

PV Sustained Cascaded Boost Converter with PID Controller

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Abstract—This paper exhibits Cascaded boost converter (CBC) sustained by solar panel with PID controller. Solar energy is a perpetuating sustainable power source which has been used and looked into most lately because of inconsistency of petroleum products. The best converter is CBC with single switch in view of high voltage increase, simple enactment and better execution. PID controller is utilized to upgrade the dynamic performance and to keep up the steady yield voltage for intended converter. A 30V PV input is changed over into an output voltage of 110V with 250W has been implemented in simulation. It is carried out by employing MATLAB/Simulink instrument.

Keywords—Cascaded boost converter, Photovoltaic, PID controller, dynamic reaction.

I. INTRODUCTION

As expanding use of sun based energy, Photo-voltaic framework ending up exceptionally well known. It offers clean energy, Eco-accommodating, and upkeep free. To make best utilization of the sun powered PV frameworks the yield is amplified either by mechanically following the sun or most extreme power point tracking under changing state of insolation and temperature. Sun oriented energy can be changed over into power utilizing sun based cell which is manufactured in PV module. Solar cells can be associated in series and parallel to get the required stack voltage and current. Since Solar boards have a nonlinear Voltage-current trademark, which relies upon the ecological elements like temperature and light [1-2].

A survey of converter requisition appeared in [3]. Distinctive topologies of DC to DC converters are exhibited, for example, Boost, Buck, Buck-Boost, Cuk, Zeta, Sepic, Flyback, Forward, Cascaded boost converter. A best advance up DC to DC converter is cascaded boost converter which is called as two phase boost converter [4]. This converter takes part in sustainable energy source conversion system, telecommunication, ventures, and transmission framework. Since it is a high pick up and high power converter, used in numerous applications. A super lift strategy enables the outline of CBC to get high voltage gain. This super lift calculation figures complex condition and gives more prominent precision and stage by stage voltage transfer gain in geometric approach [5].

PID remains for proportional– integral– derivative controller which is known as feedback criticism instrument. As the name recommends, PID calculation comprises of three fundamental coefficients: proportional, integral and derivative which are fluctuated to get ideal reaction. The whole thought of PID controller spins around controlling the error. The error is the contrast between the process variable and the set point. PID controller has all the vital elements: quick response on change of the controller input in D mode, increment in control flag to lead mistake towards zero in I mode and appropriate activity inside control error territory to dispense with motions in P mode. Derivative mode enhances security of the framework and empowers increment in gain K and abatement in indispensable time consistent T_i , which expands speed of the controller reaction. PID controllers are the regularly utilized controllers in the process industries [6-7].

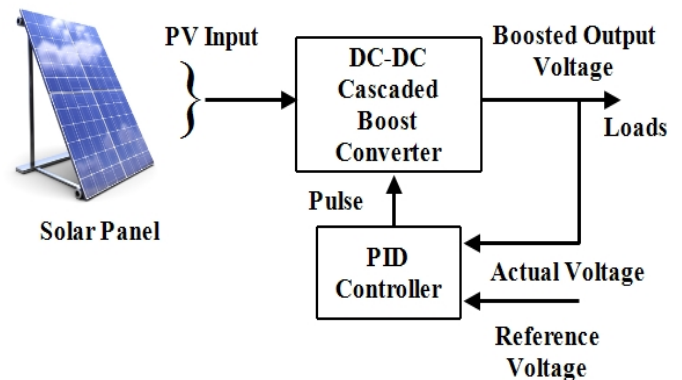


Fig. 1 Schematic block diagram of PV fed CBC utilizing PID control.

DC-DC CBC changes over lower PV input voltage into Boosted DC output voltage which is given to appropriate loads such as battery worked instruments, lighting applications, dc micro grid. Here yield voltage is given as feedback into converter. Controller analyzes the reference and actual signal to deliver the pulse to activate the power semiconductor switching circuitry of CBC. It sets or change the duty cycle to get required yield voltage which can be accomplished by utilizing this setup.

This paper is orchestrated as takes after: Segment II shows about photovoltaic. Segment III displays demonstrating of

CBC. Segment IV indicates PID tuning for intended converter. Segment V approaches simulation and results and Segment VI manages conclusion.

