

PV Module Simulink models

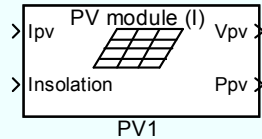


ECEN 2060
Spring 2008



Simulink models of PV modules

Current-input PV module



Inputs:

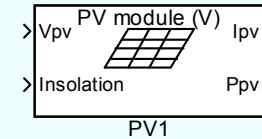
- PV current I_{PV} [A]
- Insolation [W/m^2]

Outputs:

- PV voltage V_{PV} [V]
- PV output power P_{pv} [W]

This model is well suited for the case when modules are connected in series and share the same current

Voltage input PV module



Inputs:

- PV voltage V_{PV} [V]
- Insolation [W/m^2]

Outputs:

- PV current I_{PV} [A]
- PV output power P_{pv} [W]

This model is well suited for the case when modules are connected in parallel and share the same voltage

Model parameters, in both cases, are the standard PV module data-sheet parameters:

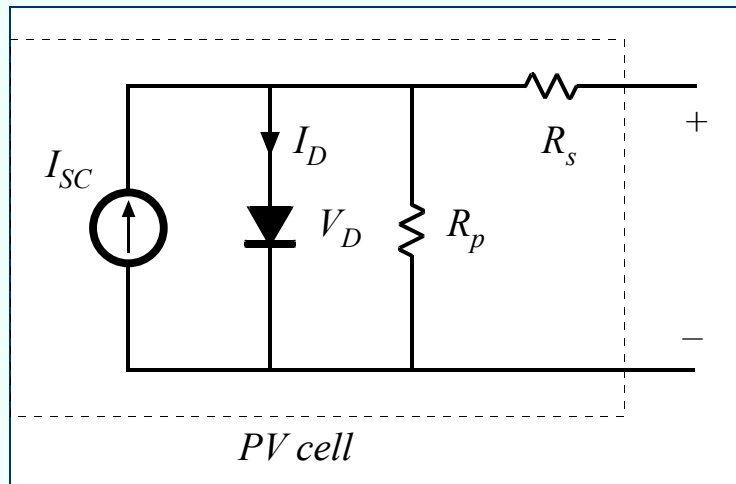
- short-circuit current I_{sc}
- open-circuit voltage V_{oc}
- rated current I_R at maximum power point (MPP)
- rated voltage V_R at MPP

under standard test conditions ($1\text{kW}/\text{m}^2$, 1.5 AM , 25°C). A bypass diode (a single diode across the entire module) can be included. Temperature effects are not modeled.

Parameters

Short-circuit current	<input type="text" value="5.45"/>
Open-circuit voltage	<input type="text" value="22.2"/>
Current at Pmax	<input type="text" value="4.95"/>
Voltage at Pmax	<input type="text" value="17.2"/>
<input checked="" type="checkbox"/> By-pass diode?	

PV cell circuit model and equations



KCL:

$$I_{SC} - I_D - \frac{V_D}{R_p} - I_{PV} = 0$$

Diode characteristic:

