Digital Controller Design and Implementation on a Buck- Boost Converter for Photovoltaic Systems

Jasim Alfandy, Advisor: Prof. Linfeng Zhang
Department of Electrical Engineering
University of Bridgeport, Bridgeport, CT

Abstract

Photovoltaic systems are widely used to convert solar energy to electricity. The output of the PV system is strongly affected by the weather. In order to maintain the stability of the power, rechargeable battery is necessary to store the electricity temporarily. The objective, in this poster, is to make the output voltage of PV (solar panel) constant to connect its rechargeable battery 12v DC.

In details, MATLAB- Simulink is used to simulate the power stage (Buck- Boost converter) and closed loop of feedback controller. Also, the Arduino Uno is used to implement and test PID (proportional, integral, derivative) controller. Results from MATLAB simulation and experiments will be presented.

Introduction

The design of a digital feedback controller to suit Buck- Boost converter is explained. The output voltage was obligatory to remain constant 12v DC or return to steady state as fast as possible, whatever input voltage that comes from a solar panel. For modeling the power stage (Buck- Boost converter) and design digital PID controller, MATLAB- Simulink is used. The simulation for finding out the dynamic response of PID controller is made after connected done with the whole circuit such a close loop control of converter with photovoltaic system figure 1.

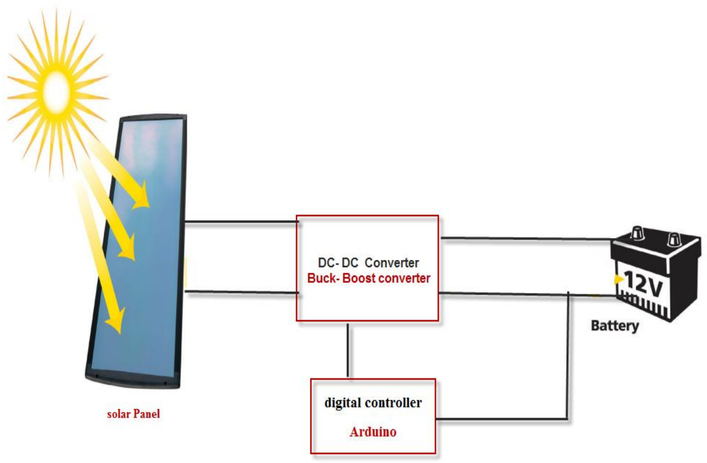

Figure 1:PV connected to BBC with feedback controller

The Buck- Boost converter is step up/ down converter that allows the output voltage to be greater or lower than the input voltage by changing duty-ratio D that can obtain from equation 1 [1]. Both of the power Pole Board (PPB) and Buck- Boost converter are important parts for design and implement feedback controller. The power pole board is an experimental power electronics laboratory kit figure 2. PWM signals for control of the MOSFET's gate may be generated from the board or supplied-

- from external source such as Arduino Uno kit.

$$\frac{V_o}{V_{in}} = \frac{1}{1-D} \quad \text{..... Equation 1}$$

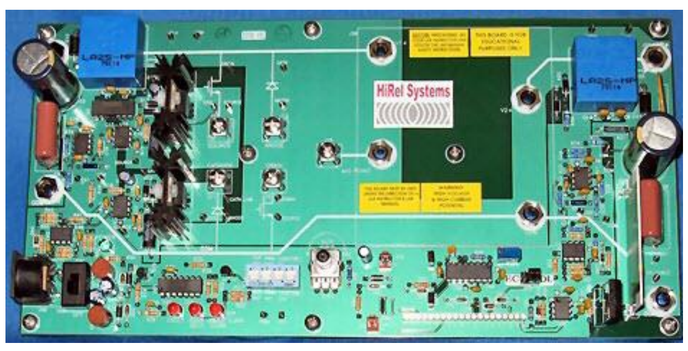

Figure 2: power pole board

Modeling a Buck- Boost Converter with PID Controller

By using Simulink program, the buck- boost converter with PID control have developed figure 3. Also, The Parameters of Buck- Boost converter are inserted in the table 1, and they have been chosen as the same as PPBs' values to get the accurate theoretically and practically results. Likewise, the PID parameters have elected by using the Ziegler–Nichols tuning method that is experimental way to tuning a PID controller. Method was proposed by Jon Ziegler and Nichols in 1940s. It is achieved by setting I (integral) and D (derivative) gains to zero. The P (proportional) gain, Kp is then increased (from zero) until it reaches the ultimate gain Ku, at which the output of the control loop oscillates with a constant amplitude.