II. PHOTOVOLTAIC

PV is a technique to create power by utilizing solar cells to change over energy from the sun into a stream of electrons by the photovoltaic impact. This PV cell delivers just lower direct current electricity which can be changed over into required higher DC output voltage by utilizing CBC.

Solar cells are described and contrasted from each other with four parameters, namely open circuit voltage (V_{oc}), short circuit current (I_{sc}), Efficiency(η) and fill factor (FF). For 250 watts solar panel determination is given in table I as follows,

TABLE I

A 250W PV PANEL SPECIFICATION

PARAMETERS	VALUES
Open circuit voltage (V_{oc})	37.6 V
Short circuit current (I_{sc})	8.81 A
Maximum voltage (V_{max})	30.5 V
Maximum current (I_{max})	8.27 A
Number of cells (Ncell)	60
Frame	Aluminum frame
Material	Polycrystalline

III. CASCADED BOOST CONVERTER

Essentially including L_2 , C_2 , D_2 and D_3 into boost converter termed as Cascaded boost converter. Fig. 2 demonstrates the circuit diagram of CBC. Single MOSFET switch (S) is handle the circuit with high switching frequency [8-9]. Schottky diodes are deployed because of high switching pace and high frequency capacity.

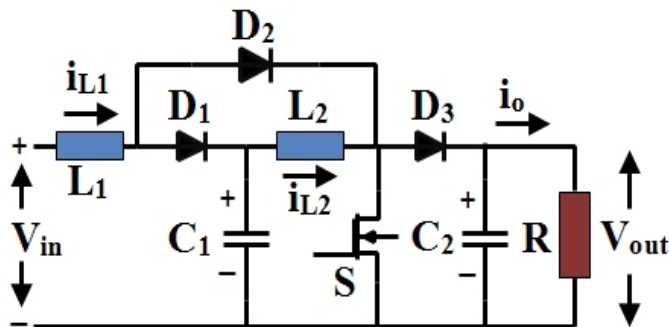


Fig. 2 Basic circuit diagram of CBC

This circuit composed of switch (S), two capacitor (C_1 , C_2), two inductor (L_1 , L_2), three diode (D_1 , D_2 , and D_3), and resistor (R). This converter works under two strategies for operation. Ensuring that CBC working under nonstop conduction mode with a particular ultimate objective to diminish the current varieties ξ through the inductor. It ought to be lower than unity.

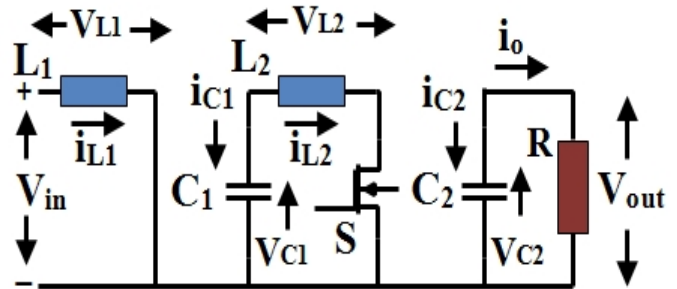


Fig. 3. Mode 1 operation of CBC

The appropriate circuit of CBC when MOSFET (S) is on in the period of DT is appeared in Fig. 3. At the course switch on condition, input voltage V_{in} occurring across inductor L_1 and capacitor C_1 voltage is accessible across inductor L_2 . Subsequently, current through inductor L_2 increases with voltage crosswise over capacitor C_1 . Voltage presented across capacitor C_1 is,

$$V_{C1} = \frac{V_{in}}{(1-D)} \tag{1}$$

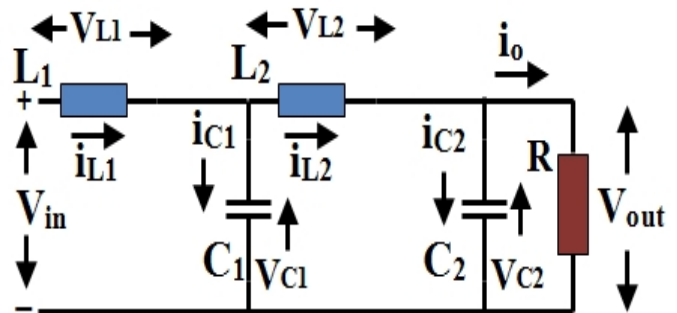


Fig. 4 Mode 2 operation of CBC

Comparable circuit of CBC when MOSFET (S) is off in the period of $(1-D)T$. At the course of Switch off condition inductor L_2 current decrements with voltage $(V_{C1}-V_{out})$. At that point voltage across capacitor C_2 present across V_{out} . Along these lines voltage across resistor V_{out} is

