Journal of Theoretical and Applied Information Technology
15th April 2012. Vol. 38 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

CLOSED LOOP CONTROL OF A NOVEL EFFICIENT THREE OUTPUT PORTS DC-DC CONVERTER WITH ZERO VOLTAGE SWITCHING

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ABSTRACT

Multiport converters, a promising concept for alternative energy systems, have attracted increasing research interest recently. Compared with the conventional approach that uses multiple converters, a multiport converter promises cost-effective, flexible and more efficient energy processing by utilizing only a single power stage. This paper presents a three output port single stage converter. To reduce the switching losses and henceforth to improve efficiency of converter system, Zero Voltage Switching (ZVS) is employed. The proposed multi output port converter with soft switching is simple and efficient. The analysis is carried out for both open loop and closed loop control. The simulation results for the same are presented in this paper.

Keywords: *Multiport DC-DC converter, Single stage converter, Zero Voltage Switching, Soft Switching, Closed Loop Control of DC-DC Converter.*

1. INTRODUCTION

Multiport dc–dc converters are particularly interesting for sustainable energy generation systems where diverse sources and storage elements are to be integrated [4-7]. This paper presents a zero-voltage switching (ZVS) three-port bidirectional dc–dc converter. A simple and effective duty ratio control method is proposed to extend the ZVS operating range when input voltages vary widely. Soft-switching conditions over the full operating range are achievable by adjusting the duty ratio of the voltage applied to the transformer winding in response to the dc voltage variations at the port [2,9]. Keeping the volt-second product (half-cycle voltage-time integral) equal for all the windings leads to ZVS conditions over the entire operating range. Furthermore, for the three-port converter a PI-loop based control strategy is proposed to maintain constant output voltage irrespective of change in the input voltage.

2. THREE OUTPUT DC-DC CONVERTER

A Multi Output DC-DC converter without ZVS arrangement is shown in Fig.1where several output voltages are provided by inserting capacitors in series. Voltages of the capacitors are controlled by the inductor current and correct switching states to share the energy stored in the inductor with each capacitor. For the present work three output ports are considered.

3.SIMULATION RESULTS.

Proposed ZVS based three out put DC-DC converter simulation circuit is shown in Fig.2 .

The input DC voltage is 100 V and is shown in Fig.3. The gate pulse for the main switch M_{t1} and voltage across M_{t1} are shown in Fig.4. The gate pulse for the auxiliary switch M_{t2} and voltage across M_{t2} are shown in Fig.5.The gate pulse for the auxiliary switch M_{t3} and voltage across M_{t3} are shown in Fig.6.The three output voltages are shown in Fig.7.

From Fig.4 it is observed that the switching of main switch Mt1 is achieved at zero voltage. Hence this ensures soft switching. As observed from Fig.7 the three output voltages are approximately equal to 99V. From this it is concluded that due to ZVS of main switch, the switching losses are reduced. To achieve this, a single coupled inductor is used. Therefore the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

proposed ZVS based three output DC-DC converter has high efficiency compared to the conventional topologies. Since only one inductor is used, the circuit complexities are reduced.

The open loop system for a disturbance in supply voltage is Fig.8. The input voltage is increased from 100V to 110V at 0.3 sec. The input voltage with this disturbance and corresponding sum of all three output voltages are shown in Fig.9. The three individual output voltages are shown in Fig.10.

From Fig.9 and fig.10, it is observed that when supply voltage was increased at 0.3 sec, all the three output values start changing at 0.3 sec and settle at a new value of 107V at 0.35 sec. Since it is desired to maintain output voltages of all three ports constant irrespective of supply fluctuation closed loop control is preferred. The closed loop system with supply disturbance is shown in Fig.11. The input voltage with this disturbance and corresponding sum of all three output voltages are shown in Fig.12. The three individual output voltages are shown in Fig.13.

From Fig.12, it is observed that in closed loop control, when input voltage is increased at 0.3 sec, the sum of all three output voltages rises at 0.3 sec and settles at the original value at 0.4 sec. Therefore a constant volatge is maintained at the output side.

