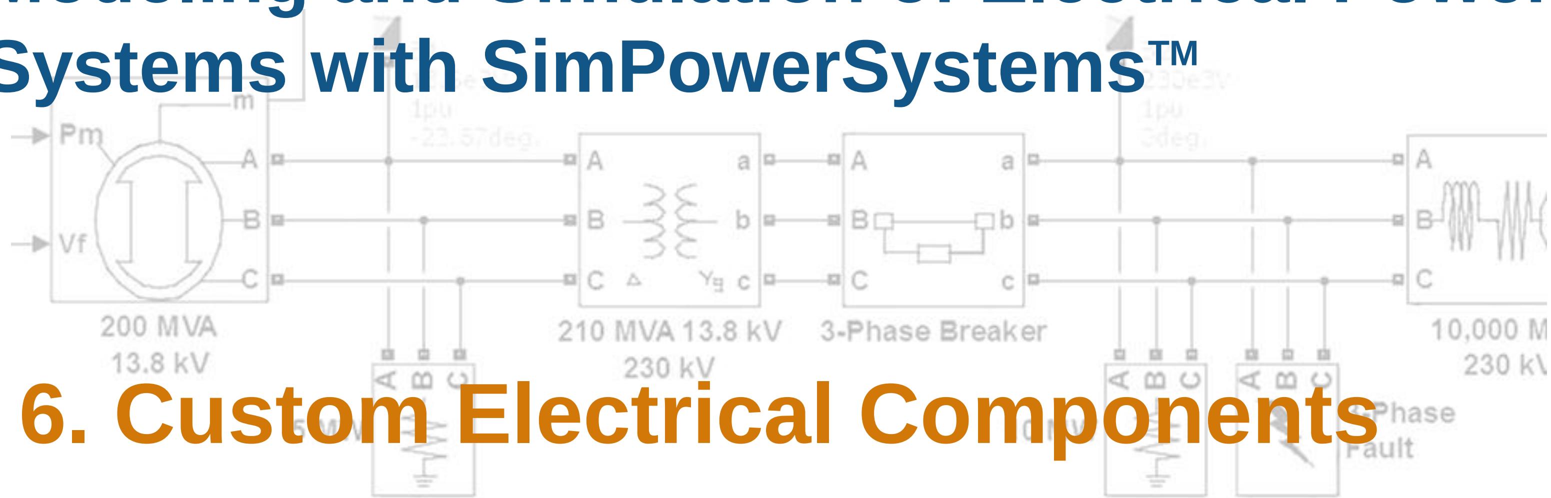
SimPowerSystems Hands-on Workshop:
Modeling and Simulation of Electrical Power Systems with SimPowerSystems™



6. Custom Electrical Components

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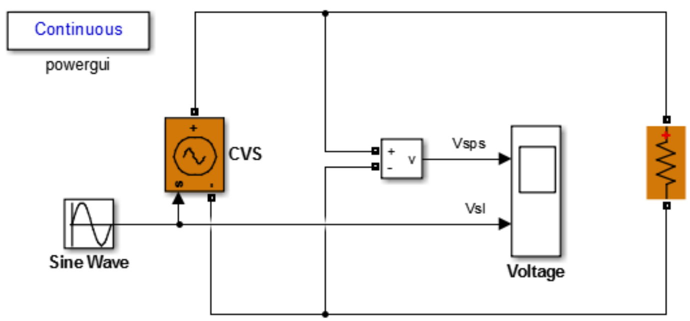
Outline

- Simulink-based electrical components
- Modifying Specialized Technology library components
- Simscape Language and Simscape Components library
- Simscape and SimPowerSystems interfaces
- Model sharing and IP protection

Simulink-based electrical components

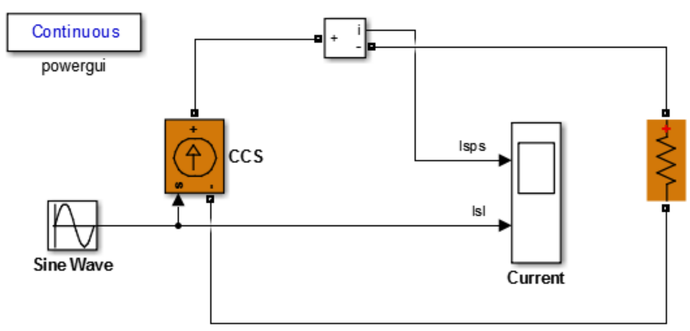
Controlled voltage and current sources

```
>> controlled_voltage_source
```



The ***voltage*** across the source terminals equals the input Simulink signal, regardless of the current requirement

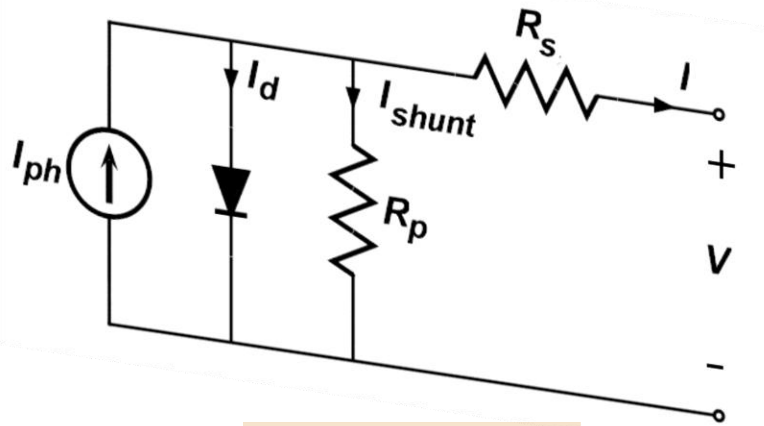
The ***current*** through the source terminals equals the input Simulink signal, regardless of the voltage requirement




```
>> controlled_current_source
```

