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# Modeling And Stability Analysis Of A New Transformerless Buck-Boost Converter For Solar Energy Application

V VENKATA KRISHNA REDDY

Assistant Professor (Adhoc), Department of Electrical and Electronics Engineering,

JNTUA College Of Engineering (Autonomous), Pulivendula, Kadapa, Andhra Pradesh.

G.VEERA SANKAR REDDY

Assistant Professor(Adhoc),Department of EEE

JNTUA College of Engineering(Autonomous),Pulivendula,

Kadapa, Andhra Pradesh

B. Sushma - 21191A0206

V. Chandrahasareddy - 21191A0263

M. Karthik - 21191A0234

Department of Electrical and Electronics Engineering,

JNTUA College Of Engineering (Autonomous), Pulivendula, Kadapa, Andhra Pradesh.

**ABSTRACT**

A study and configuration of a new transformerless buck-boost converter is proposed in this work. The normal buck-boost converter has simple configuration and high efficiency. The disadvantage of the normal converter is restricted voltage gain, negative output voltage, floating power switch, discontinuous output and input currents. For eliminating the disadvantages of the normal converter, a new transformer less buck-boost converter is proposed. The proposed new transformer less buck-boost converter consists of two switches, two capacitors, two inductors and one resistor load in the circuit. The two power switches of the proposed converter operate simultaneously. The proposed buck-boost converter gives the voltage gain is squared or quadratic times of normal converter which makes it suitable for solar energy applications. In continuous conduction mode, a voltage gain, operating principles, small-signal model and voltage stress are described for the proposed converter. To improve the stability of a system, a PI controller is used in the proposed converter. The structure of the proposed buck-boost converter circuit is simulated in MATLAB/ SIMULINK

**Keywords** - High voltage gain, transformerless buck-boost converter, small signal model, voltage stress.

## I.INTRODUCTION

In recent years, extensive use of electrical equipment has increased rapidly. As the insist for power is significantly increasing, naturally replenished energy sources have received a bundle of attention as an alternatives way of generating directly electricity. Using renewable energy sources is able to eliminate harmful emissions from polluting the environment while also offering inexhaustible resources of primary energy. There are various non-conventional energy sources such as wind turbines, solar energy and fuel cells. However, fuel cells & solar cells have small output voltage. So that a high efficiency and step-up DC-DC converter is preferred in the power conversion systems to amplify the voltage supplied to the grid or be compatible in other applications. Basically, the conventional or traditional buck-boost converter is capable of give an extra voltage gain by means of an extremely high duty cycle. A DC-DC converter is a necessary component of alternative and portable devices, renewable energy alteration and many industrial applications. A DC-DC converter is mainly use to transfer the unregulated dc voltage to regulated dc voltage. The solar cell output or rectifier output is the variable dc voltage. The buck-boost converter is the main converter in DC-DC converters. The buck-boost converter mainly depends on duty ratio and it gives the more voltage or low voltage. Switching conversion is better than the linear voltage regulation. The normal buck-boost converter presents inverter topology and simple construction. But it has a few disadvantages such as irregular output and input currents, floating power switch, restricted voltage gain and output voltage is negative. Series connection of normal DC-DC converter is not a feasible to attain high voltage gain. In cascaded high step-up DC-DC converter is used to attain high voltage gain. Cascaded topology requires large number of switches so it has more switch losses. To obtain more voltage gain, isolated converter topologies are used.

Transformers and coupled inductors be here in the isolated topology, due to this converter size, price and losses are more increases. Non-isolated converter topologies are used to defeat the drawbacks of isolated converter topologies. The three basic non-isolated converters are Cuk converter, zeta converter and Sepic converter. These three converters exhibit some disadvantages. The disadvantage of a Sepic converter circuit is a fourth order one and difficult to control. Buck converter exhibit the negative polarity voltage as similar to the normal buck-boost converter and it has the major disadvantage is it requires the large current carrying capacitors. Mainly basic non-isolated converters have limited voltage gain and disadvantage of this converters are non-ignorable. The Peng and Hwu proposed a new converter, which is a arrangement of KY converter and conventional synchronously rectified buck converter.

This converter gives the positive output voltage, continuous output current and every instance operates in continuous conduction mode. But its voltage gain is two times of the duty ratio. So it does not give the large vary of output voltage. Based on Cuk converter, the proposed buck-boost converter has the small output voltage swell, smallest radio frequency nosiness and one common-ground control switch. However, as a seventh-order circuit, the converter has complex construction, and both input and output terminal don’t allocate the same ground. Besides the voltage gain is still restricted. In arrange to achieve the more voltage gain, a voltage-lift technique is employed in Luo converters. But this converter is more difficult, volume, losses and cost increases. Especially in regulate to achieve high voltage step-up or step-down gain, these converters should be operating under extremely high or low duty cycle. So in order to eliminate all the drawbacks, a new transformerless buck-boost converter is proposed.

