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Modelling and Control Design for Full Bridge DC-DC Converter

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***Abstract:** In this paper, modeling and analysis of full bridge dc-dc converter is present using state space averaging technique. Isolated dc-dc converter is widely used in power applications. Mainly full bridge dc-dc converter is used where high power and high voltage required. The transformer is used here to produce a higher voltage in secondary voltage side. PI controller is used to stabilize the output of the converter. Simulation is done for getting different outputs by giving same input. To observe the stability and transient response results are obtained using matlab simulink.*

***Keywords:** Full Bridge, DC-DC converter, state space, isolated, transient response.*

I. INTRODUCTION

Nowadays power electronics converters play keyroles within variety of applications such as electric vehicle, Electric charger, Renewable energy conversion system, Power system and Power delivery devices with the concept of clean and green energy to save the environment. Isolated type of converter is used where the output needs to be isolated from input. In this type of converter, transformer is used with high frequency. Full bridge dc-dc converter is the type of isolated converter. In this converter first DC is converted into high frequency AC and then AC is step up or step down as required. Finally, it is rectified back to DC . Circuit diagram of Full bridge dc dc converter as shown in Fig.1. Here we used mosfet as switching devices and on secondary side centre tap rectification is used. Output voltage is given by Vo = 2d*n*Vin

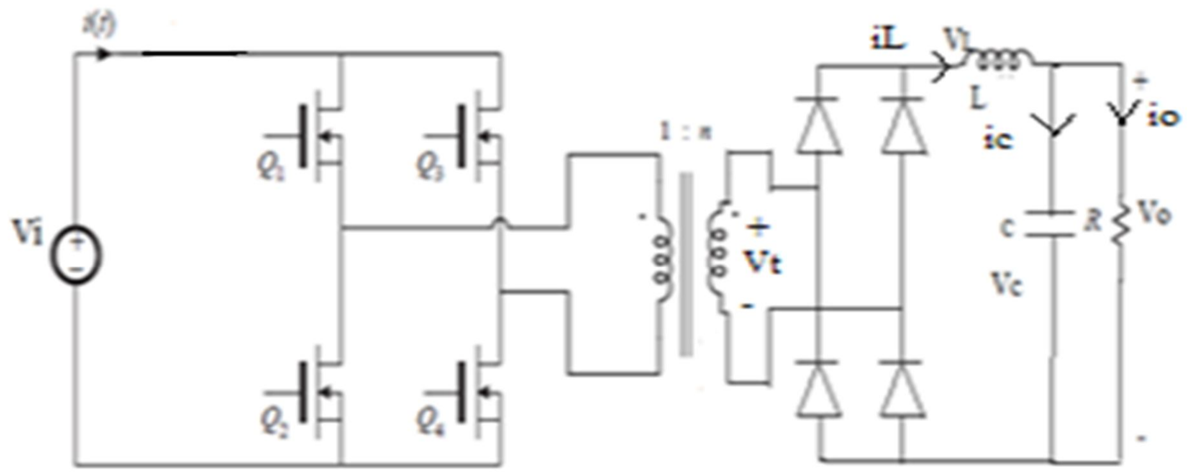

Fig.1. Full bridge dc-dc converter

This paper outlines the design and analysis of a full-bridge dc - dc converter. In the starting stage of designing of the full bridge dc-dc converter, we estimate the required parameters according to the known data of the converter. In the first simulation model, we have done the simulation with input voltage (40 volt) and fixed output voltage (385 volt). In the second simulation model, we have done the simulation with respect to the input voltage (40V) and output voltages (80V and 150V). For this simulation results we used Matlab Simulink. Objectives of this paper are to developed the model using average state space and analyse the model. Also to designs a controller to achieve a well controlled and high performance system. The paper has been organized as follows: Converter topology is given in section II. Operation and analysis of converter is given in section III. Converter parameter analysis is given in section IV. Simulation results are given in section V.

