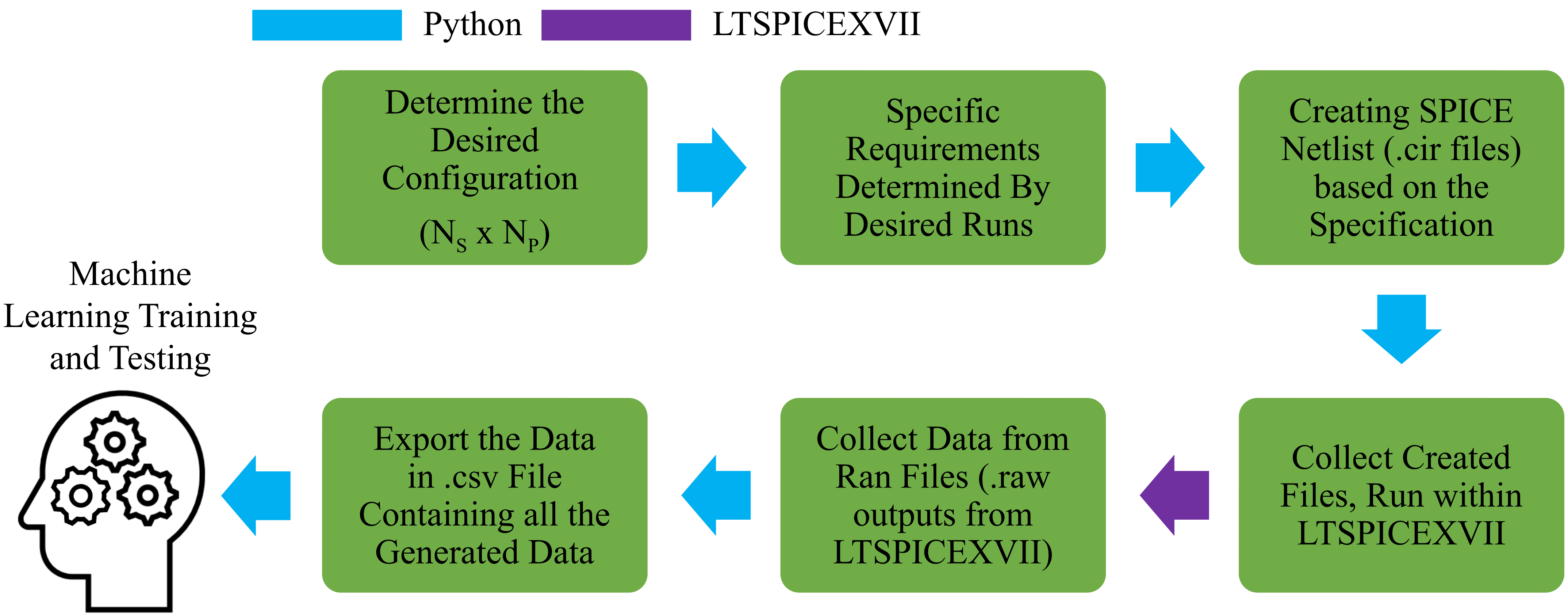
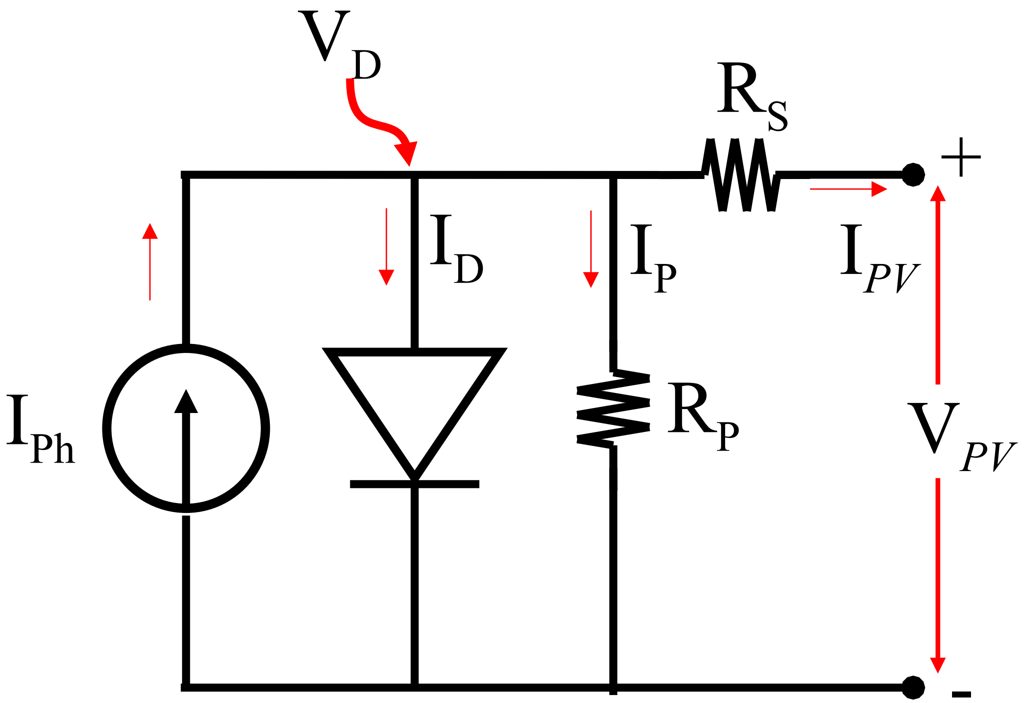