$$V_{out} = \frac{V_{in}}{(1-D)^2} \tag{2}$$

Typical state space conditions are combined equations of each state (turn ON and OFF state) of switching of converter. These conditions are utilizing Duty cycle degree (D). State space averaging representation for CBC is given underneath,

$$\dot{X} = Ax + BU \tag{3}$$

$$\begin{bmatrix} \dot{i}_{L_1} \\ \dot{i}_{L_2} \\ \dot{V}_{C_1} \\ \dot{V}_{C_2} \end{bmatrix} = \begin{bmatrix} 0 & 0 & -\frac{(1-D)}{L_1} & 0 \\ 0 & 0 & \frac{1}{L_2} & -\frac{(1-D)}{L_2} \\ \frac{(1-D)}{C_1} & -\frac{1}{C_1} & 0 & 0 \\ 0 & \frac{(1-D)}{C_2} & 0 & -\frac{1}{C_2 R} \end{bmatrix} \begin{bmatrix} i_{L_1} \\ i_{L_2} \\ V_{C_1} \\ V_{C_2} \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} [V_{in}] \quad (4)$$

$$\dot{Y} = Cx + DU \quad (5)$$

Where $C = [0$

While plotting ofCBC it is fundamental to consider per unit inductor ripple current and per unit capacitor ripple voltage. Plan equations for discovering inactive components esteems are appeared in underneath,

$$L_1 = \frac{D(1-D)^4 R i_{L_1}}{\Delta i_{L_1} f} \quad (6)$$

$$L_2 = \frac{D(1-D)^2 R i_{L_2}}{\Delta i_{L_2} f} \quad (7)$$

$$C_1 = \frac{D V_{C_1}}{(1-D)^2 R \Delta V_{C_1} f} \quad (8)$$

$$C_2 = \frac{D V_{C_2}}{R \Delta V_{C_2} f} \quad (9)$$

TABLE II

CALCULATED DESIGN VALUES FOR CBC

PARAMETERS	VALUES
Inductor 1	0.1227 mH
Inductor 2	0.5627 mH
Capacitor 1	33.643 μF
Capacitor 2	250 μF
Resistor	50 Ω
Duty Cycle	53.29 %
Frequency	50000 Hz

The above table II of substance helps to draw CBC in MATLAB/Simulink. Open loop and closed loop Simulink model of this converter has been executed utilizing figured parameters regards.

IV. PID CONTROLLER

The proportional rectifies instances of error, the integral revises aggregation of error, and the derivative part revises exhibit error versus error in the last time. Subsequently it is having joined merits of interest of P, I, and D controller. The impact of the derivative part is to check the overshoot caused by P and I. At the point when the error is vast, the P and the I will push the controller yield. This controller reaction rolls out

error improvement rapidly, which thus causes the derivative to all the more forcefully balance the P and the I.

Tuning a control hoop is the modification of its control parameters to ideal esteems for an objective reaction. Steps including in PID tuning for converter is givenbeneath,

- Modeling
- Calculating PID consistent Values (K_p, K_i, K_d)
- Simulation

Too High K_p will prompt wavering in values and will have a tendency to produce a balance K_i will neutralize the counter balance. Higher Value of K_i infers that the Set point will come to the Process variable too quick. If this activity is quick, the procedure variable is inclined to be shaky. K_D monitors this.

PWM is a modulation method which is defined as the normal estimation of voltage and current sustained to the load is controlled by turning the switch between supply and load on and off at a quick rate. Simply PWM technique gives pulse to set the duty cycle ratio which is characterized as the proportion ofswitching on time to total switching period.Simple PID control of CBC is shown in fig. 5. The PWM generation for converter is displayed in Fig. 6.