II. CONVERTER TOPOLOGY

The arrangements of the components used and their operation, will shows the converter characteristics which give rise to many different topologies, such as buck, boost, Fly-back and bridge converters. The strategic placing of the components will expose them to certain electrical and thermal stress which translates to volume, weight and cost of the overall system. To minimize the volume weight and cost, the designer has to find a balance between converter performance and customer satisfaction.

Isolation transformer for this design is given for two reasons, safety and step-up capability. Although the output voltage of 80-150V. It is in safe range.

The input voltage is beyond anything that we would want to come in contact with. That is why, the galvanic isolation provided by a transformer would be appreciated. Additionally, the transformer allows one to set a turns-ratio to assist with large difference between input and output voltages, as is the case in this design.

III. OPERATION AND ANALYSIS OF CONVERTER

Some of the assumptions are to be made for operation and analysis of the converter.

- Mosfets used here and diodes are identical
- The output filter so designed that inductor current is continues in each switching period.

Switch S1 and S4 are operated by same gating signal and switch S2 and S3 are operated by same gating signal. S1 ans S4 is one pair and S2 and S3 is another pair which are shifted in phase by 180 with gating signals of each other.

State space equations for different interval of steady state operation are described as follows:

Interval1: In this interval, switches S1 and S4 are in on mode and delivering energy to load via transformer and diodes D1 and D4. Inductor L stored the energy.

$$\mathrm{nVi} = L\frac{diL}{dt} + Vo \quad ; \quad \mathrm{C}\frac{\mathrm{dVo}}{\mathrm{dt}} = \mathrm{iL} - \frac{\mathrm{Vo}}{\mathrm{R}}$$

$$L\frac{diL}{dt} = n\mathrm{Vi} - \mathrm{Vo} \quad ; \quad \mathrm{Vt} = \mathrm{nVi} \qquad \mathrm{iL} = \frac{i}{n} \qquad (1)$$

Interval2: In this interval, all four switches are open. capacitor C transfer the power to the load.

$$L\frac{diL}{dt} = -\mathrm{Vo} \quad ; \quad \mathrm{C}\frac{\mathrm{dVo}}{\mathrm{dt}} = -\frac{\mathrm{Vo}}{\mathrm{R}}$$

$$\mathrm{Vt} = 0 \quad ; \quad \mathrm{iL} = 0 \qquad (2)$$

Interval3 : In this interval, switches S2 and S3 are in on mode and delivering energy to load via transformer and diodes D2 and D3. Inductor L stored the energy.

$$L\frac{diL}{dt} = -n\mathrm{Vi} - \mathrm{Vo} \; ; \quad \mathrm{C}\frac{\mathrm{dVo}}{\mathrm{dt}} = \mathrm{iL} - \frac{\mathrm{Vo}}{\mathrm{R}}$$

$$\mathrm{Vt} = -\,\mathrm{nVi} \quad ; \quad \mathrm{iL} = \frac{\mathrm{i}}{\mathrm{n}} \qquad (3)$$

Interval4: In this interval, all four switches are open. capacitor C transfer the power to the load. This interval gives same equation as interval2.

The full-bridge dc-dc converter is extending the range of the function to 2TS. So volt-second balance and current-second balance is obtained over two switching periods.

Ampere- second balance to the capacitor current is given as follows:

$$\mathrm{ic} = 0$$

$$\mathrm{D}*\left(\frac{-\mathrm{Vo}}{\mathrm{R}}\right) + (1\text{-}\mathrm{D})*\left(\mathrm{io} - \frac{\mathrm{Vo}}{\mathrm{R}}\right) = 0$$

$$\mathrm{io} = \frac{\mathrm{Vo}}{(1-\mathrm{D})\mathrm{R}} \qquad (4)$$

Volt-second balance to the inductor voltage is given as follows:

$$VL = 0$$

$$-DVo + (1-D)(nVi - Vo) = 0$$

$$Vo = 2n * D * Vi \qquad (5)$$

IV. CONVERTER PARAMETERS ANALYSIS

Full bridge dc-dc converter specifications and design values of components examples are as follows: Input voltage Vi = 40V, Output voltage = 80V – 150V, switching frequency = 100KHz, Power = 64-225W, ripple current = 20% and ripple voltage is 1%. Load resistance = $\frac{V^2}{P}$ = 100Ω.

