Microcontroller based Single Inductor multi-output boost DC-DC converter

Neelankani Dagor
Reva university Bengaluru, Karnataka, India

Vishwanath V
Assistant Professor, Department of Electrical Enggineering
Reva university Bengaluru,karnataka

Abstract- This paper presents micro-controller based on single inductor multi output DC-DC boost converter. Generally for multi-output DC-DC boost converters transformers were used which increases the number of elements of circuit. This results in increased cost and circuit size. An effort is been made to reduce the cost and size of the circuit by introducing micro-controller based single inductor multi output DC-DC boost converter.In this circuit PV array is connected in input side and for maximum power point tracking incremental conduction method is used. This circuit is analyzed and simulated. Simulation is carried out by using matlab. Simulation results and waveforms are added. Laboratory prototype hardware implementation is done.

Key words: DC-DC Converters, multi-output, MPPT, PV-Panels, Single-inductor, micro-controller.

I. INTRODUCTION

In various electrical and electronics circuits according to the requirements of applications the different voltage levels are needed. In case of alternating current circuits the voltage levels can be step-up and step down easily with the help of transformer. But in case of direct current circuits the different voltage levels is achieved by using DC-DC converters. Nowadays, dual-output or multi-output dc-dc converters are utilized in various domestic and household appliances such as cameras, CD-players, etc. Generally transformer is used for multi-output DC-DC converter for achieving different levels of voltages according to the applications. But there are certain disadvantages of using transformer as it increases cost and size of circuit. Thus it is not feasible to use transformers for small applications.The micro-controller based single inductor multi output DC-DC converter is developed to reduce the problem of increased cost and size in the circuit. The figure below shows the block diagram of proposed new topology.

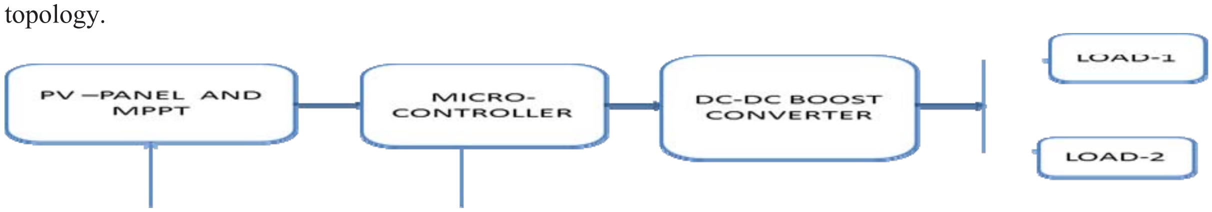
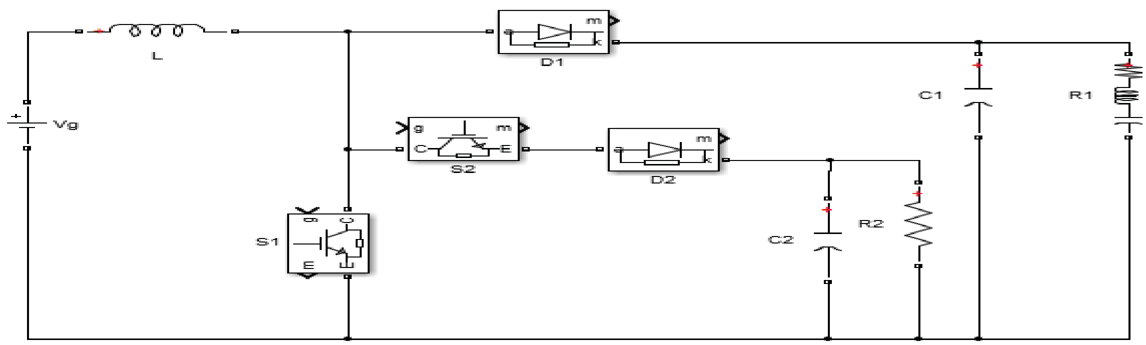


Figure 1 shows the block diagram of proposed topology.

II. WORKING PRINCIPLE

Figure2 below shows circuit diagram of proposed topology of single inductor multi-output boost dc-dc converter.



