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Controlling of Boost Converter by Proportional Integral Controller

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Abstract

Currently, most devices are working on dc voltage. However, sometimes it should increase the voltage to make the output larger than the input voltage. In this research, the control design for one type of converters is presented. Thus, the proposed proportional and integral (PI) controller will control the boost DC-DC converter in order to regulate the output voltage and track the reference value. The equations of the boost converter are derived and simulated later on. In addition, the overall system is simulated using Matlab/Simulink and the results are recorded for different values of parameters of the PI controller.

Disciplinary: Electrical Engineering & Technology.

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1 Introduction

The main goal of a DC-DC converter is to supply a controlled DC yield voltage to the load from a fixed DC input voltage. By regulating a line voltage that is changing in quantity in numerous cases the DC input voltage is obtained. In many scenarios that demand adjusted DC power usually utilized DC-DC converters, for example, computers, medical devices, communication devices, TV receivers, and chargers of battery (Meena, 2014). Thus a produce voltage higher than the input voltage which can get from Boost converters and is increasingly employed as front-end converters for battery sources. always in this type of device, the input voltage is smaller than the output potential. On other hand, the proportional-integral-derivative is a rigid controller which is used in so many applications to reach good and acceptable performance for the system. However, because of the problems of noise in the derivative parameter of the proportional-integral-derivative (PID) controller, so proportional-integral (PI) controller will overcome this problem. A PI behaves as a regulator to gives more methodology to deal with devices and is demanded as a decent option to process switching power converters. The principle preferred position of the PI control scheme is its capacity to wipe out the impacts of the converter's parameter setting that prompts dynamics and static response for any surprise change which sometimes accrue as in load (Kumar and Seenithangam, 2010) as well the simplicity in design and good performance. Sharma et al. (2013) proposed a close loop for boost converter by using a proportional- integral- derivative controller. This system is used to settle the voltage even if there is a change in the load. In (Kadhim, 2019) the PI controller is linked like feedback for the boost converter to ensure that the voltage is kept constant.

The main objective of this paper is to use the proportional-integral controller as a controller of feedback loop controlling mechanism, in order to control the suggested DC-DC converter, accordingly that it has been used for a very long in ventures for many control applications. However, in systems that have higher-order control, it is hard to design a PI controller (Shah and Agashe, 2013) with different controllers.

2 Boost Converter

A boost converter is part of a group of DC-DC converters called switch-mode converters. The circuits having a place with this class are fly-back, buck, push-pull, and buck-boost converters are fundamentally the same. The yield voltage is arranged by modifying the ratio of on/off time. As this subset doesn't utilize resistive components to dissipate extra power, the efficiencies are seen in the 80-95% range (Kripakaran and Gopikrishna, 2016; Almawlawe and Kovandzic, 2018). Figure 1 shows the circuit of the boost converter and the analysis of this circuit will be as follows.

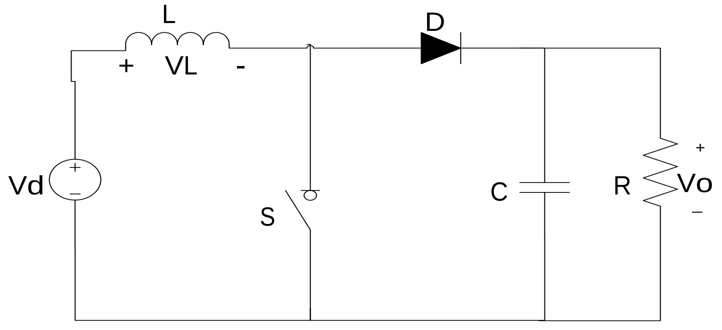

Figure 1: Boost converter (Rashid, 2017).

Where V_d is the input voltage (V), L is the inductance (mH), V_L is the inductance voltage (V) , S , C is the capacitor (μF), R is the resistive load (Ω), and V_0 is the output voltage (V).

