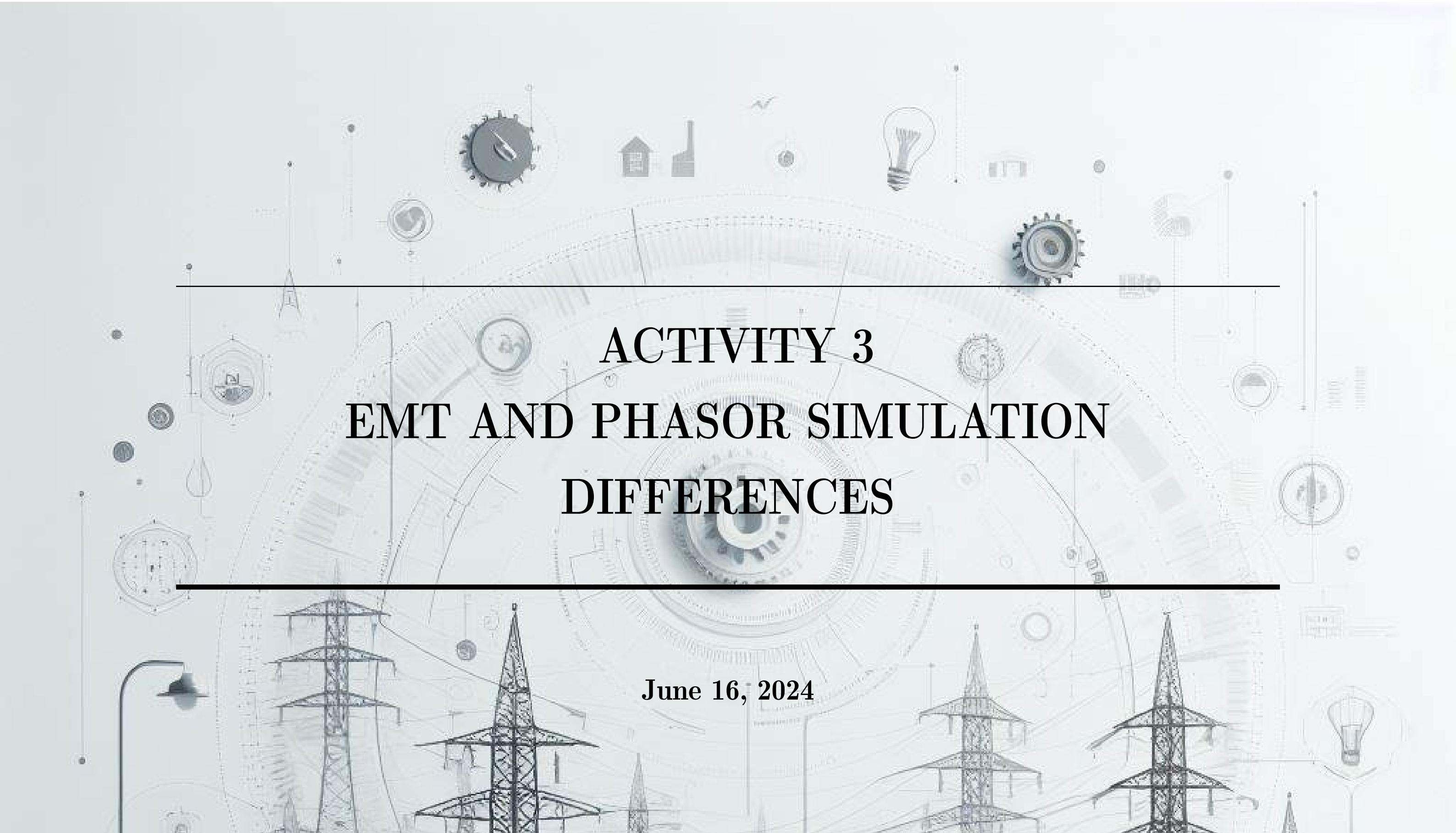

ACTIVITY 3
EMT AND PHASOR SIMULATION DIFFERENCES

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- UPC -

Contents

1 Differences between EMT and phasor models in a load change scenario

Both models consist on the exact same three phase network with 7 buses, with modeled synchronous generators, power converters in current source mode (grid following), transmission line models (Pi model) and three-phase RL loads. Figure 1