Working principle of this topology can be understood by three modes. These modes are explained below: Mode 1- The switches S1 and S2 are switched ON together at instant t_0.The inductor gets charged from the input source. ΔI_1 is given by $\Delta I_1 = \frac{V_g D_1 T}{L}$……………………………………………5.1

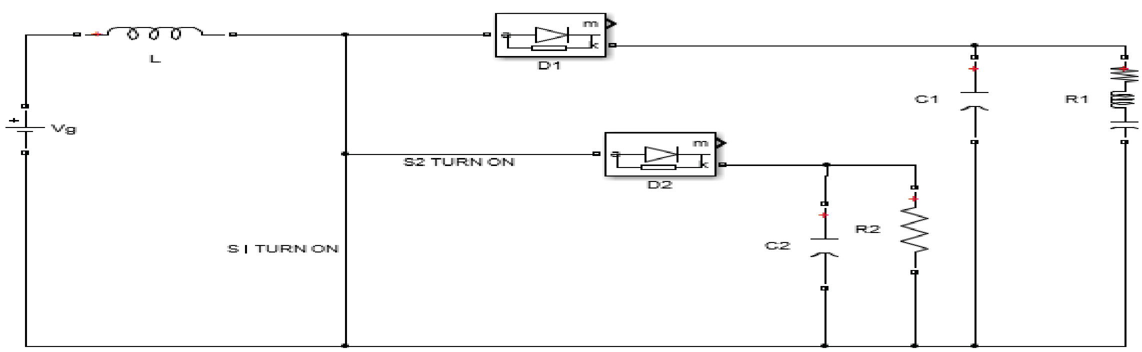


Figure 3above shows the equivalent circuit diagram of mode-1.

Mode 2- The switch S1 is switched OFF at instant t_1 and switch S2 is continued to stay in switched ON position. Inductor current decreases through capacitor C_2. ΔI_2 is given by

$\Delta I_2 = \frac{(V_{02} - V_g)(D_2 - D_1)T}{L}$…………………………………5.2

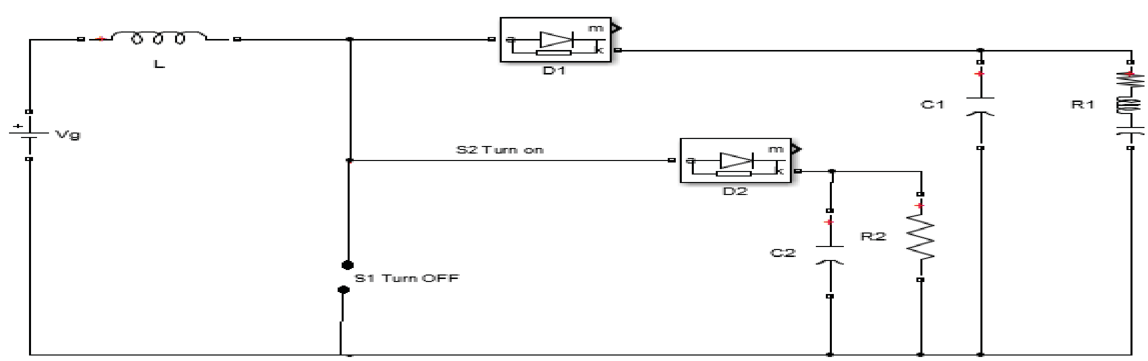


Figure 4 above shows the equivalent circuit for mode-2.