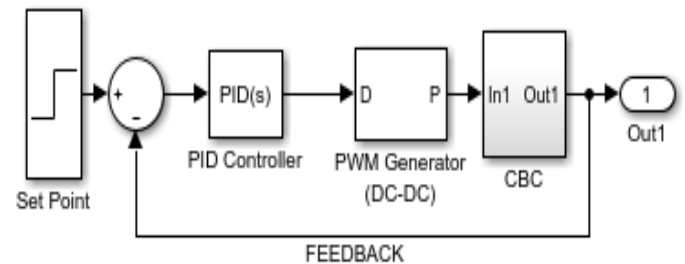


Fig. 5 Simple PID control of CBC

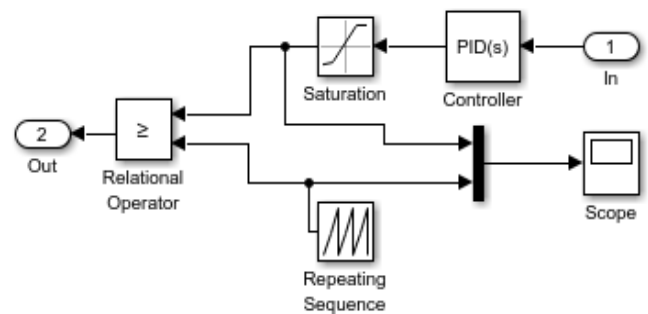


Fig. 6 PWM generation representation

Ziegler-Nichols Rules used to set values of relative proportional gain K_p , integral time T_i and derivative time T_d . This will give stable operation of a plant and impact the dynamic performance [10]. These constant esteems are figured by the equation of Ziegler and Nichols rules which is available in many journals and books. It is able outline P, PI, and PID controller utilizing this method.

The general transfer function for Continuous time PID controller is,

$$G_c(s) = K_p \left(1 + \frac{1}{T_i s} + T_d s \right) \quad (10)$$

$$G_c(s) = \frac{-1.279e06}{s^4 + 2809s^3 + 1.056e08s^2 + 1.484e11s - 2.789e05} \quad (11)$$

The above equation is a continuous transfer function for CBC that has been found using MATLAB/Command window environment. The gain values for PID controller are $K_p=0.1$; $K_i=327.09$; $K_d=7.643e-6$; and for PI controller are $K_p=0.1$, $K_i=7.33e-5$;

V. SIMULATION AND RESULTS

To comprehend the fundamental reaction of any framework, open loop simulation is required. Fig. 7 demonstrates open loop outline of cascaded boost converter which is sustained from 250W PV board. Since it is a high gain converter, it brings out 110V. Yield current is 1.603A. Output voltage of Open loop CBC is exhibited in fig. 8.

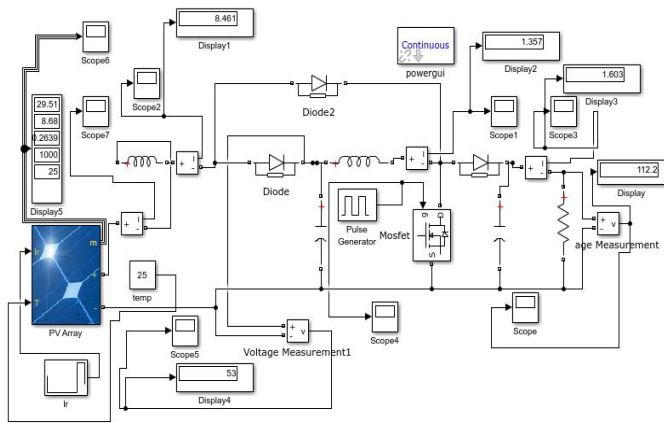


Fig. 7 Simulink model of open loop control of PV fed CBC

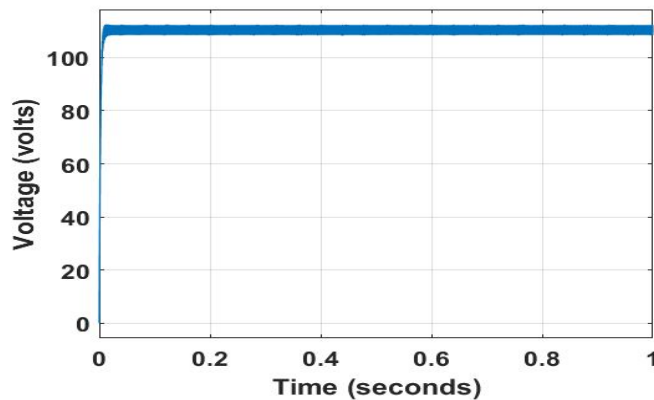


Fig. 8 Output Voltage waveform of Open loop CBC

The below Fig. 9 shows output voltage of open loop control of CBC with ideal DC voltage source. This waveform contains peak overshoot which will not present in system when controller is employed.

