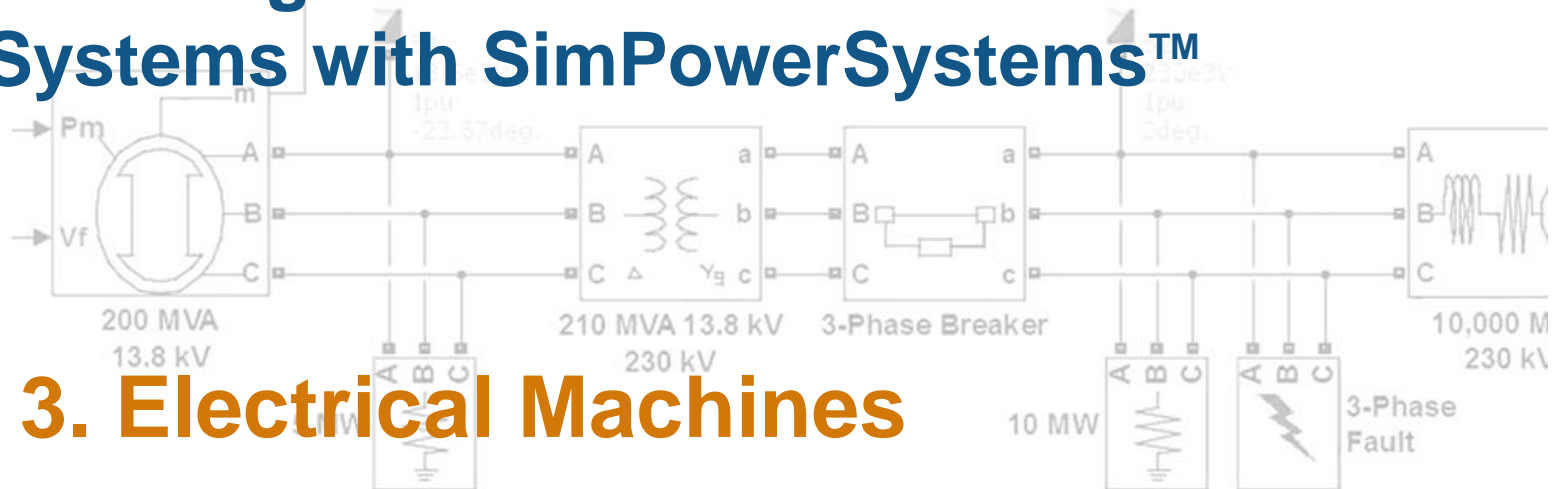


SimPowerSystems Hands-on Workshop: Modeling and Simulation of Electrical Power Systems with SimPowerSystems™