Simulink-based electrical components

Photovoltaic solar cell example



$$I = I_{ph} - \boxed{I_s(e^{\frac{V+IR_s}{NV_t}} - 1)} - \frac{V + IR_s}{R_p}$$

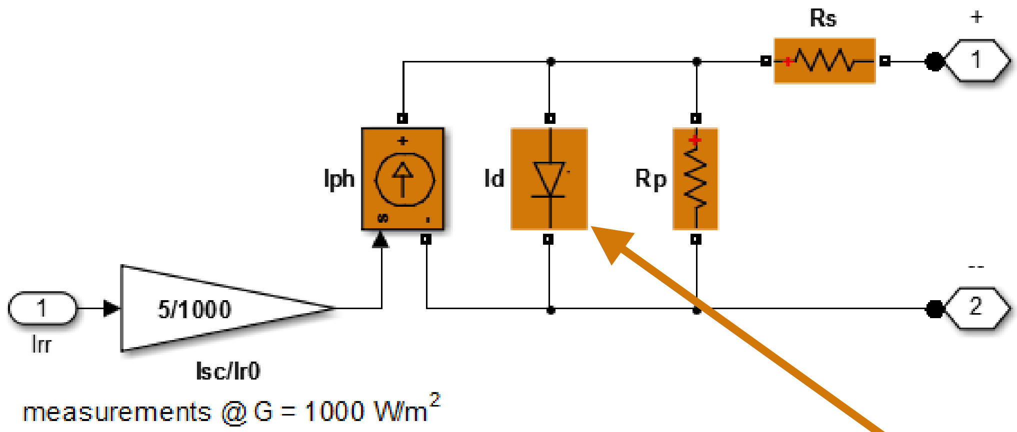
exponential diode

Where:

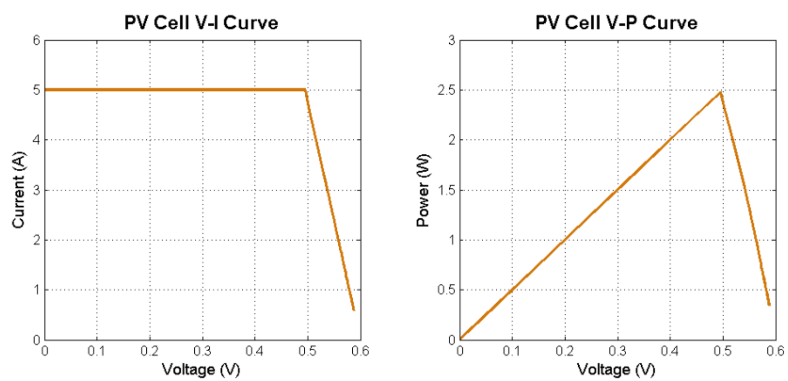
- I_{ph} **Solar induced current (proportional to irradiance)**
- I_s **Diode saturation current (exponential behavior)**
- N **Diode quality factor (emission coefficient)**
- V_t **Thermal voltage** kT/q (**k: Boltzmann constant, T: device temperature)**
- R_p **Shunt resistance (models leakage currents, primarily due to defects)**
- R_s **Series resistance (models bulk and contact resistances)**

Simulink-based electrical components

Photovoltaic solar cell example



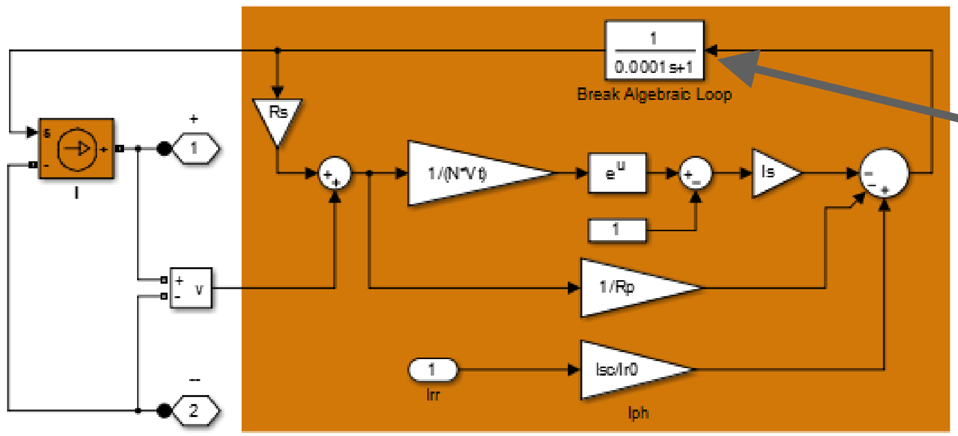
SPS diode is modeled as a piecewise linear switch




```
>> sps_solarcell
```