2.1 Case 1

When the switch is closed as shown in Figure 2, the diode will be in reversed bias because the capacitor voltage and the input supplies the inductor only.

$$V_L = V_d \quad (1),$$

$$V_L = L\, di/dt \quad (2),$$

$$di/dt = V_d/L \quad (3),$$

$$di/dt = \Delta i/\Delta t = \Delta i/\Delta T \quad (4),$$

$$(\Delta i)_{closed} = V_d D_u T/L \quad (5),$$

where D_u is the duty cycle.

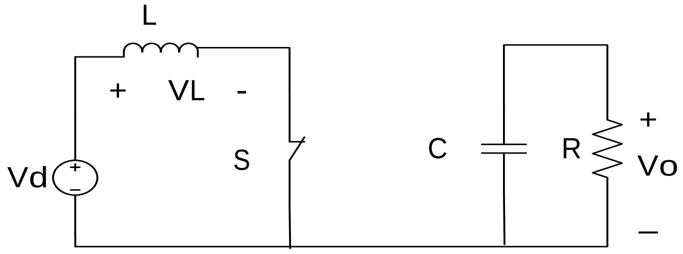

Figure 2: Boost converter when the switch is closed

2.2 Case 2

At this point when the switch is opened as shown in Figure 3. The diode will be at forward biasing and the capacitor will receive the energy from the supply and inductor, so the capacitor voltage will be increase to double.

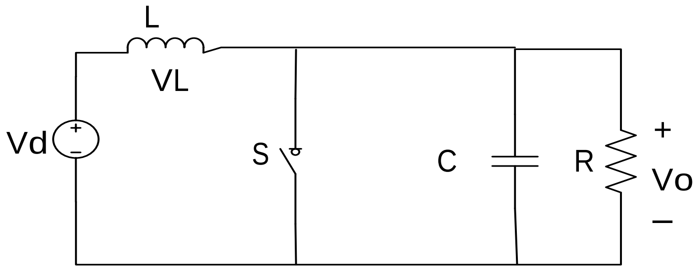

Figure 3: Boost converter when the switch is opened.

$$V_L = V_d - V_0 \quad (6),$$

$$L\, di/dt = di/dt = V_d - V_0/L \quad (7),$$

$$di/dt = \Delta i/\Delta t \quad (8),$$

$$di/dt = \Delta i/(1 - Du)T \quad (9),$$

$$(\Delta i)_{opened} = (V_d - V_0)(1 - D_u)T/L \quad (10).$$

At steady-state operation

$$(\Delta i)_{closed} + (\Delta i)_{opened} = 0 \quad (11),$$

$$V_0 = V_d/(1 - Du) \quad (12).$$

From Equation (12), we have observed the yield voltage is greater or equal to the input voltage in the boost converter.

3 Proportional Integral Controller

The PI regulator is intended to get the required working point for the boost converter, and thus adjusting the output of the converter, with the goal that it is extremely nearer to the working point in the state of the surprising disturbances of load and set point variation. In the PI control sketch, proportional gain (K_p) and integral time (T_i) are designed (Subramanian and Kayalvizhi, 2015) as in equation (15). Figure 4 shown the basic block diagram of the PI controller.

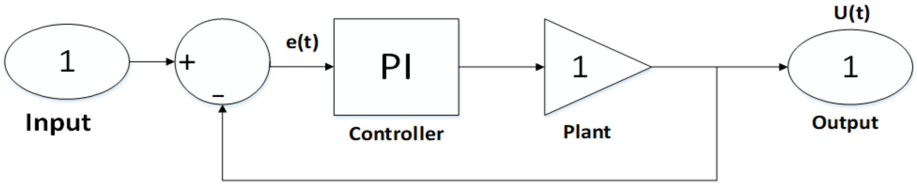

Figure 4: Basic block diagram of PI Controller (Bhowate and Shraddha, 2015)

$$U(t) = K_p.e(t) + K_i.\int_0^t e(t)\,dt \qquad (13),$$

where

e(t) = Error (different between desired and actual value of output)

K_p = Proportional parameter is used to decrease the rise time

K_i = Integral parameter is used to eliminate the overshoot and settling time.

The weighted sum of these two sections is utilized to modify the process via a control element. By "tuning" two constants in the PI regulator, the PI can give control action designed for certain requirements [7].