<u>For output of 80V</u>

Let the margin of voltage is + 20-30%, average we get the Vomax = 100V.

Turns ratio of transformer is given by

$$n = Ns/Np = 100/40 = 2.5$$

Voltage across inductor is given by ,

$$VL = nVi - Vo = 40*2.5 - 80 = 20V$$

$$VL = \frac{diL}{dt}; \quad L = VL * \frac{DTs}{Iripple} = 500\mu H.$$

Capacitor value is given by,

$$C = Iripple * \frac{DTs}{Vripple} = 80\mu F$$

<u>For output voltage of 150V</u>

Let the margin of voltage is + 20-30%, average we get the Vomax = 187.5V. Turns ratio of transformer is given by

$$n = \frac{Ns}{Np} = \frac{187.5}{40} = 4.68 \sim 4.7$$

Voltage across inductor is given by ,

$$VL = nVi - Vo = 40*4.7 - 150 = 38V$$

$$VL = \frac{diL}{dt}; \quad L = VL * \frac{DTs}{Iripple} = 506\mu H.$$

Capacitor value is given by,

$$C = Iripple * \frac{DTs}{Vripple} = 80.01\mu F$$

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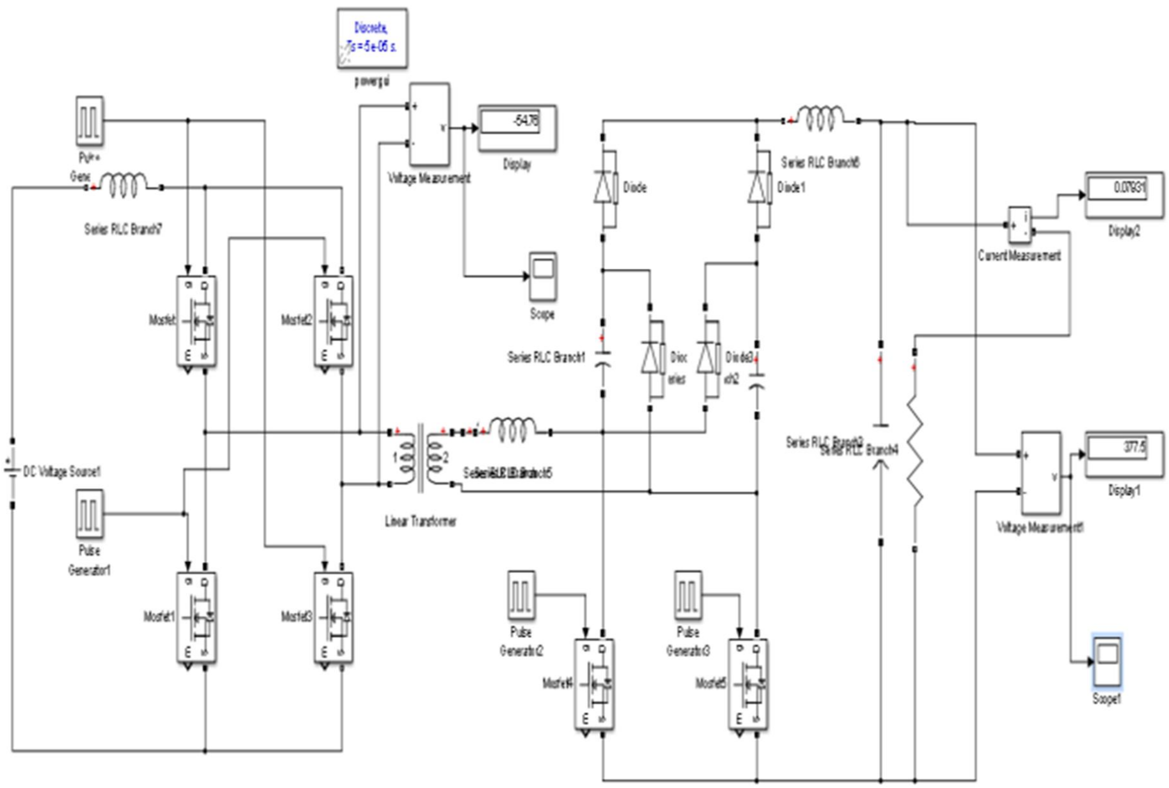
V. SIMULATION RESULTS