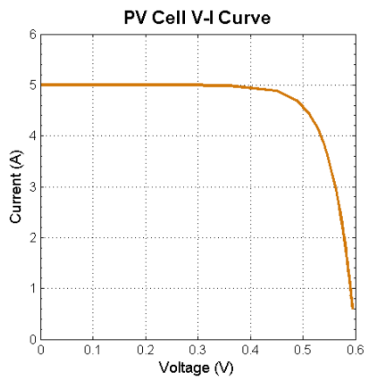
Simulink-based electrical components

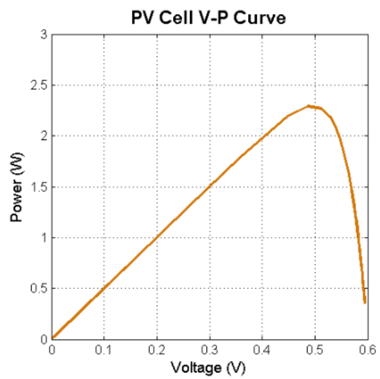
Photovoltaic solar cell example



Always need to **properly** break the algebraic loop

$$I = I_{ph} - I_s * (e^{(V + I * R_s) / N * V_t} - 1) - (V + I * R_s) / R_p$$

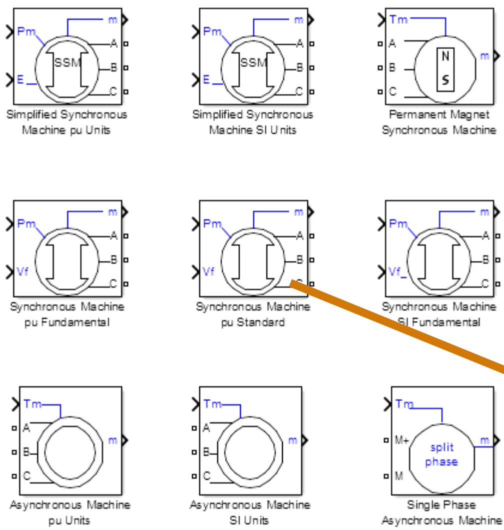




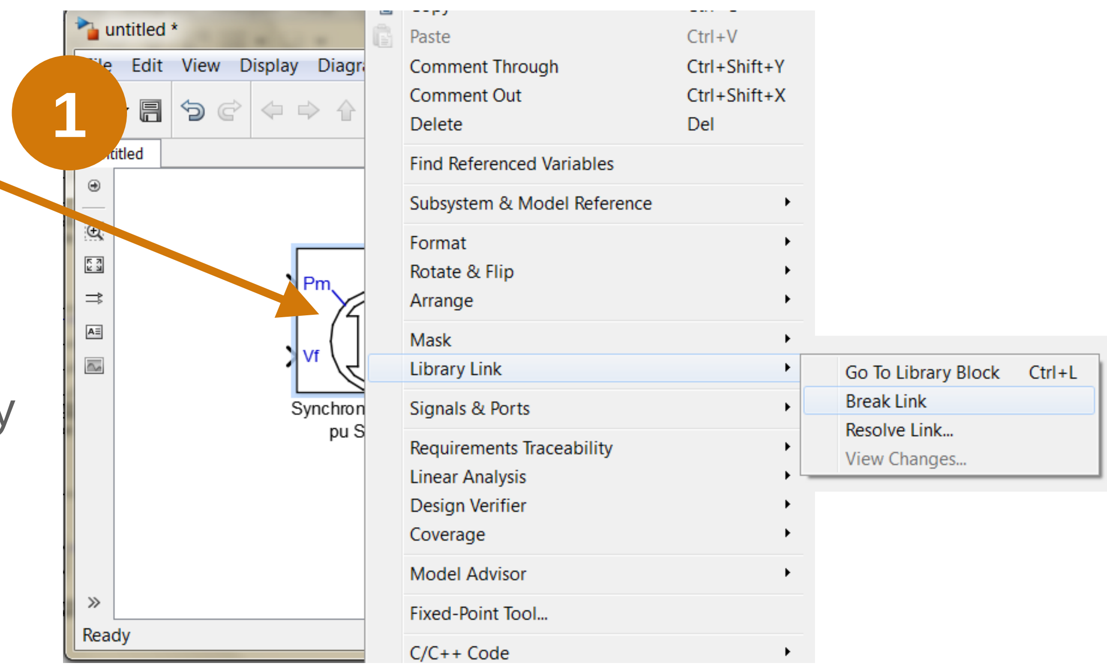

```
>> sl_solarcell
```

Modifying Specialized Technology library components

Custom synchronous machine example



Original machines library
powerlib/Machines

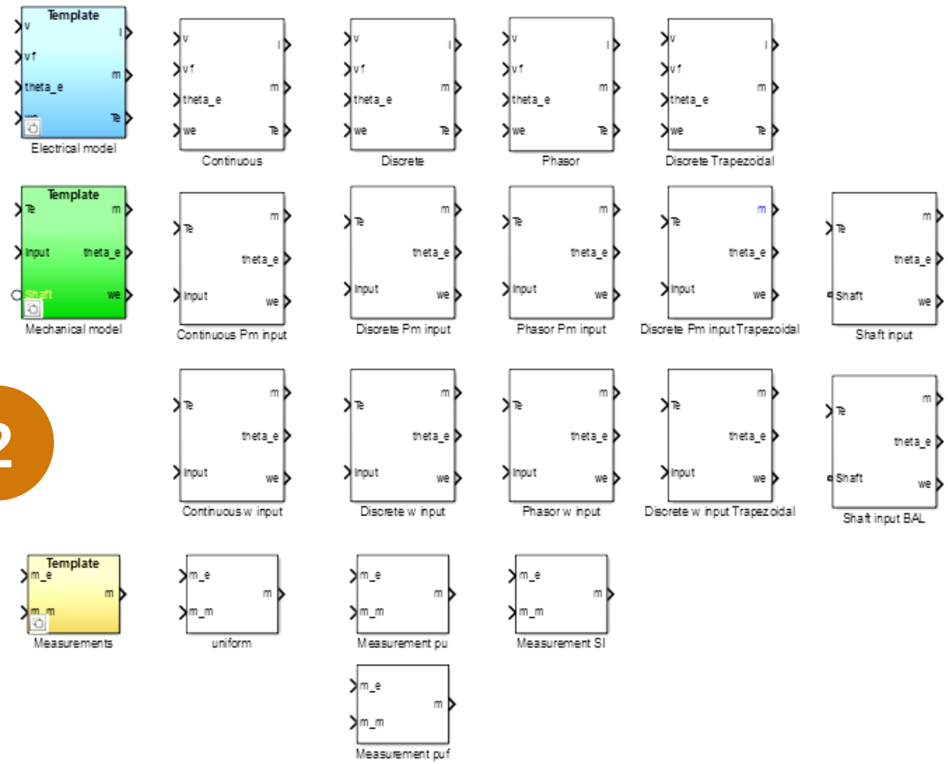