Mode 3- The switch S2 is switches OFF at instant t_2 and switch S1 is already switched OFF which is continued to be OFF in mode 3. Now inductor current will decrease through capacitor C_1.ΔI_3 is given by

$$\Delta I_3 = \frac{(V_{01} - V_g)(1 - D_2)T}{L} \quad \text{......................................5.3}$$

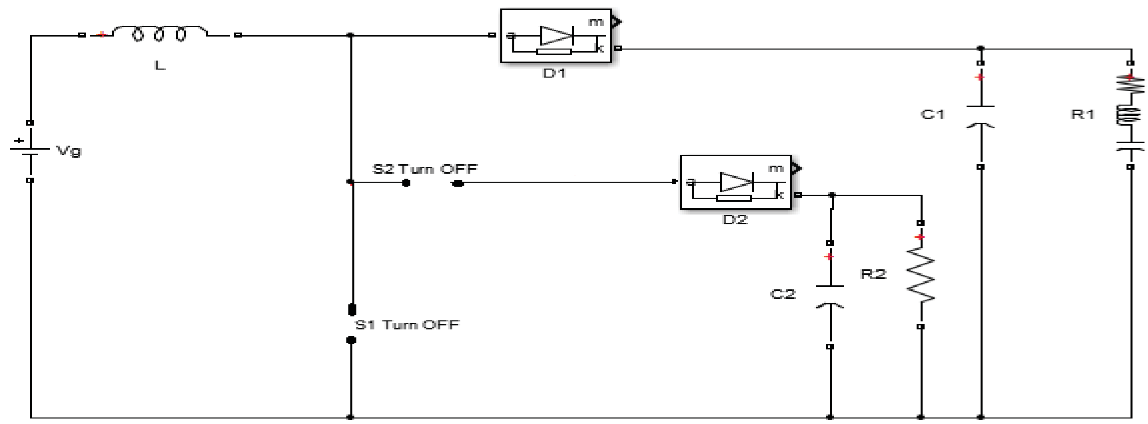


Figure 5 above shows equivalent circuit diagram for mode-3.

Waveforms

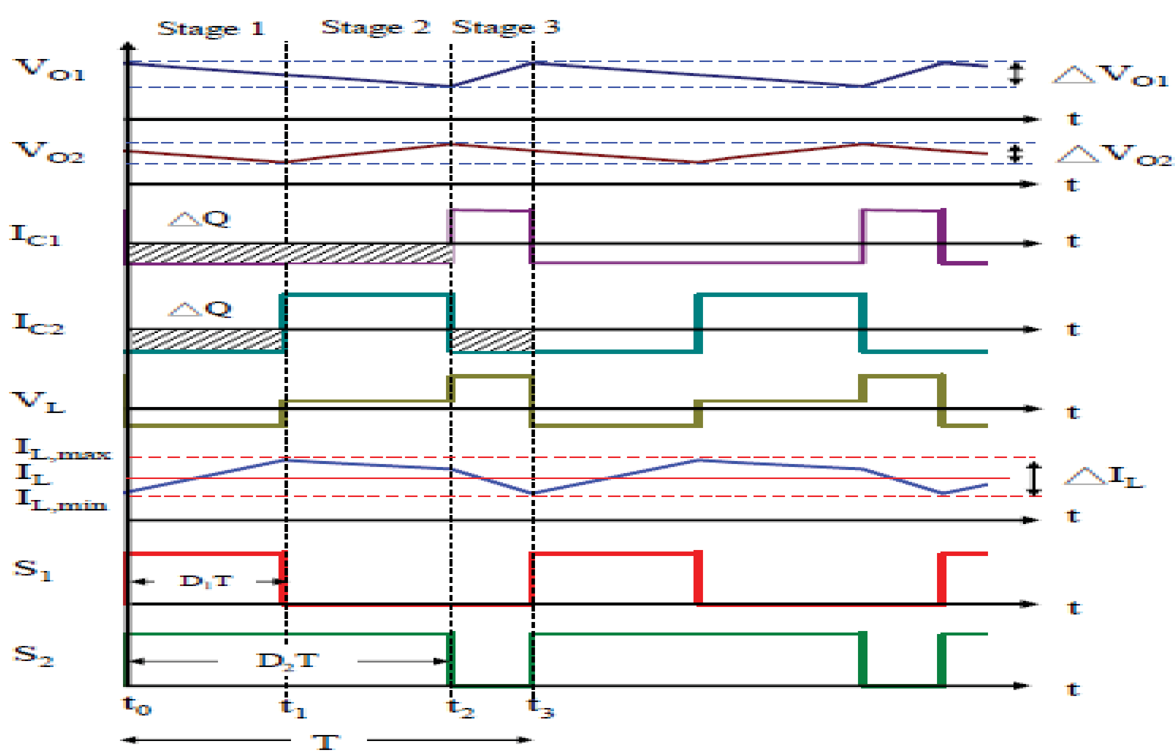


Figure 6 shows the waveforms of single inductor multi-output boost dc-dc converter.