The proposed new transformerless buck-boost converter is obtaining by accumulation the additional network into the conventional buck-boost converter. The main advantage of the proposed converter is that its voltage squared or quadratic times of the traditional buck-boost converter. The proposed buck-boost converter can attain high voltage or low voltage without extreme duty cycle. The proposed converter output voltage is positive and common ground with input voltage.

## OBJECTIVES

1. To analyse non-isolated high step-up DC/DC converter
2. To identify high efficiency high step-up converter
3. To analyse positive output cascaded converters
4. To conduct interleaved high step- up DC/DC converter
5. To assess novel transformer-less adjustable voltage quadruple DC/DC converter

## II.METHODOLOGY

1.Understand the fundamental operation of your new converter.
2.Develop mathematical models (both large-signal and small-signal).
3.Analyze the stability of the converter using appropriate techniques.
4.Validate your theoretical findings through simulations (and potentially experiments).

## III.RESULTS AND DISCUSSIONS

### PROPOSED TRANSFORMERLESS BUCK-BOOST CONVERTER

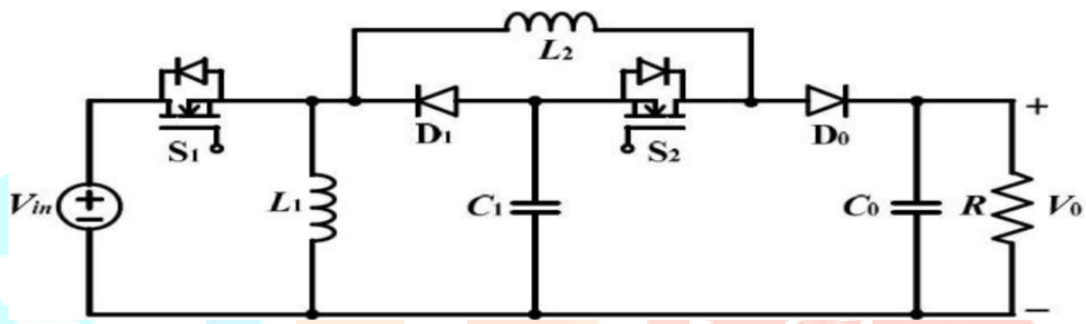



**Fig 1 circuit diagram of proposed new transformeless buck-boost converter**

The proposed new converter as shown in Fig 1. It consists of two power switches (S1 and S2), two capacitors (C1 and C0), two inductors (L1 and L2), two diodes (D1 and D0), and one resistive load R. The Power switches (S1 and S2) of the proposed converter operate simultaneously. According to the state of the power switches and diodes, different unique time-domain waveforms for this proposed buck-boost converter working in Continuous conduction mode (CCM) are display in Fig. 2, and the possible function states for the proposed buck-boost converter are shown in Fig.3.when the power switches S1 and S2 are conducted while the diodes D1 and D0 are do not conduct. At the time of switches S1 and S2 are conducted, the two inductors L1 and L2 are magnetized, and both the charge pump capacitor C1 and the output capacitor C0 are discharged are shown in fig 3(a). When the power switches S1 and S2 are in off state whereas the diodes D1 and D0 are conducted for its forward biased voltage. Hence, both the inductor L1 and L2 are demagnetized, and both the charge pump capacitor C1 and the output capacitor C0 are charged are shown in fig 3(b). Here, in order to consider the circuit we understood that the converter operate in balanced state, all the components of the circuit are standard, and all capacitors are huge enough to keep the voltage transversely them constant.