Break the link and save the original block to a user defined library
i.e. mySMBlocks_userDefinedLib

Modifying Specialized Technology library components

Custom synchronous machine example

2

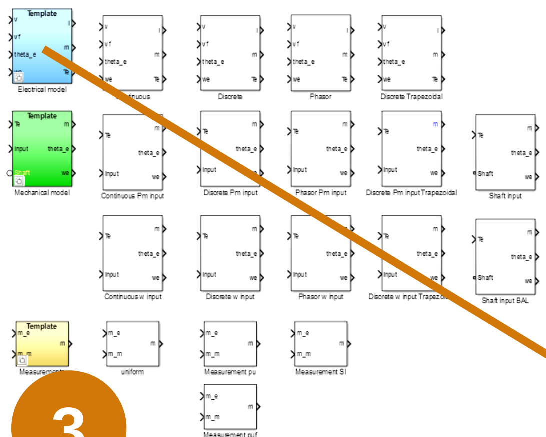


Copy the underlying machine model library to a new user defined library

i.e. spsSynchronousMachineModel → mySMModels_userDefinedLib

Modifying Specialized Technology library components

Custom synchronous machine example



3

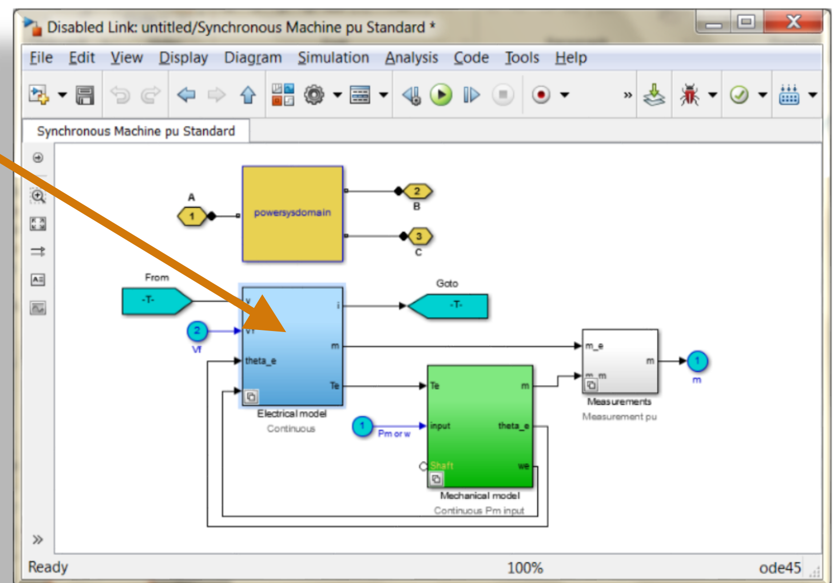
Modify any of the blocks in this new library and update the configurable subsystem template blocks