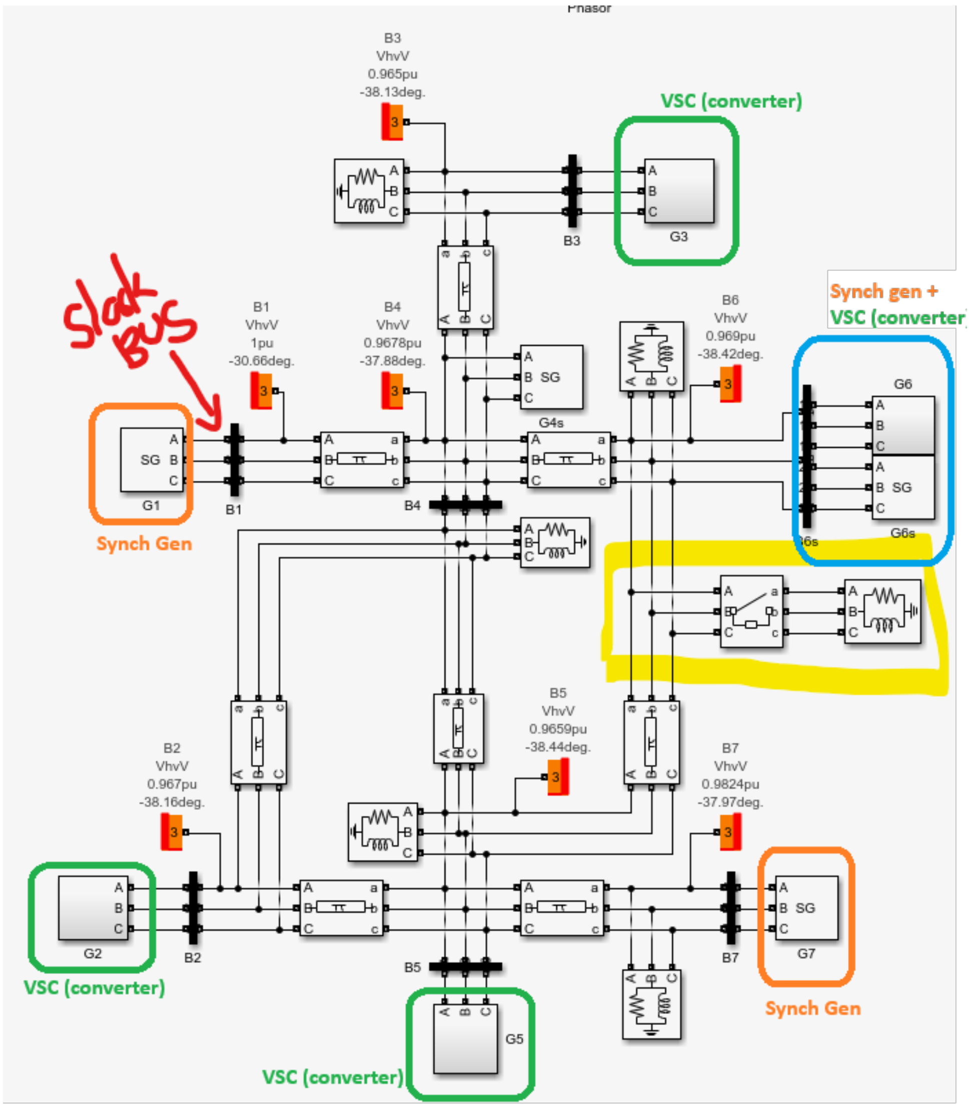

Figure 1: detail (yellow) of the circuit breaked introducing the load change

1.1 Key differences of EMT and Phasor-based modelling

Phasor simulations approximate system behavior, focusing on steady-state and slower electromechanical phenomena, using algebraic equations with complex variables and larger time steps, making them computationally faster but less detailed.