Python
LTSPICEXVII
Determine the Desired Configuration
(N_S x N_P)
Specific Requirements Determined By Desired Runs
Creating SPICE Netlist (.cir files) based on the Specification
Collect Created Files, Run within LTSPICEXVII
Collect Data from Ran Files (.raw outputs from LTSPICEXVII)
Export the Data in .csv File Containing all the Generated Data
Machine Learning Training and Testing

Typically PV Cell Modelling



Where,

I_{Ph} = Photon Current

I_D = Diode Current

R_P = Shunt Resistance

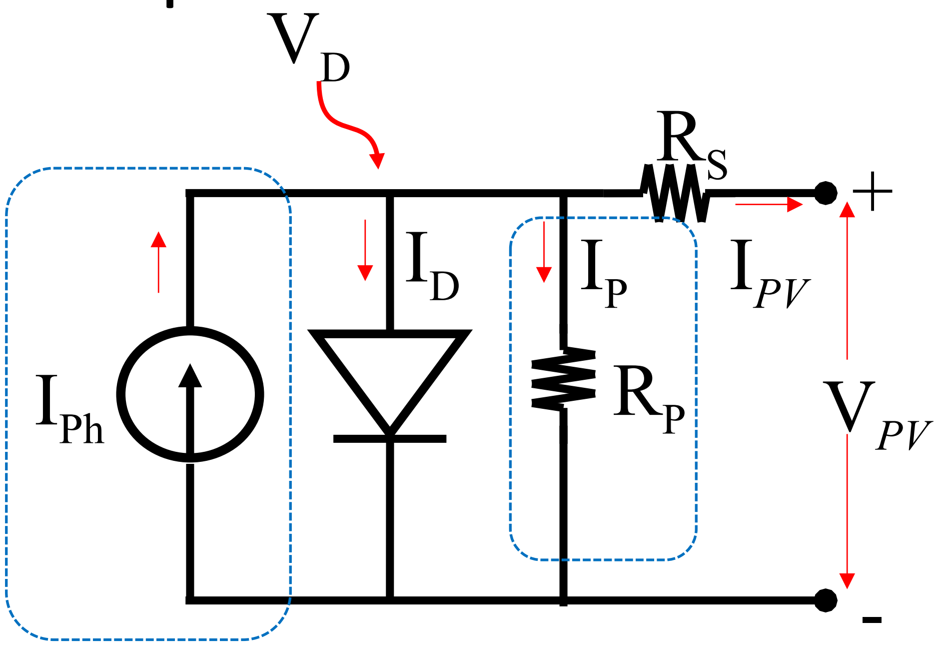
I_P = Current Across the Shunt Resistor