Open loop simulation

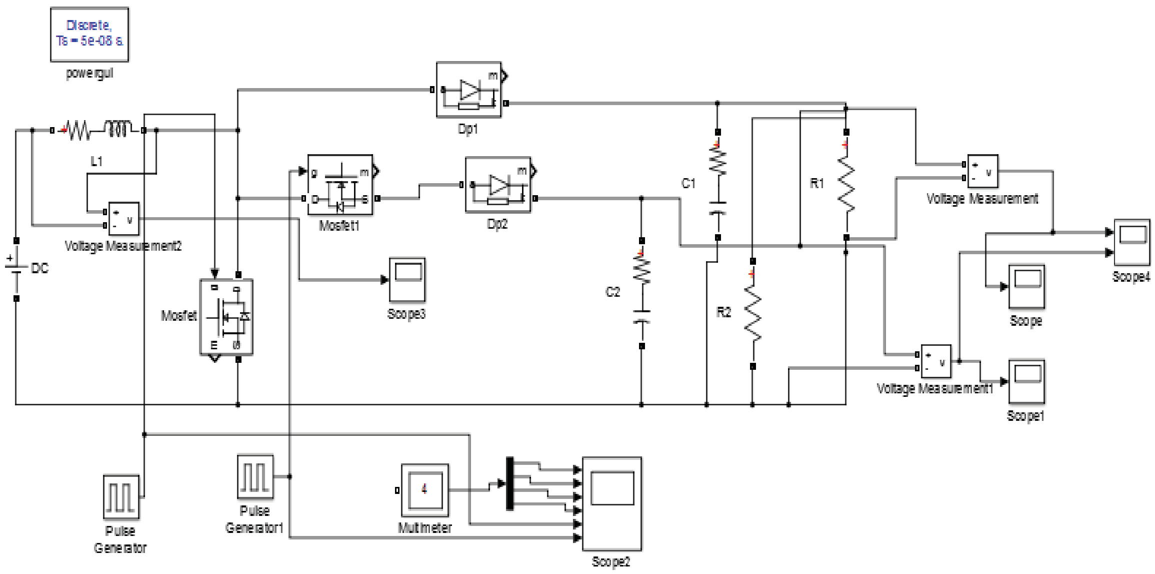


Figure 7 above shows the simulation circuit for open loop

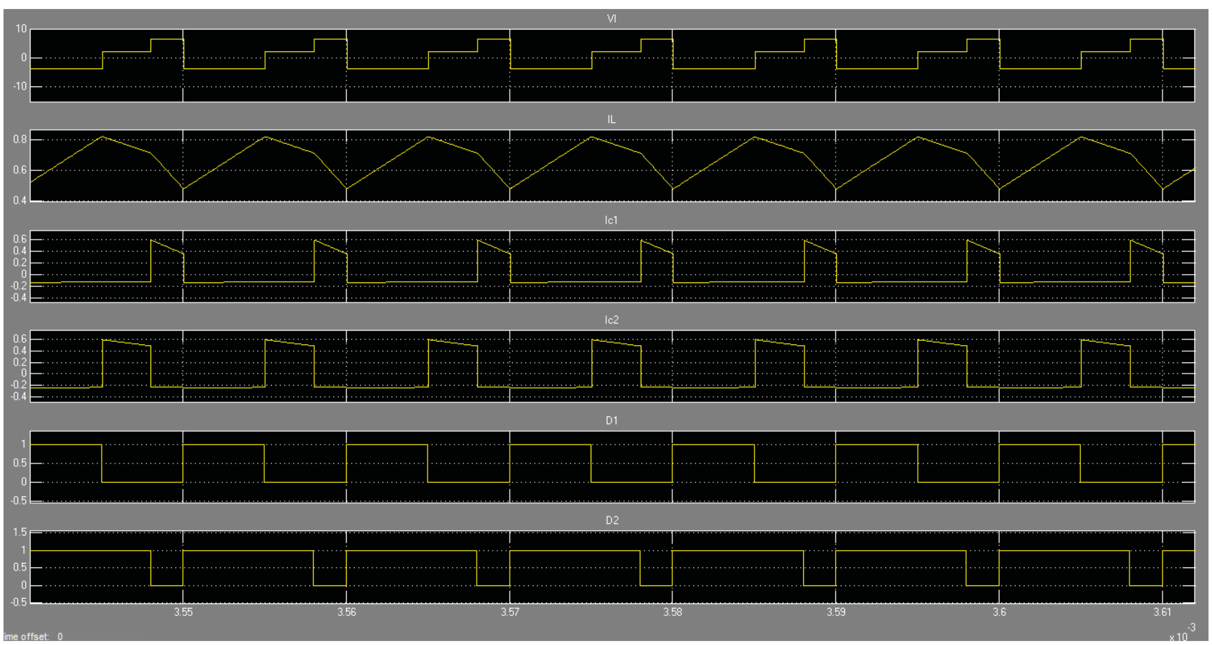


Figure 8 above shows simulated waveforms of open loop circuit- from the top sequence is in following order first is inductor voltage, second is