4 Simulation and Discussion

The simulations have been performed for the circuit of boost converter and parameters recorded in Table 1. The behaviour of the PI regulator for the boost converter is evaluated in MAT LAB/Simulink.

Table 1: Circuit parameters

Parameter's name	Symbol	Value
Voltage input	Vin	12 V
Voltage output	Vo	24 V
inductor	L	16.66 mH
Capacitor	C	5μF
Nominal switching frequency	Fs	100 kHz
Resistance load	R	100 Ω

The simulation model achieved by Matlab/Simulink appears in Figure 5 (Pachauri and Yogesh, 2016). The contrast between the output voltage and reference voltage gets to the PI regulator and yield of the PI controller, and thus the duty cycle of the power switch (n- channel MOSFET) is changed.

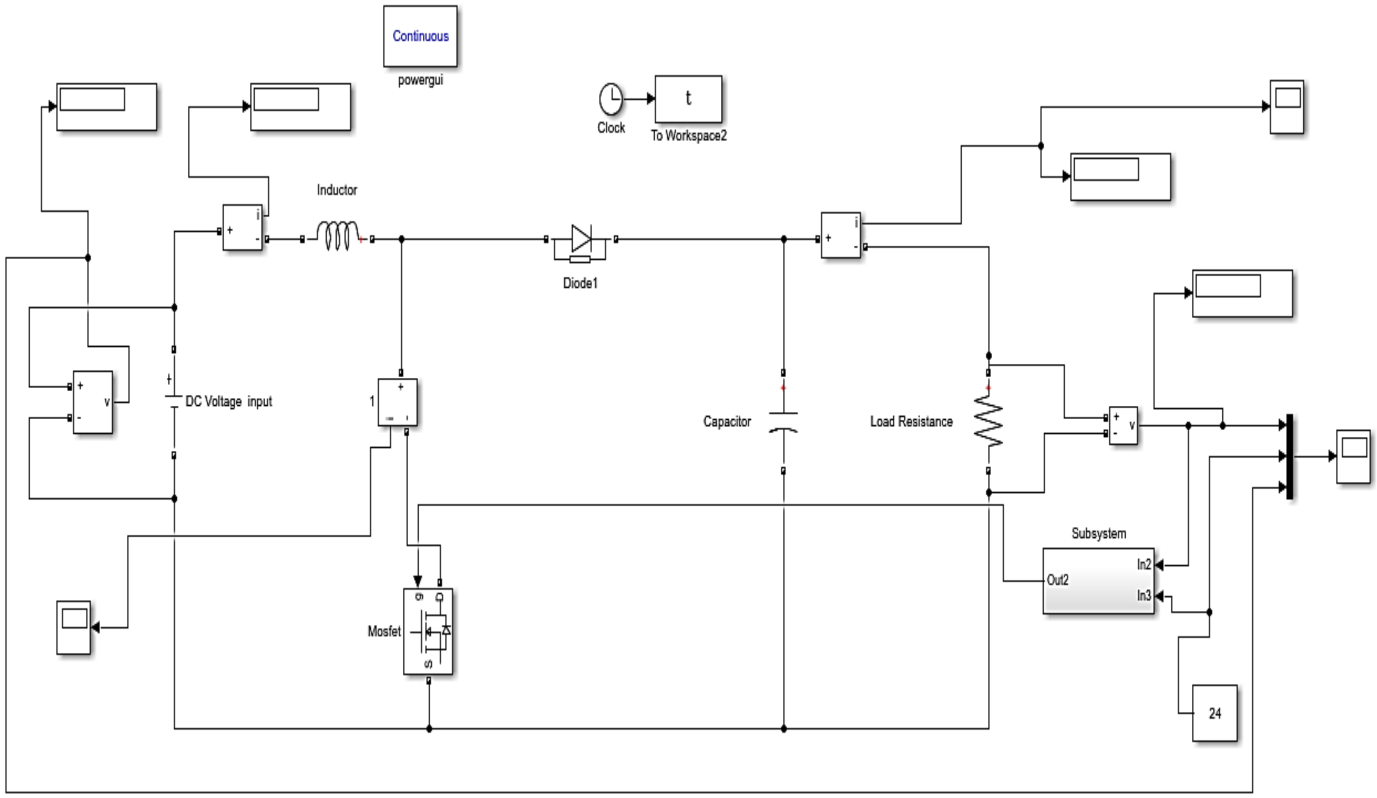

Figure 5: Simulation of the boost converter.