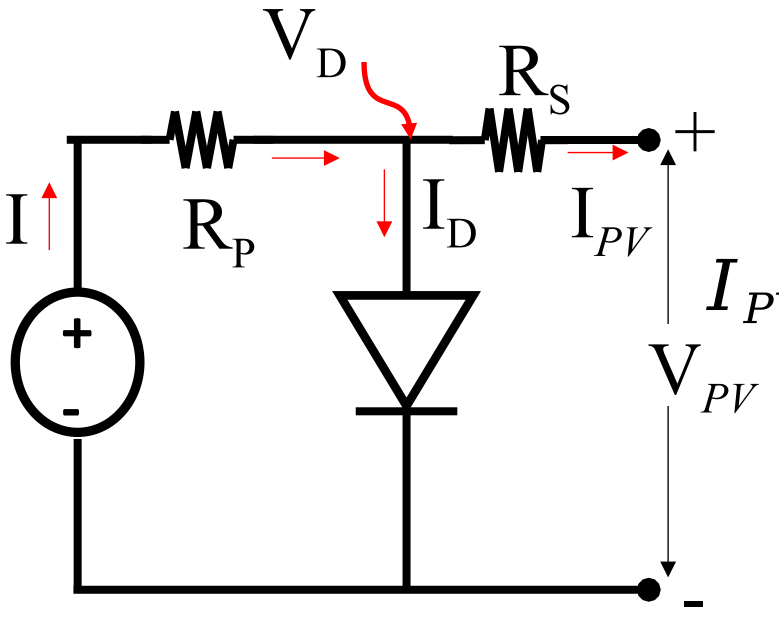
R_S = Series Resistance

I_{PV} = Current Generated by PV Cell

V_{PV} = Voltage Across a PV Cell

Proposed PV Cell Modelling





$V_{Ph} = I_{Ph} \text{ x } R_P$

Using Kirchhoff's Current Law

$$I = I_D + I_{PV} \quad \text{------------} \quad (1)$$

Rearrange this equation gives

$$V_D = V_{Ph} - I\,R_P$$

$$V_D = I_{Ph} R_P - (I_D + I_{PV}) R_P \quad \text{------------} \quad (2)$$

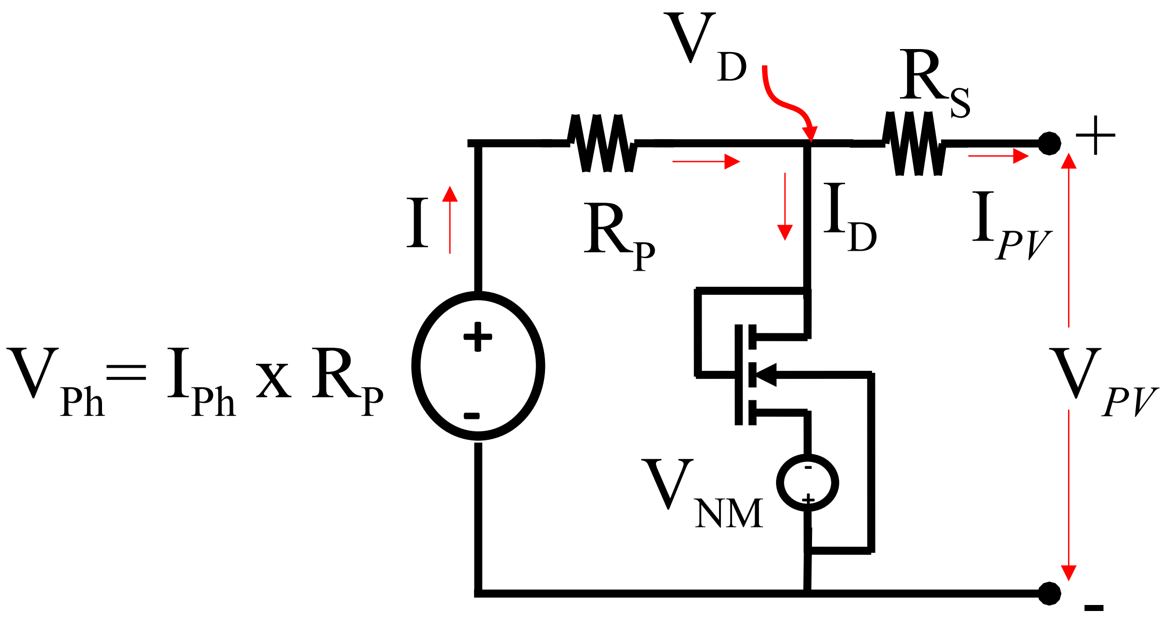
$$V_D = V_{PV} + R_S I_{PV} \quad \text{------------} \quad (3)$$