4.CONCLUSION

A novel ZVS (Single Inductor) based three ouput port DC-DC converter is proposed. From the simulation results it is concluded that soft switching of main switch is achieved due to which the losses are minimized. From the simulation results it is concluded that the closed loop system with PI controller maintains constant output volatge irrespective of disturabance in the supply voltage.

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

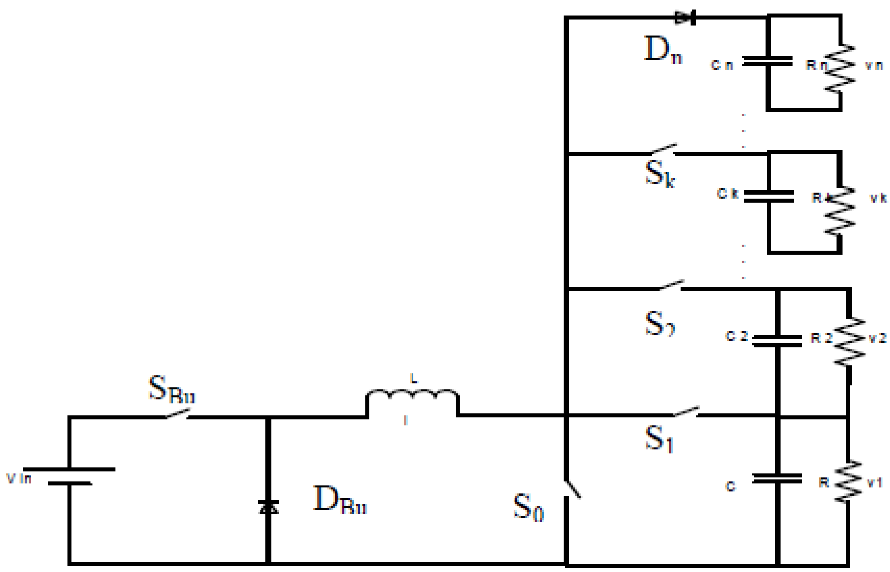

Fig.1 Multiport DC-DC Converter

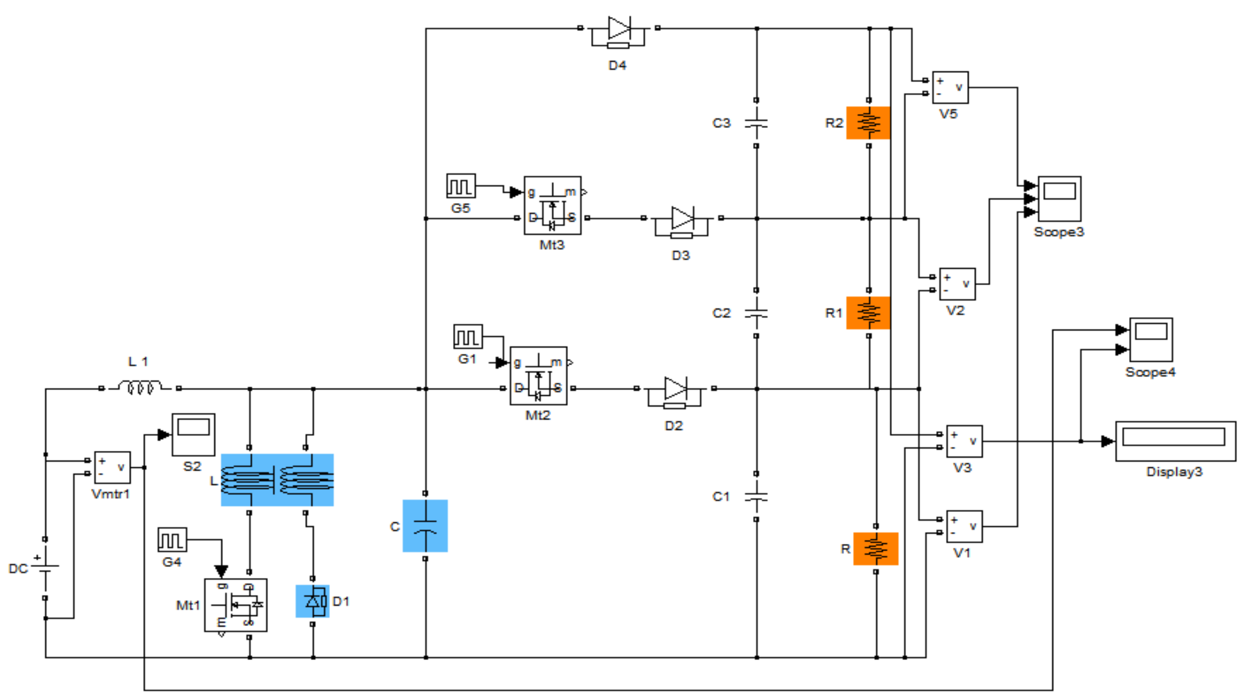

Fig.2 ZVS based three output DC-DC Converter Simulation Diagram

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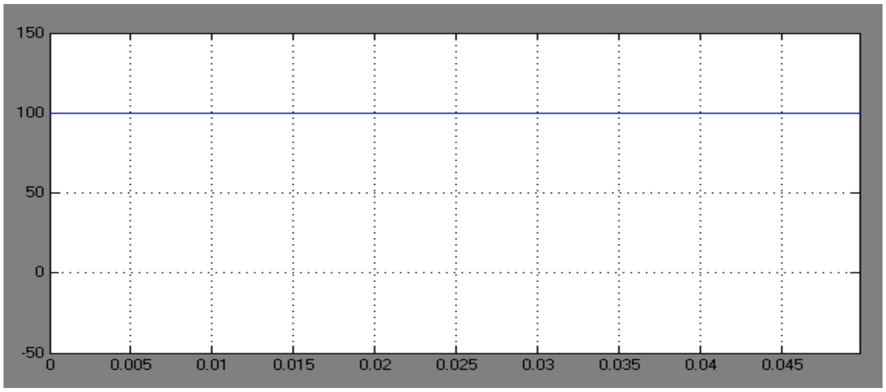

Fig.3 DC input voltage

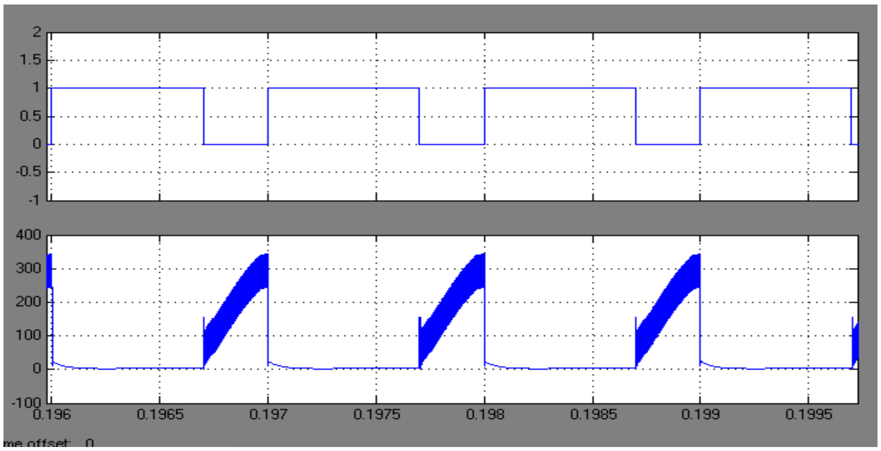

Fig.4 Gate Pulse and V_{ds} across Main SwitchM_{t1} (ZVS)

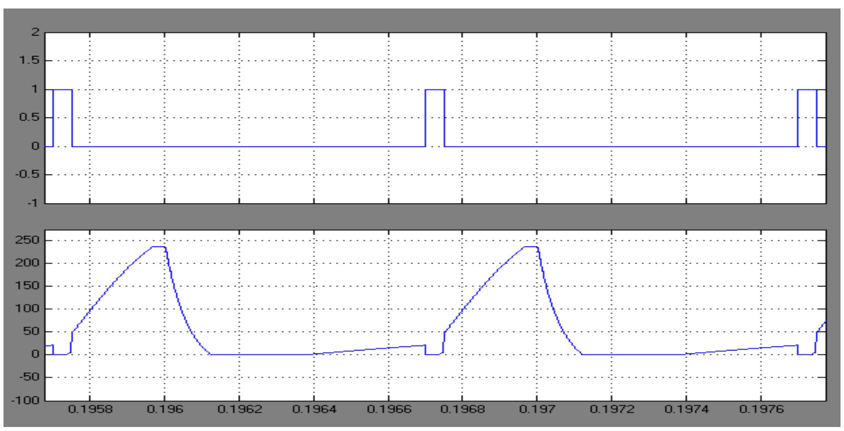

Fig.5 Gate Pulse and V_{ds} across auxiliary SwitchM_{t2}

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

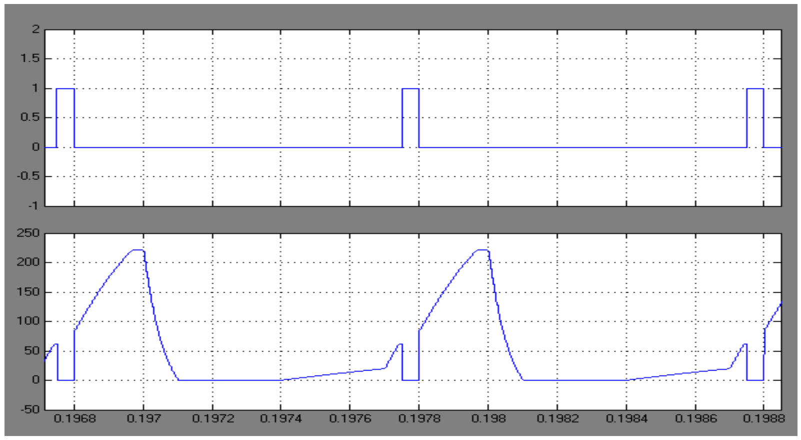

Fig.6 Gate Pulse and V_{ds} across auxiliary SwitchM_{t3}

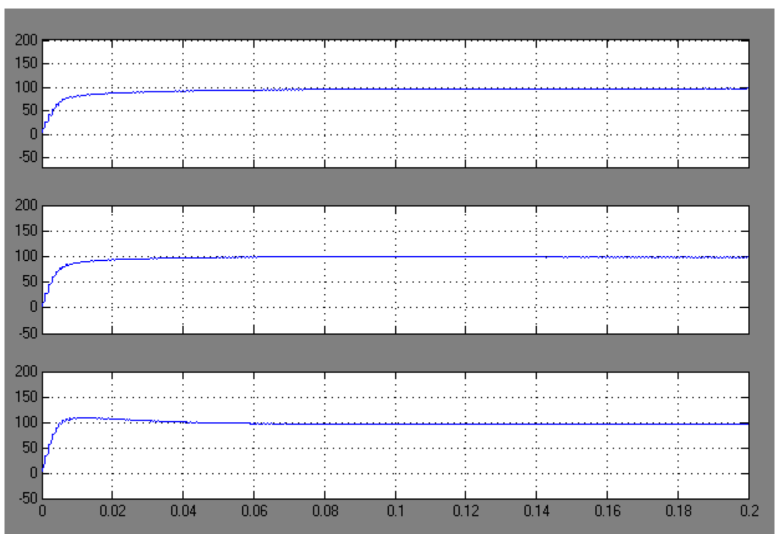

Fig.7 Three Output port voltages V_1, V_2 and V_3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