EMT simulations, on the other hand, capture fast transients by solving differential equations with real variables, providing detailed modeling of components and nonlinearities with smaller time steps, which makes them more computationally intensive but highly precise for rapid, dynamic events.

The difference between both simulink files resides in the way every VSC converter is modeled Figure 10, in the EMT file the VSCs are modeled using an EMT average model, in the phasor file the VSCs are modeled simplifying out the current inner loop. Figure 3

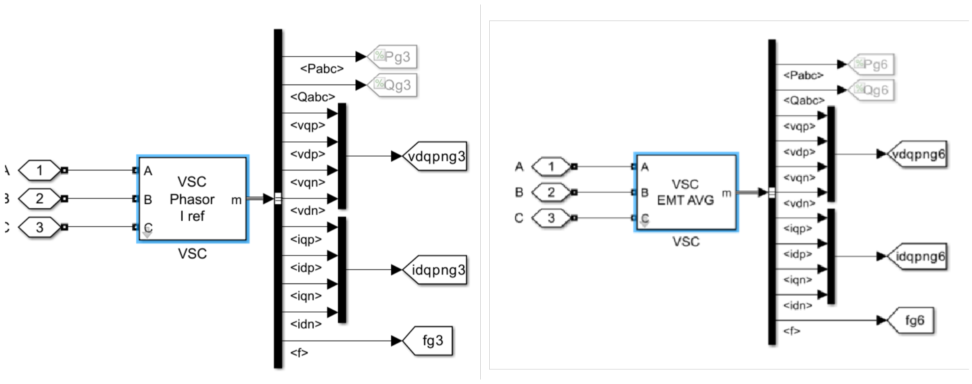

Figure 2: both different models for phasor and electromagnetic transient

As shown in Figure 3, the phasor model introduces certain simplifications to develop an equivalent steady-state model. These simplifications significantly reduce simulation time, particularly when using large time steps.