i.e. mySMModels_userDefinedLib

4

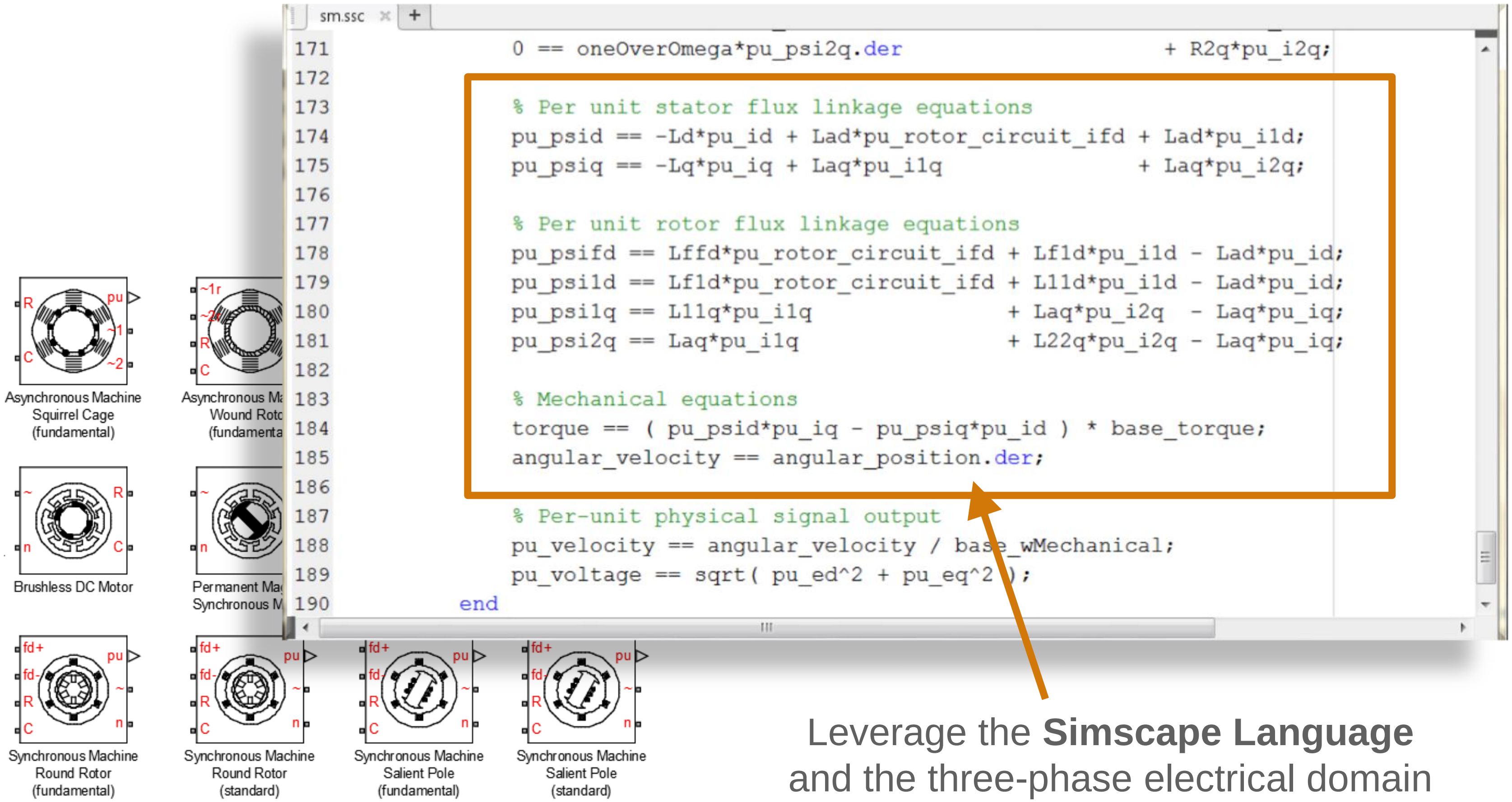
Replace the configurable subsystem templates under the mask of the original block with your modified templates

