POWER SYSTEMS

SOLAR PV

B22228
P.LALITHENDH

QUESTION:

1. Show the effect on I-V and P-V characteristics by changing R_{sh}.

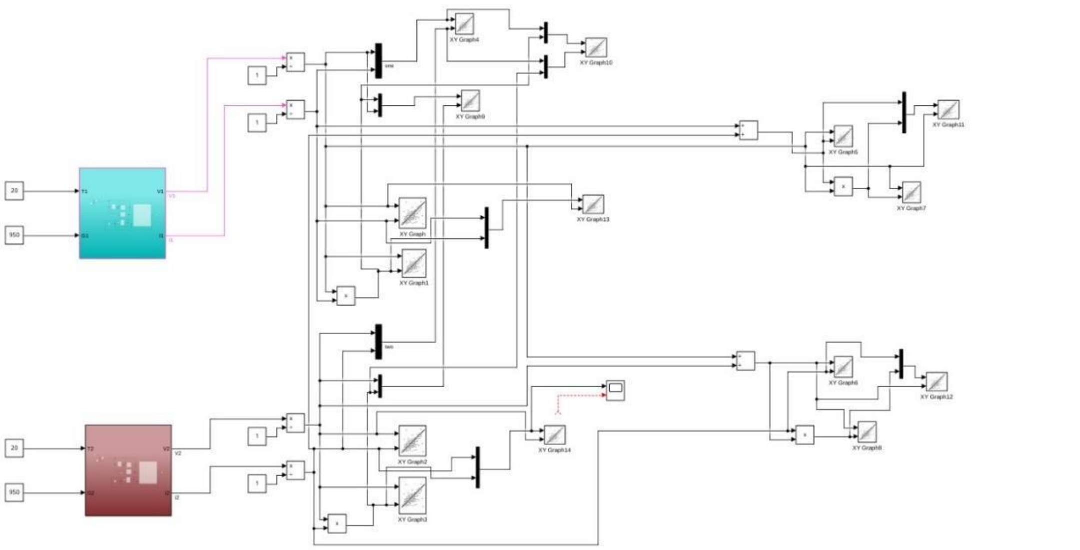
On Solar Irradiance (G = 950 Wm^{-2}). Keeping T = 20^{o} C, and R_s = 0.22 Ω and assume all other values as default. Vary R_{sh} = 100000, 360 Ω. Plot all curves on same graph with different R_s. Calculate fill factor (FF). Comment on the obtained curves in 4-6 lines.

1. Introduction

Solar cells are fundamental components in photovoltaic systems, converting sunlight into electrical energy. Their performance is governed by several parameters, including series resistance (Rs) and shunt resistance (Rsh). The shunt resistance represents the leakage pathways for current in a solar cell, while the series resistance arises from the resistive losses within the cell and its connections. High Rsh is desirable because it minimizes leakage current, whereas low Rsh can cause significant power loss.

This study explores the impact of varying shunt resistance on the current-voltage (I-V) and power-voltage (P-V) characteristics of a solar cell. Simulations are conducted using MATLAB Simulink under specific conditions of solar irradiance (950 W/m²) and temperature (20°C). The fill factor (FF), a key performance indicator, is also calculated and analyzed for each scenario.

CIRCUIT AND IMPLEMENTATION:



For the purpose of this study, Rs was kept constant at 0.22 Ω while the value of Rsh was varied between 360 Ω (low) and 100,000 Ω (high). Solar irradiance was fixed at 950 W/m², and the temperature was kept constant at 20°C to isolate the effects of Rsh

3 RESULTS AND OBSERVATIONS:

3.1. **I-V Characteristics**

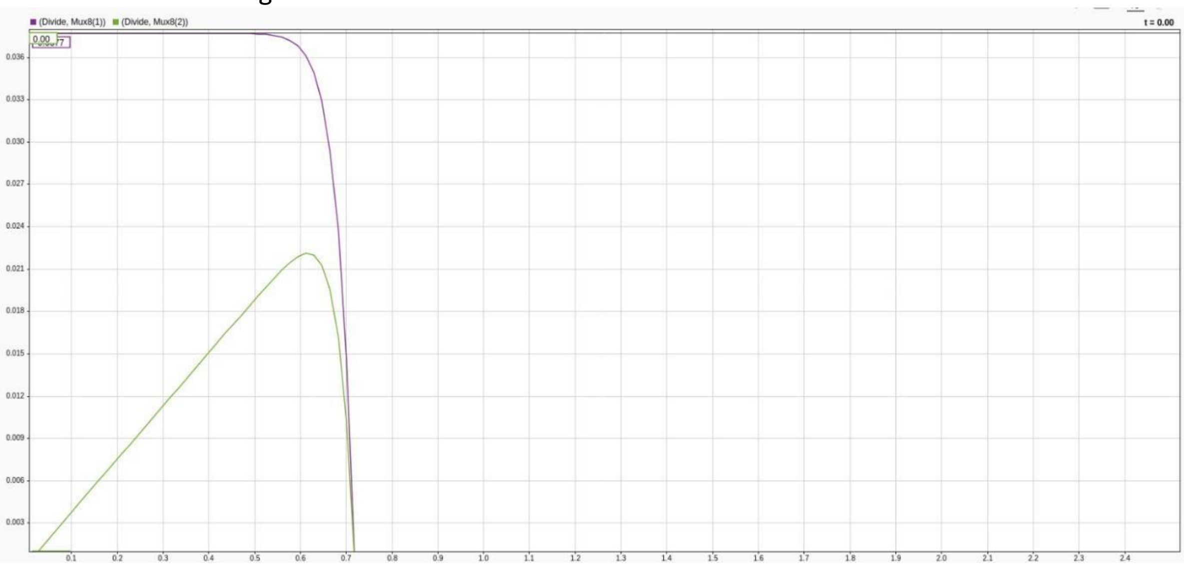
The I-V curves for different values of shunt resistance are plotted in Figure 1. The key observations are as follows:

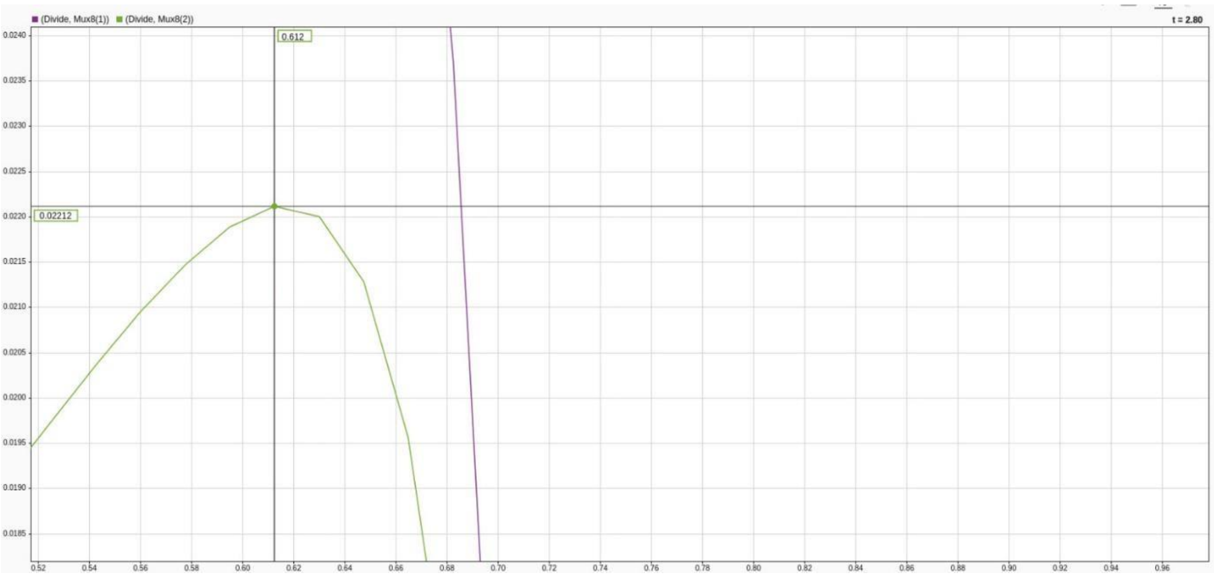
- High Shunt Resistance (100,000 Ω):
  - The curve shows a steep slope near the open-circuit voltage (Voc) and higher short-circuit current (Isc).
  - The high value of Rsh minimizes the leakage current, leading to improved solar cell performance.

3.2. P-V Characteristics

The P-V curves for different values of shunt resistance are plotted i. These observations are made:

- **High Shunt Resistance (100,000 Ω)**:
  - The maximum power point (MPP) is higher, which indicates better power output.
  - The curve reaches a sharper peak, reflecting high efficiency as more current is directed through the load.