Equating (2) and (3) gives

$$V_{PV} + R_S I_{PV} = I_{Ph} R_P - I_D R_P - I_{PV} R_P$$

$$I_{PV} = \frac{1}{(R_S + R_P)} (I_{Ph} R_P - I_D R_P - V_{PV}) \quad \text{-------} \quad (4)$$

Presence of I_D is cause of non-linearity in the I_{PV} mathematical modelling.



$$I_D = I_S\left(e^{\frac{V_D}{nV_t}} - 1\right) \quad \text{------------------------------} (5)$$

Hence, the diode can be replaced with an NMOS based diode by shorting the gate and drain terminal.

A voltage source, VNM is connected between the body and source terminal of the NMOS for lowering the threshold voltage.

$$I_D = I_M = \frac{K_n}{2}\left(\frac{W}{L}\right)(V_{GS} - V_{tn})^2(1 + \lambda V_{DS})$$

Since $V_G = V_D$, the V_{GS} will be equal to V_{DS}

$$I_M = \frac{K_n}{2}\left(\frac{W}{L}\right)(V_D - V_{tn})^2(1 + \lambda V_D) \quad \text{-----} (6)$$

Where,

I_M = Current across the NMOS

K_N = Process Transconductance

W= Width of NMOS

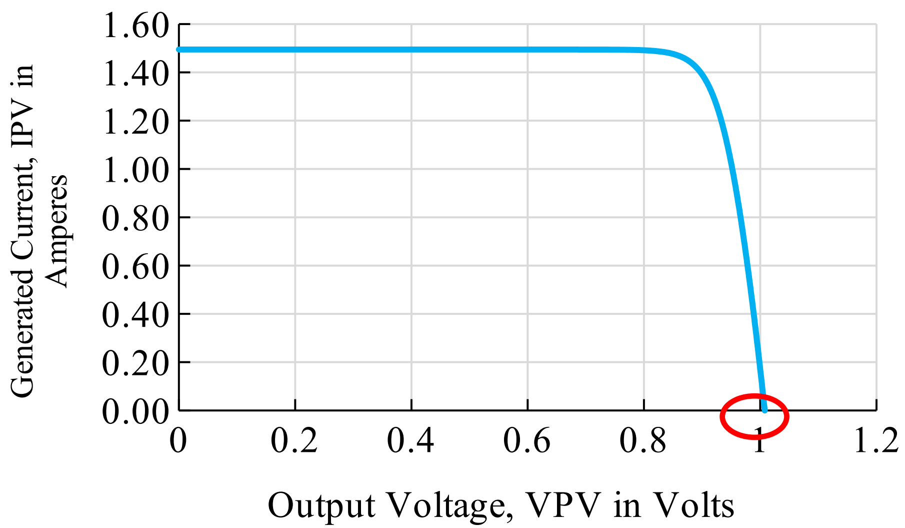