- Different EMT and phasor models implemented

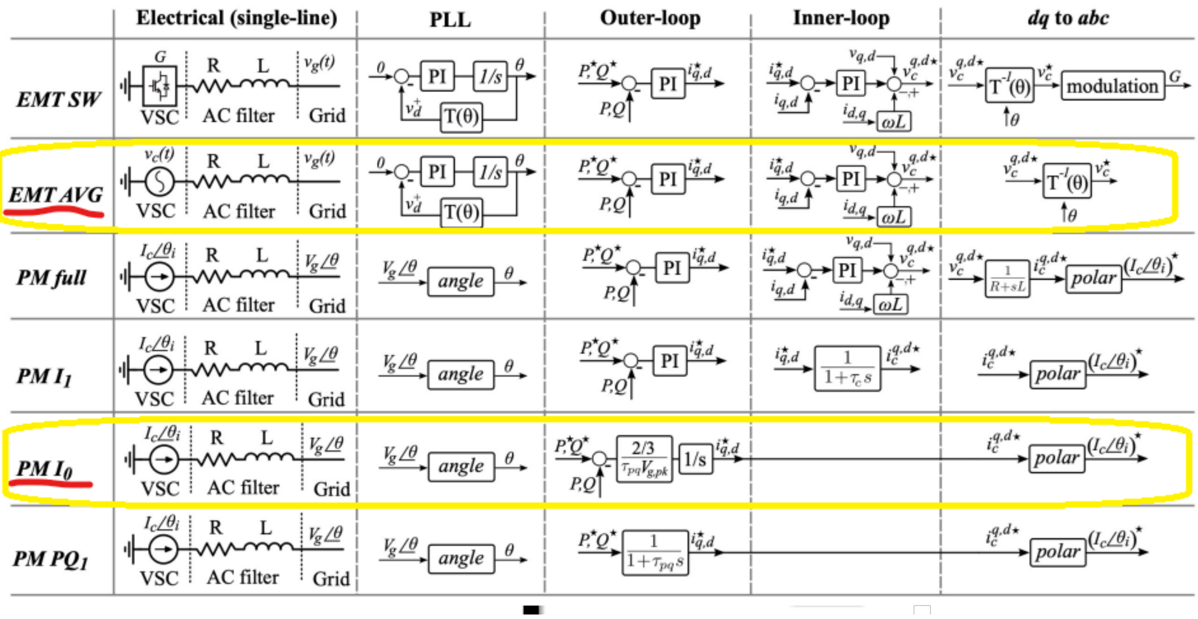

Figure 3: how each model is implemented

1.2 Small simulation step

Simulating the EMT model EMT load.slx with 10 us time step, the difference in execution time between both models is not very relevant Figure 4.

```
>> EMT_Phasor_parameters
EMT_load.slx Ts=10us, t=5seconds
Elapsed time is 124.586724 seconds.
Phasor_load.slx Ts=10us, t=5seconds
Elapsed time is 163.679653 seconds.
```

Figure 4: Elapsed time for both simulink models

Comparing both simulation results between both models, focusing on the magnitudes, voltages (Vg6) and currents (Ig6pv) of VSC G6 and the torque of Synchronous Generator G6s (Te6s).Figure 5.