To adjust the duty cycle of the MOSFET switch by PI controller as shown in Figure 6 (Tehrani, 2010).

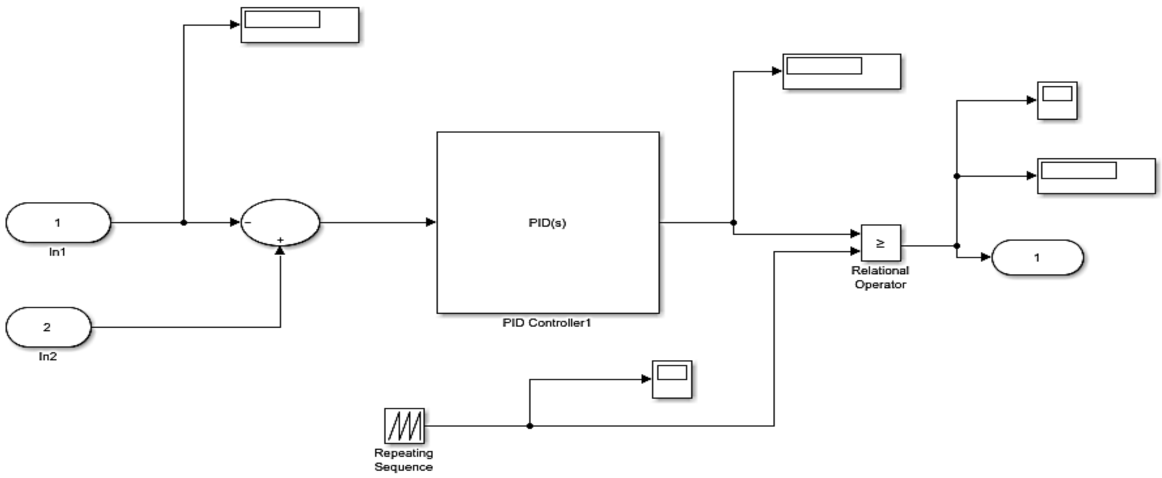

Figure 6: Simulation of subsystem controller.

By changing the value of the PI controller to note the effect on the boost converter output voltage response, Figures 7-11 for PI = 20, 5, 0.09, 0.01, 0.012 respectively.

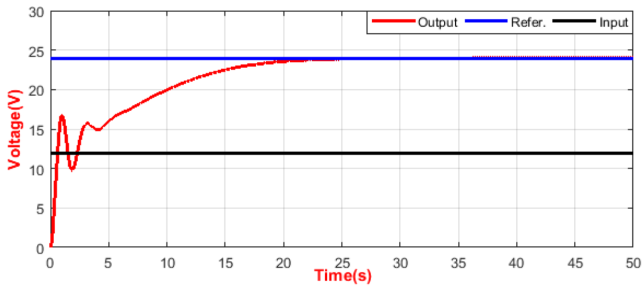

Figure 7: The proportional value of PI = 20.

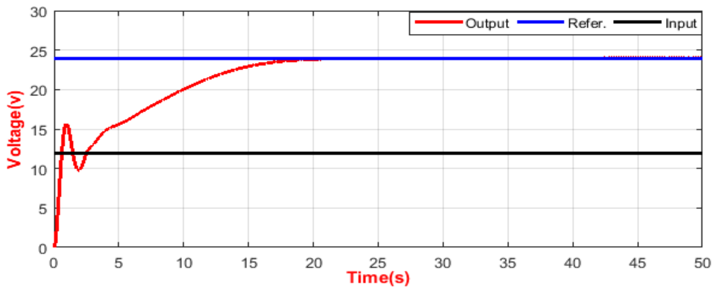

Figure 8: The proportional value of PI = 5.