L= Length of NMOS

V_{GS} = Voltage between gate and source terminal

V_{DS} = Voltage between gate and source terminal

V_{tn} = Threshold voltage of NMOS transistor

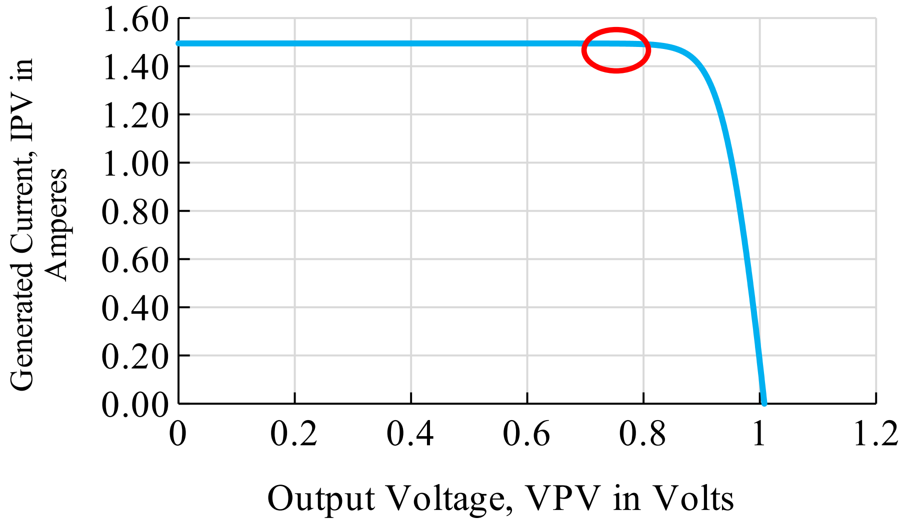
λ = Channel Length Modulation



For computing the W/L Ratio, eq (5) and eq (6) are equated for the data point when $I_{PV} = 0A$

$$\frac{W}{L}=\frac{2I_S\left(e^{\frac{V_{PV}}{AV_t}}\right)}{K_n(V_D-V_{tn})^2(1+\lambda V_D)} \quad \text{-----}(6)$$

Note V_{PV} is the open load voltage of the PV cell as shown in figure on left.
Generally, it's a constant provided in datasheet.



For computing the V_{NM}, the threshold voltage equation of NMOS is used which is shown below:

$$V_{tn}=V_{tno}+\gamma \quad \text{¿ -----}(6)$$

For computing V_{NM}, first V_{tn} is computed.
The datapoint when I_{PV} starts decreasing from I_{ph}. This means the NMOS just turned-on and current flowing through it.

Substituting I_m from eq (6) and V_D from eq (3) into equation no (4).

