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Modeling Analysis and Closed Loop Control of Dc to Dc Boost Converter

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Abstract- **Conventional power generation has some limitations such as very costly production cost, heavy transmission & distribution loss, limited reach, big threat for environment & public health global warming, greenhouse effect, acid rain Etc. To overcome these limitations we can use renewable energy sources like wind, tides, solar, geothermal heat, and biomass. In this paper I am using solar energy source. Solar energy source generate small amount of DC power, to step up this small amount of DC power I am using PE converters Like DC/DC step-up boost converter. This paper presents a Modeling Analysis and Control of a DC/DC Boost Converter. Power for the boost converter can come from any suitable DC sources such as batteries, solar panels, rectifiers and DC generators. A boost converter is a DC to DC converter with an output voltage greater than the source voltage. This system has a nonlinear dynamic behavior, as it work in switch-mode. In this paper I analyze the equations of a boost converter and propose a design components, simulation and modeling of DC/DC boost converter.**

Index Terms—Boost Converter, PID controller, Astable Multivibrator.

I. INTRODUCTION

In numerous mechanical applications, it is required to change over a settled voltage DC source into a variable voltage DC source. A DC-DC converter changes over specifically from dc to DC and essentially known as a DC converter. A DC converter can be considered as DC likeness an AC transformer with a constantly factor turn proportion. Like a transformer, it can be utilized to advance down or venture up a DC voltage source. The DC/DC converters are broadly utilized as a part of managed switch mode DC control supplies. The contribution of these converters is an unregulated DC voltage, which is acquired by reasonable DC sources, for example, batteries, sun powered boards, rectifiers and DC generators. In these converters the normal DC output voltage must be controlled to be likened to the coveted esteem despite the fact that the input voltage is evolving. From the vitality perspective, output voltage direction in the DC/DC converter is accomplished by always modifying the measure of vitality ingested from the source and that infused into the heap, which is thus controlled by the relative spans of the assimilation and infusion interims. The DC/DC support converter just needs four outside segments Inductor, Electronic switch, and Diode and output capacitor. The converter can work in the two unique modes relying upon its vitality stockpiling limit and the relative length of the exchanging time frame. These two working modes are known as the discontinuous conduction mode (DCM) and continuous conduction mode (CCM).

II. OUTSIDE COMPONENTS DC/DC BOOST CONVERTER

A. Inductor

This present level demonstrates where the inductance can be relied upon to drop altogether if the DC inclination current is expanded further. This applies for the most part to ferrite centers in lieu of powdered iron. Powdered iron centers show "delicate" immersion qualities. This implies their inductance drop from higher DC levels is substantially more continuous than ferrite centers. The rate at which the inductance will drop is likewise a component of the center shape. (Also see Saturation Current).

The impedance of an inductor is the aggregate protection from the stream of current, including the AC and DC part. The DC part of the impedance is basically the DC protection of the winding. The AC segment of the impedance incorporates the inductor reactance.

$Z = XL = 2\pi fL$

B. Boost Regulator (DC-DC)

An essential dc-to-dc exchanging converter topology that takes an unregulated input voltage, and produces a higher, directed output voltage. This higher output voltage is accomplished by putting away vitality in an inputrmation inductor and afterward exchanging the vitality to the output by turning a shunt switch (transistor) on and off.

C. DIODES

The timeframe amid which the overabundance transporters are separated from the region of the intersection is known as the capacity time. The recuperation interim ends up plainly finished when the dispersion capacitance is revived and the intersection hindrance capacitance is charged. A diode has switch properties if its invert recuperation time is significantly less than the beat time frame. On the off chance that we need to expand speed of operation, we should diminish the recuperation time.

D. CAPACITOR

Artistic capacitors are for the most part prevalent than different sorts and subsequently can be utilized as a part of a tremendous scopes of utilization. DC blocking capacitor: In this application the capacitor obstructs the section of DC current (after totally charged) but then enables the AC to go at certain part of a circuit.

E. IGBT FUNDAMENTALS

The Insulated Gate Bipolar Transistor (IGBT) is a minority-bearer gadget with high input impedance and vast bipolar current-conveying capacity. Numerous fashioners see IGBT as a gadget with MOS input attributes and bipolar output trademark that is a voltage-controlled bipolar gadget. To make utilization of the upsides of both Power MOSFET and BJT, the IGBT has been presented. It's a useful coordination of Power MOSFET and BJT gadgets in solid shape. It consolidates the best credits of both to accomplish ideal gadget qualities.