i.e. mySMBlock



Simscape Language and Simscape Components library

Three-phase electrical domain

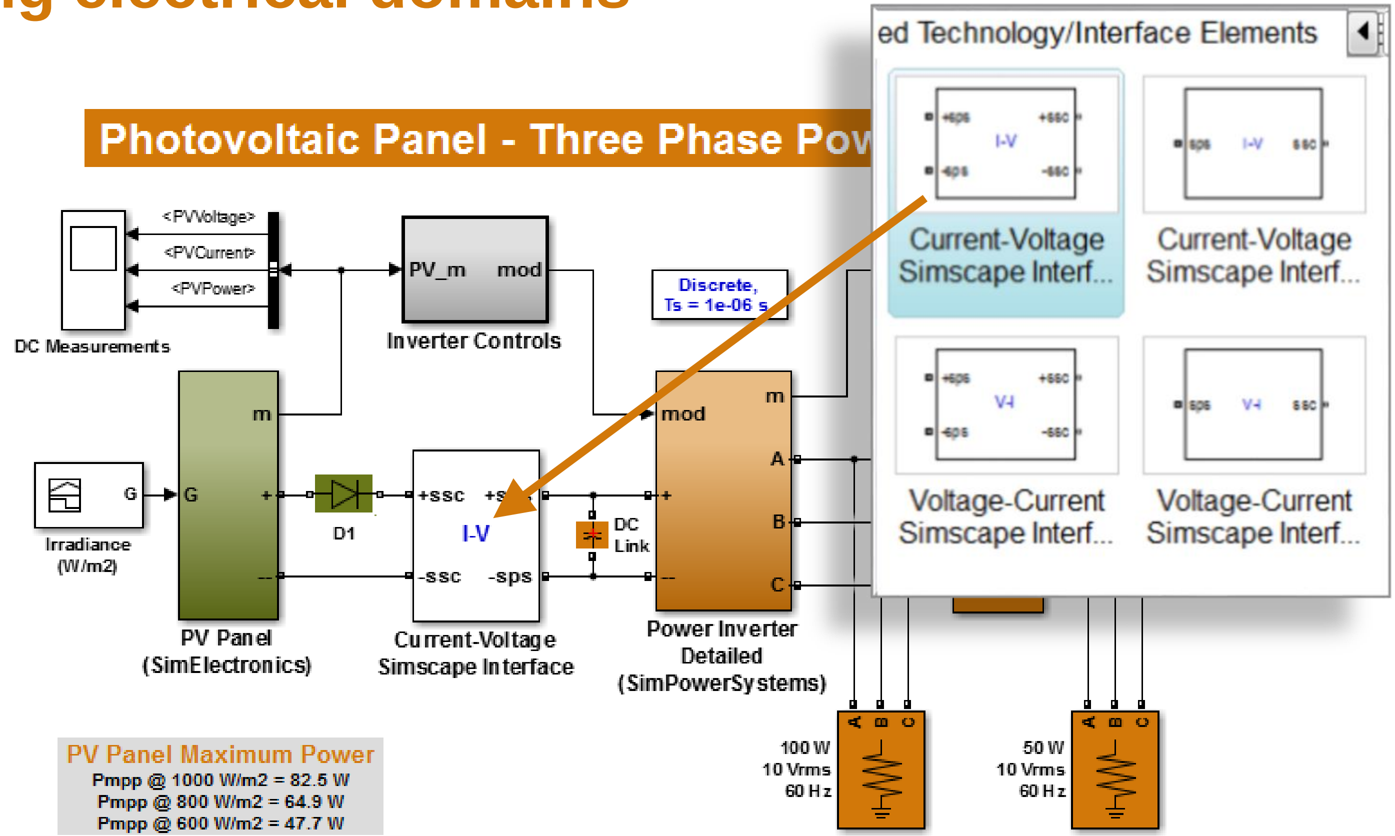


Leverage the **Simscape Language** and the three-phase electrical domain to create custom components

```
>> simscape_custom_generator
```

Simscape and SimPowerSystems interfaces

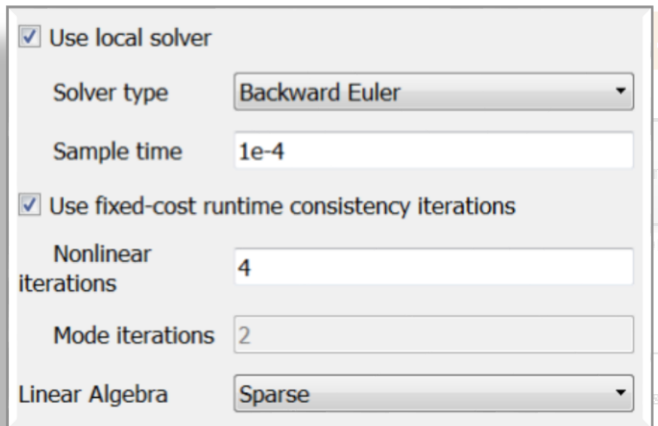
Interfacing electrical domains



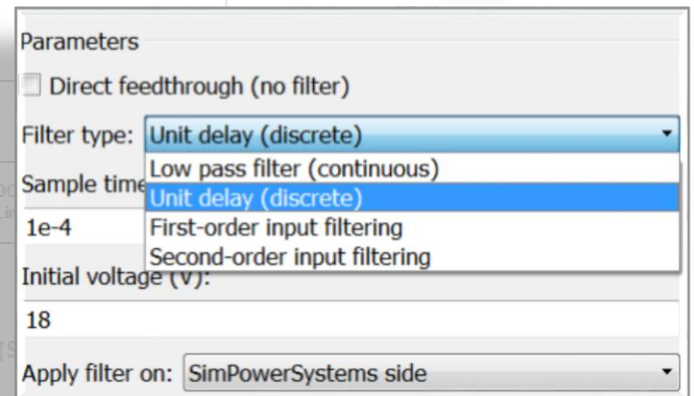

```
>> sps2se_pvinverter_avg
>> sps2se_pvinverter_det
```