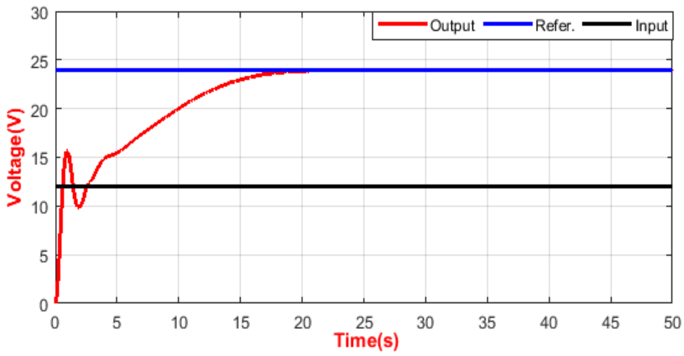

Figure 9: The proportional value of PI = 0.09.

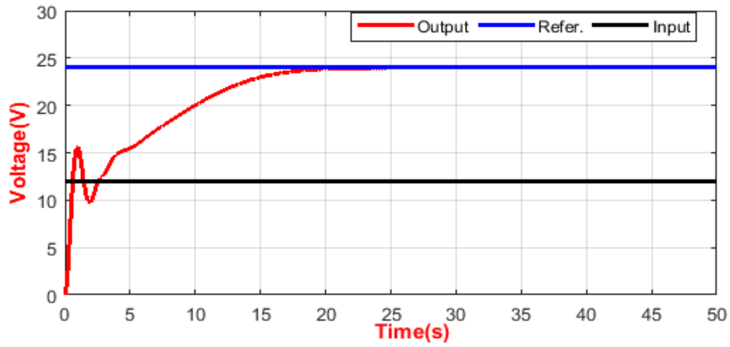

Figure 10: The proportional value of PI = 0.01

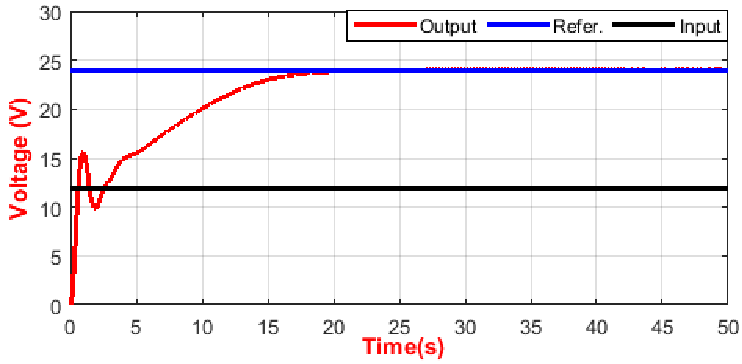

Figure 11: The proportional value of PI = 0.012

We have observed from change the value of P controller just at Figure 11 and thus when P =0.012 the response of output voltage is advanced. When changing the value of I of the controller.

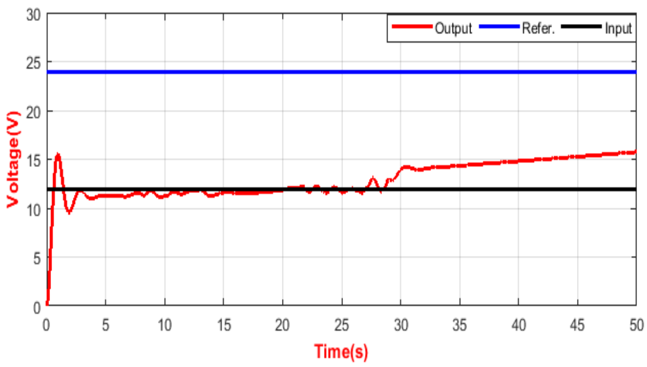

Figure 12: The value of $K_i = 5$

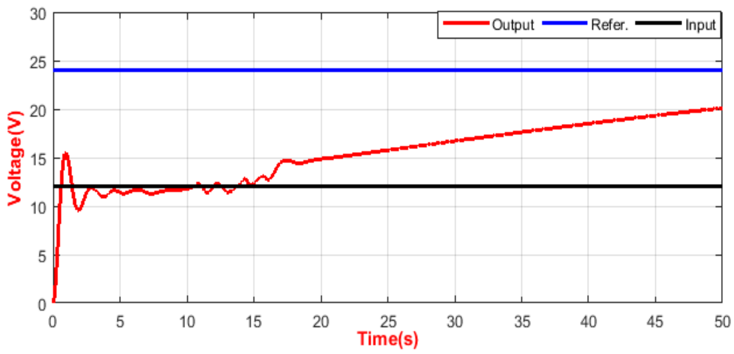

Figure 13: The value of $K_i = 10$

Figures 12-16 give result integral parameter (K_i) = 5, 10, 25, 50, and 75, respectively.