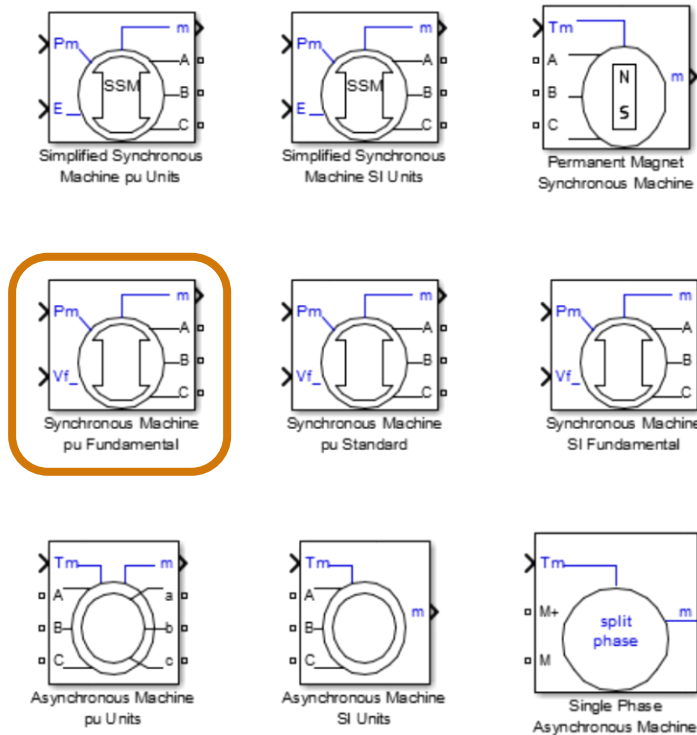


Carlos Osorio
Principal Application Engineer
MathWorks – Natick, MA

Outline

- Machine measurements
- Machine initialization
- Load flow calculation
- Connections to mechanical loads and prime movers

Electrical machines library



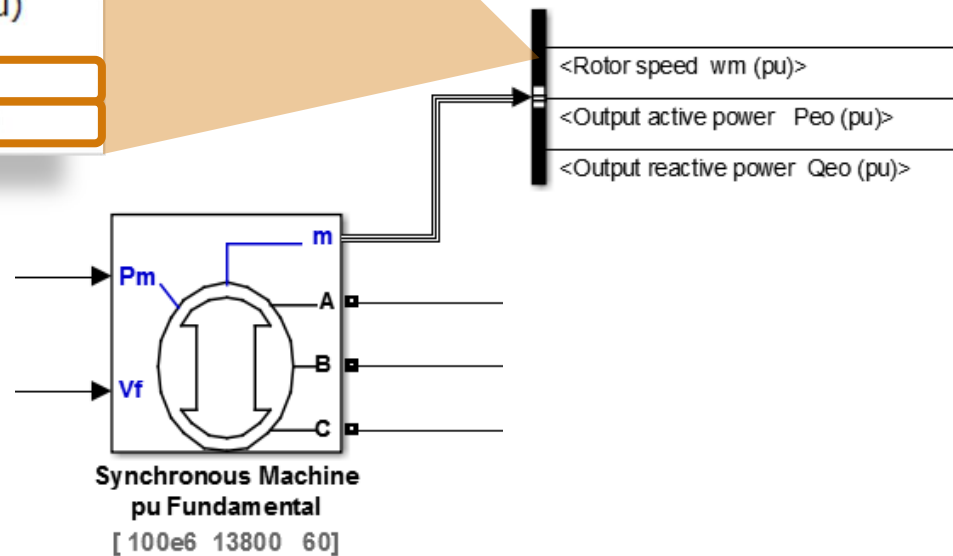
- Synchronous and asynchronous machines
- Detailed and simplified models
- Generator mode or motor mode
- PQ generators or PV generators
- SI units or per unit system

Machine measurements

Signals in the bus

- ▷ Stator current
- ▷ dq0 components
- ▾ Mechanical
 - Rotor angle deviation δ theta (rad)
 - Rotor speed ω_m (pu)
 - Electrical power P_e (pu)
 - Rotor speed deviation $d\omega$ (pu)
 - Rotor mechanical angle theta (deg)
 - Electromagnetic torque T_e (pu)
 - Load angle δ (deg)
- Output active power P_{eo} (pu)
- Output reactive power Q_{eo} (pu)