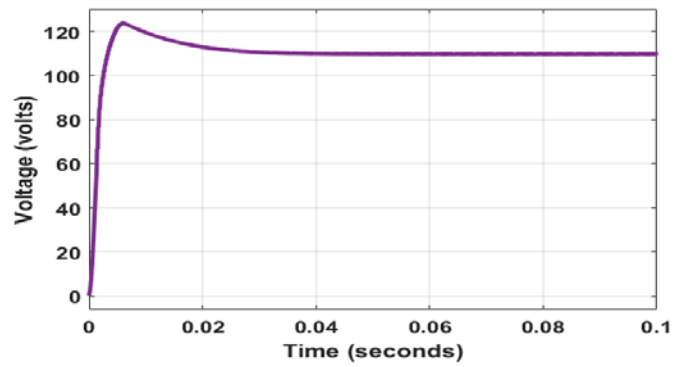


Fig. 9 Output voltage for open loop CBC with ideal DC source

The required duty cycle value has been taken by using PWM generation technique. The below Fig. 10 displays the pulse which is used to turn on the power semiconductor of CBC.

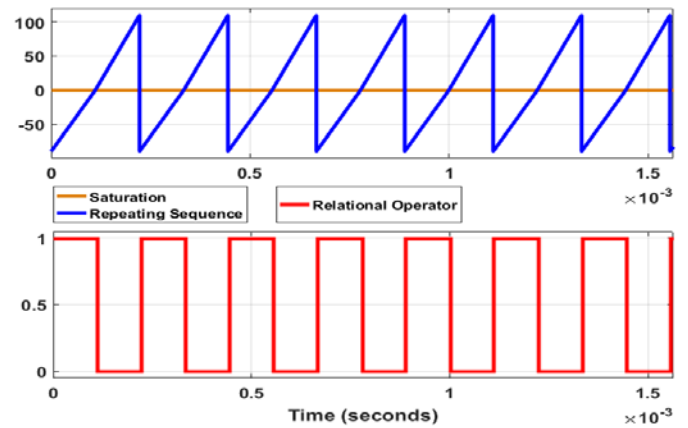


Fig. 10 Pulse width modulation signal of CBC

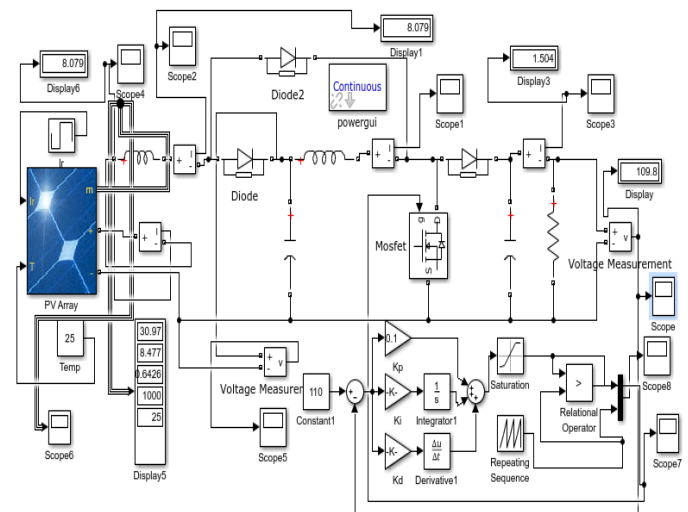


Fig. 11 Simulink model of PV fed CBC with PID controller

Appropriate values have been given to elements of this circuit. PID controller affected the dynamic performance and provided desired output voltage and good shaped output waveform.