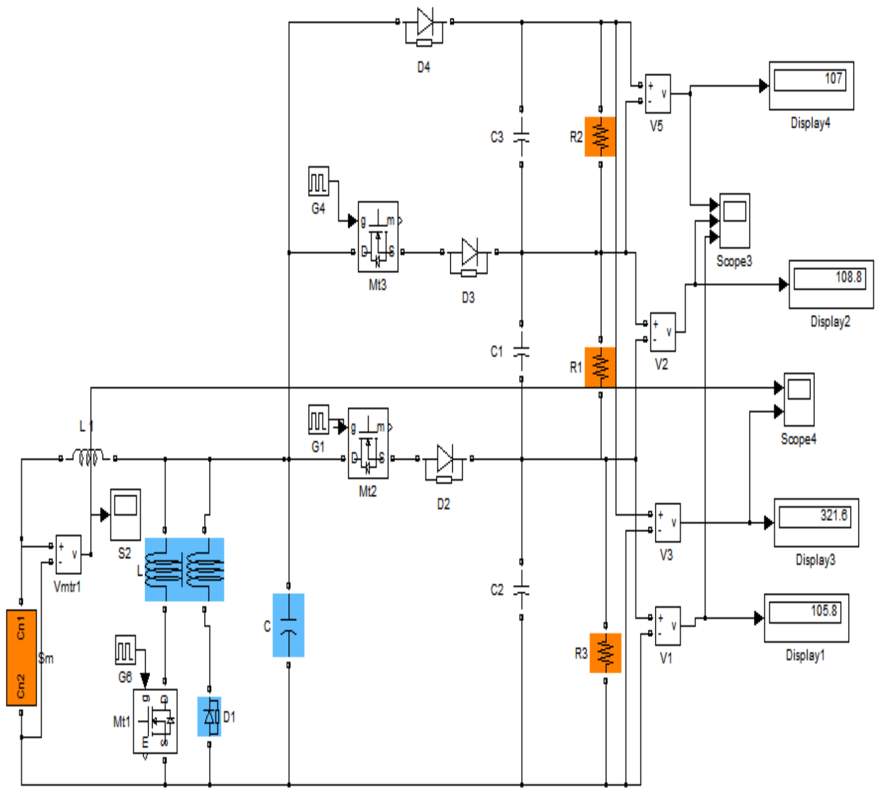

Fig.8 Open Loop System with Source Side Disturbance

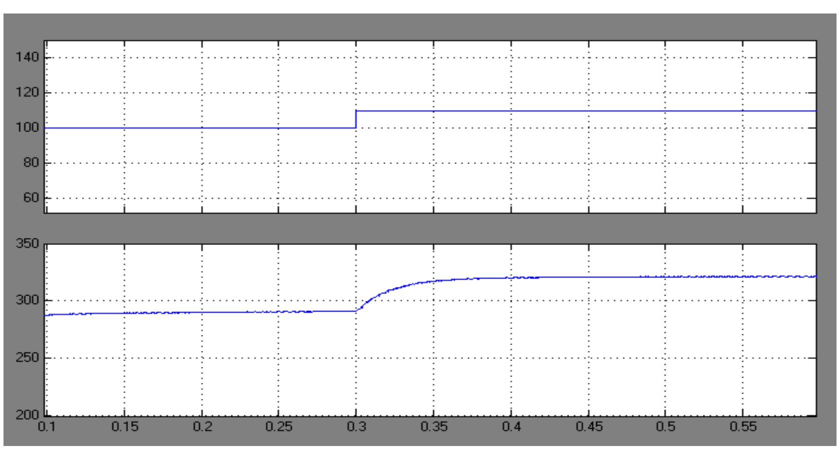

Fig.9 Input and sum of all three output voltages (V_1+V_2+V_3) with supply voltage disturbance