Internal machine quantities are output as a Simulink bus signal

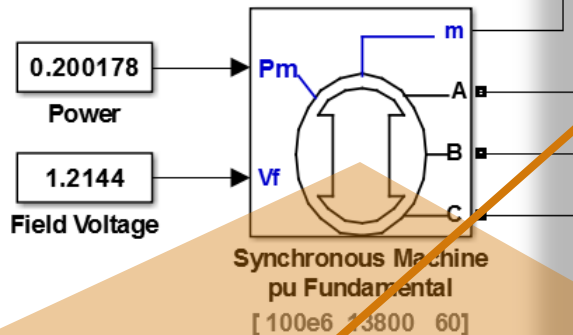


```
>> single_generator_init
```

Machine initialization

powergui

Machine Initialization



Machines info:

```
Machine: Synchronous Machine pu Fundamental
Nominal: 100 MVA 13.8 kV rms
Bus Type: Swing generator
Uan phase: -0.00°
Uab: 13800 Vrms [1 pu] 30.00°
Ubc: 13800 Vrms [1 pu] -90.00°
Uca: 13800 Vrms [1 pu] 150.00°
Ia: 1045.9 Arms [0.25 pu] -36.87°
Ib: 1045.9 Arms [0.25 pu] -156.87°
Ic: 1045.9 Arms [0.25 pu] 83.13°
P: 2e+07 W [0.2 pu]
Q: 1.5e+07 Vars [0.15 pu]
Pmec: 2.0019e+07 W [0.2002 pu]
Torque: 1.062e+05 N.m [0.2002 pu]
Vf: 1.2144 pu
```

Machine
information

Machine list:

Synchronous Machine pu Fundamen

Bus type:

Swing bus

Terminal voltage UAB (Vrms):

13800

Active power guess (Watts):

20000

Reactive power (Vars):

X

Phase of UAN voltage (deg):

0

Machine initialization frequency (Hz):

60

Initial condition:

Auto

Update

Compute and Apply

Close

Machine
settings

Initialize
machine

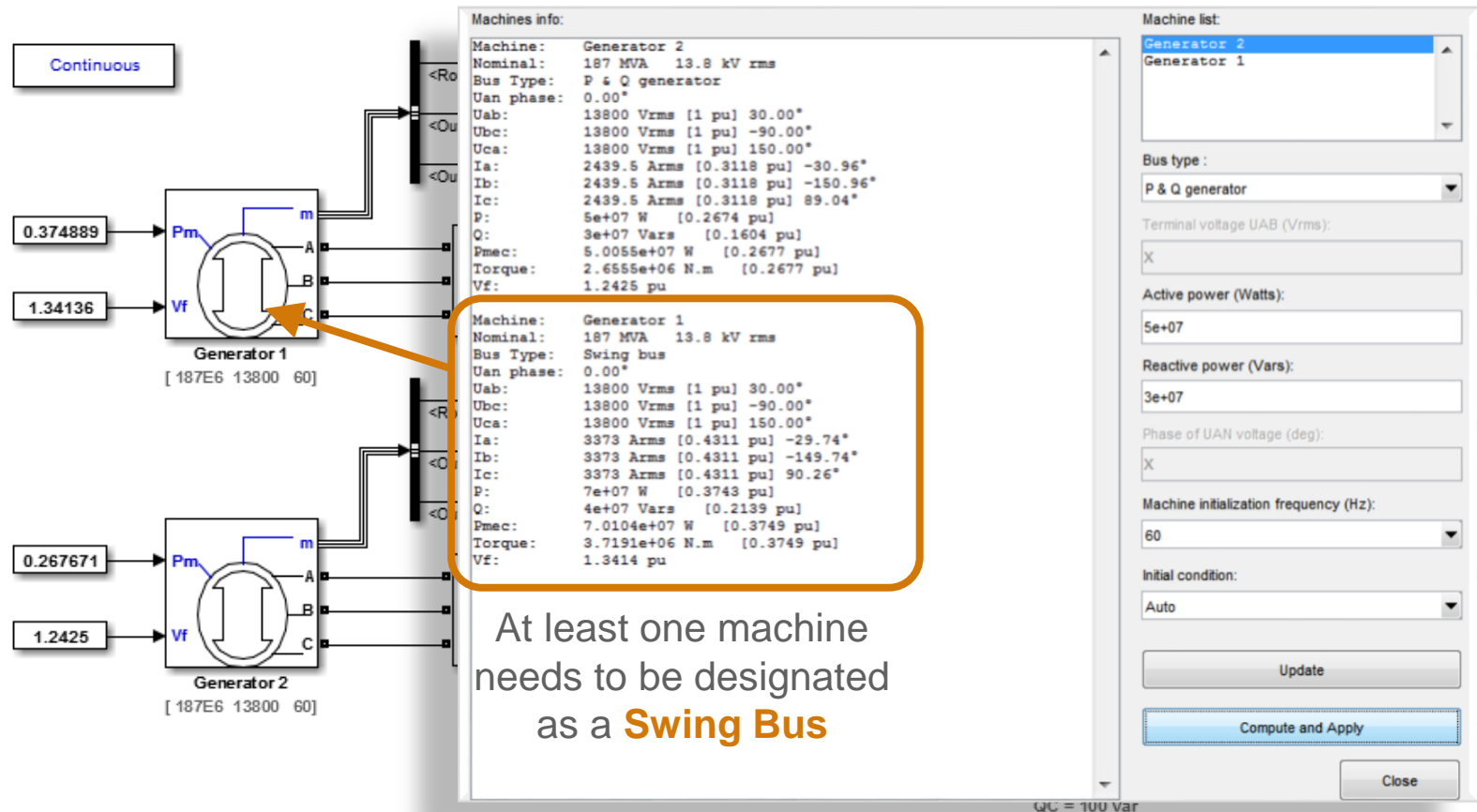
Initial conditions [dw(%) th(deg) ia,ib,ic(pu) pha,phb,phc(deg) Vf(pu)]:

[0 -84.9674 0.25 0.25 0.25 -36.8699 -156.87 83.1301 1.2144]

```
>> single_generator_initFinish
```

Machine initialization

Multiple machines



Continuous

0.374889

1.34136

Generator 1
[187E6 13800 60]

0.267671

1.2425

Generator 2
[187E6 13800 60]

Machines info:

Machine: Generator 2
Nominal: 187 MVA 13.8 kV rms
Bus Type: P & Q generator
Uan phase: 0.00°
Uab: 13800 Vrms [1 pu] 30.00°
Ubc: 13800 Vrms [1 pu] -90.00°
Uca: 13800 Vrms [1 pu] 150.00°
Ia: 2439.5 Arms [0.3118 pu] -30.96°
Ib: 2439.5 Arms [0.3118 pu] -150.96°
Ic: 2439.5 Arms [0.3118 pu] 89.04°
P: 5e+07 W [0.2674 pu]
Q: 3e+07 Vars [0.1604 pu]
Pmec: 5.0055e+07 W [0.2677 pu]
Torque: 2.6555e+06 N.m [0.2677 pu]
Vf: 1.2425 pu

Machine: Generator 1
Nominal: 187 MVA 13.8 kV rms
Bus Type: Swing bus
Uan phase: 0.00°
Uab: 13800 Vrms [1 pu] 30.00°
Ubc: 13800 Vrms [1 pu] -90.00°
Uca: 13800 Vrms [1 pu] 150.00°
Ia: 3373 Arms [0.4311 pu] -29.74°
Ib: 3373 Arms [0.4311 pu] -149.74°
Ic: 3373 Arms [0.4311 pu] 90.26°
P: 7e+07 W [0.3743 pu]
Q: 4e+07 Vars [0.2139 pu]
Pmec: 7.0104e+07 W [0.3749 pu]
Torque: 3.7191e+06 N.m [0.3749 pu]
Vf: 1.3414 pu