Simscape and SimPowerSystems interfaces

Interfacing electrical domains



1. Use the Simscape local solver to simulate slower dynamics



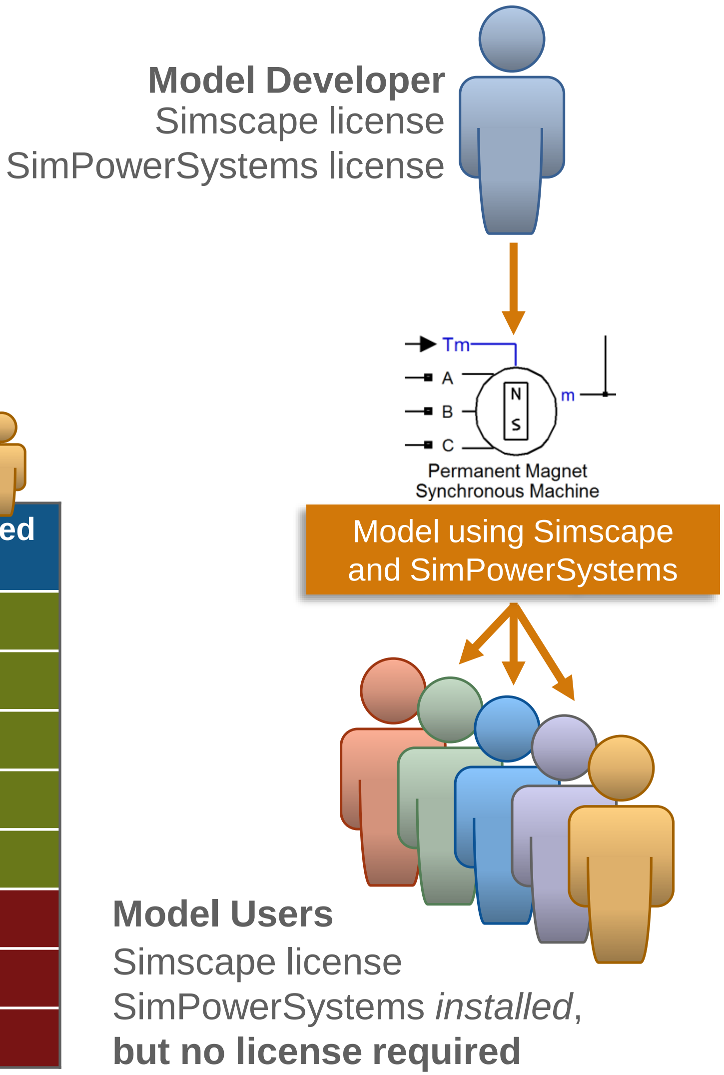
2. Use the appropriate filter in the interface block to break the algebraic loop

```
>> sps2se_pvinverter_avg
>> sps2se_pvinverter_det
```

Model sharing and IP protection
Simscape Editing Mode

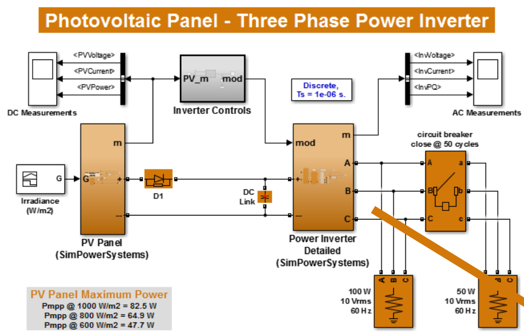
- Share SimPowerSystems models with other Simscape users
- Simulate, analyze and generate code without requiring an extra SimPowerSystems license

Function	Full Mode	Restricted Mode
Add or delete regular Simulink blocks	Yes	Yes
Change Simulink solver, simulate	Yes	Yes
Change numerical parameters	Yes	Yes
Access PowerGUI functions, settings	Yes	Yes
Generate code	Yes	Yes
Add/delete blocks from SimPowerSystems	Yes	No
Make or break physical connections	Yes	No
Change block parameterization options	Yes	No



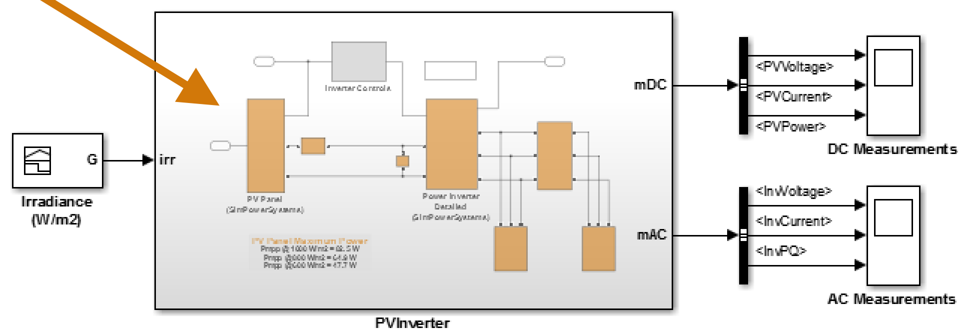
Model sharing and IP protection

Protected model reference



1

Group the part(s) of the model you want to protect in a subsystem – note that only normal Simulink signals can be allowed to cross the subsystem boundaries



PV Panel Maximum Power
Pmpp @ 1000 W/m2 = 82.5 W
Pmpp @ 800 W/m2 = 64.9 W
Pmpp @ 600 W/m2 = 47.7 W

```
>> pvinverter_det_vsub
```

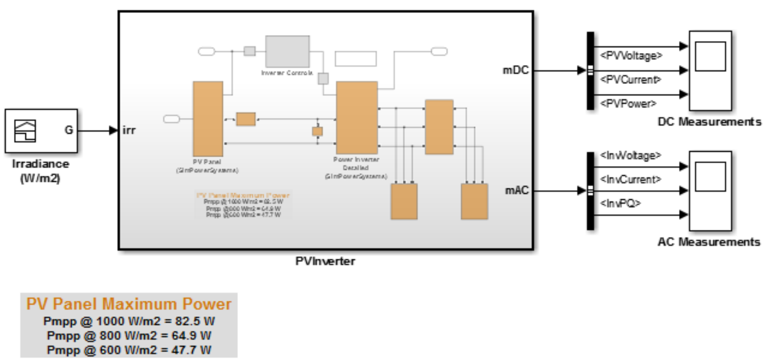
Model sharing and IP protection

Protected model reference

2

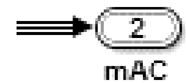
Convert the subsystem to an **Atomic** unit