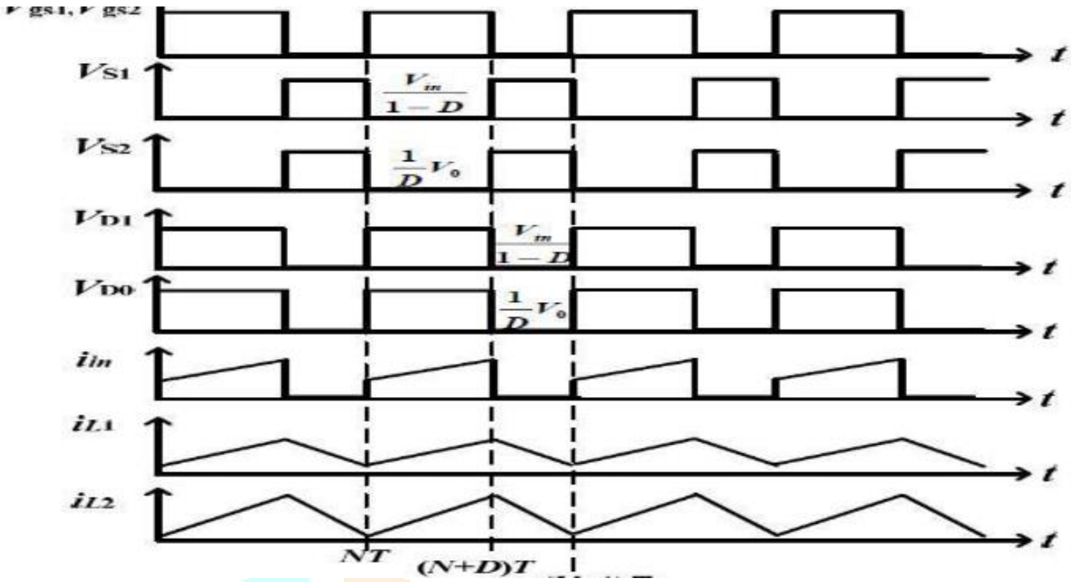



**Fig 2 Time-domain waveforms for the proposed buck-boost converter operating in CCM.**

**Operating Principles:**

The proposed converter consists of two states of operation. The two states are state 1 and state2 and they are operated in CCM. The operating time interval of state1 is (NT<t< (N+D) T). The operating time interval of state2 is ((N+D) T<t< (N+1) T).

**State1: (NT<t< (N+D) T)**

State1 is operated in the time interval between (NT<t< (N+D) T). During in this interval, the switches S1 and S2 are ON, while the diodes D1 and D0 are OFF. The inductor L1 is magnetized from the input voltage Vin. While the inductor L2 is magnetized from the input voltage Vin and the charge pump capacitor C1. Also, the output energy is supplied from the output capacitor C0 are shown in fig 3(a). The equations of the state can be written as

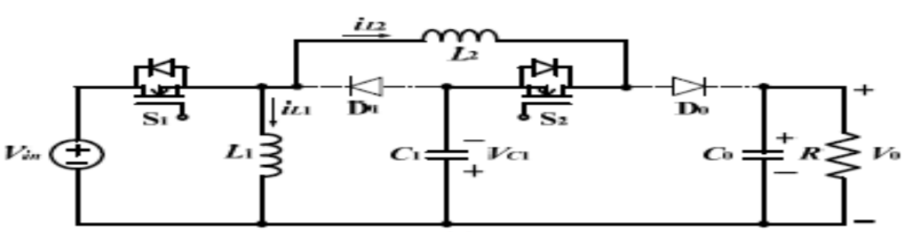


**Fig 3(a) equivalent circuit of the state1 of the proposed buck-boost converter**

**State2: ((N+D) T<t< (N+1) T)**

State2 is during the time interval between ((N+D) T<t< (N+1) T). During in this interval, S1 and S2 are OFF, while diodes D1 and D0 are ON. The energy stored in the inductor L1 is transfer to the charge pump capacitor C1 through the diode D1. At the similar instant, the energy stored in the inductor L2 is transfer to the charge pump capacitor C1, output capacitor C0 and the resistive load R through the diodes D0 and D1 are shown in fig3(b). The equations of the state 2 can be written as

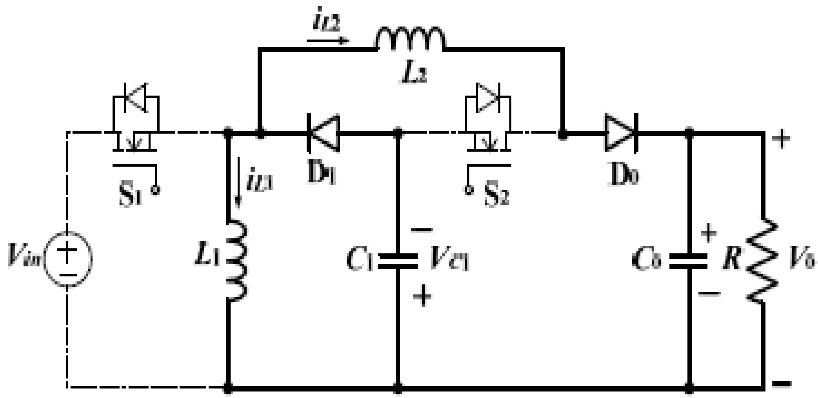



**Fig 3(b) equivalent circuit of state2 of the proposed buck-boost converter**

**SIMULATION DIAGRAM AND RESULTS**

The circuit diagram of the new transformerless buck boost converter is simulated using the MATLAB/SIMULINK software to confirm the above mentioned analysis. Circuit parameters chosen are shown in the below table