Machine list:
Generator 2
Generator 1

Bus type:
P & Q generator

Terminal voltage UAB (Vrms):
X

Active power (Watts):
5e+07

Reactive power (Vars):
3e+07

Phase of UAN voltage (deg):
X

Machine initialization frequency (Hz):
60

Initial condition:
Auto

Update

Compute and Apply

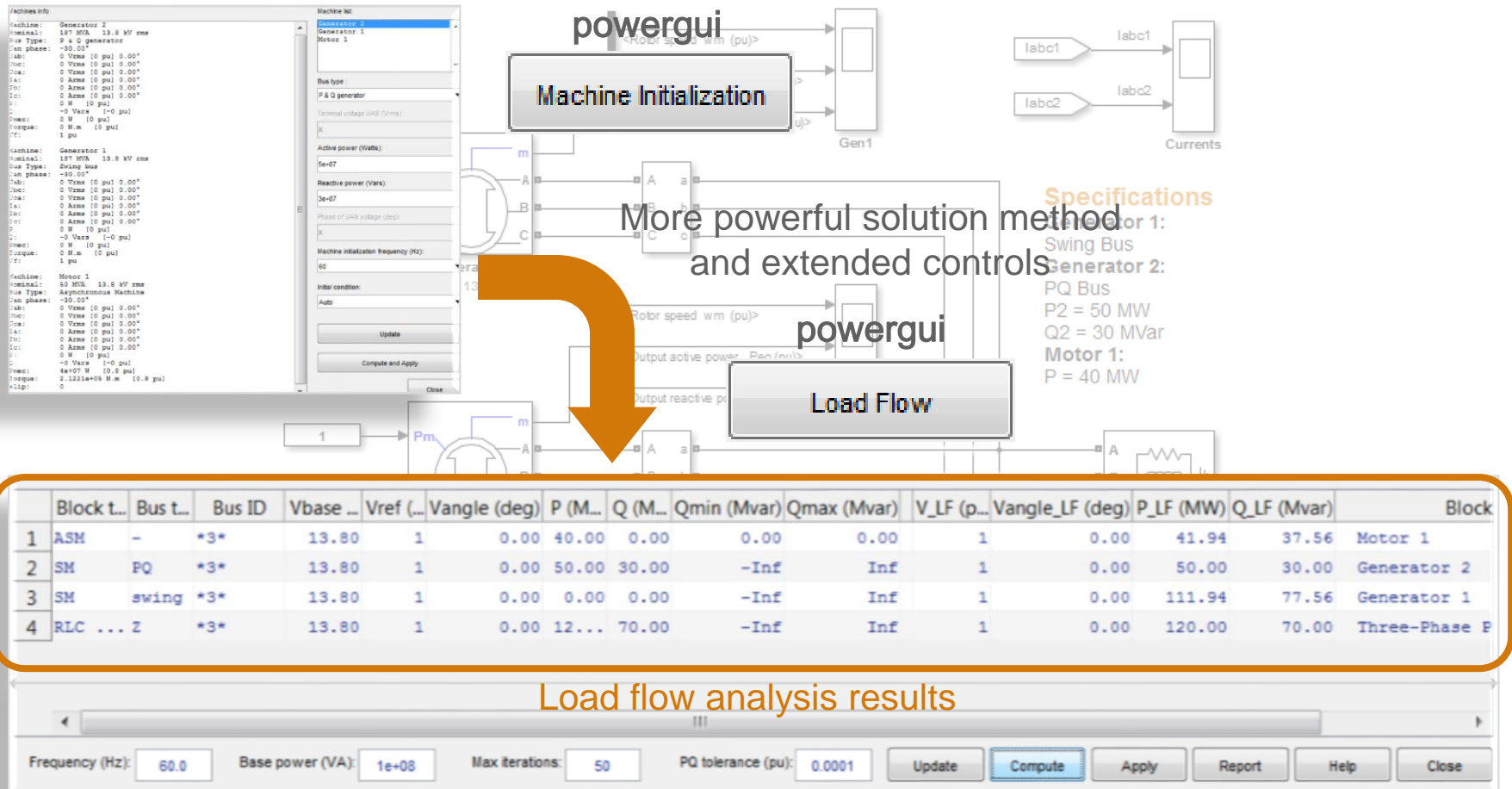
Close

QC = 100 var

At least one machine needs to be designated as a **Swing Bus**

```
>> two_generators_initFinish
```