Simulation is carried out using MATLAB simulink for input voltage of 40V. Given model shows the full bridge dc-dc converter in open loop system.



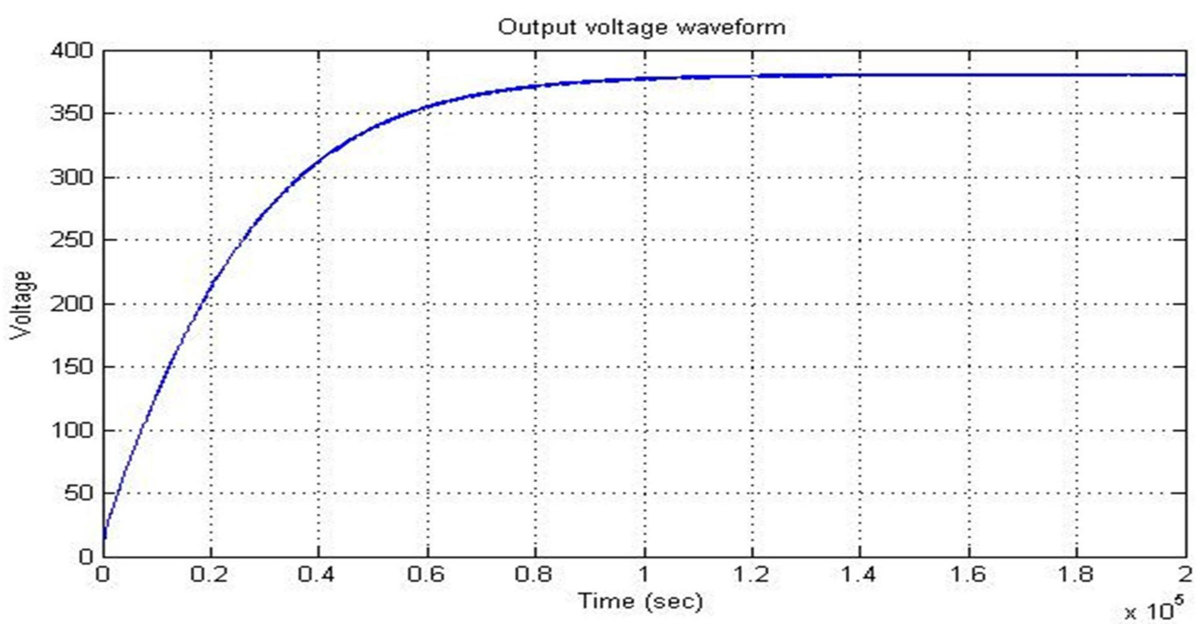


Fig.2 Simulation result of Output voltage