inductor current, third is current through capacitor C1, fourth is current through capacitor C2, fifth is duty ratio of switch S1, sixth is duty ratio of switch S2.

Simulation circuit of proposed topology

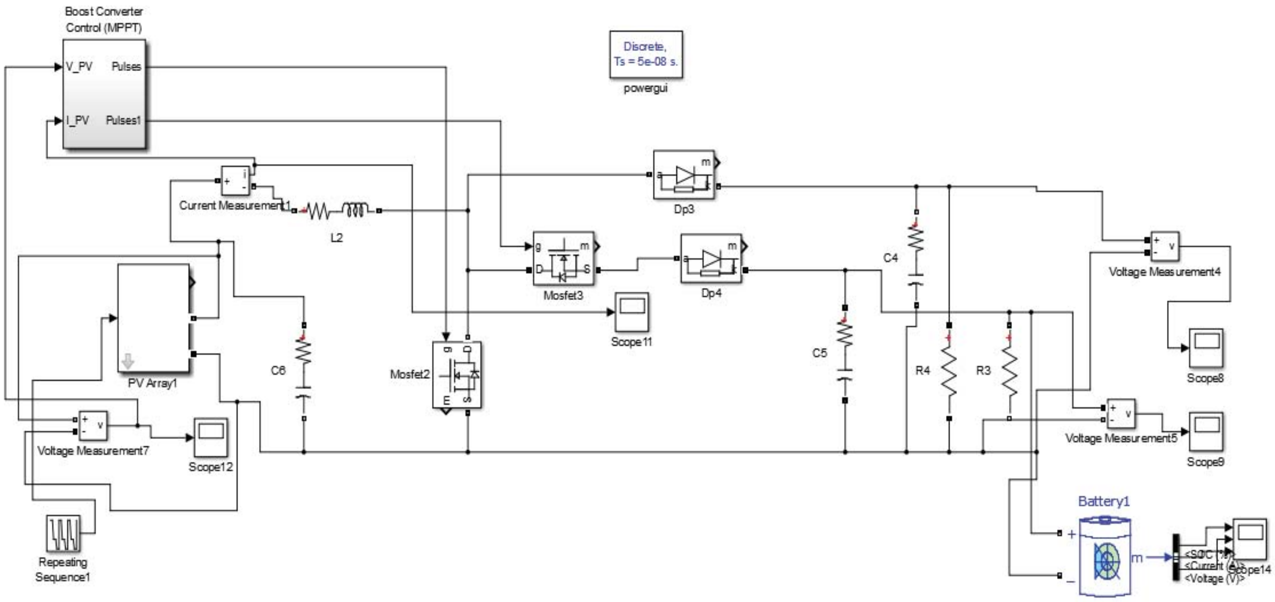


Figure 9 above shows the simulation circuit of proposed topology.