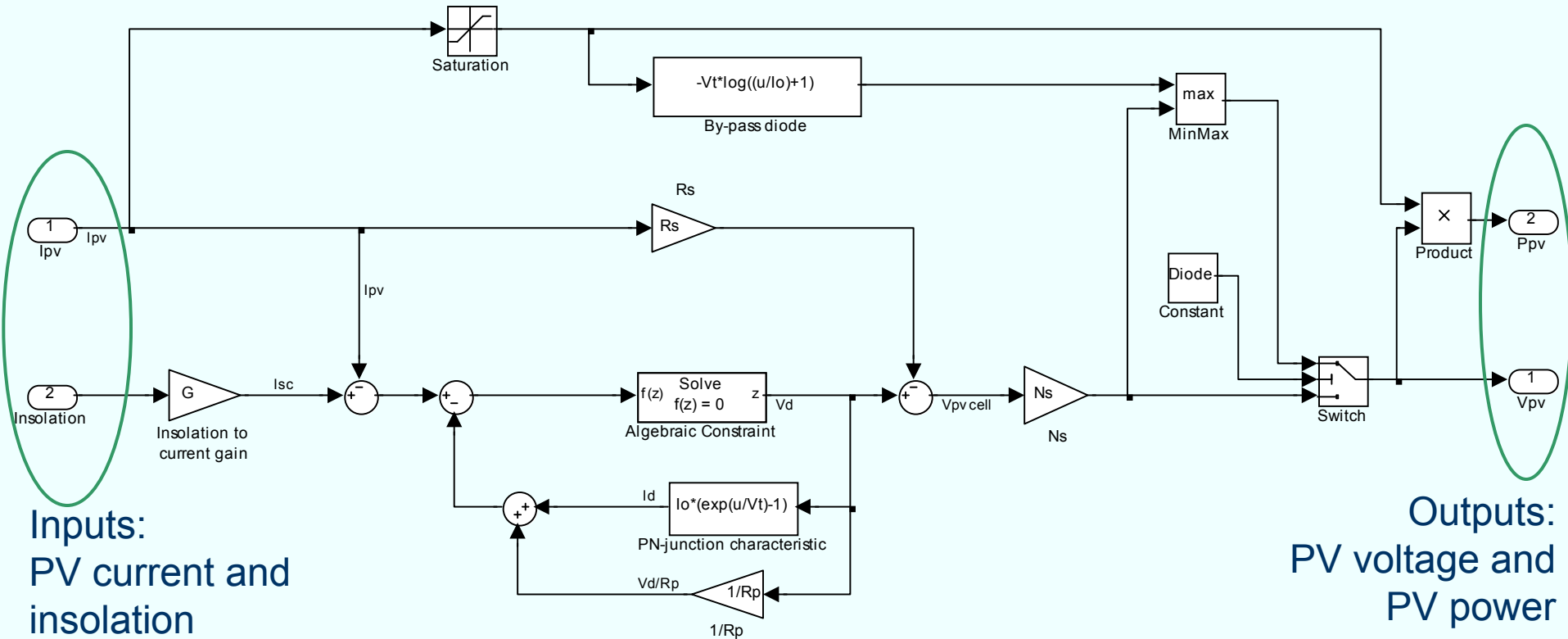
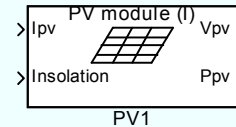
$$I_D = I_o \left(e^{V_D/V_T} - 1 \right)$$

KVL:

$$V_{PVcell} = V_D - R_s I_{PV}$$

Simulink Implementation

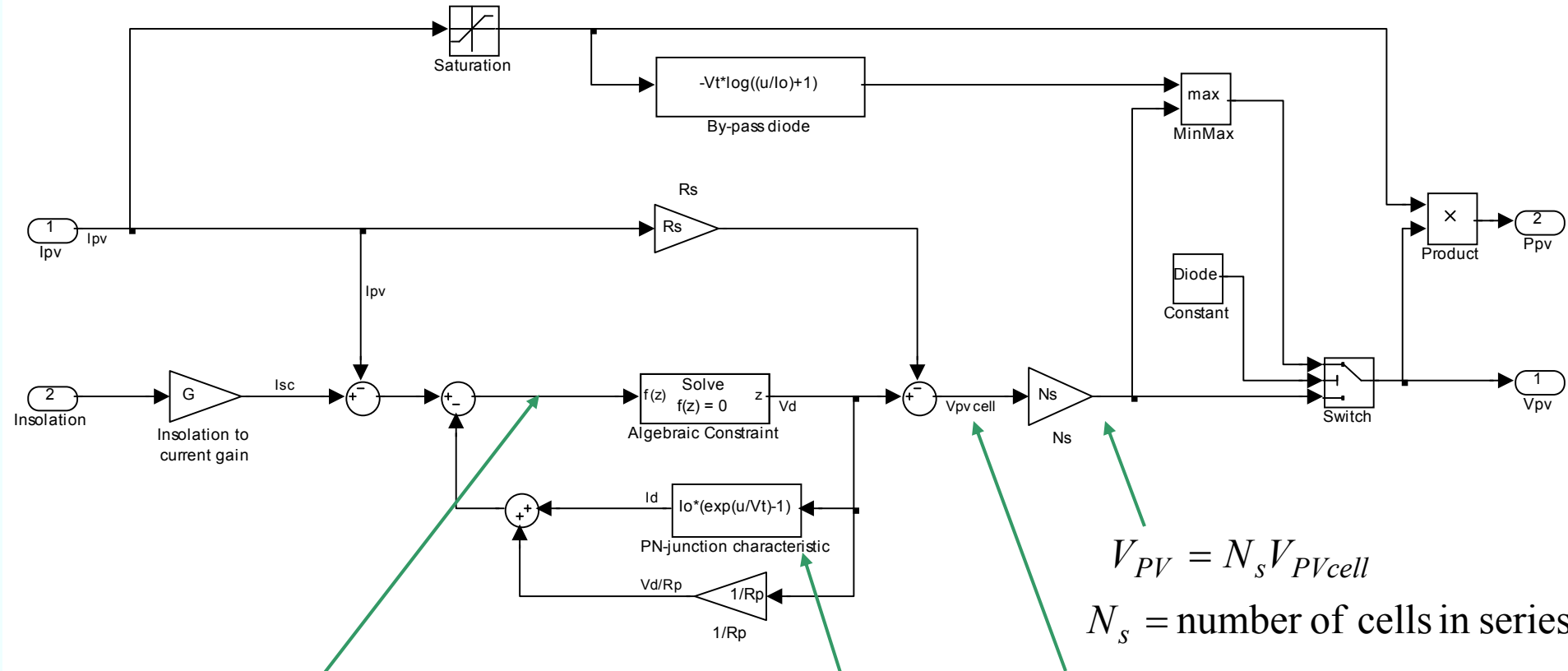
- Both PV module models are implemented as masked subsystems in Simulink
- Look Under Mask (right-click or Edit menu) reveals details of the model implementation
- Details of the current-input PV module model:



Inputs:
PV current and
insolation

Outputs:
PV voltage and
PV power

Inside the current-input PV module model



$$I_{SC} - I_D - \frac{V_D}{R_p} - I_{PV} = 0$$

KCL solved for V_D
using Algebraic
Constraint block

$$I_D = I_o \left(e^{V_D/V_T} - 1 \right)$$

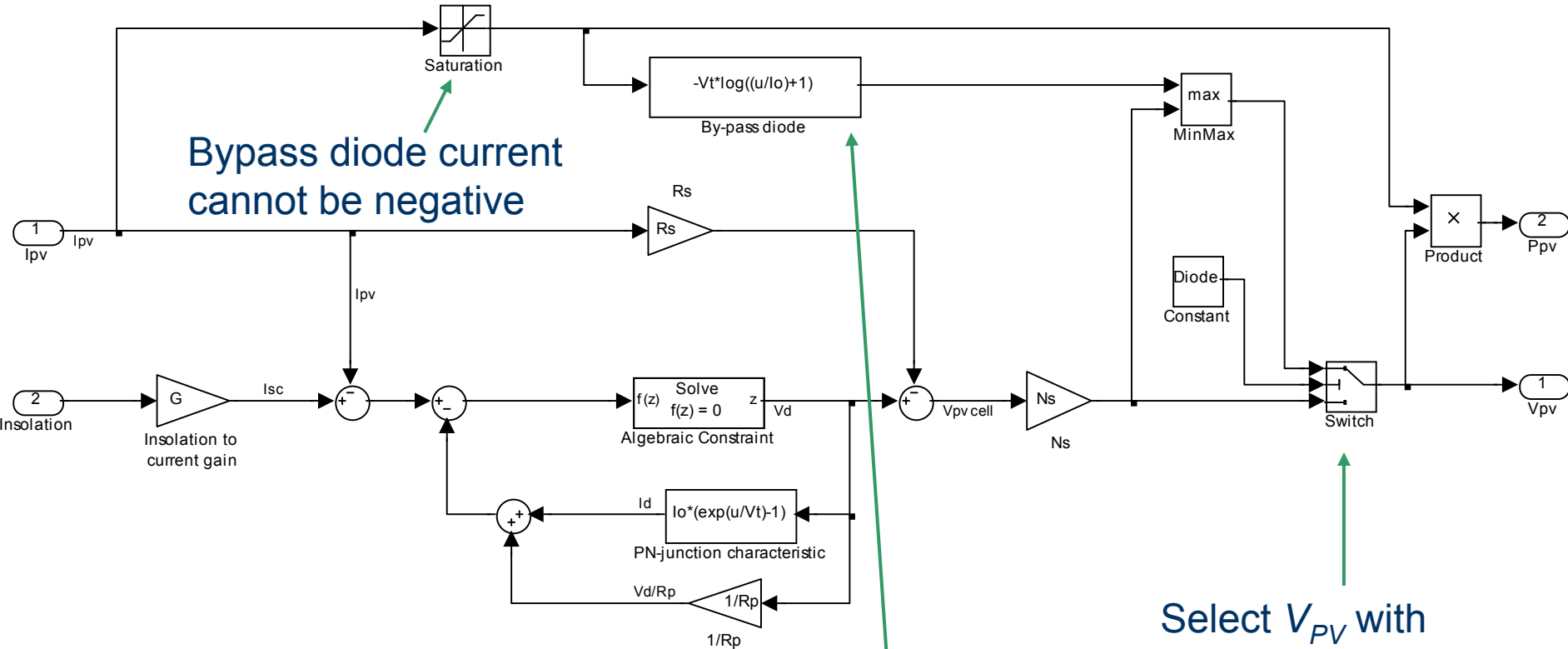
$$V_{PVcell} = V_D - R_S I_{PV}$$

$$V_{PV} = N_s V_{PVcell}$$