Low driving force and a straightforward drive circuit because of the inputrmation MOS door structure. It can be effortlessly controlled when contrasted with current controlled gadgets (thyristor, BJT) in high voltage and high current applications.

III. CONVERSION MODES

The DC/DC converter has two modes, a Continuous Conduction Mode, CCM for efficient power conversion and Discontinuous Conduction Mode DCM for low power or stand-by operation.

Fig.1. Circuit Schematic of Step-up DC/DC Converter

A. Continuous Conduction Mode

Mode 1 ($0<t\leq ton$)

Mod1 starts when IGBT's is exchanged on at t=0 and ends at t=ton. The identical circuit for the Modes1 is appeared in Fig. 2a. The inductor current iL(t) more prominent than zero and increase straightly. The inductor voltage is Vi.

Mode 2 ($ton<t\leq Ts$)

Mode2 starts when IGBT's is turned off at t=ton and ends at t=Ts. The comparable circuit for the Mode2 is appeared in Fig. 2b. The inductor current reduction until the IGBT's is turned on again amid the following cycle. The voltage over the inductor in this period is Vi-Vo. Since in relentless state time necessary of the inductor voltage more than one day and age must be zero.

$Vi*ton + (Vi - Vo)toff = 0$

Where

Vi : The input voltage,

Vo : The average output voltage,

ton : The switching on of the IGBT's,

toff : The switching off of the IGBT's.

Dividing both sides by Ts and rearranging items output

Where Ts : The switching period,

D : The duty cycle.

Fig.2. Equivalent Circuit for boost Converter in CCM (a) Mode 1 ($0<t\leq ton$) (b) Mode 2 ($ton<t \leq Ts$)

Thus, Vo is inversely proportional to (1-D). it obvious that the duty cycle, D cannot be equal to 1 otherwise there would be no energy transfer to the output. Assuming a lossless circuit, Pi=Po, then

$Ii * Vi = Io * Vo$ And

Where

Io: The average output current.

Ii: The average input current.

B. Discontinuous Conduction Mode

In the event that the present completing the inductor tumbles to zero preceding the following turn-on of the exchanging IGBT's, at that point the lift converter is said to work in the intermittent conduction mode.

Fig.3. Equivalent Circuit for boost Converter in DCM (a) Mode 1 ($0<t\leq ton$) (b) Mode 2 ($ton<t \leq (D+D1)Ts$ (c) Mode 3 $(D+D1)Ts < t \leq Ts$

If we equate the integral of the inductor voltage as over one time period to zero, so

$ViDTs + (Vi - Vo) D1Ts = 0$

Then

And

From Fig. 3c, the average input current, which is equal to the inductor current, is

And

By and by, since Vo is held steady and D shifts because of variety in Vi, it is more helpful to get the required obligation cycle (D), as a component of load current for changes estimations of Vo/Vi. The basic inductance, Lbc, is characterized as the inductance at the limit edge amongst ceaseless and intermittent modes and is characterized as:

Where

R: The equivalent load, Ω.

Fs: The switching frequency, Hz

The exchanging recurrence has been picked discretionarily to limit the extent of the lift inductor and breaking point the loss of the semiconductor gadget. At higher frequencies the exchanging misfortunes in the IGBT's expansion, and along these lines decrease the general proficiency of the circuit. At bring down frequencies the required yield capacitance and lift inductor measure increments, and the volumetric proficiency of the supply debases.

C. Choice of the Inductor

Extensive inductance esteems tend to build the start-up time marginally while little inductance esteems enable the curl current to increase to more elevated amounts previously the turn kills. Inductors with a ferrite center or proportional are suggested. It ought to be guaranteed that the inductor's immersion current rating for most noteworthy productivity is to be utilized a curl with low DC protection. Lift inductance is chosen in view of the most extreme permitted swell current at minimum duty cycle (D), at greatest input voltage (Vi). Given that the exchanging recurrence, Fs, the lift inductor esteem might be ideally resolved to set the converter working mode in the required load and line extend. The basic inductance is characterized as the inductance at the limit edge amongst constant and intermittent modes

Where,

Fs: The switching frequency, Hz

D: The duty cycle,

R: The equivalent load, Ω.

D. Choice of the Diode

The lift diode turn around voltage rating is restricted to the output voltage. The diode conducts when the power switch is in the "OFF" state and gives a present way to the inductor to the output. Like the IGBT's the worst– case top current through the diode happens at low line input voltage and most extreme load. Other imperative contemplations in choosing the diode other than its capacity to obstruct the required off– state voltage push and have adequate pinnacle and normal current dealing with ability, is quick exchanging qualities, low reverse–recuperation, and low forward voltage drop.