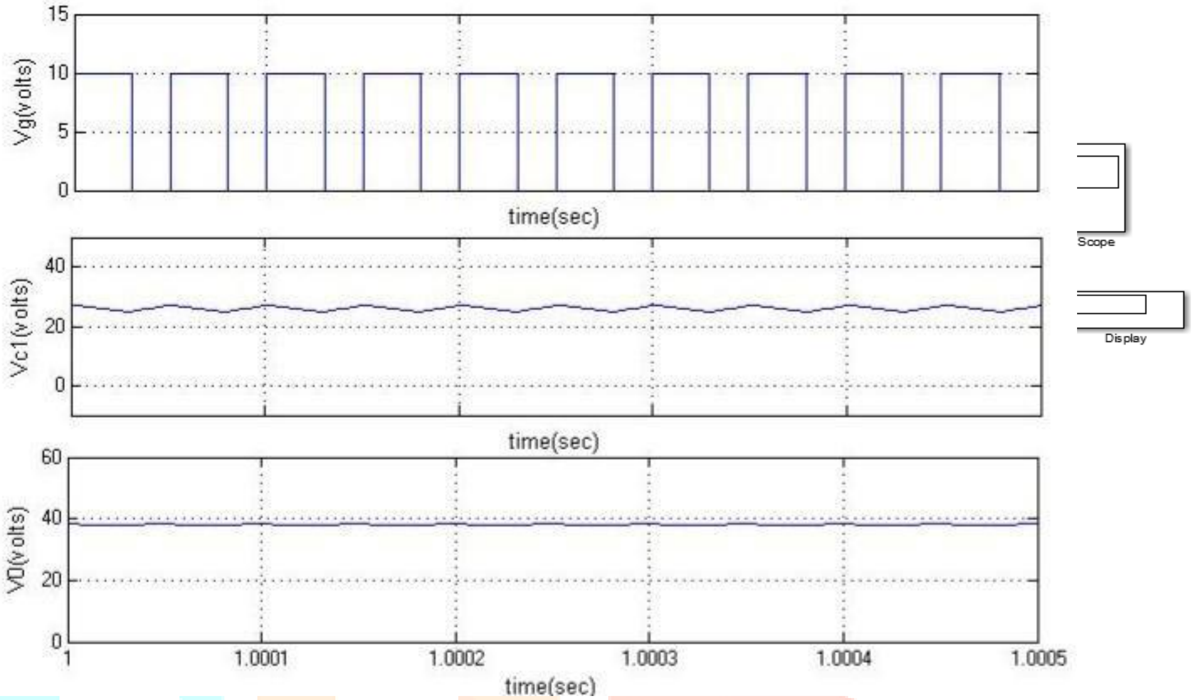
**(a)Without Feedback**

**SPECIFICATION OF THE PARAMETERS**

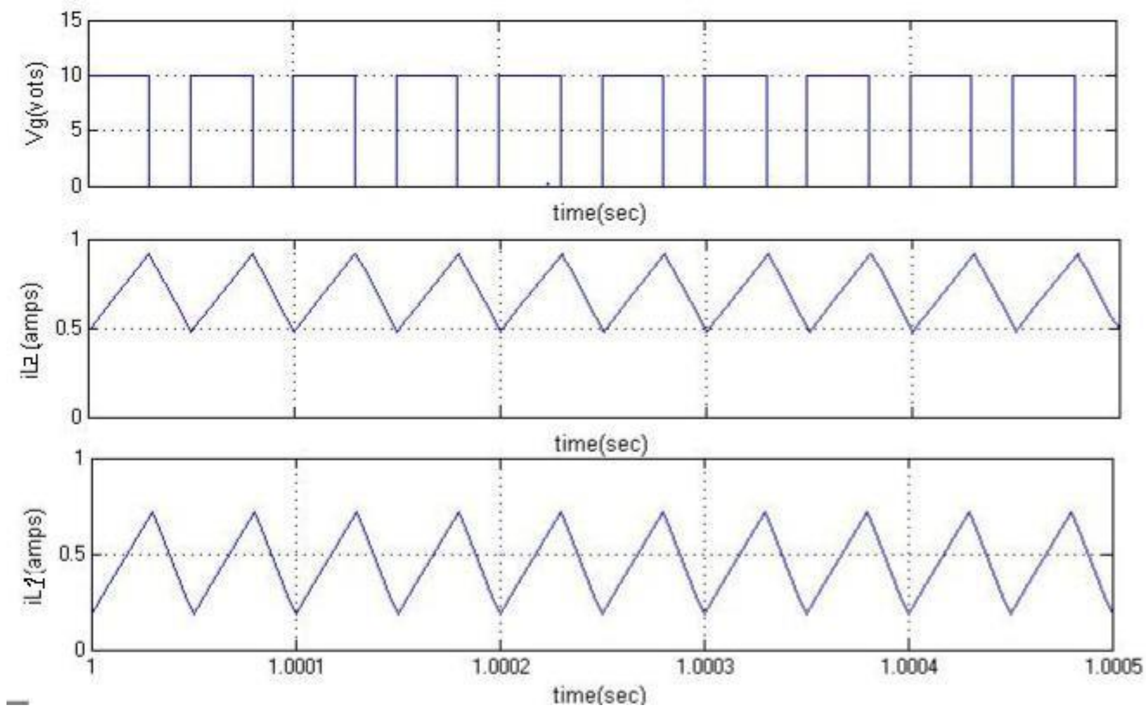
These parameters are taking as fixed for conducting the experiment. These values are shown in the below table.