Note: λ is ignored in eq(6). Since it too small compared to V_D

$$I_{PV} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Where,

$$a = \frac{K_n R_s^{\;2} \left(\frac{W}{L}\right)}{2}$$

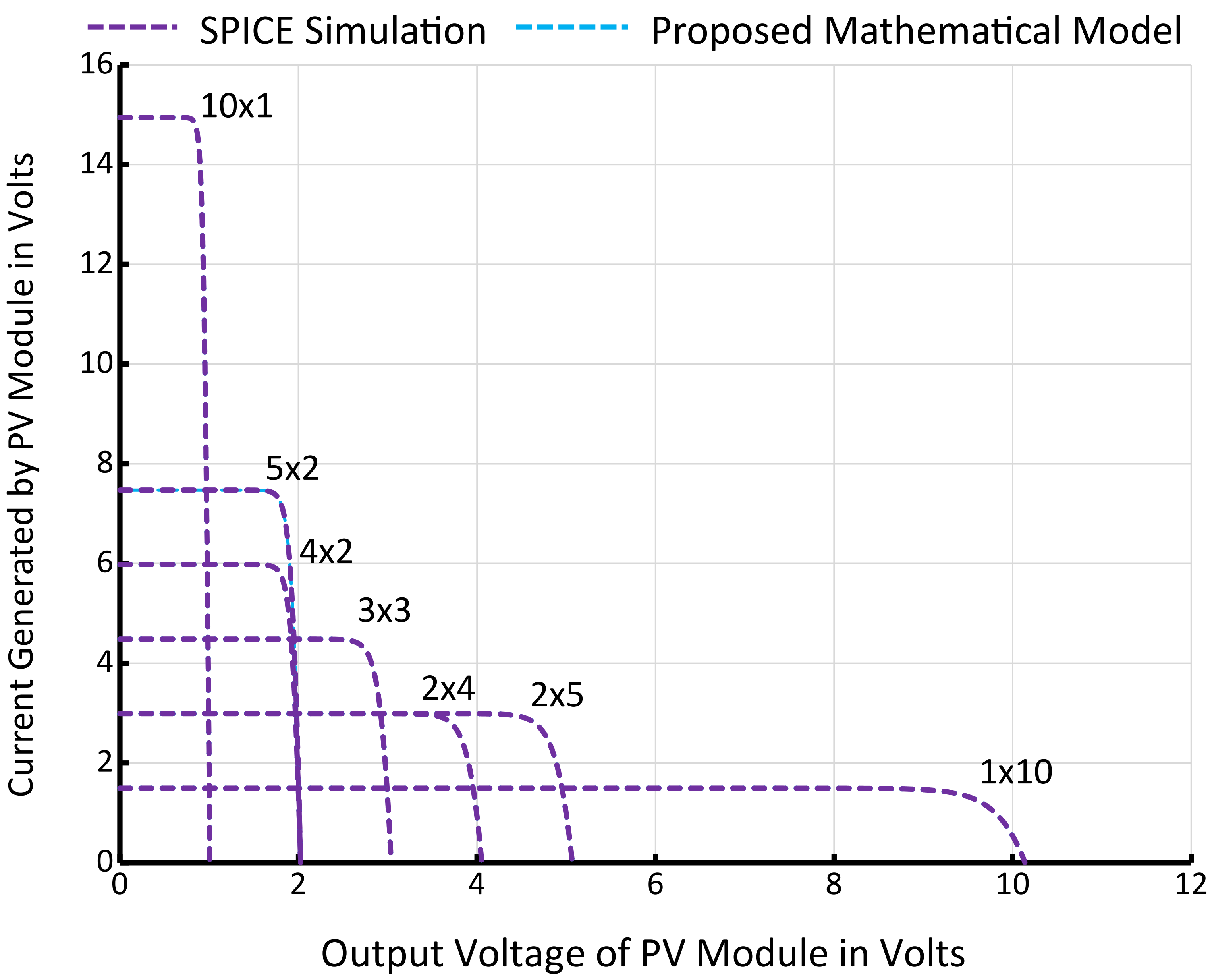
$$b = R_P + R_S + K_n R_S \left(\frac{W}{L}\right)\left(V_{PV} - V_{tn}\right)$$

$$c = \frac{K_n}{2}\left(\frac{W}{L}\right) V_{PV}^{\;2} - \frac{K_n}{2}\left(\frac{W}{L}\right) V_{PV} V_{tn} + V_{PV} + \frac{K_n}{2}\left(\frac{W}{L}\right) V_{tn}^{\;2} - I_{ph} R_P$$

Results

Type of PV Cells (AMO Sunlight (135.3mW/cm^2) GaAs/Ge Single Junction Solar Cells.

- ✓ J_{SC} = 30.5 mA/cm^2, V_{OC}= 1.025V, Area of PV Cell = 7 cm x 7 cm.



Significance of this work

- Parameter extraction from PV Cells and Modules is very challenging task. The proposed technique will simply the process.
- Same is the case with multi-junction PV cells and Module. The proposed technique will make the modeling them much easier.
- The large-scale PV farm are getting popular over the years. Due to simplicity of the proposed technique will make the solar farm simulation less resource intensive.