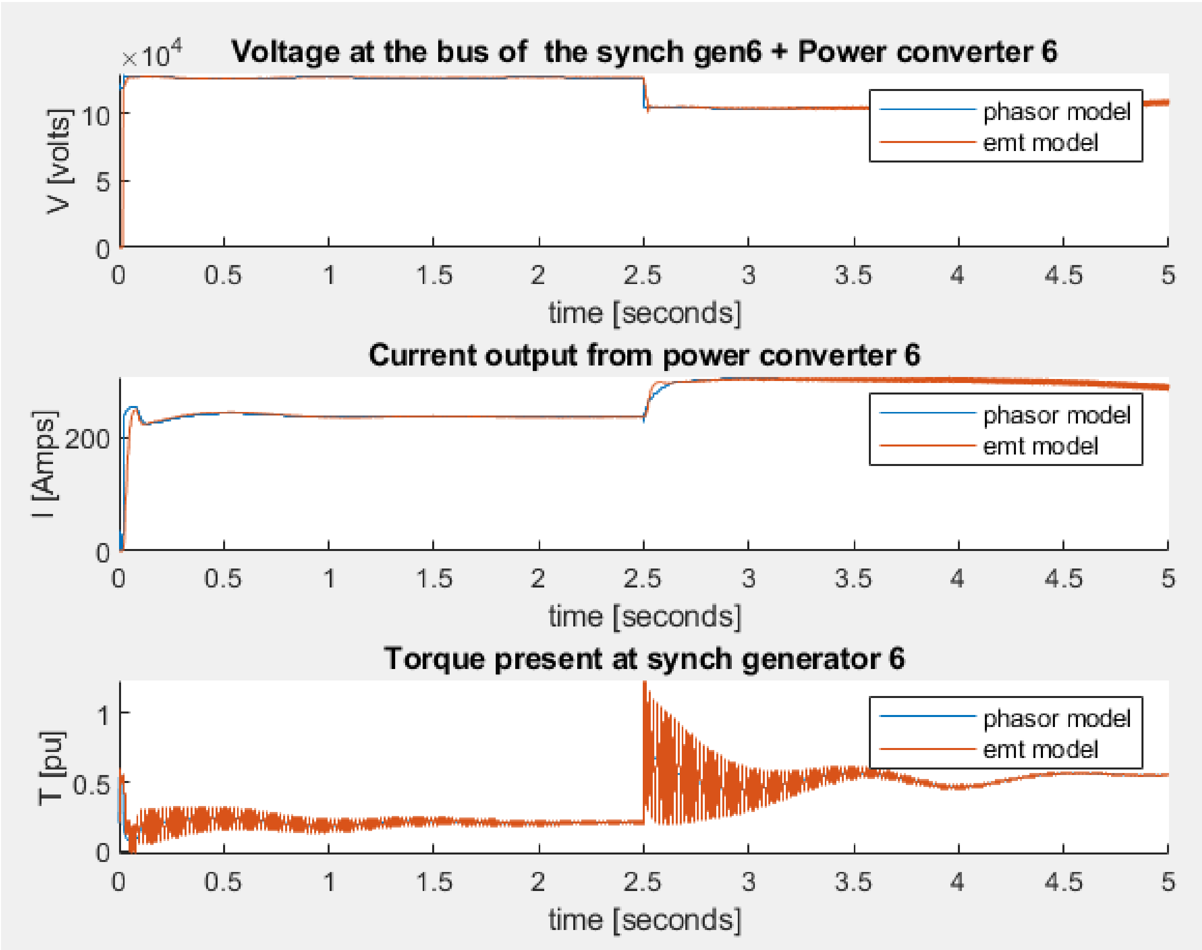

Figure 5: Comparison of both models, Ts=10us

There is almost no difference between both models in steady state values, as expected, the main difference is found in the dynamic response and is not that pronounced. (Figure 6). By only using the phasor model we would be missing out important resonant behaviours (Torque) or even critic dynamic responses against load changes (Voltage and current).