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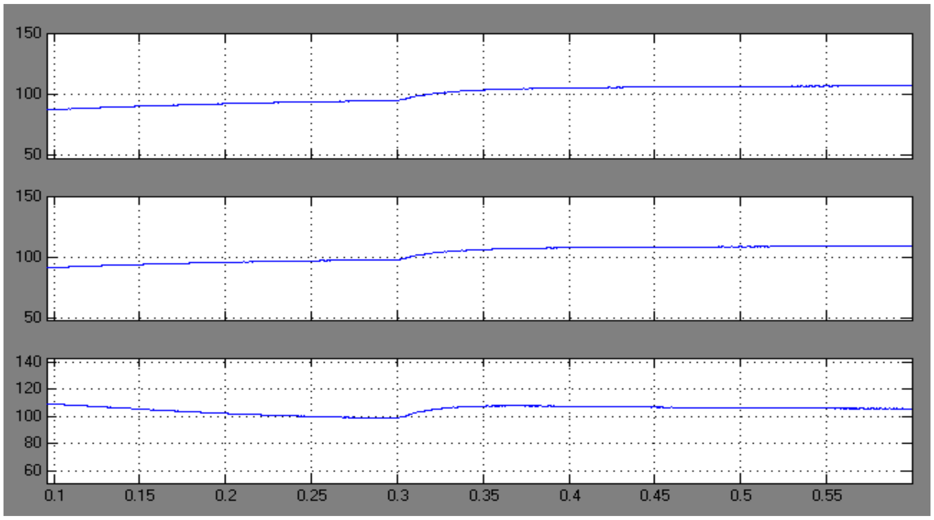

