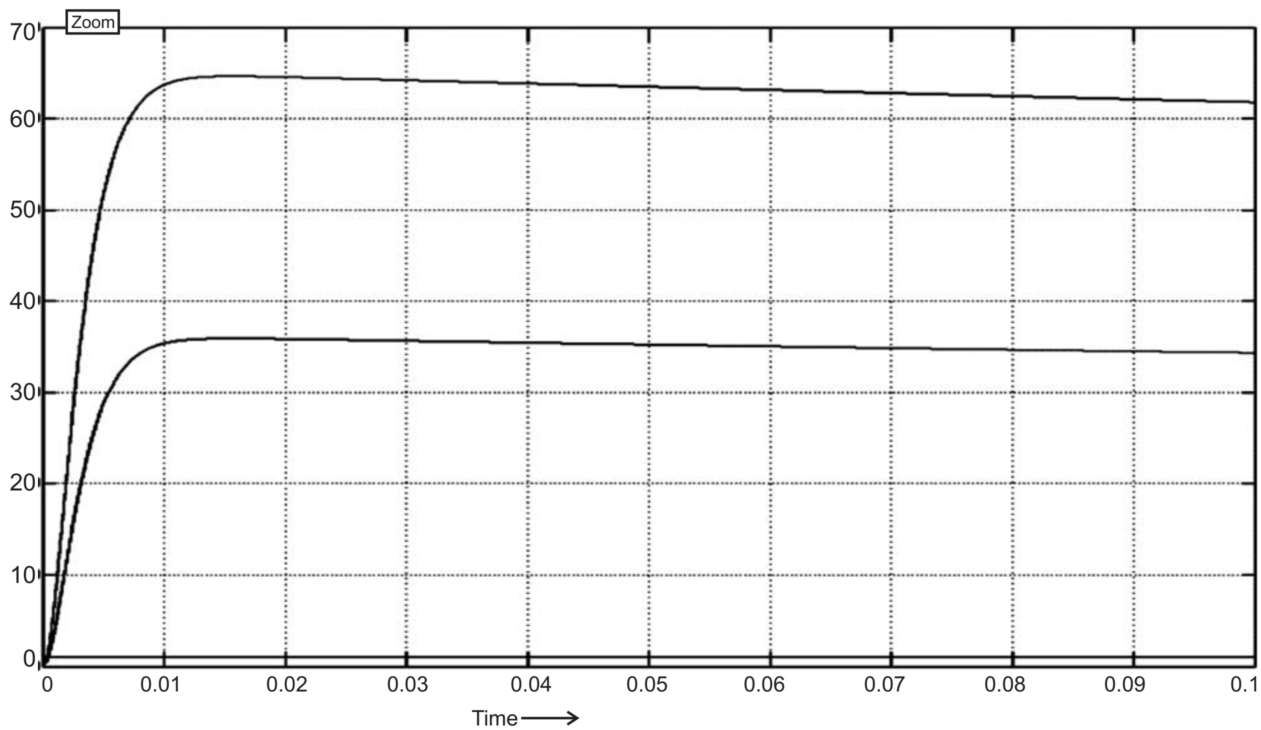

Figure 13: Speed and Torque obtained for 240 V

Table 3

Output comparison of both the linear input voltage (*a*) 100 V and (*b*) 240 V

Key Parameters	*Liner Input Voltagwe*	
	100 V	*240V*
Output current	23 A	37 A
Output voltage	165 V	230 V
Speed	23 RPM	63 RPM
Torque	43 Nm	35 Nm
Output power	3600W(4.82hp)	8500W(11.39hp)

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