MPPT Block logic in simulation of proposed topology

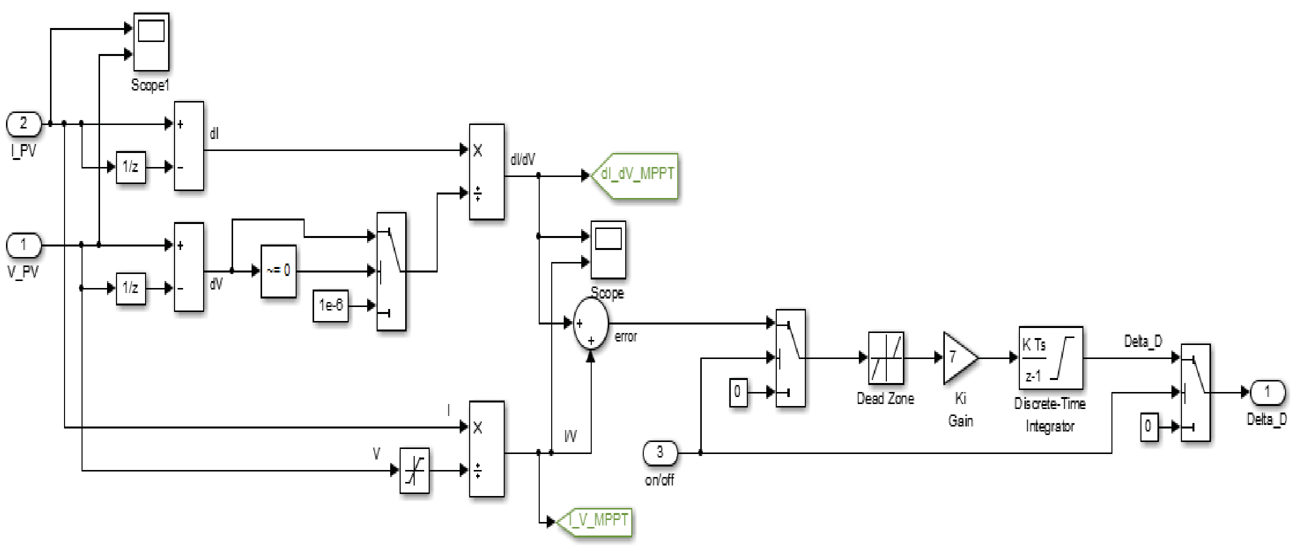


Figure10 shows MPPT block logic in simulation of proposed topology.