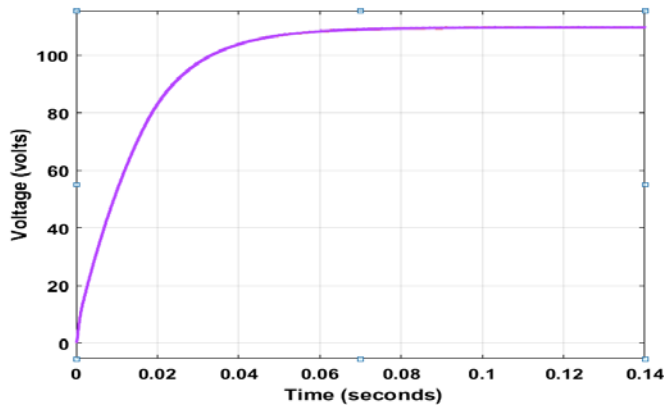


Fig. 12 Output voltage for CBC with PID controller

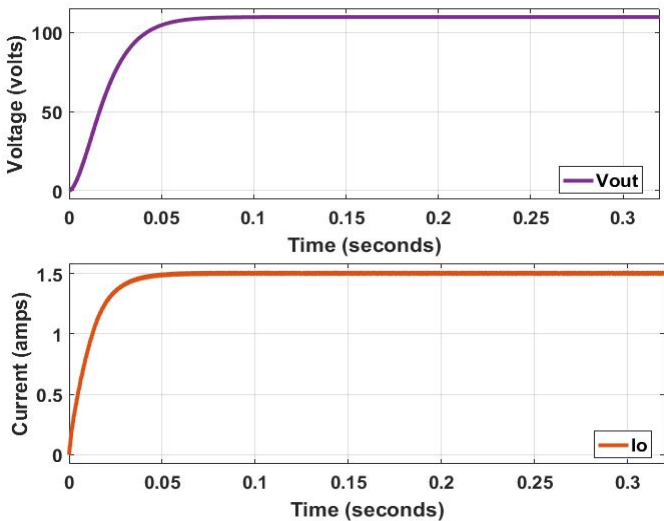


Fig. 13 Output Current and Voltage for CBC with PID controller

In closed loop control (PID) of CBC, obtained output voltage is 110.2V and output current is 1.502A.

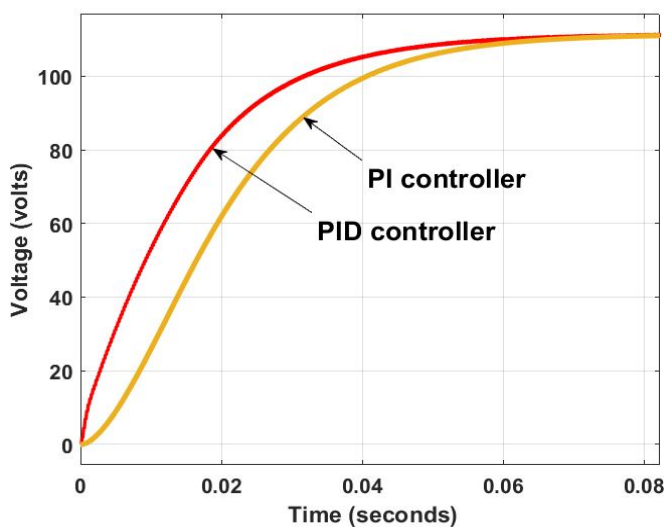


Fig. 14 Comparison of output voltages for PID and PI controller for CBC

For proper understanding of time domain response of converter, it is necessary to compare different controllers. PI and PID controller for CBC have been compared and its execution parameters esteems have been given in Table III.

TABLE III

PERFORMANCE SPECIFICATIONS FOR CBC

Controller	Rise Time (ms)	Delay Time (ms)	Peak Time (ms)	Settling Time (ms)
PID	30	13	70	80
PI	40	19	80	90

VI. CONCLUSION

In this paper, modeling and PID controller design of cascaded boost converter has been implemented with PV panel input. PID controller has provided great dynamic response characteristics for CBC. The comparison of simulation results of CBC with various sort of approach has shown advantages of PID controller. Finally the desired output voltage 110 volts has been accomplished from PV's 30 volts through PID controller.

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