| Parameter | Description | Value |
|---|---|---|
| Vin | Input voltage | 18[V] |
| $F_s$ | Switching Frequency | 20[kHz] |
| D | Duty ratio | 0.4-0.6 |
| $L_1$ | Inductor | 1[mH] |
| $L_2$ | Inductor | 3[mH] |
| $C_1$ | Charge pump capacitor | 10[μF] |
| $C_2$ | Output capacitor | 20[μF] |

## SIMULATION DIAGRAMS



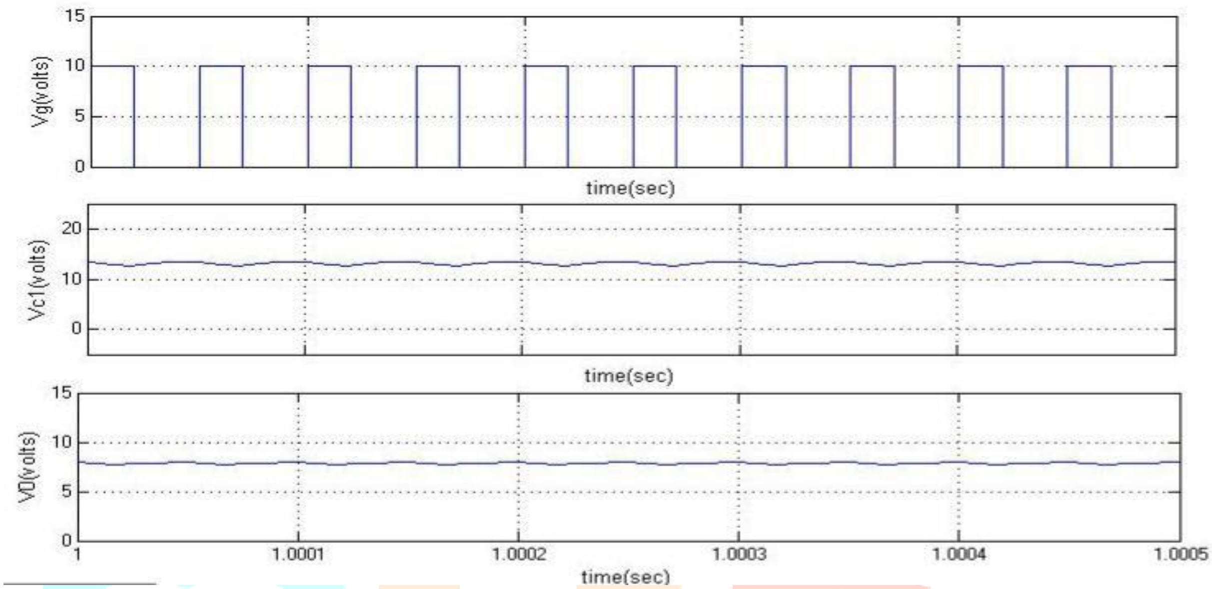

**The proposed buck-boost converter operating in step-up mode with duty ratio 0.6. ($V_g$, $V_{c1}$ and $V_0$)**




**The proposed buck-boost converter operating in step-up mode with duty ratio 0.6.**

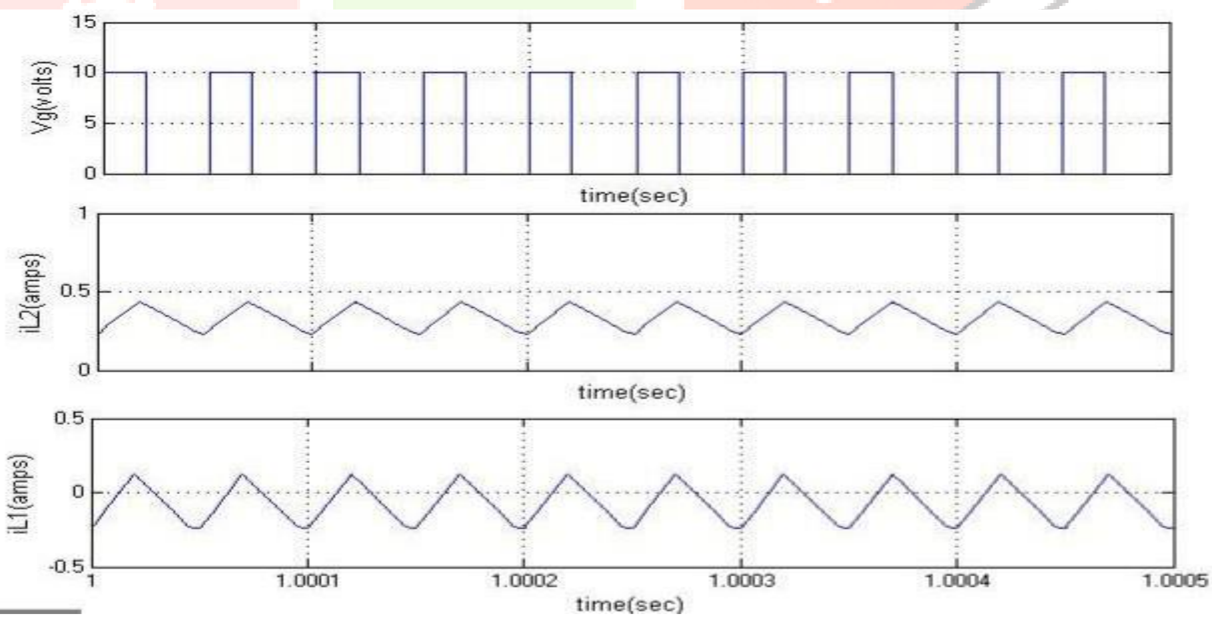
**($V_g$, $i_{L2}$ and $i_{L1}$)**

For the proposed Converter operating in step-up mode with the duty ratio 0.6. The output voltage across the load is $V_0$=38.27V, voltage across the charge pump capacitor is $V_{C1}$=25.8V, the inductor current $i_{L1}$=0.34A and $i_{L2}$=0.55A.