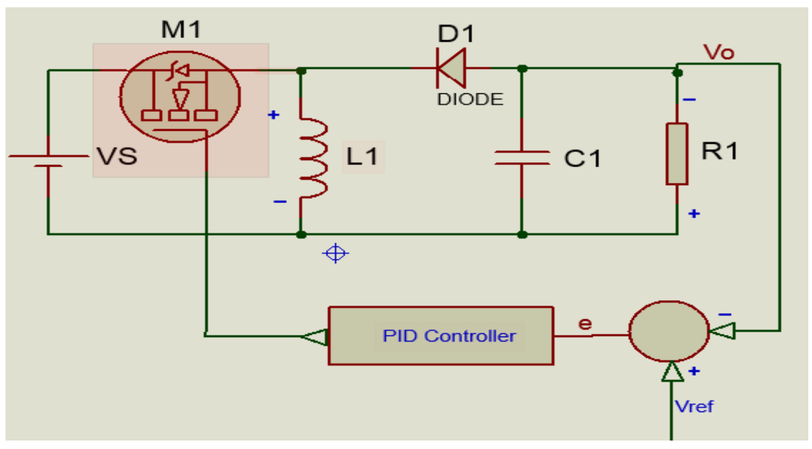

Figure 3: Buck- Boost converter with PID controller

components	Vin (v)	R load(Ω)	L (µH)	C (µF)	set point (v)
Values	8	20	100	697	12

Table 1: Buck- Boost components

After run Simulink, the dynamic response of buck- boost converter with PID has been shown in the figure 4 where the output voltage is constant 12V .

Figure 4:The dynamic response of output voltage of BBC

Also the data of time scope to find out the characteristic of the output voltage got recording. The rise time is 126.96us that is very small time needs to reach steady stead value 12 V. the overshooting is 0.505%.

Implementation of the Controller

In this section, Arduino which is the open source microcontroller has been used as PID controller after code got written in Arduino c language then downloaded into Arduino to make it works as a standalone device [2]. Furthermore, the frequency of Arduino has been increased to reach 15 KHz. The whole circuit has setup figure 5. Also, potentiometer which is an adjustable resistor has been installed where set point can be chosen.

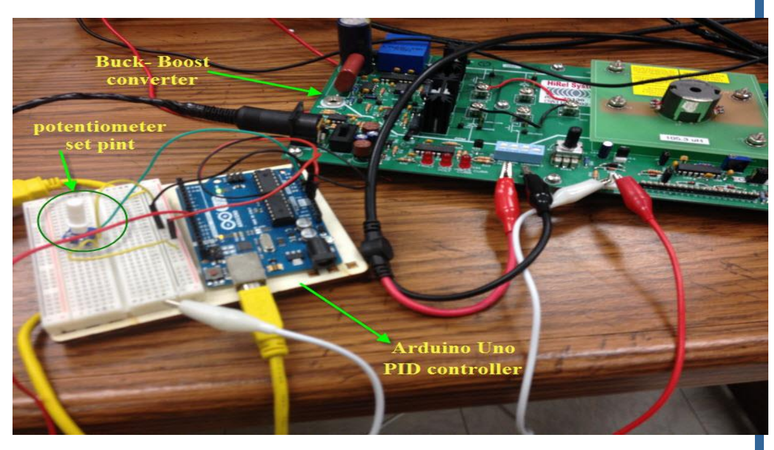

Figure 5:The final connection Arduino with BBC

Practically, digital PID controller has been tested in lab with input voltage from 9 till 16 volt, and it has worked properly and accurately to get constant 12 V dc .

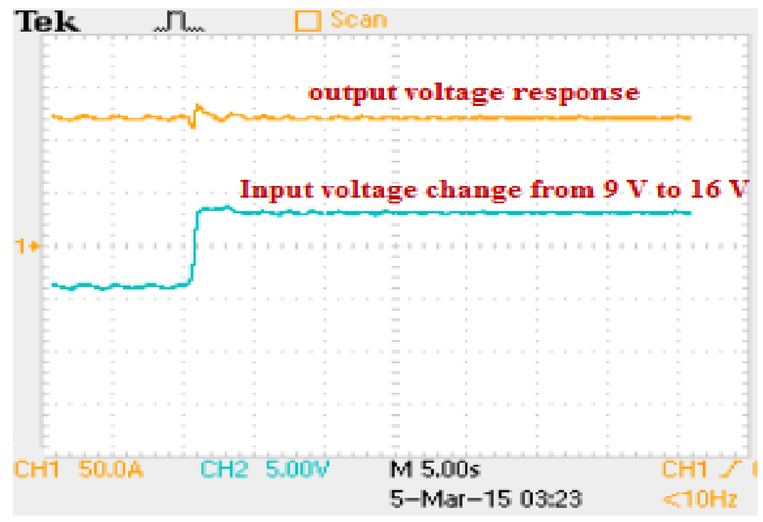

Figure 5: dynamic response of PID control when in put voltage change from 9 to 16 voltage

Conclusion

The Arduino Uno can be functioned as a digital PID controller to regulator the buck- boost converter fed by solar panel for getting constant 12 V when input voltage got fluctuating. The non oscillating output voltage that got would use to charge rechargeable battery 12 V DC. The controller has been tested in MATLAB and practically, and it has been operated correctly.

References

[1]- Mohan, N., Power Electronics: A First Course. 2012, Hoboken NJ: John Wiley & Sons, Inc. 270.

[2]- Arduino Playground – HomePage. (n.d.). Retrieved March 3, 2015, from http://playground.arduino.cc/