N_s = number of cells in series

Inside the current-input PV module model

Bypass diode current cannot be negative



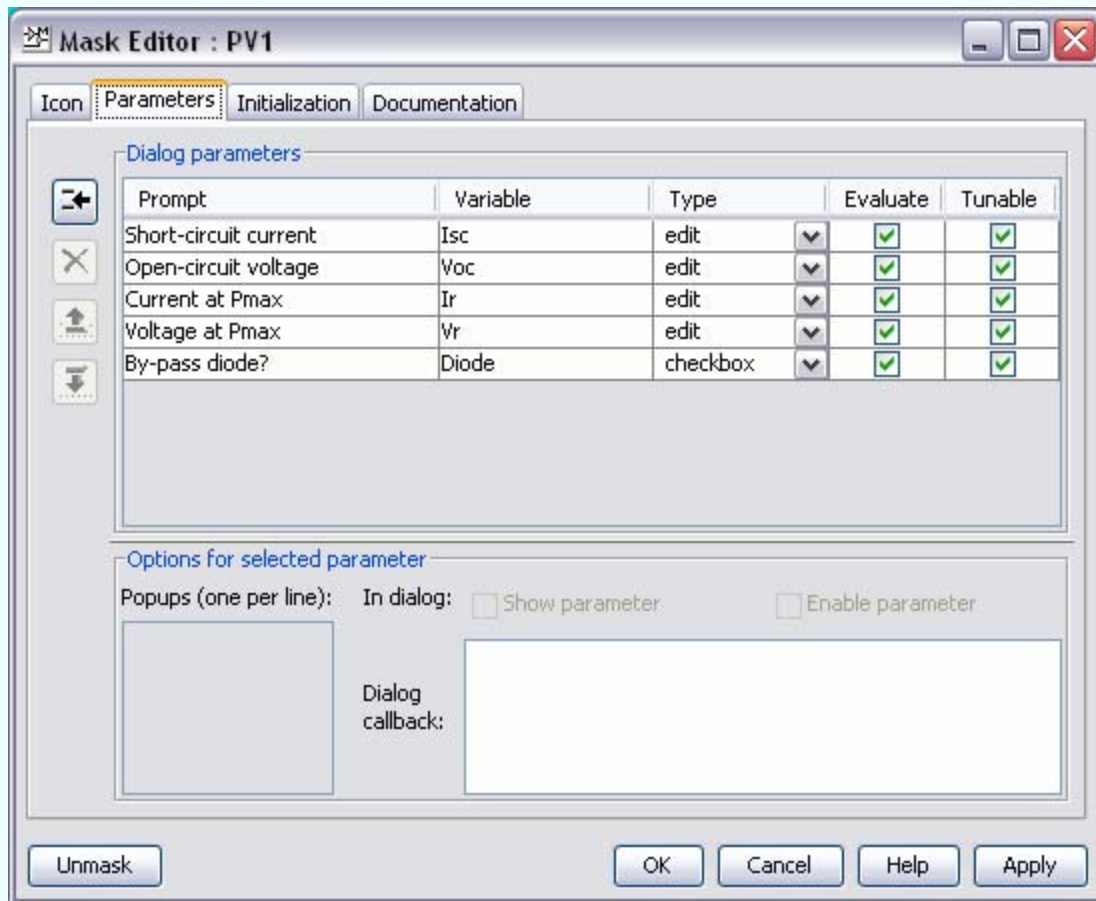
Select V_{PV} with bypass diode ("Diode" = 1) or without bypass diode ("Diode" = 0)

$$V_{D_{bypass}} = V_t \ln \left(\frac{I_{bypass}}{I_o} + 1 \right)$$

Bypass diode voltage (if forward biased)