3.3 I-V Characteristics:

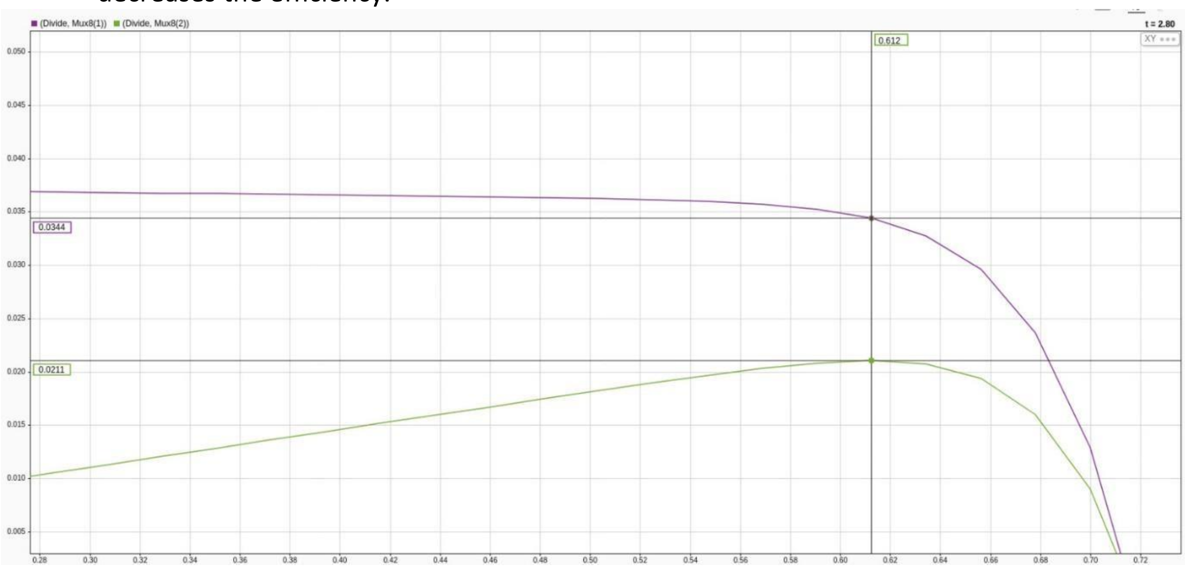
Low Shunt Resistance (360 Ω):

- The I-V curve exhibits a more flattened slope near Voc , indicating significant current leakage.
- Reduced Rsh leads to lower Isc diminishing the overall efficiency of the cell due to energy losses through the shunt path.

3.4 P-V Characteristics:

Low Shunt Resistance (360 Ω):

- The maximum power point (MPP) is reduced due to higher leakage current.
- The curve shows a much lower peak, indicating a substantial loss in power output, which decreases the efficiency.



4: Fill Factor (FF) Calculation

The fill factor is defined as:

FILL FACTOR:

$$\frac{V_{MPP} I_{MPP}}{V_{oc} I_{SC}}$$

Where:

- V_MPP = Voltage at the maximum power point
- I_MPP = Current at the maximum power point
- V_oc = Open-circuit voltage = 0.7
- I_sc = Short-circuit current = 0.04

FOR 100000 OHMS
V_MPP= 0.612
I_MPP= 0.0377

FF= 0.82

FOR 360 OHMS
V_MPP= 0.612
I_MPP= 0.0344

FF= 0.75

For Rsh=100,000 ΩR:

- Voc is higher, and Isc is higher, resulting in a larger fill factor, indicating better efficiency.

For Rsh=360 ΩR:
Voc and Isc are both reduced, and the fill factor is lower, indicating reduced efficiency due to increased power losses.

Comments on the Obtained I-V and P-V Curves:

1. **Impact of High Shunt Resistance (100,000 Ω):**
   - The I-V curve exhibits a steep slope, particularly near the open-circuit voltage, indicating minimal leakage current and efficient operation.
   - The P-V curve reaches a higher and sharper peak, demonstrating better power output at the maximum power point (MPP).

   - A higher fill factor (FF) is observed, which correlates with higher efficiency and better utilization of the available solar energy.
   - Overall, the solar cell performs optimally when the shunt resistance is high, as expected, because the leakage paths for current are minimized.
2. **Impact of Low Shunt Resistance (360 Ω):**
   - The I-V curve shows a more gradual slope near Voc , signifying significant leakage currents through the shunt path.
   - The maximum power point (MPP) on the P-V curve is noticeably lower, indicating reduced power output due to higher current losses.
   - The fill factor (FF) is significantly lower for low shunt resistance, showing that the cell is less efficient and cannot deliver maximum power.
   - With lower shunt resistance, more current bypasses the load, resulting in reduced overall efficiency and poor energy harvesting capabilities.
3. **General Observations:**
   - Higher Rsh leads to better performance, as expected from the theoretical analysis, minimizing current leakage and improving both power output and fill factor.
   - Lower Rsh causes significant degradation in performance, flattening the I-V curve and resulting in a marked decrease in the efficiency of the solar cell.
   - The fill factor (FF) serves as a key indicator of solar cell performance, and its increase with Rsh demonstrates the importance of minimizing leakage currents for efficient operation.

6 Conclusion:

This study demonstrates that the shunt resistance Rsh significantly affects the performance of a solar cell. A higher Rsh leads to better efficiency, as reflected by the steeper I-V curve, higher P-V peak, and larger fill factor. On the other hand, a lower Rsh results in higher leakage currents, flattening the I-V curve and reducing the maximum power output.
Therefore, in practical solar cell design, maximizing Rsh is critical for ensuring minimal power loss and maximizing output efficiency. Fill factor (FF) is an important indicator that increases with Rsh , signifying improved cell performance.