Fig.10 Three Output port voltages V_1, V_2 and V_3 with supply disturbance

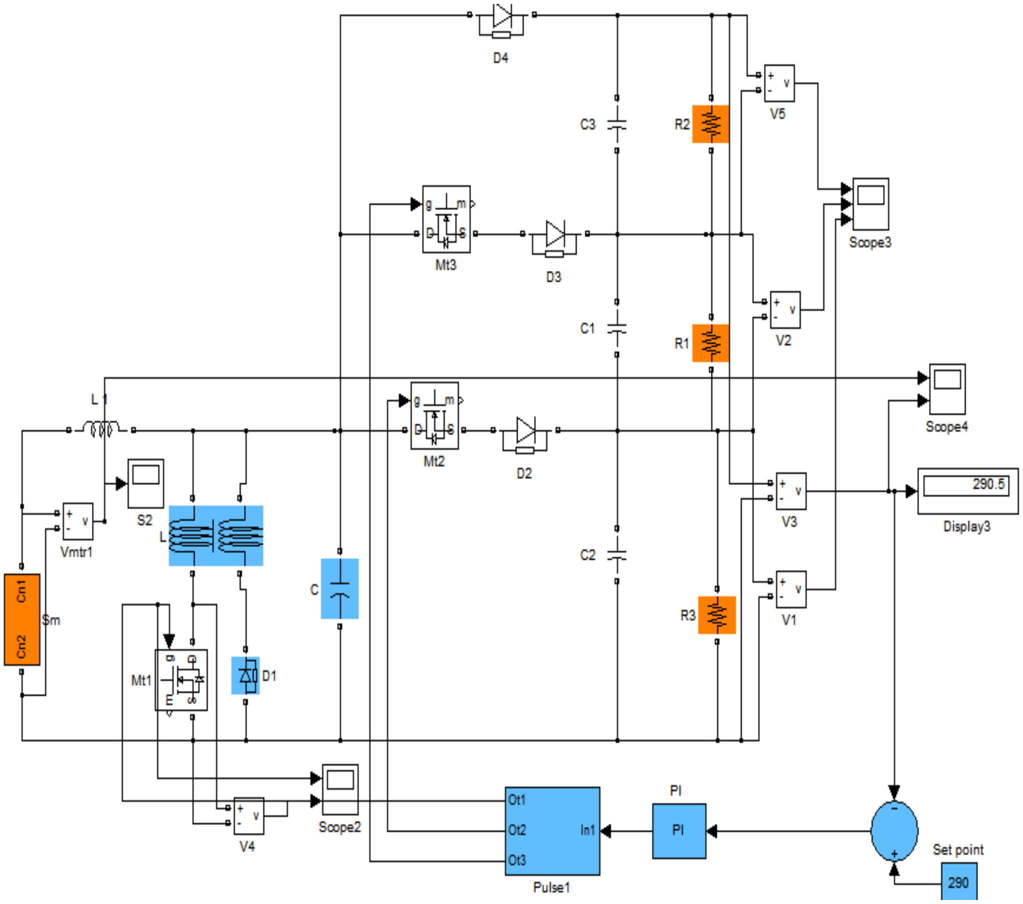

Fig.11 Closed loop system with source side disturbance

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

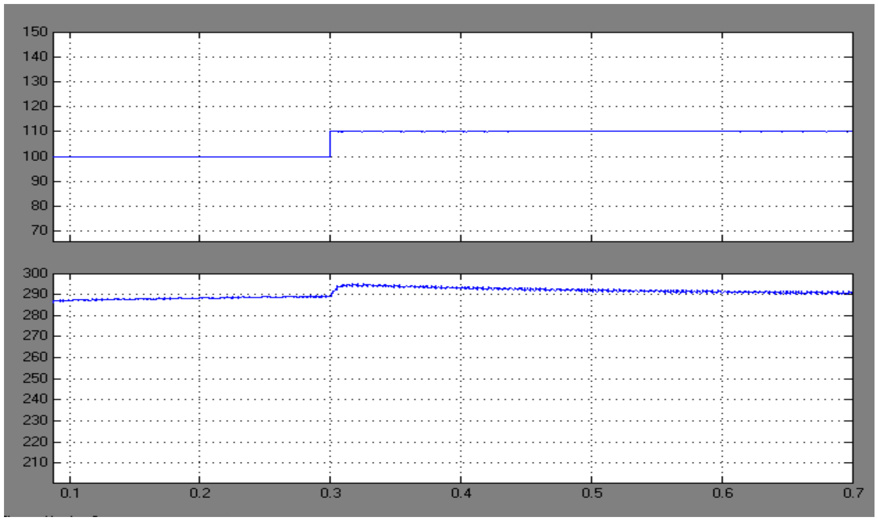

Fig.12 Input and sum of all three output voltages (V_1+V_2+V_3) with supply voltage disturbance-Closed loop control

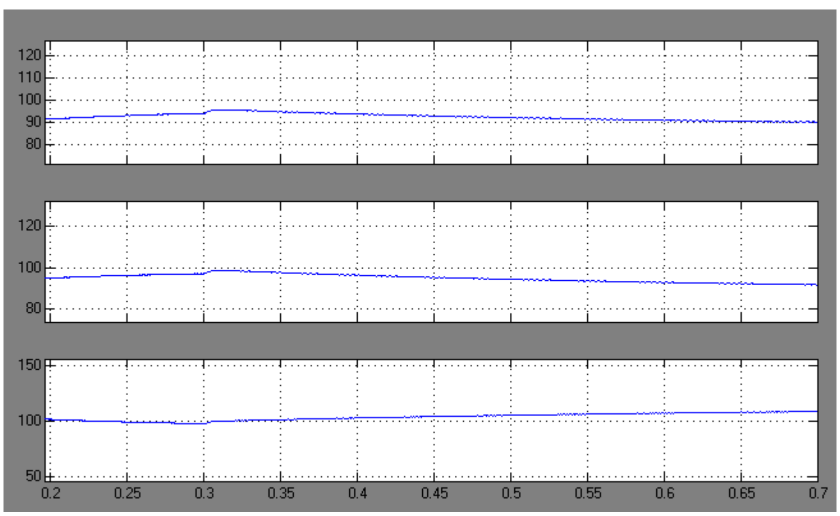

Fig.13 Three Output port voltages V_1, V_2 and V_3 with supply disturbance- Closed loop control