Load flow calculation



Specifications

Generator 1:
Swing Bus
PQ Bus
P2 = 50 MW
Q2 = 30 MVar

Generator 2:
PQ Bus
P2 = 50 MW
Q2 = 30 MVar

Motor 1:
P = 40 MW

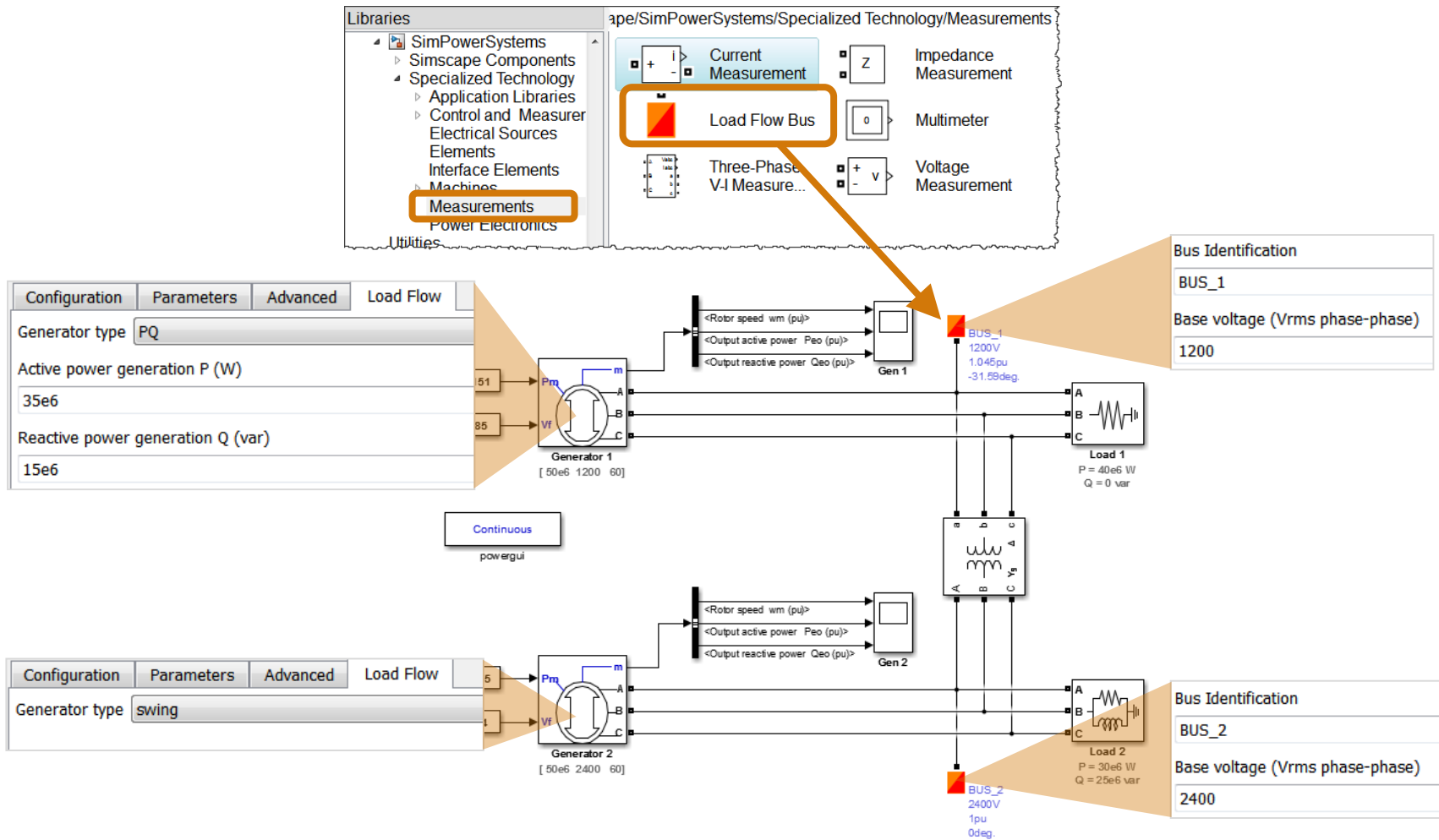
Block	t...	Bus t...	Bus ID	Vbase ...	Vref (...)	Vangle (deg)	P (M...	Q (M...	Qmin (Mvar)	Qmax (Mvar)	V_LF (p...	Vangle_LF (deg)	P_LF (MW)	Q_LF (Mvar)	Block
1	ASM	-	*3*	13.80	1	0.00	40.00	0.00	0.00	0.00	1	0.00	41.94	37.56	Motor 1
2	SM	PQ	*3*	13.80	1	0.00	50.00	30.00	-Inf	Inf	1	0.00	50.00	30.00	Generator 2
3	SM	swing	*3*	13.80	1	0.00	0.00	0.00	-Inf	Inf	1	0.00	111.94	77.56	Generator 1
4	RLC ... 2		*3*	13.80	1	0.00	12...	70.00	-Inf	Inf	1	0.00	120.00	70.00	Three-Phase P

Load flow analysis results

Frequency (Hz): 60.0 Base power (VA): 1e+08 Max iterations: 50 PQ tolerance (pu): 0.0001 Update Compute Apply Report Help Close

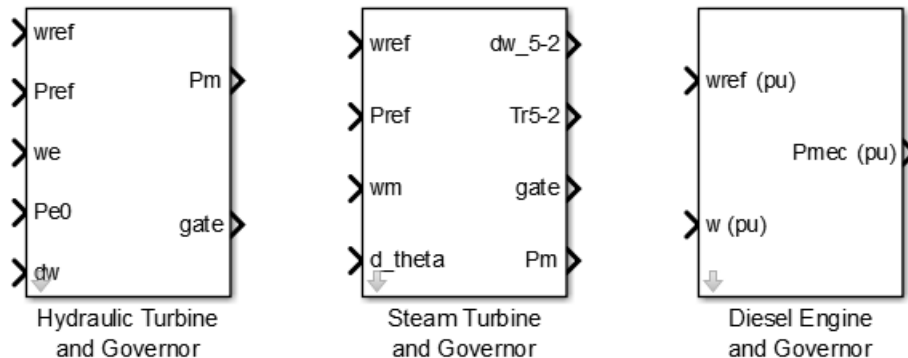
```
>> two_generators_motor
```


Load flow calculation

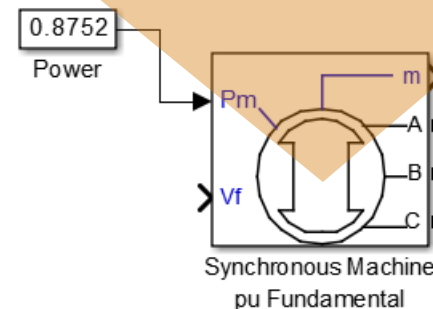
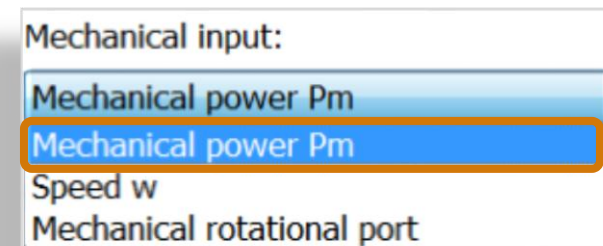


```
>> two_generators_loadFlowFinish
```

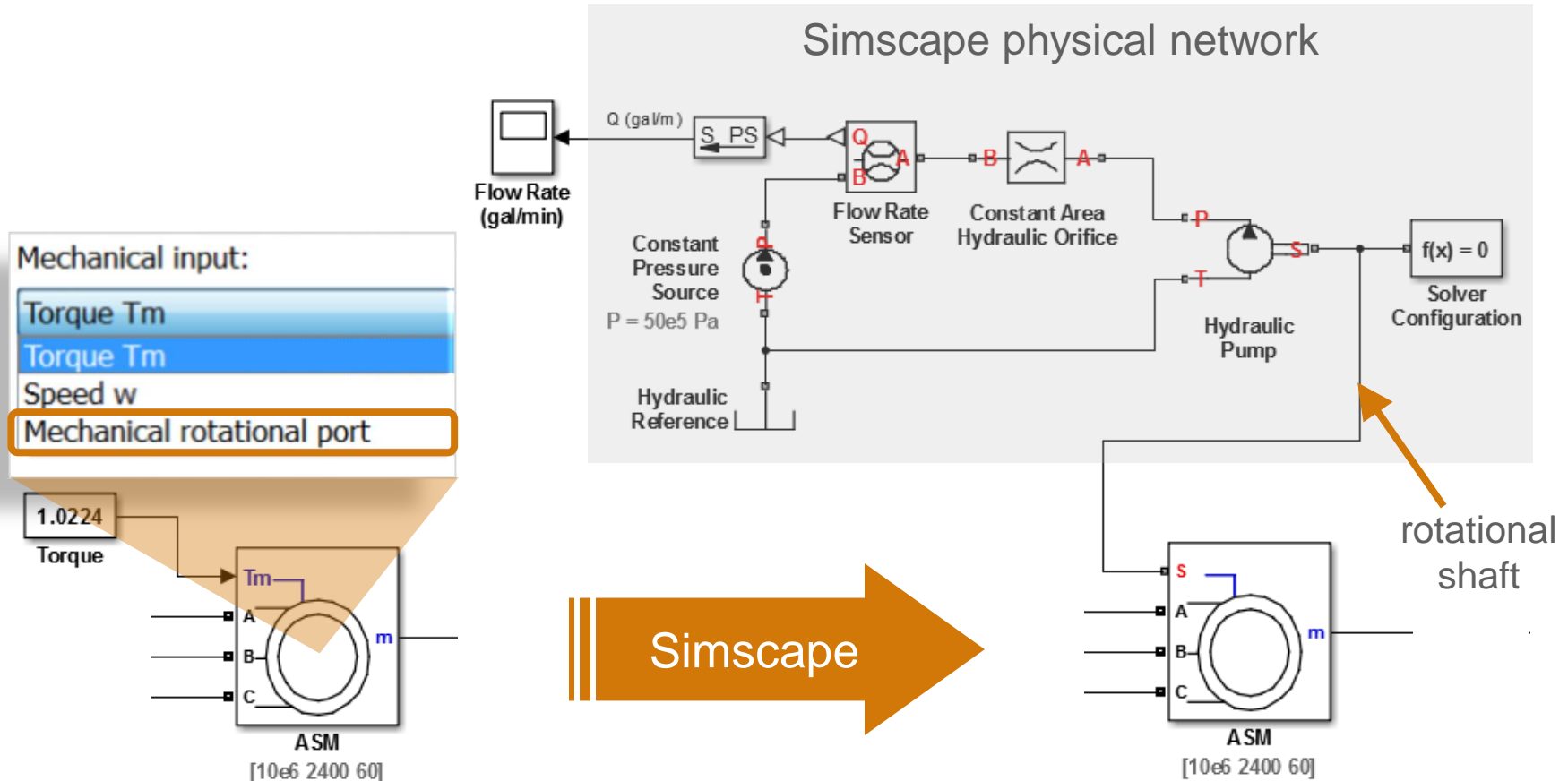

Connections to mechanical loads and prime movers



Direct connections to mechanical power sources – for generators – and loads – for motors – using standard Simulink signals



Connections to mechanical loads and prime movers



```
>> motor_simscapepump
```