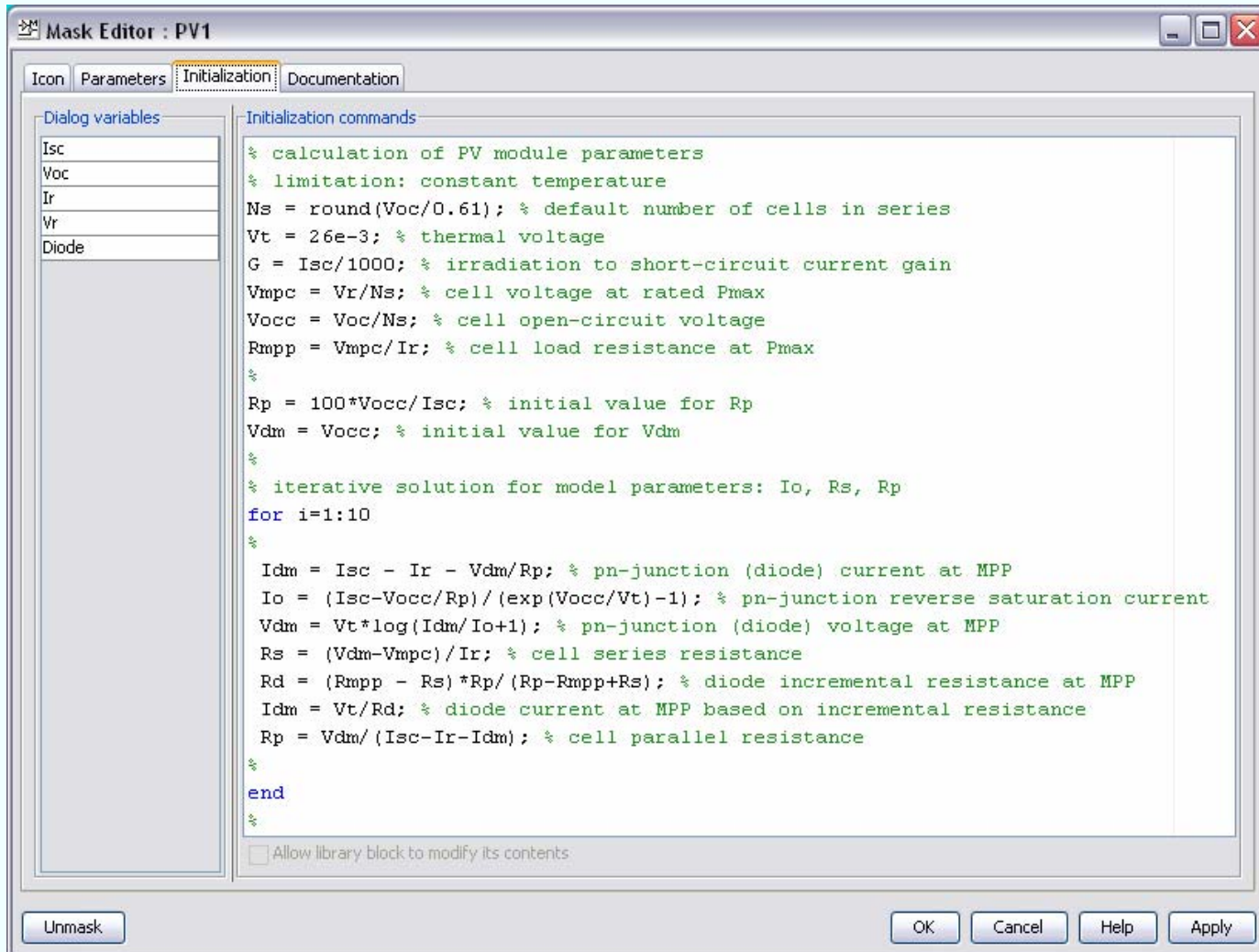
Model Mask: Parameters

- Edit Mask (right-click or Edit menu), click on Parameters
- This is where the masked subsystem model parameters are defined