Block Parameters (Subsystem)



3

Specify the inport/outport signal attributes – data type, port dimensions, sample time, etc. – of the atomic unit explicitly

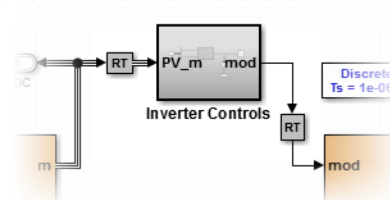


Create the appropriate <bus object> data type for any bus ports

4

Change the solver to ***FixedStepDiscrete***

Add **Rate Transition** blocks where needed



Check the **Inline parameters** option

Configuration Parameters → Optimization → Signals…

```
>> pvinverter_det_asub
```

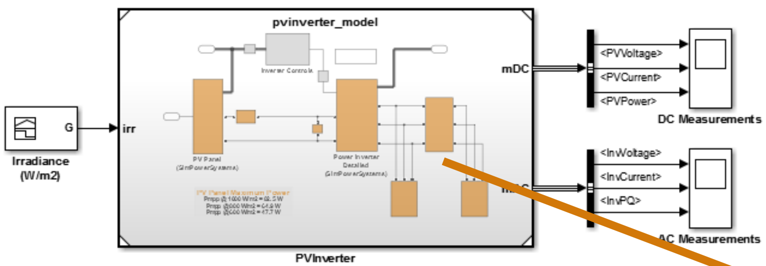
Model sharing and IP protection

Protected model reference

5

Convert the subsystem to a **Reference Model**

Subsystem & Model Reference → Convert Subsystem to…



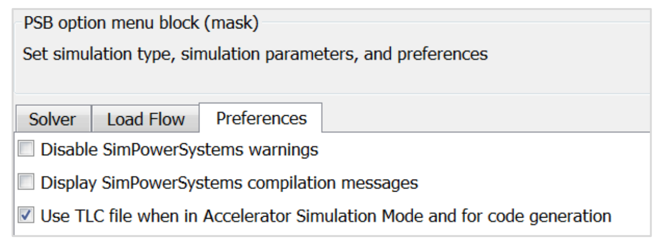
PV Panel Maximum Power
Pmpp @ 1000 W/m2 = 82.5 W
Pmpp @ 800 W/m2 = 64.9 W
Pmpp @ 600 W/m2 = 47.7 W

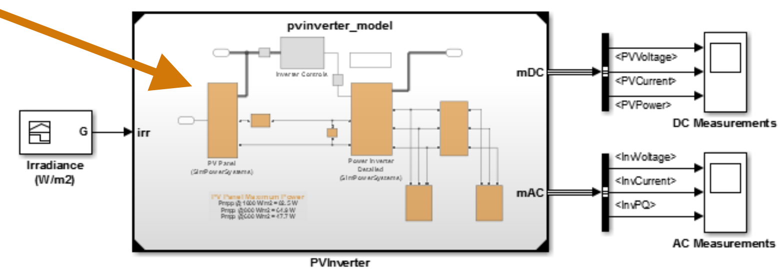
6

Switch the **Simulation Mode** of the referenced model to **Accelerator**

Block Parameters (ModelReference)

On the referenced model **powergui** → **Configure parameters** menu check the **Use TLC file…** option





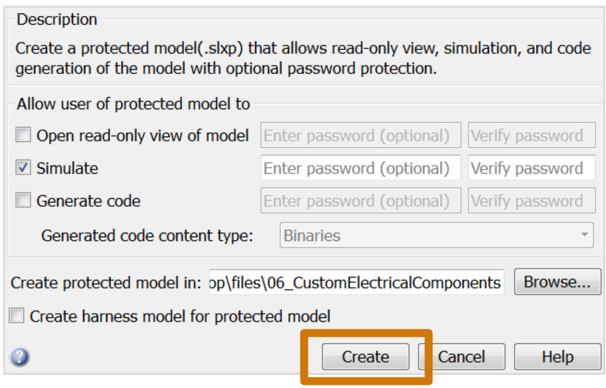

```
>> pvinverter_det_mrefacc
```

Model sharing and IP protection

Protected model reference

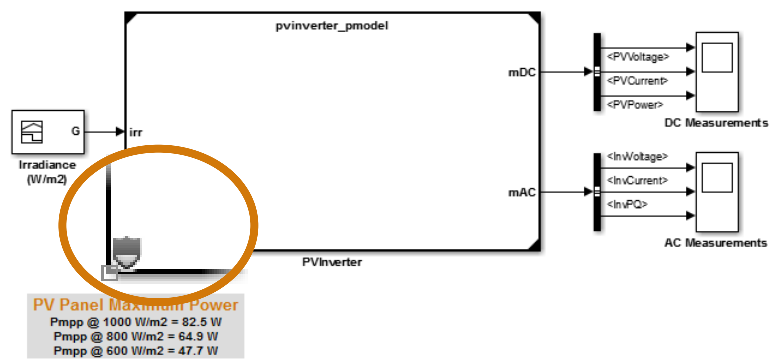
7 Create the **Protected Model**

Subsystem & Model Reference → Create Protected Model …



Photovoltaic Panel - Three Phase Power Inverter

Protected Model Reference




```
>> pvinverter_det_pmref
```