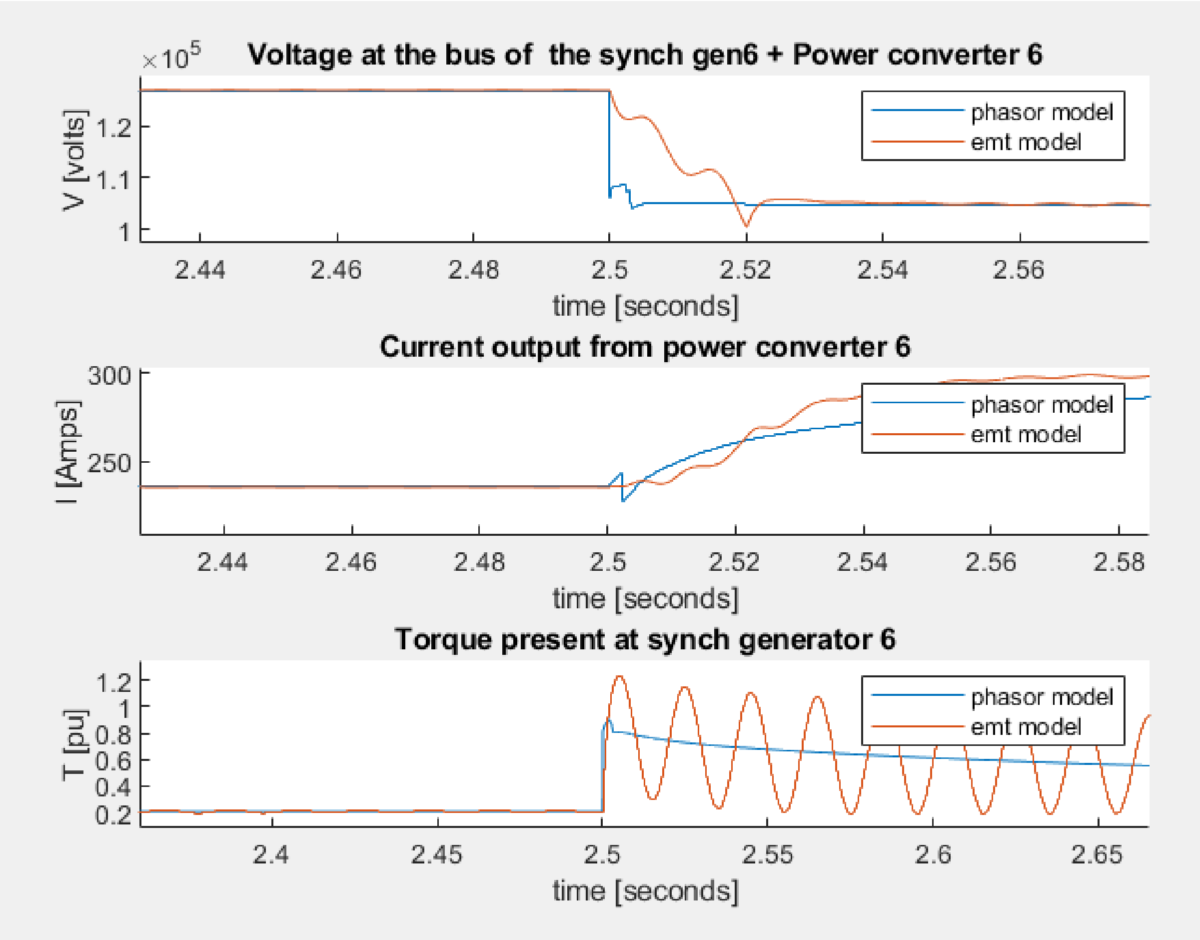

Figure 6: Detail of the comparison of both models, Ts=10us

1.3 Increasing simulation step

Increase the time step (variable Ts in the parameter file) of the Phasor Model from 10 us to 150 us.

```
Phasor_load.slx Ts=10us, t=5seconds
Elapsed time is 154.188426 seconds.
Phasor_load.slx Ts=150us, t=5seconds
Elapsed time is 15.992903 seconds.
```

Figure 7: Elapsed time for phasor model , various Ts

Rising the Ts simulation step from 10 to 150us makes simulink very happy, the simulation now takes just 10% of what it used to take Figure 7.

But the difference in the results for increased Ts is negligible as seen in Figure 8.