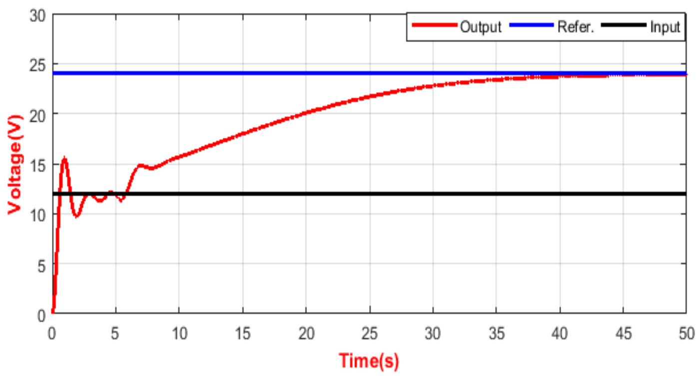

Figure 14: The value of $K_i = 25$

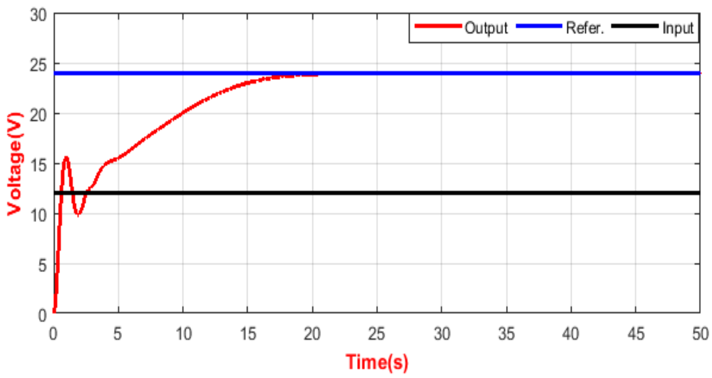

Figure 15: The value of $K_i = 50$

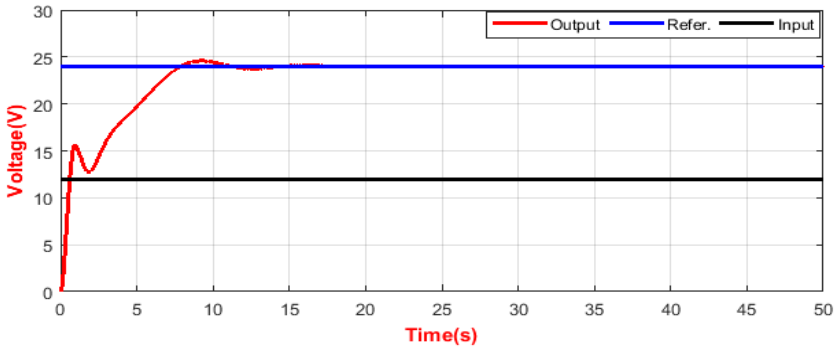

Figure 16:The value of $K_i = 75$.

Behaviour of the various output voltage of the boost converter is given in Figures 7-16. It is observed that change values of P and I give the best performance in terms of less peak overshoot, less settling time, and less rise time. Moreover, it is easy to implement with MATLAB/Simulink.

5 Conclusion

Results of the simulation show that the proposed PI controller regulates satisfactorily the output voltage of the boost converter irrespective of load disturbances. Performance evaluations of simulated controllers are carried out here from which it is discovered that PI regulator performs successfully for the chosen converter when settling time is the performance measure whereas PI controller makes less over-shoot. Different control methods can be proposed as future work and it can compare these methods to prove the ability of the suggested technique.

6 Data Availability Statement

The data for this study can be available upon a request made to the corresponding author.

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