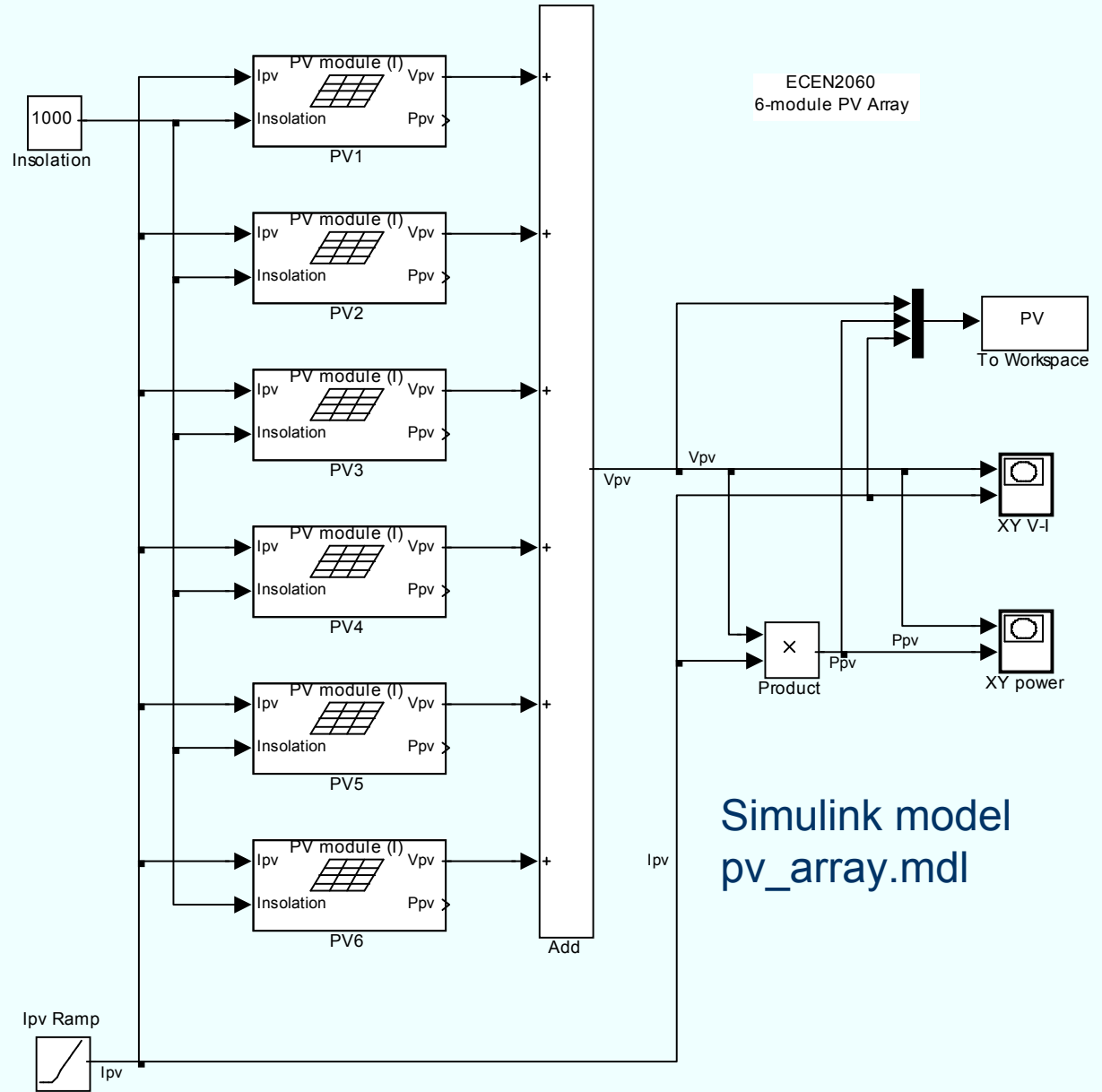
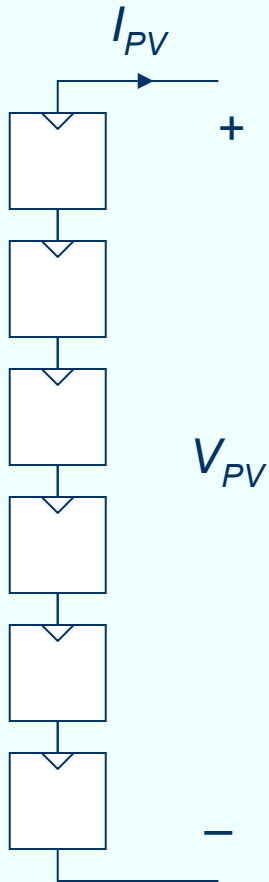
Model Mask: Initialization