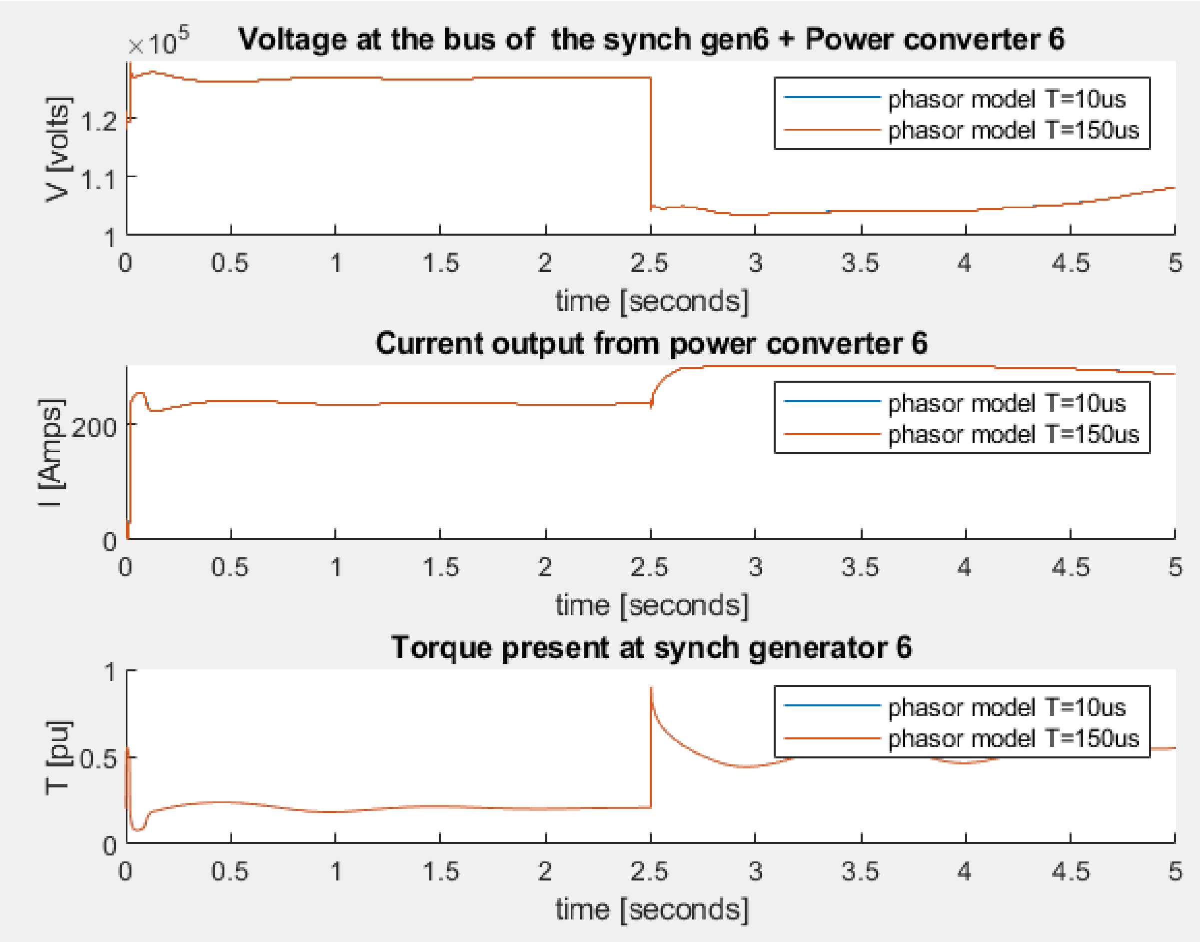

Figure 8: Comparison of the same phasor model, T=10us and Ts=150us

This makes the phasor model simulation a very powerfull tool if the dynamics of the system dont need to be taken into a very fine account. Figure 9.