E. Choice of the capacitance required

The essential foundation for choosing the output channel capacitor is its capacitance and equal arrangement protection, ESR. Since the capacitor's ESR influences productivity, low-ESR capacitors will be utilized for best execution. For diminishing ESR is additionally conceivable to associate couple of capacitors in parallel. The output channel capacitors are met a output voltage swell. Particulars, and also its capacity to deal with the required swell current anxiety. An inexact articulation for the required capacitance as a component of swell voltage prerequisite, ΔVo, D, exchanging recurrence, Fs and output voltage,

F. Introduction to PID Control

This introduction will show you the characteristics of the each of proportional (P), the integral (I), and the derivative (D) controls, and how to use them to obtain a desired response.

The transfer function of the PID controller looks like the following:

Kp = Proportional gain

KI = Integral gain

Kd = Derivative gain

1. Get an open-circle reaction and figure out what should be moved forward
2. Add a corresponding control to enhance the ascent time
3. Add a subordinate control to enhance the overshoot
4. Modify each of Kp, Ki, and Kd until the point that you acquire a coveted general reaction. You can simply allude to the table appeared in this archive to discover which controller controls what qualities.

IV. CLOSED LOOP SIMULINK CIRCUIT OF DC TO DC BOOST CONVERTER

The closed loop simulink is shown in Fig.4.

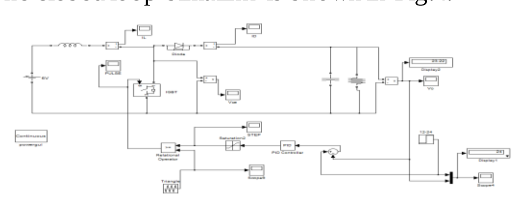

Fig.4.Closed loop Simulink diagram

A. Closed Loop Simulation Output Waveforms

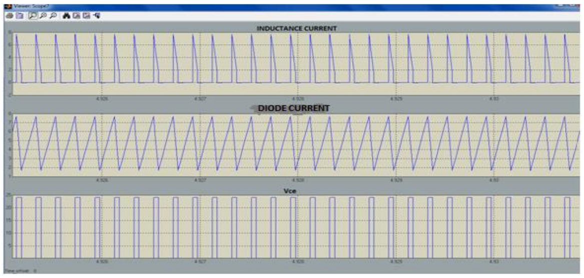

Fig.5. Simulated Response of Inductor Current, diode current and Collector-Emitter Voltage

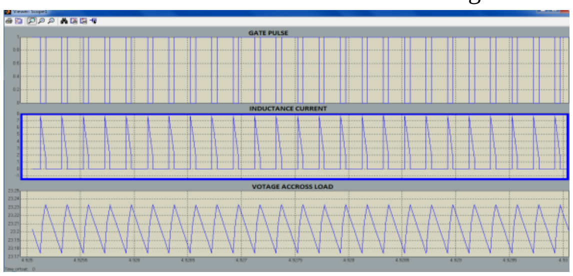

Fig.6. Simulated Response of gate pulse, Inductor Current and Collector-Emitter Voltage

Simulation input voltage is 6V and output voltage is 12V to 24V

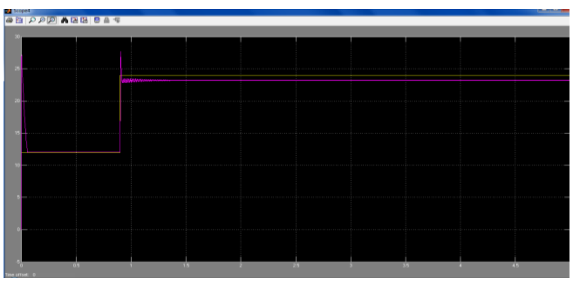

Fig.7. Simulated output voltage waveforms

Simulation input voltage is 100V and output voltage is 200V and step voltage is 400V