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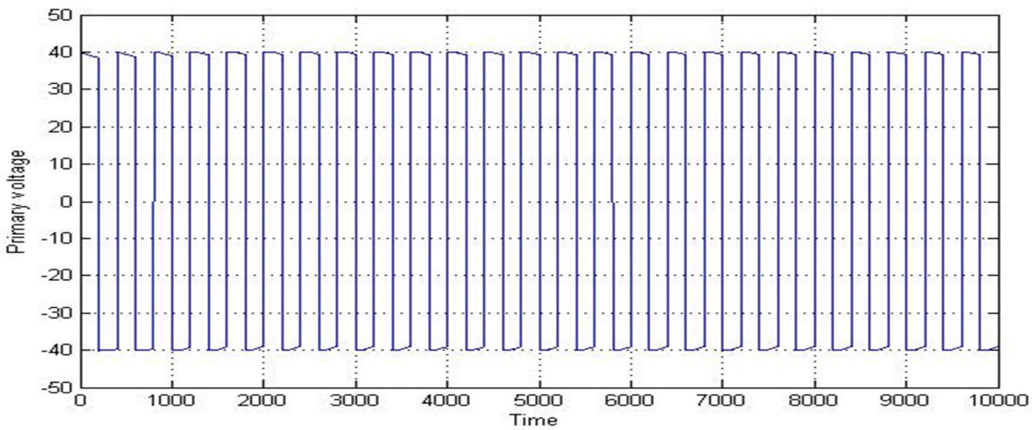
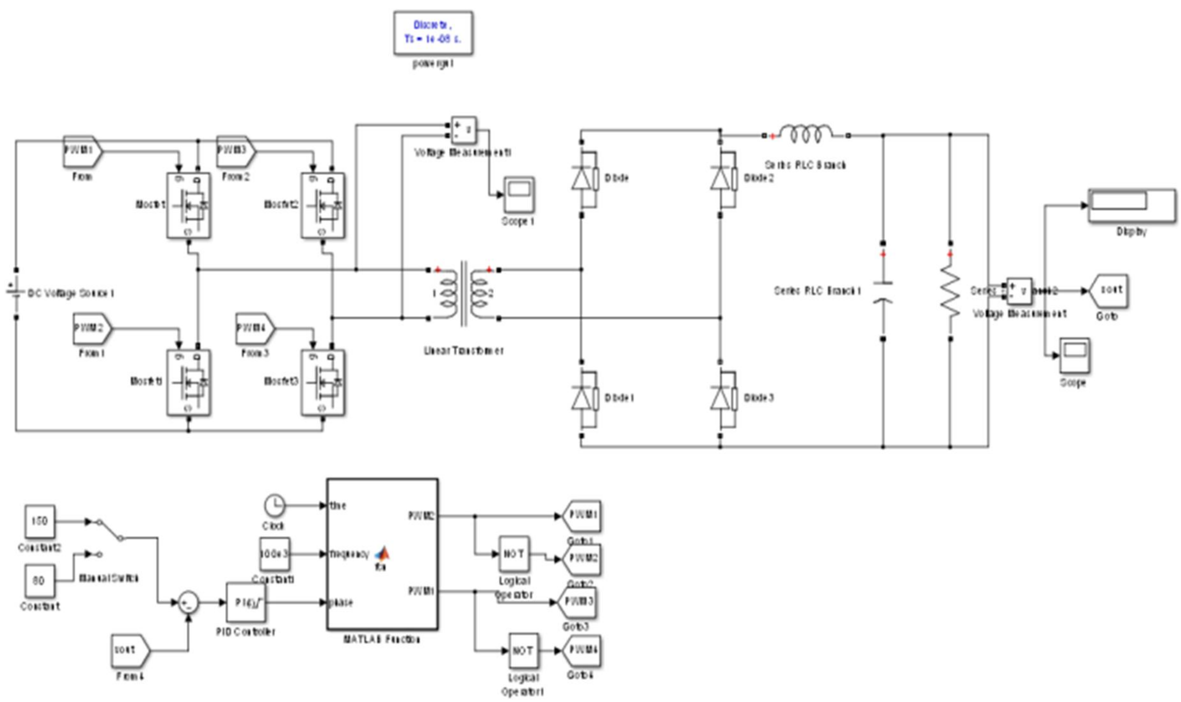


Fig.3 Simulation result of primary voltage of transformer

Given model shows the full bridge dc-dc converter in closed loop system.