MPPT by incremental conductance method + integral regulator

$\frac{di}{dv}+\frac{i}{v}=0$………………………… 6

Simulated output waveforms of proposed topology

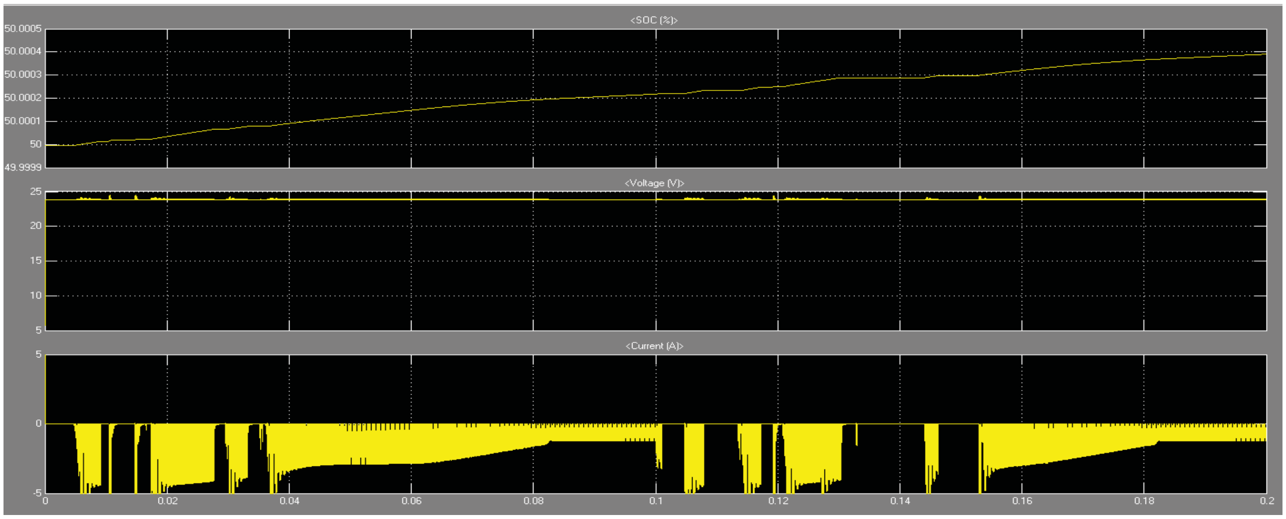
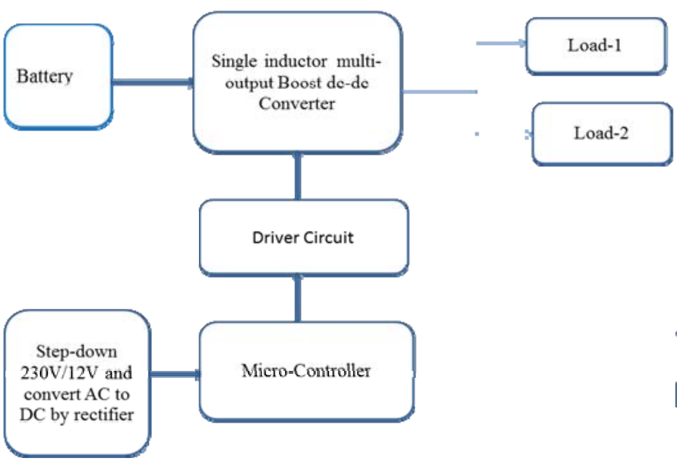


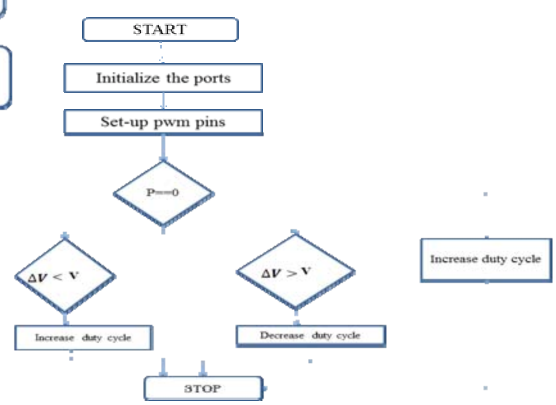
Figure 11 shows the simulated output voltage waveforms across output-2.

Battery is connected across output-2. Battery is charging by 24 volts. As we know when battery charges current is negative.

III. LABORATORY PROTOTYPE HARDWARE IMPLEMENTATION

Figure 12 below shows Block Diagram of the New Implemented Hardware and flow chart of the program.





Components Required To Develop Hardware

Driver circuit- The main function of driver circuit is increase the switching voltage of micro controller to the sufficient level so that connected switch such as MOSFET, IGBT should operate properly. Following components required for driver circuit is mentioned here-IRFP250,Diode 1N4007,Capacitor 1000uF/50V , 1000uF/25V,Opto-coupler MCT2E,Transistor 2n2222 and transistor CK100,Resistors 100and 1000 ohms. Main circuit is single inductor multiple output dc-dc converter. It gives dual output with boosting the input voltage. Following components required for hardware implementation are give below- Two diodes IN5819,Two capacitors 10 and 33 micro-farad, two MOSFETs IRF630,One inductor 56 micro Henry, resistors 22 and 82 ohms. In this project arduino uno micro-controller board depend on atmega328.This board requires only 5volts for working. Coding can be done easily on computer and with the help of data cable can be dump in board.