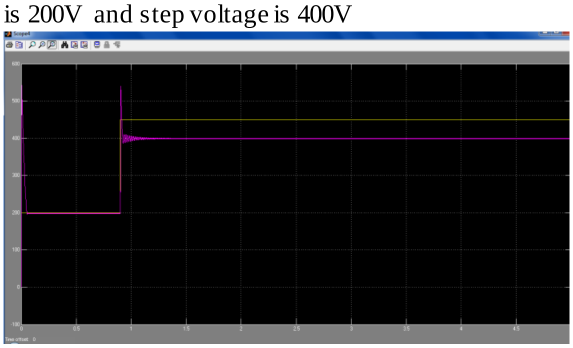

Fig.8. Simulated output voltage waveforms

V. OPEN LOOP DC TO DC BOOST CONVERTER KIT

The open loop DC to DC Boost converter kit design is shown in Fig.9 the open loop converter kit as two parts,

1. Pulse Generator Part,
2. Boost Converter Part.

Fig.9. Open Loop DC to DC Boost converter kit

A. Pulse Generator Part

Astable Multivibrator can create square like on off states. Astable Multivibrator is a two phase exchanging circuit in which the yield of the main stage is sustained to the contribution of the second stage and the other way around. The yields of both the stages are integral. This free running multivibrator produces square wave with no outside activating Pulse. The circuit has two states and switches forward and backward starting with one state then onto the next, staying in each state for a period relying on the releasing of a capacitor through a resistor.

A. Open Loop DC to DC Boost Converter Kit Results

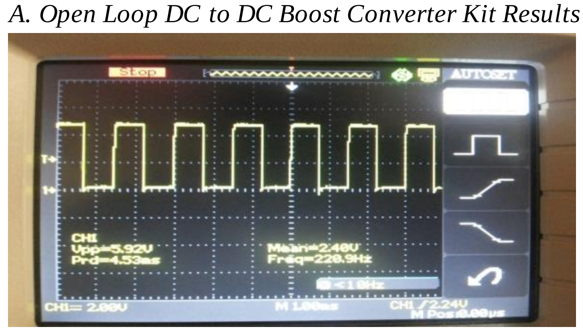

Fig.10. Kit Response of gate pulse when Ton=Toff

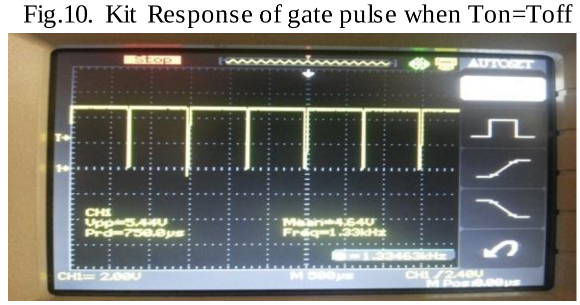

Fig.11. Kit Response of gate pulse when Ton>Toff

Fig.12 .Kit Response of gate pulse when Ton<Toff

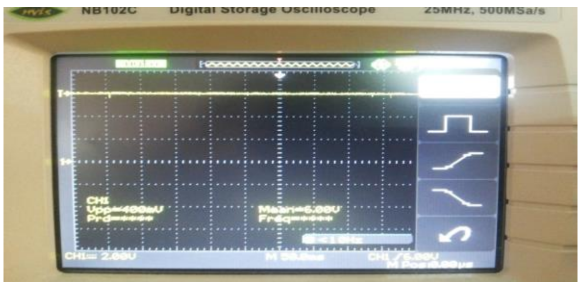

Fig.13. Kit Input Voltage 6V

Fig.14. Kit Output Voltage 17.4V when Input Voltage is 6V

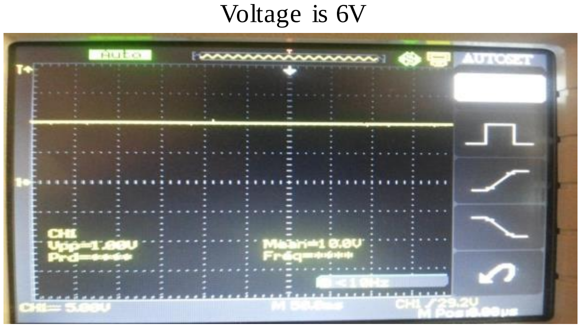

Fig.15. Kit Input Voltage 10V

Fig.16. Kit Output Voltage 28.8V when Input voltage is 10V

VI. CONCLUSION

Analysis of Boost Converter we will get equation for L, C and R. This system has a nonlinear dynamic behavior, as it work in switch-mode. Using PID control output voltage of a DC/DC Boost Converter can control. Design of DC/DC boost converter using Astable Multivibrator for pulse generator. In this paper analyze the equations of a boost converter and propose a design components, simulation and modeling of DC/DC boost converter.

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