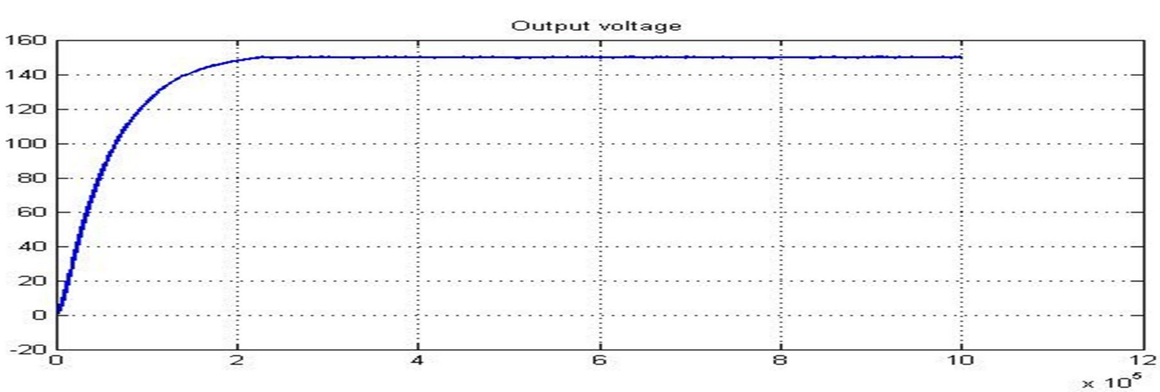


Fig.4 Simulation result of Output voltage (150V)

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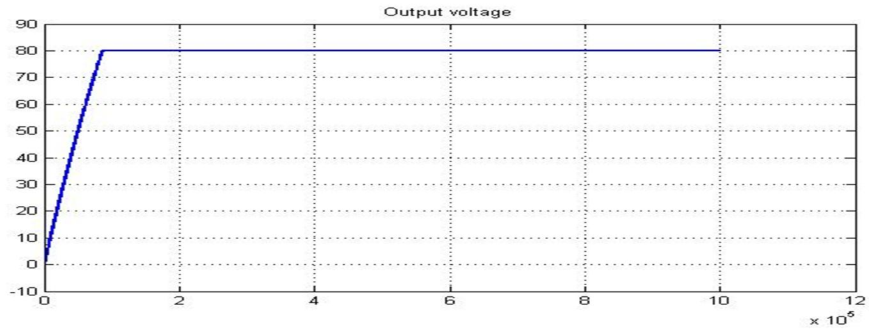

Fig.5 Simulation result of Output voltage (80V)

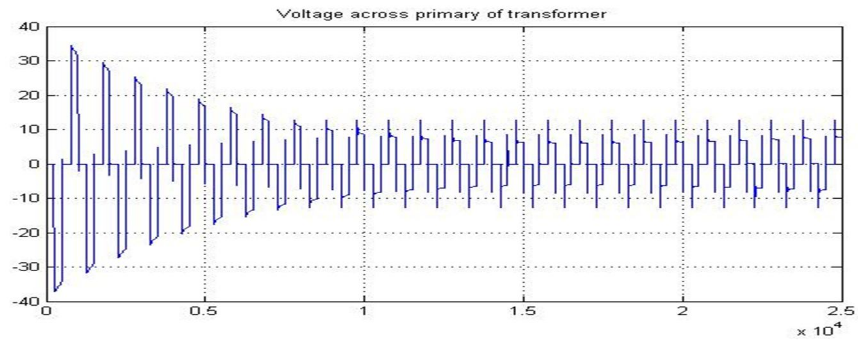

Fig.6 Simulation result of primary voltage transformer

VI. SUMMARY AND CONCLUSION

Full-Bridge dc-dc converter is simulated using Matlab Simulink. Full bridge dc-dc converter is suitable for high voltage applications. These suffer from higher voltage stress across the power semiconductor devices. Analysis of full bridge dc-dc converter has been presented in given paper. This converter uses high frequency switching and inductors, transformers, and capacitors to smooth out switching noise into regulated dc voltages. Closed loop control system has been designed using PI controller. It is shown that the controller is effective in regulating the output voltage of converter in changing input voltage disturbances. The Designed converter is appropriate for the many applications like LED drivers, electrical vehicles, and fuel-cell system.

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