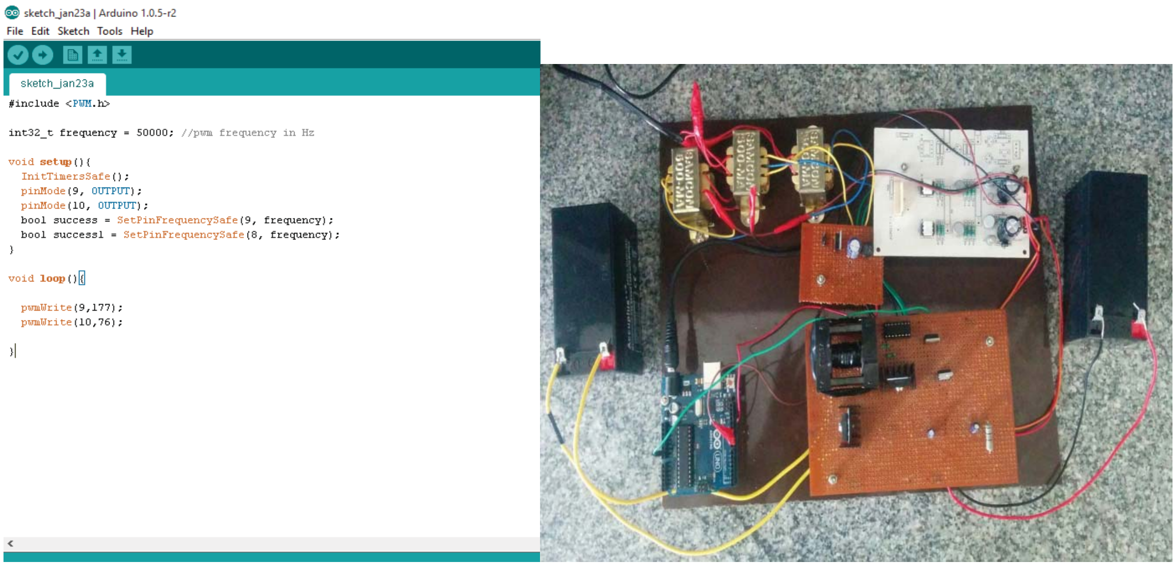


Figure13 above shows Program instructions snap for micro-controller and Photo snaps of laboratory prototype Hardware module.

Output waveform of hardware implementation

Figure14 above shows during hardware implementation gate pulses for switch S2 and S1respectively.

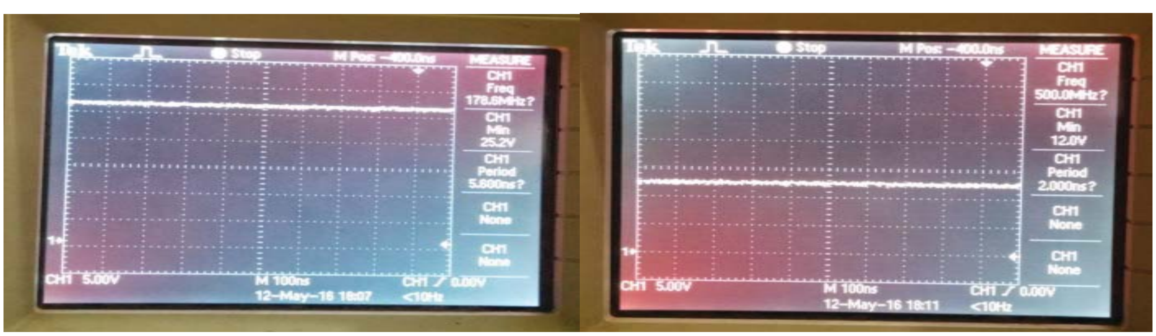


Figure15 above shows simulated output waveforms of proposed topology of V01 and V02 respectively.

IV. CONCLUSION

In this paper a new topology of micro-based controller single inductor multiple outputs Boost DC-DC converter is simulated and implemented. From simulated and hardware output results it can be concluded that this new proposed topology is more efficient and less expensive. In this paper simulated output waveforms and hardware implemented waveforms are attached.

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