- Edit Mask (right-click or Edit menu), click on Initialization
- The MATLAB code computes model parameters I_o , R_s , R_p based on the model parameters (short-circuit current I_{sc} , circuit voltage V_{oc} , rated voltage V_r , and rated current I_r)



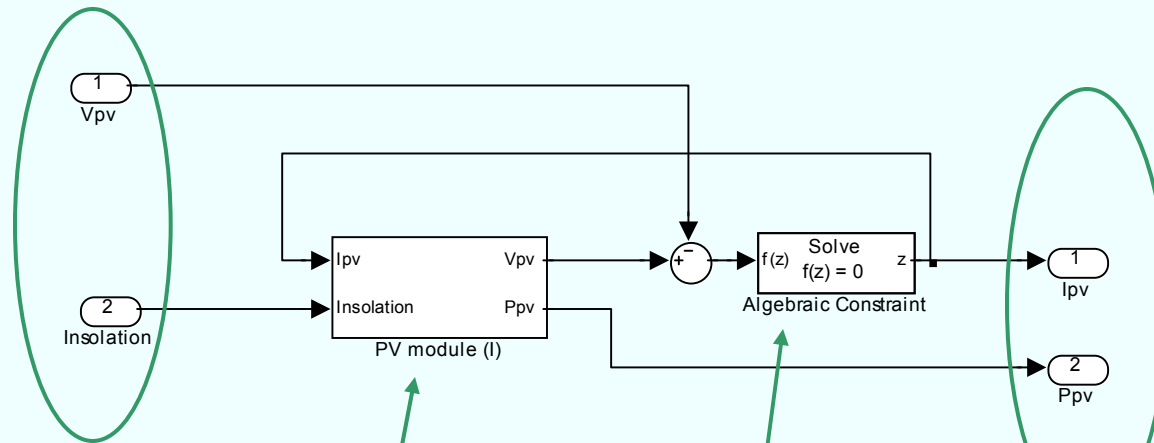
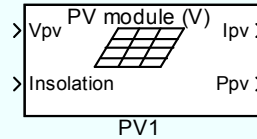
Application Example: PV Array

PV array consisting of 6 PV modules connected in series



Simulink model
pv_array.mdl

Inside the voltage-input PV module



Inputs:
PV voltage and
insolation

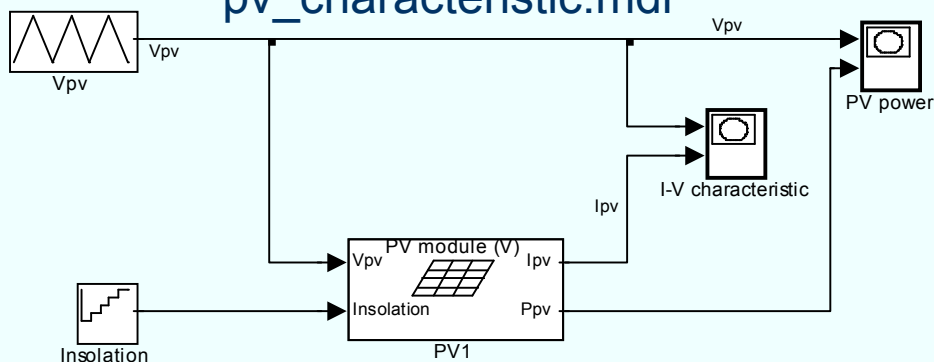
Current-input
PV model

Algebraic
Constraint block
solves for I_{PV} that
results in V_{PV}

Outputs:
PV voltage and
PV power

Application Example: PV Module Characteristics

Simulink model:
pv_characteristic.mdl



$Insolation = 200, 400, 600, 800, 1000 \text{ W/m}^2$