**The proposed buck-boost converter operating in step-down mode with duty ratio 0.4.**

**($V_g$, $V_{c1}$ and $V_0$)**

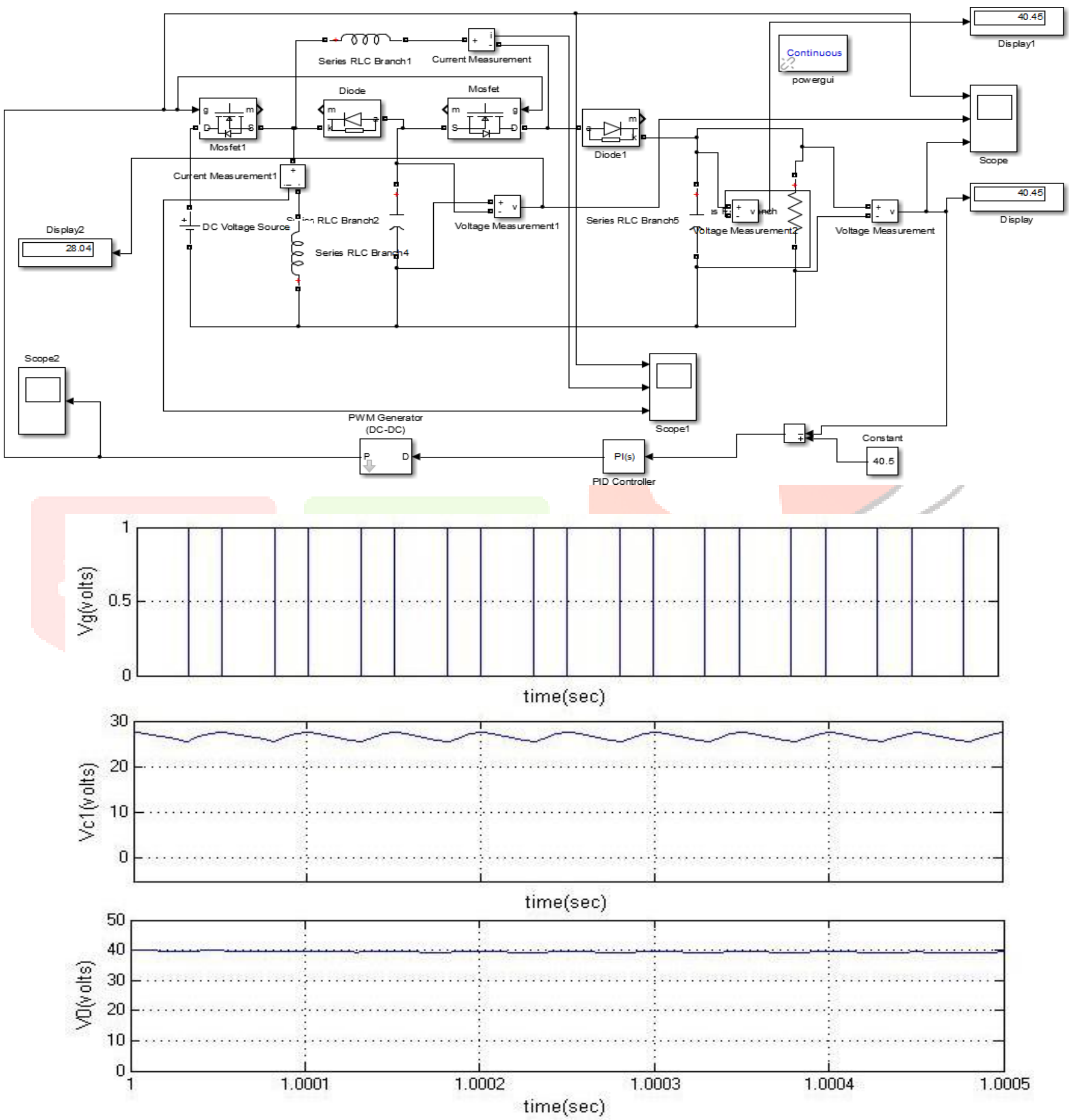



**The proposed buck-boost converter operating in step- down mode with duty ratio 0.4.**

**($V_g$, $i_{L2}$ and $i_{L1}$)**

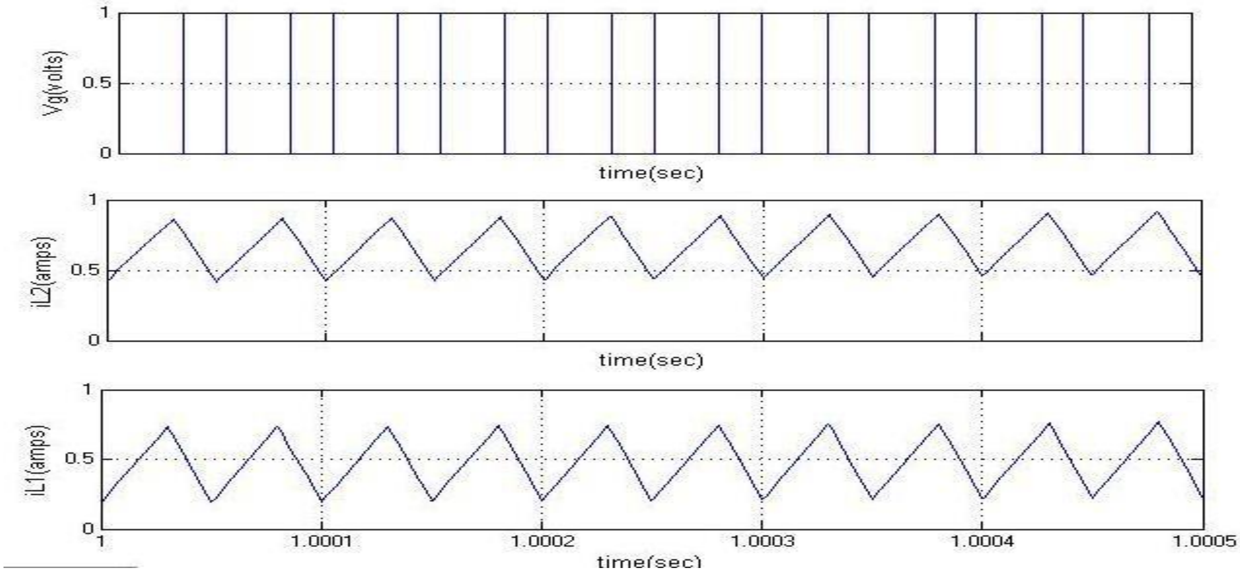
For the proposed Converter operating in step-up mode with the duty ratio 0.4. The output voltage across the load is $V_0$=6.89V, voltage across the charge pump capacitor is $V_{C1}$=12V, the inductor current $i_{L1}$=0.15A and $i_{L2}$=0.44A.

