LAB # 04

Analyzing Boost Converter Design Using PV Array

Objective:

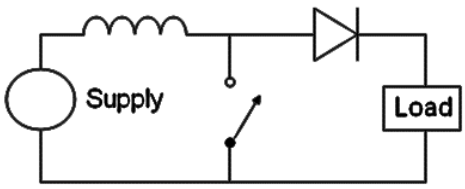
- To understand the working principle of boost converter
- To learn how to calculate values of D (duty cycle), L (inductor) and C (capacitor) for boost converter
- To analyze the working of boost converter with PV array
- To observe input output characteristics (power, voltage & current) of boost converter by varying its duty cycle

Component required:

- PV Array
- Inductor
- Capacitors
- Constants
- PWM Generator
- IGBT (insulated Gate bipolar transistor)
- Diode
- Current Measurements
- Voltage Measurements
- Scope
- Display

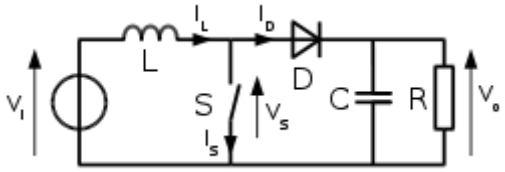
Related Theory:

A DC-to-DC converter is an electronic circuit or electromechanical device that converts a source of direct current (DC) from one voltage level to another. It is a type of electric power converter. Power levels range from very low (small batteries) to very high (high-voltage power transmission).
A boost converter (step-up converter) is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load).
It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element: a capacitor, inductor, or the two in combination.
To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter).



Operation:

The key principle that drives the boost converter is the tendency of an inductor to resist changes in current by creating and destroying a magnetic field. In a boost converter, the output voltage is always higher than the input voltage. A schematic of a boost power stage is shown in figure below.



(a) When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores some energy by generating a magnetic field. Polarity of the left side of the inductor is positive.

(b) When the switch is opened, current will be reduced as the impedance is higher. The magnetic field previously created will be destroyed to maintain the current towards the load. Thus, the polarity will be reversed (means left side of inductor will be negative now). As a result, two sources will be in series causing a higher voltage to charge the capacitor through the diode D.

Equations:

- For duty cycle D

$$D = 1 - \frac{v_s}{v_o}$$

- For finding L, we use following equation:

$$L_{min} \geq \frac{D \times (1-D)^2 \times R}{2 \times f_s}$$

- For finding the value of C, we use:

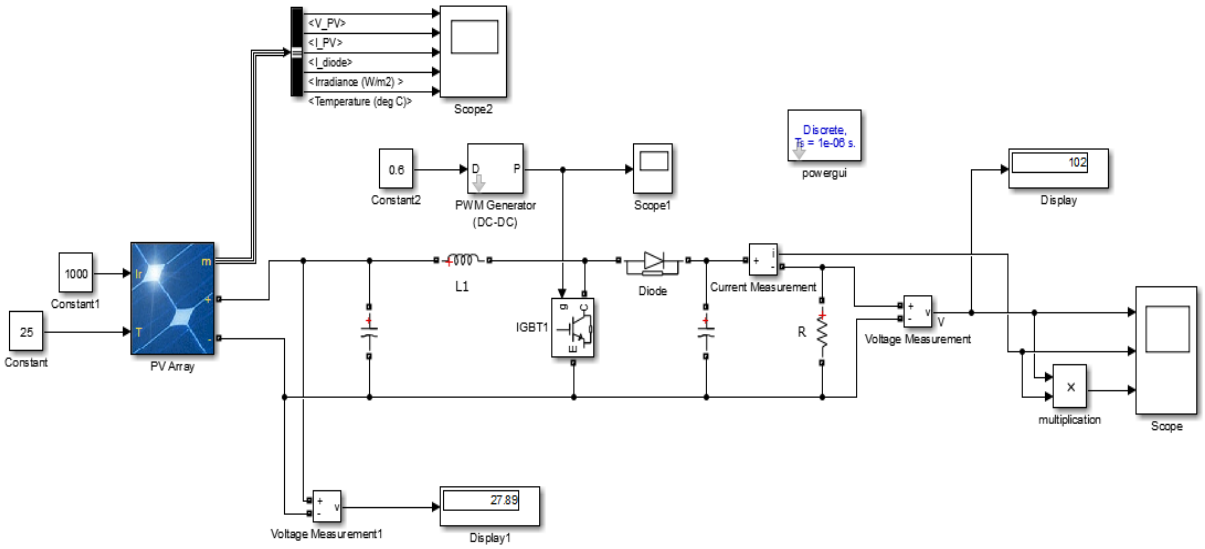
$$C_{min} \geq \frac{D}{f_s \times R_o \times \frac{\Delta v_o}{v_o}}$$

Boost Converter Design Calculations:

Design a boost converter that will have an output of 86V from a 32-V source of PV array. Design for continuous inductor current and an output ripple voltage of less than one percent. The load is a resistance of 50Ω. Assume ideal components for this design.

Solution:

Simulation diagram:



Scope Output of Different Parameter of PV Array:

PWM Scope Output:

Output Waveforms of P_o, V_o and I_o:

Conclusion and Comments: