Fundamental about the initialisation of a dynamic simulation for power system

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When simulating a power system, it is always important to start from a steady operating point.

The steady state operating points of the power flow in the grid is calculated by a specific algorithm called “Load flow” or “Powerflow”

From this steady state calculation all the states in the grid (power system + control) have to be initialized

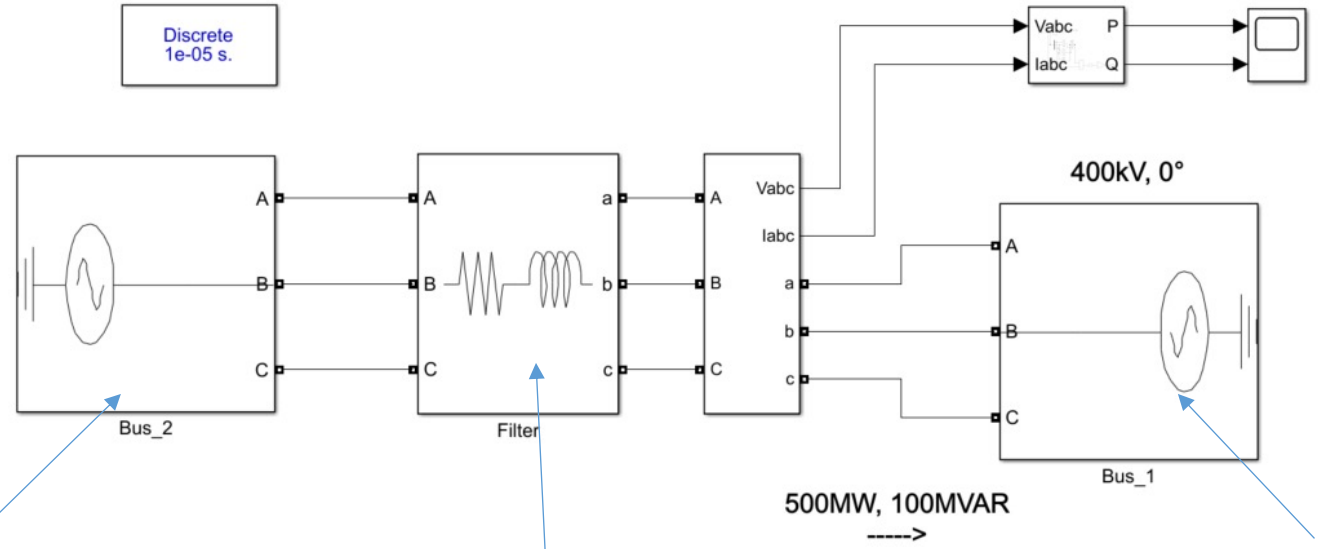
The aim of this tutorial is to explain how to initialize a dynamic simulation from the results obtained with the Powerflow

This tutorial is applied to Matlab Simulink – Simpower system but the principle can be applied to any kind of software dedicated to power system.

Prerequisite :

Some notion about per unit system
knowledge about Simpower system
Load flow

Step 1 : Basics about initialization

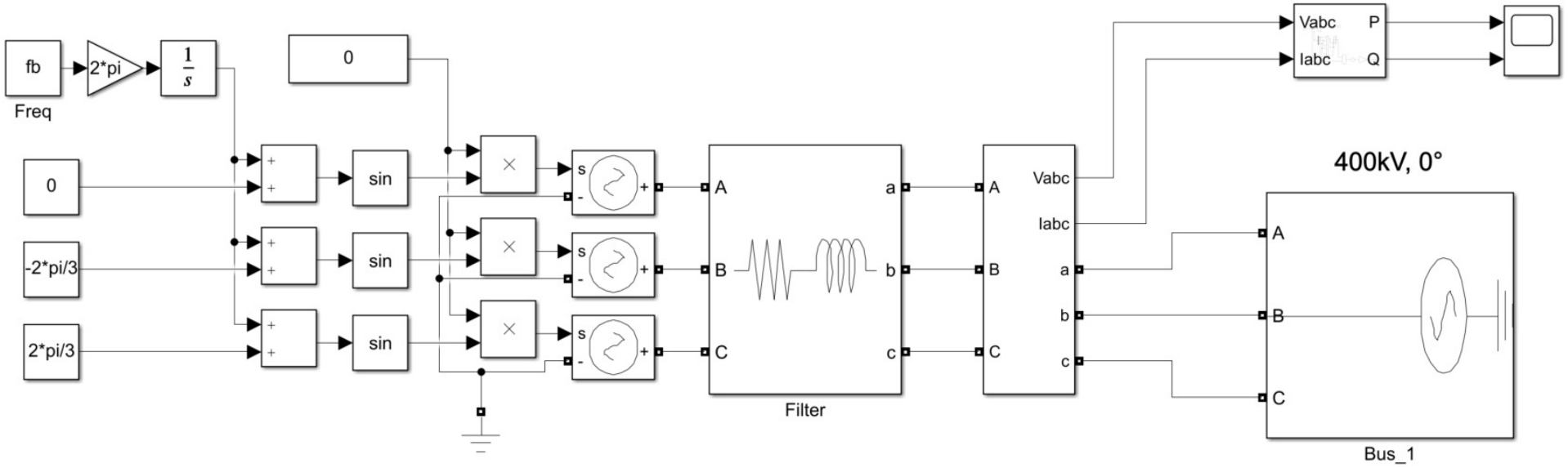


Base Per unit

Sb = 1 GW
Ub = 400 kV
Fb = 50 Hz

Compute the magnitude and the phase of Vm (Vm_RMS,Theta0) in order to obtain a 500 MW and 100 MVAR power exchange from Vm to V1

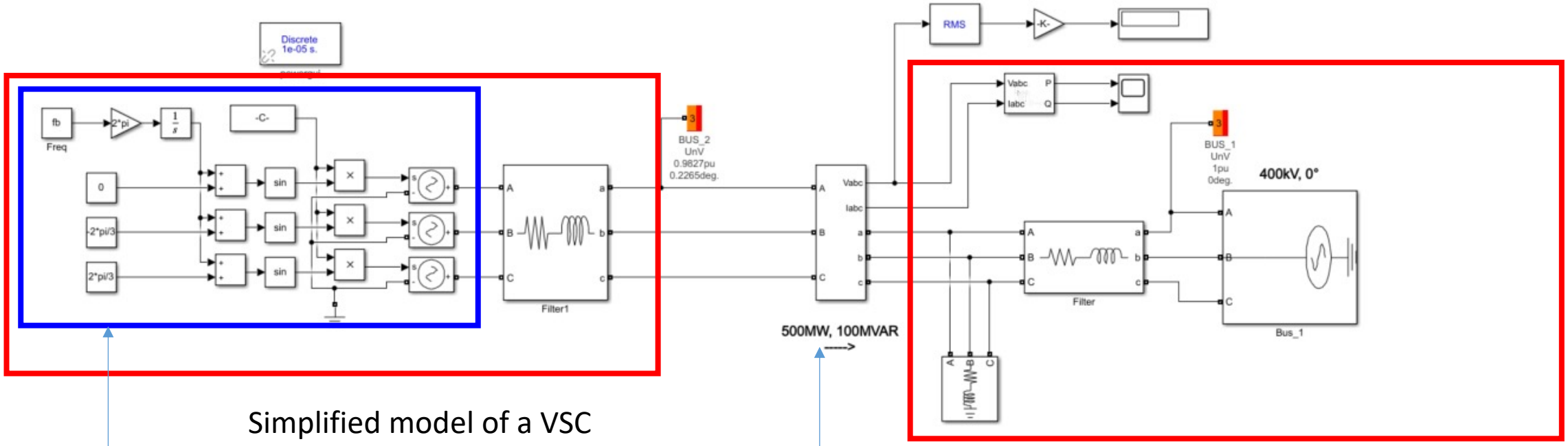
Step 2 : Controlable voltage source



The voltage source source (Vm) is replaced by a controllable voltage source

Update the parameters of these blocks to obtain the same power exchange

Step 3 : Link between the load flow and the initalization of the voltage source



Simplified model of a VSC

Variable voltage source Vm

Point of common coupling of the VSC to a power network

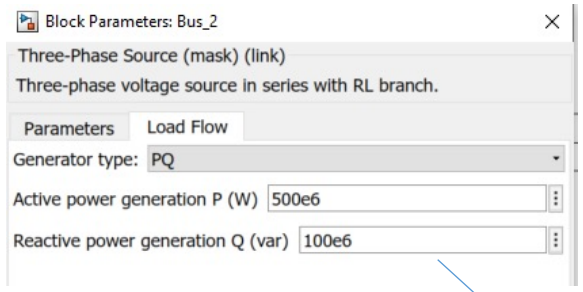
Example of an elementary network

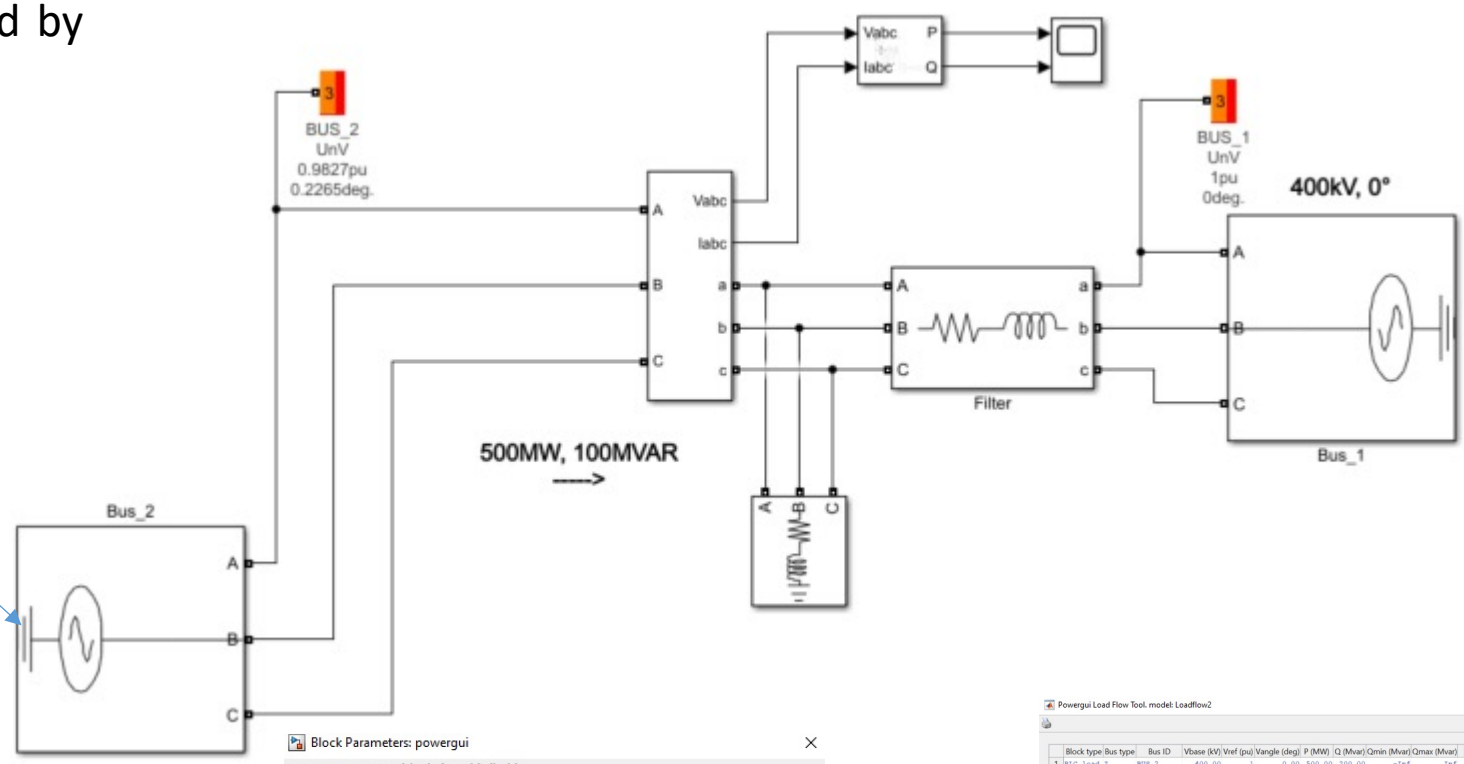
The loadflow calculates the different electrical variable in the power system

From the information calculated by the loadflow it is asked to initialize the variable voltage source Vm

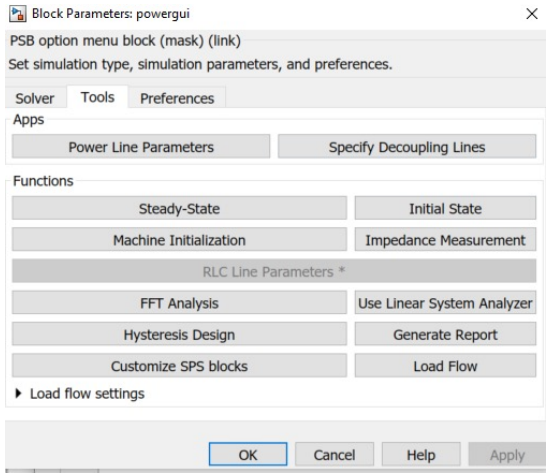
Step 3 : Link between the load flow and the initalization of the voltage source

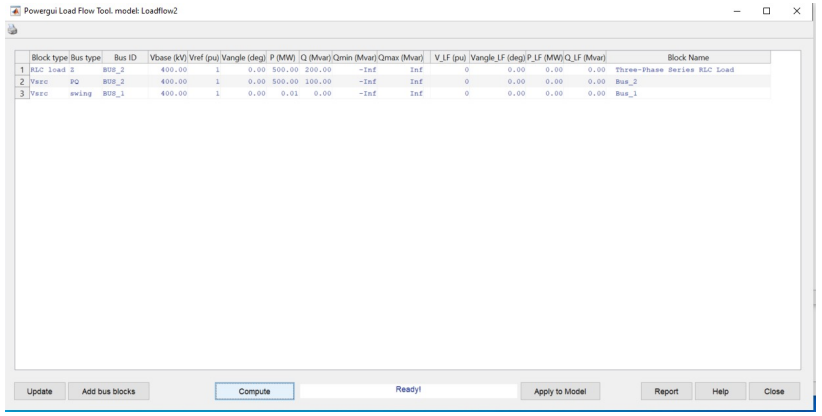
The VSC model is replaced by an ideal voltage source



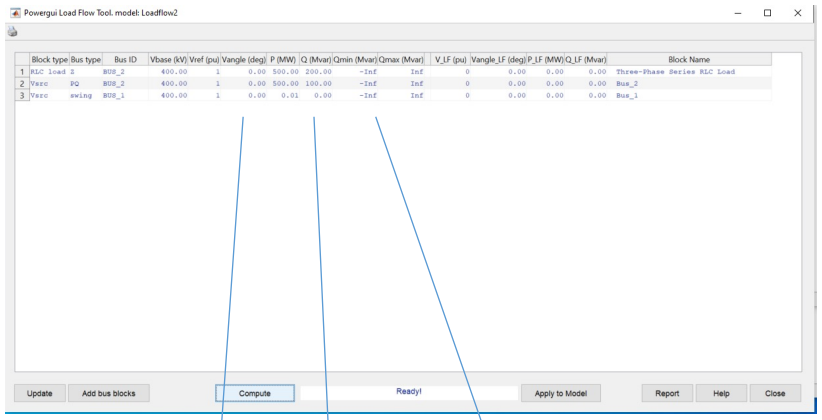


Run the load flow from the Simulink windows.



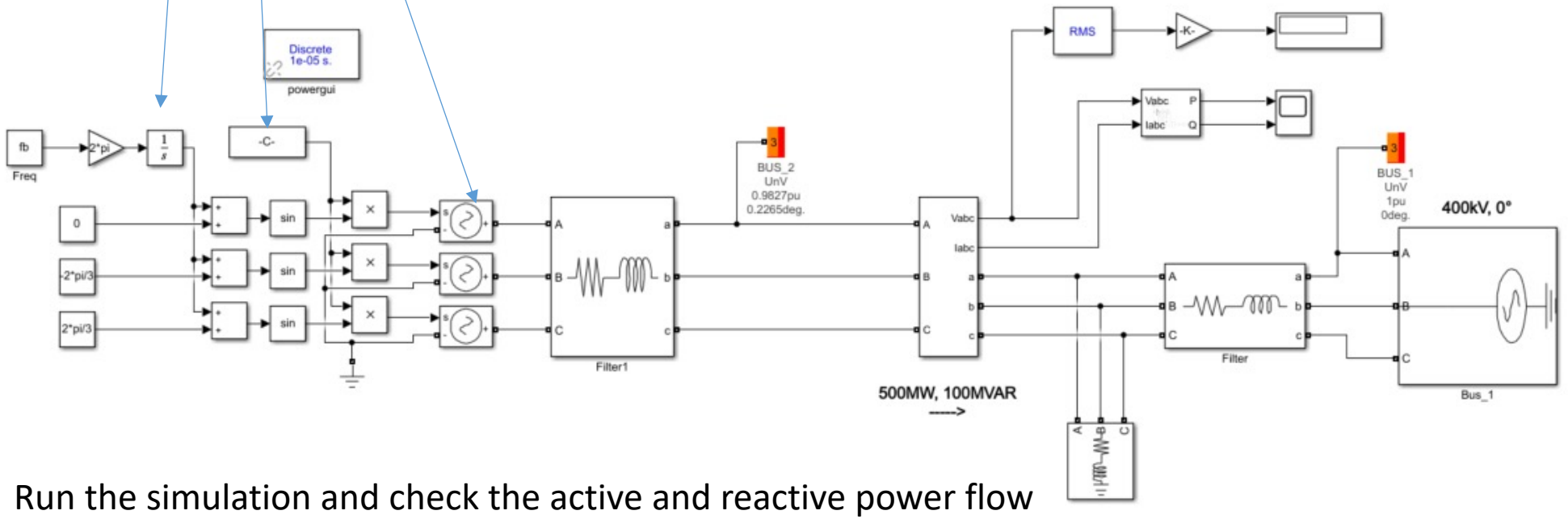


Step 3 : Link between the load flow and the initalization of the voltage source



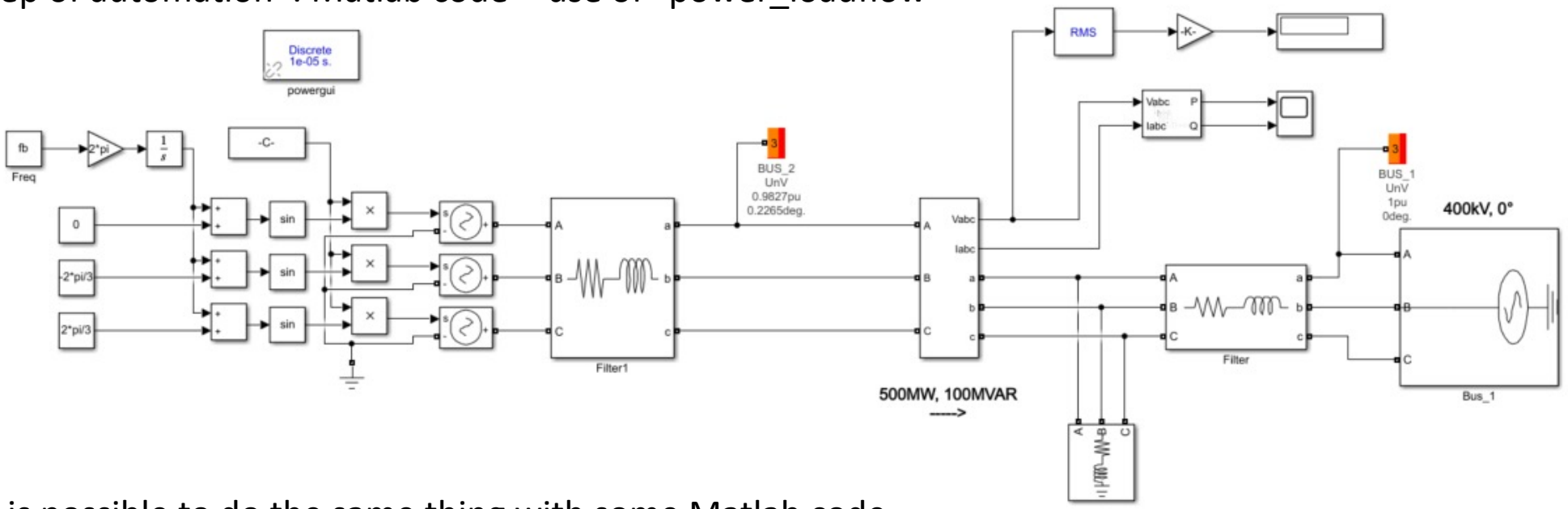
Update then Compute

From the load flow computation, it is possible
To initialize the variable voltage source



Run the simulation and check the active and reactive power flow

First step of automation : Matlab code - use of “power_loadflow”



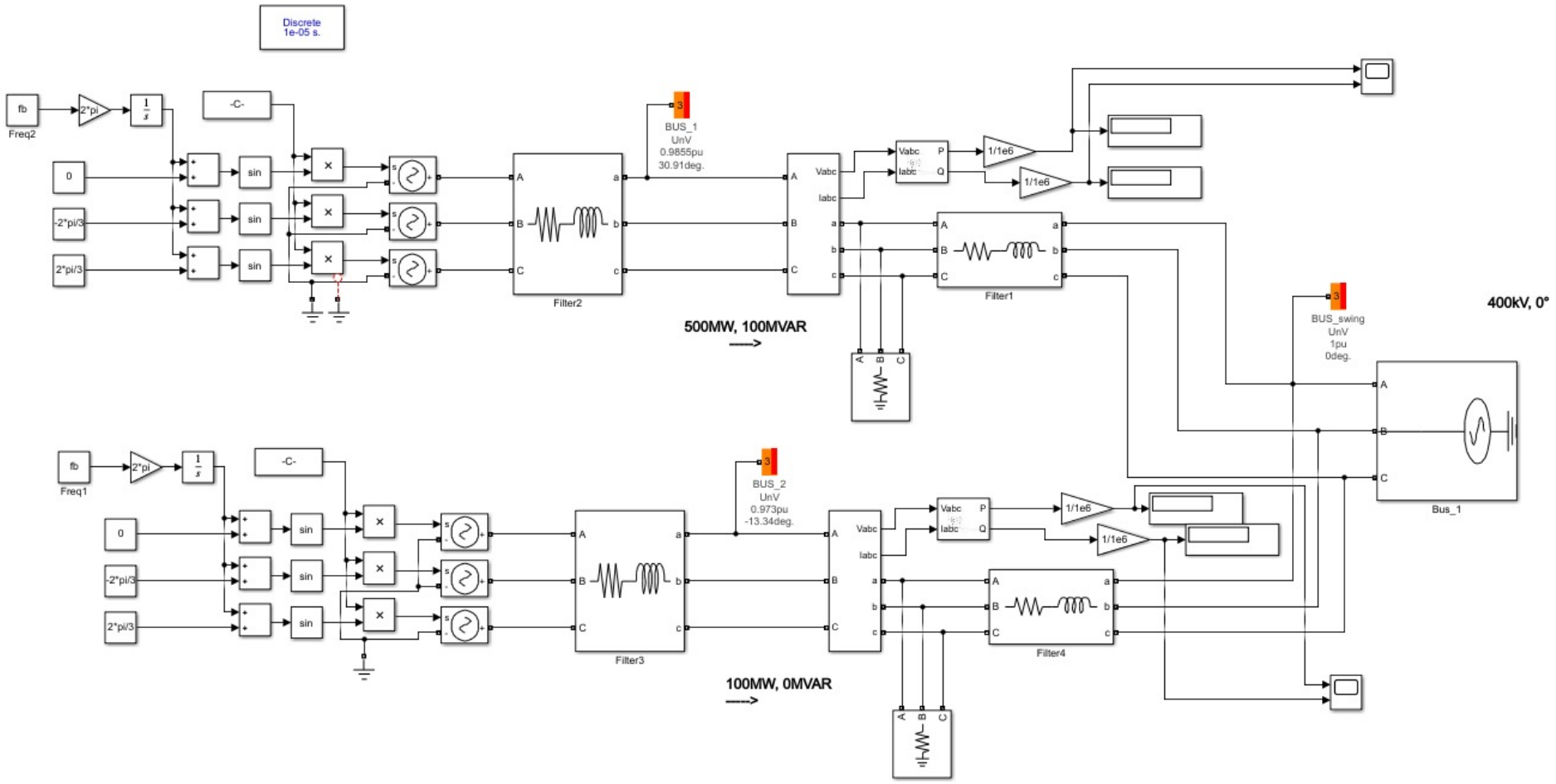
It is possible to do the same thing with some Matlab code

LF = power_loadflow('-v2’,name of the file','solve’);

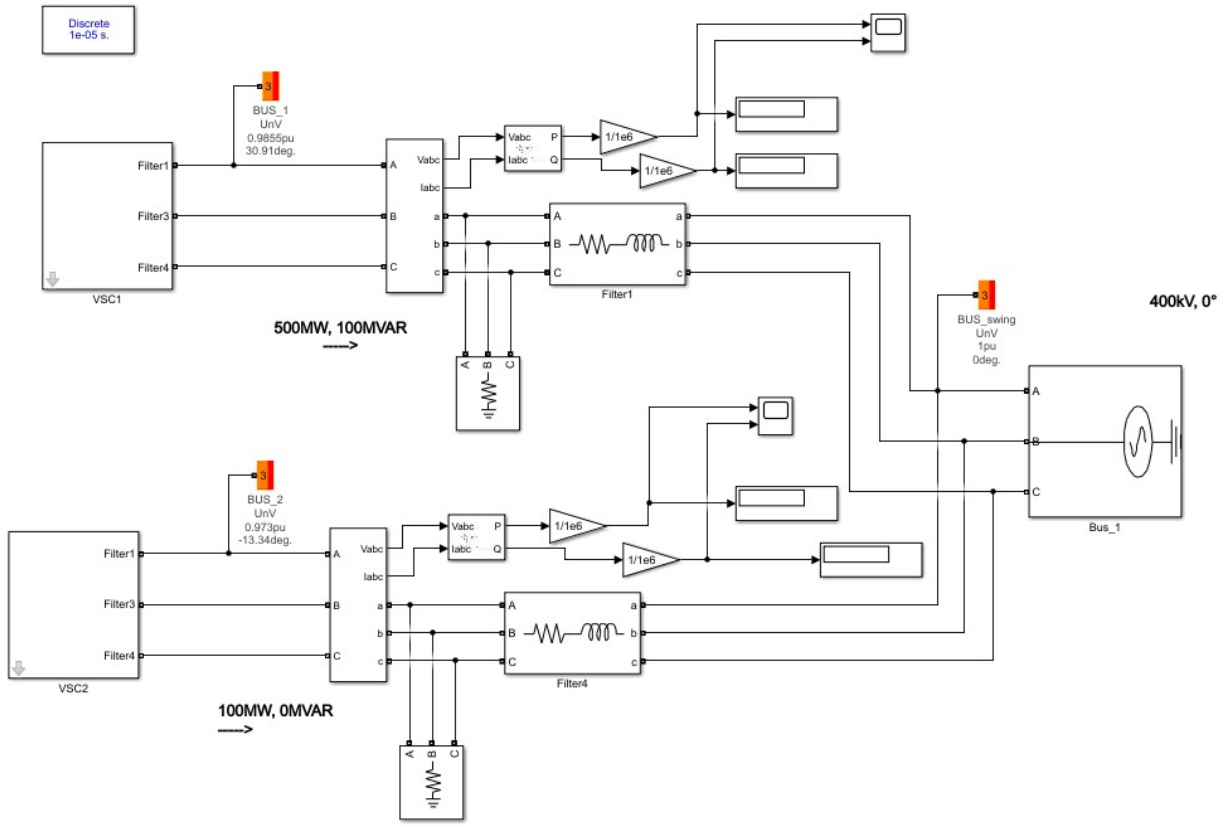
The results are saved in a structure LF

The key information is stored in the variable LF.bus(1).Vbus

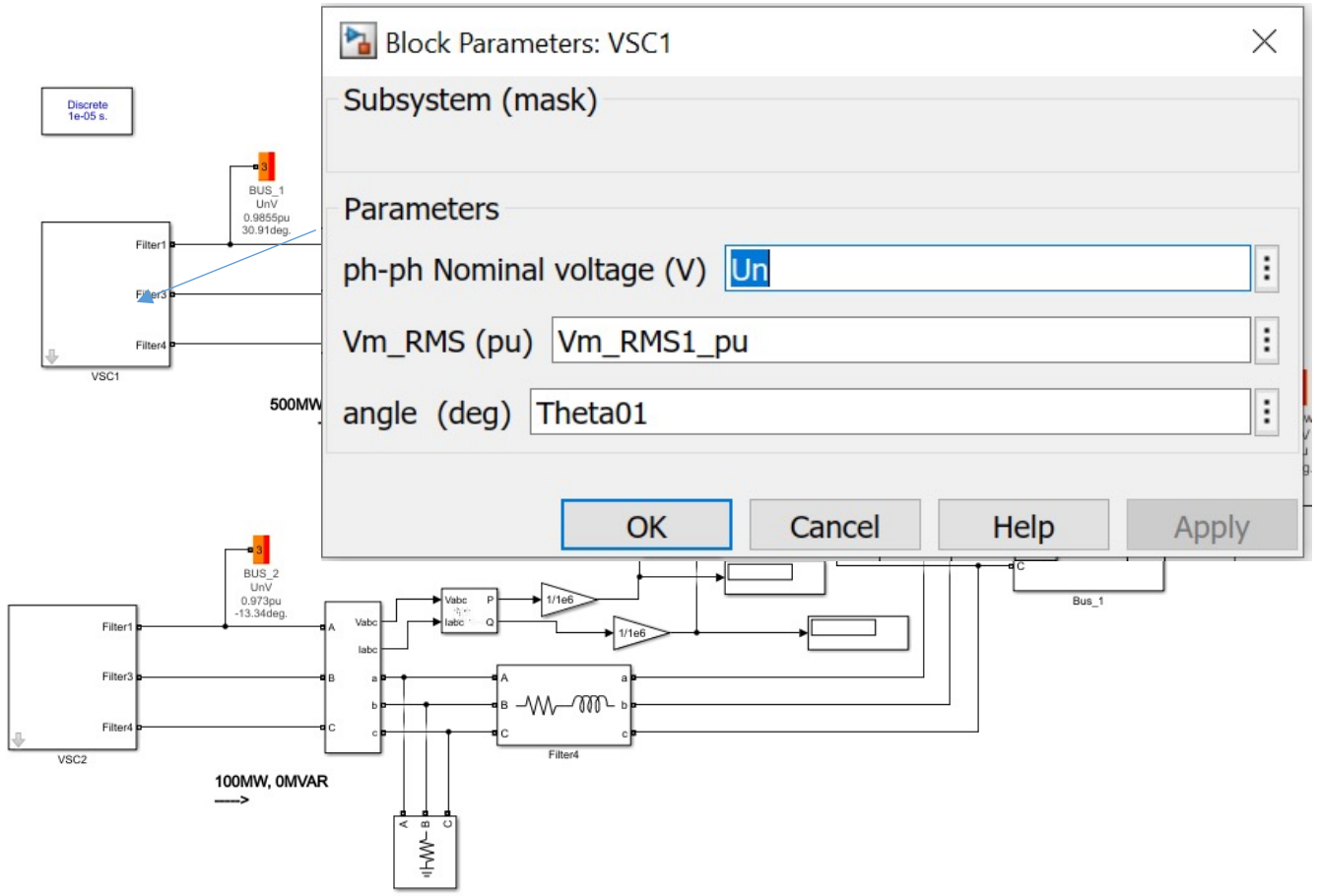
Build a small script in order to automate the previous process



Use the same kind of method as previously to initialize this grid with two power sources – Different values for the power exchange

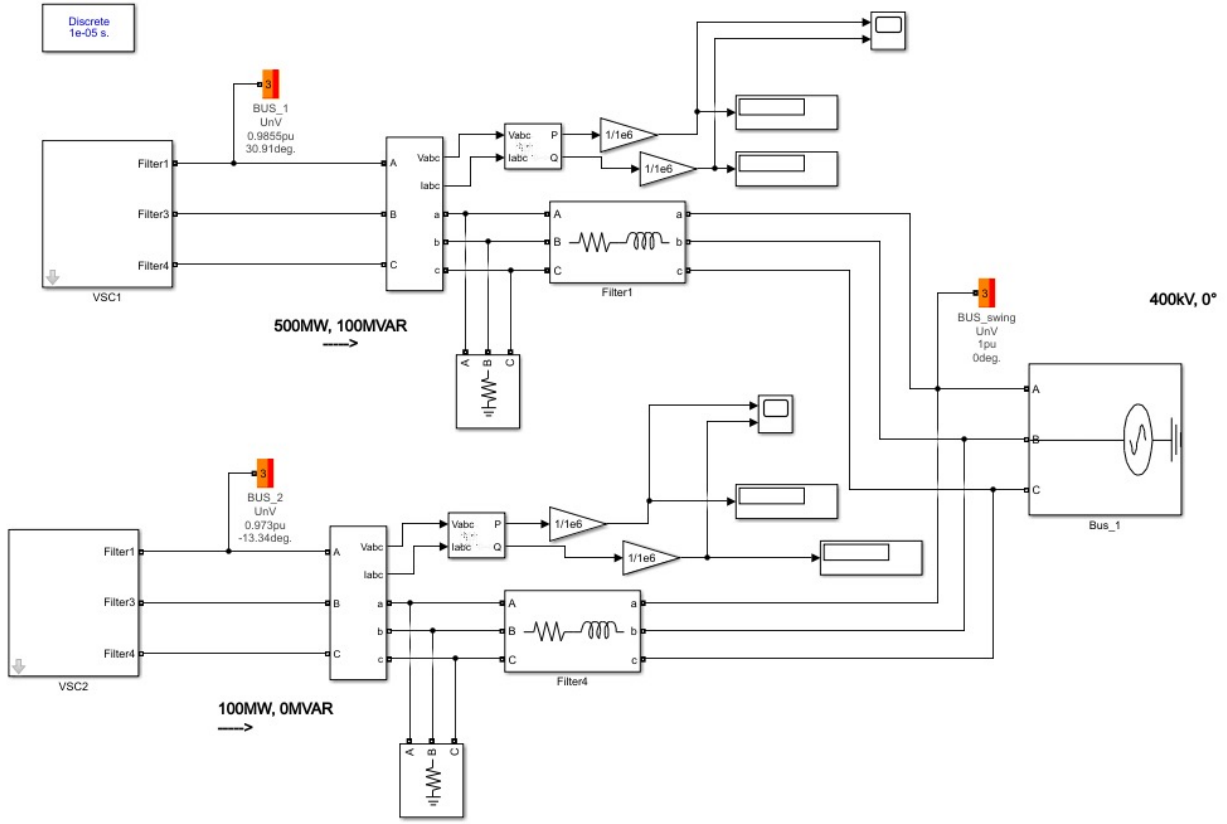


It is possible to group the different elements which are included in the voltage source model
Then, it is possible to mask this group and define the main parameters of this mask
Look to the way to parametrize this mask : Ctrl + M then “Parameters and Dialogue” + Initialization



The calculation of the Voltages (magnitude and phase) is done in per unit

Modify the mask in order to use only perunit values for the RMS value of the voltage



VSC2 is supposed now to be a PV node : P = 100 MW V = 1.02 pu

Find the solution to initialize the simulation with these new parameters

Step 6 : Automation of the link between power flow and the voltage source initialization

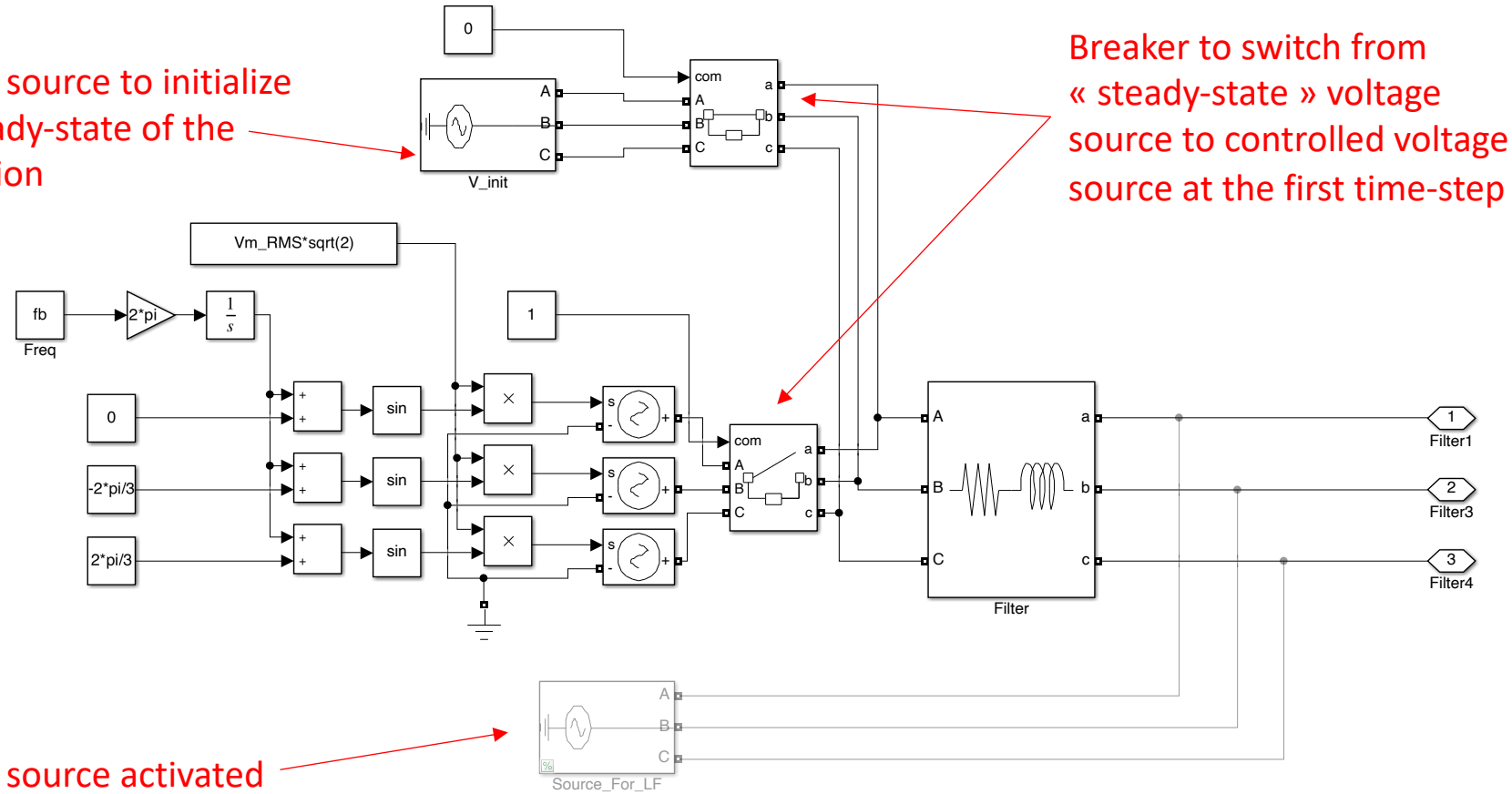
Second step of automation : comment – uncomment programmatically and run loadflow

Open file Loadflow4.slx

Each VSC has been modified as illustrated below

Voltage source to initialize the steady-state of the simulation

Breaker to switch from « steady-state » voltage source to controlled voltage source at the first time-step



Voltage source activated when loadflow is computed

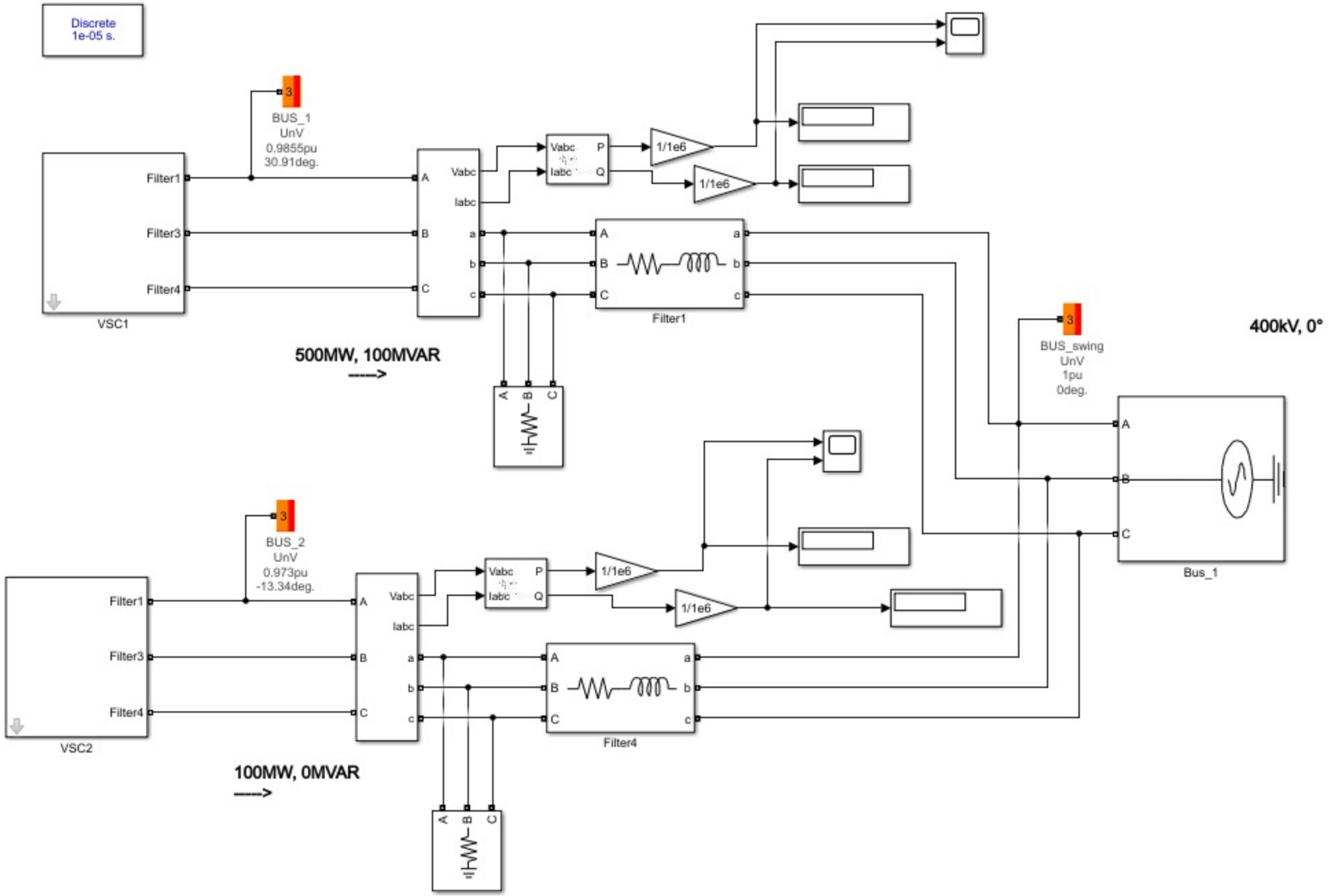
The automation can be divided into 3 steps:

1- Comment the Filter and uncomment the Source_For_LF block

2- Run the loadflow and get the results

3- Compute the initial voltage and angle of the controlled voltage source, uncomment the Filter and Comment the Source_For_LF block

All these steps are done in the LF_auto.m script


Discrete
1e-05 s.
BUS_1
UnV
0.9855pu
30.91deg.
Filter1
Filter3
Filter4
VSC1
Vabc
Iabc
P
Q
1/1e6
1/1e6
A
B
C
a
b
c
Filter1
500MW, 100MVAR
----->
BUS_swing
UnV
1pu
0deg.
400kV, 0°
Bus_1
BUS_2
UnV
0.973pu
-13.34deg.
VSC2
Filter4
100MW, 0MVAR
---->