**(b) With Feedback**




**The proposed converter with PI controller in step-up mode with Feedback**

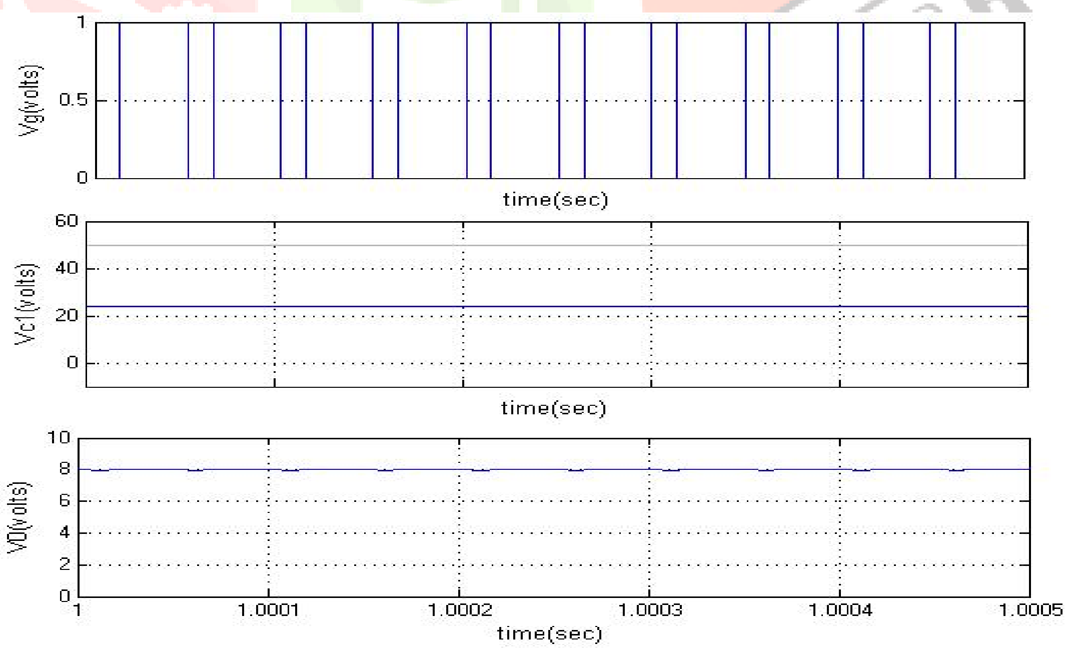
**($V_g$, $V_{c1}$ & $V_0$)**




**The proposed converter with PI controller in step-up mode with feedback**

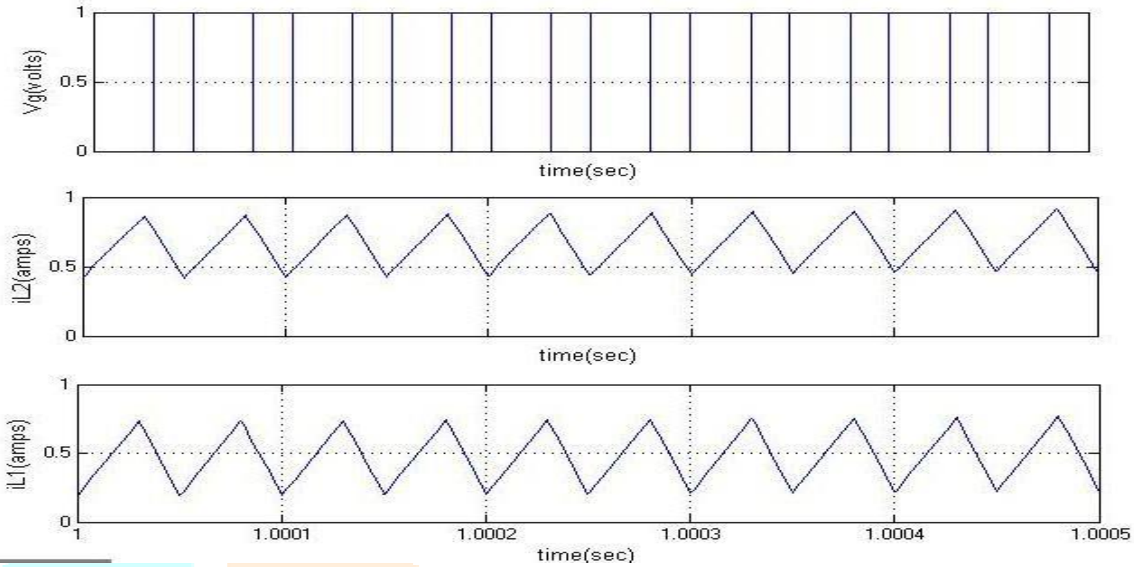
**($V_g$, $i_{L2}$ & $i_{L1}$)**

By using PI controller in the feedback, the stability of the converter is improved and it maintains the constant voltage irrespective of the load conditions. The load value changes from 140Ω to 150Ω, it maintains the constant voltage. The values of KP=0.0002, Kd=1.1455 are used in the PI controller in the step-up mode. The output voltage across the load is $V_0$=40.5v maintains constant in step-up mode irrespective of the load conditions. The proposed converter operating in step down mode with feedback. In step-down mode, the load value changes from 30Ω to 40Ω it maintains the constant voltage. The values KP and Kd are taken based on the trial and error method. The output voltage maintains constant $V_0$=8volts across the load, irrespective of the load conditions in step-down mode.




**The proposed converter with PI controller in step-down mode with feedback**

**($V_g$, $V_{c1}$&$V_0$)**




**The proposed converter with PI controller in step-down mode with feedback ($V_g$, $i_{L2}$& $i_{L1}$)**

**Comparison between proposed converter without and with feedback**

| | **Transformer less buck-boost converter without feedback** | **Transformer less buck-boost converter with feedback** |
|---|---|---|
| No. of switches | 2 | 2 |
| No. of diodes | 2 | 2 |
| No. of inductors | 2 | 2 |
| No. of capacitors | 2 | 2 |
| Output voltage (buck mode) | 6.89 | 8 |
| Output voltage (boost mode) | 38.27 | 40.5 |

**Comparison of voltages**

## IV.CONCLUSION

The proposed converter is a fourth order circuit. This realizes the optimization between the converter structure and its more voltage gain to overcome the drawback of the normal buck boost converter. The steady-state analyses, operating principles and small signal modeling are explained in this work. By using this proposed buck-boost converter without using the extreme duty cycle, high or low output voltage gain is obtained.A PI controller is used in the feedback of the proposed system, it improved the stability of the system. By using the PI controller in the feedback, the output voltage maintains constant irrespective of load conditions. The matlab/simulation results are proved that the proposed new transformerless buck-boost converter exhibits the merits such as high step-up/step-down voltage gain, simple construction, output voltage is positive and simple control strategy. The proposed converter is mainly suitable for industrial Application

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