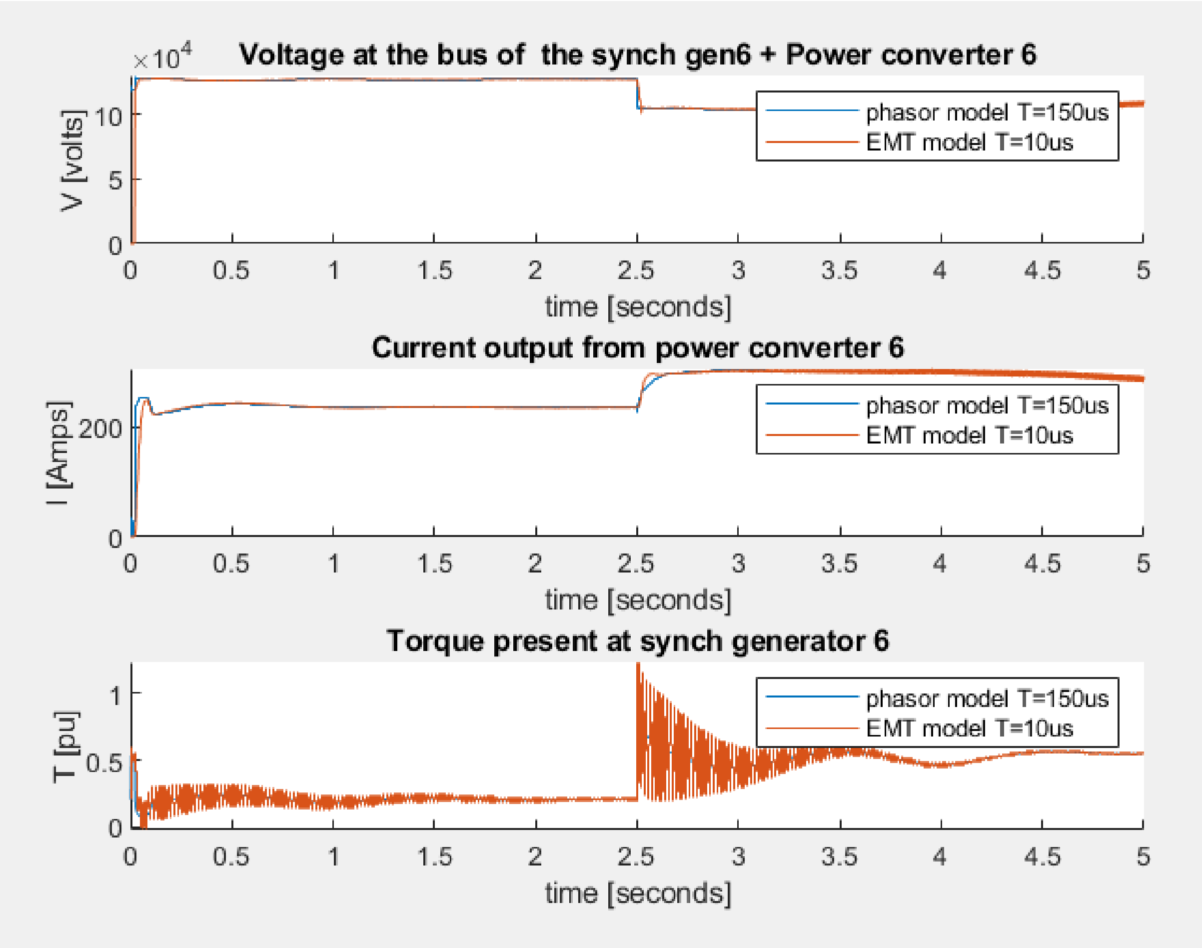

Figure 9: same as Figure 5 but now with Ts=150us

2 Differences between EMT and phasor models in a Generation disconnection scenario

Simulating a Generator disconnection (mis simulation) with (EMT G1.slx and Phasor G1.slx), the exact same grid but different scenario. We will be focusing on the Bus6 impact of G1 disconnection, there are two transmission lines in between.

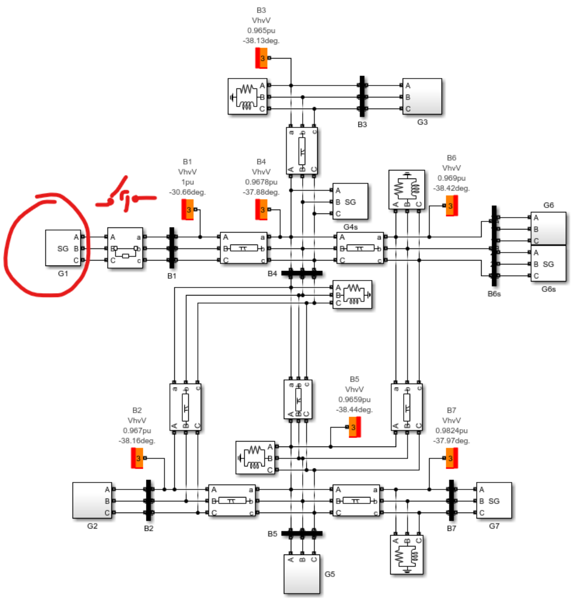

Figure 10: Simulink blocks for the same grid , with a circuit breaker in G1

2.1 Small simulation time

The elapsed time figures is very similar to previous cases, similar simulation time and down to 10% when Ts is changed to 150us. Figure 11

```
>> EMT_Phasor_parameters
EMT_G1.slx Ts=10us, t=5seconds
Elapsed time is 145.861831 seconds.
Phasor_G1.slx Ts=10us, t=5seconds
Elapsed time is 150.535000 seconds.
Phasor_G1.slx Ts=150us, t=5seconds
Elapsed time is 12.621293 seconds.
```

Figure 11: Elapsed time figures for G1 simulations

The Generator G1 disconnection at 2,5seconds had very to no little impact in the voltage levels of bus6, this is due to Generator 6 and VSC 6 being so close to the measurement point and two transfer lines in between dampening the effects. Figure 12. After G1's disconnection in t=2,5s, the bus6 sees an increase in current output to overcome the lack of G1, Synchronous generator 6 also sees a sudden increase in torque as it fights against the sudden grids power drop.

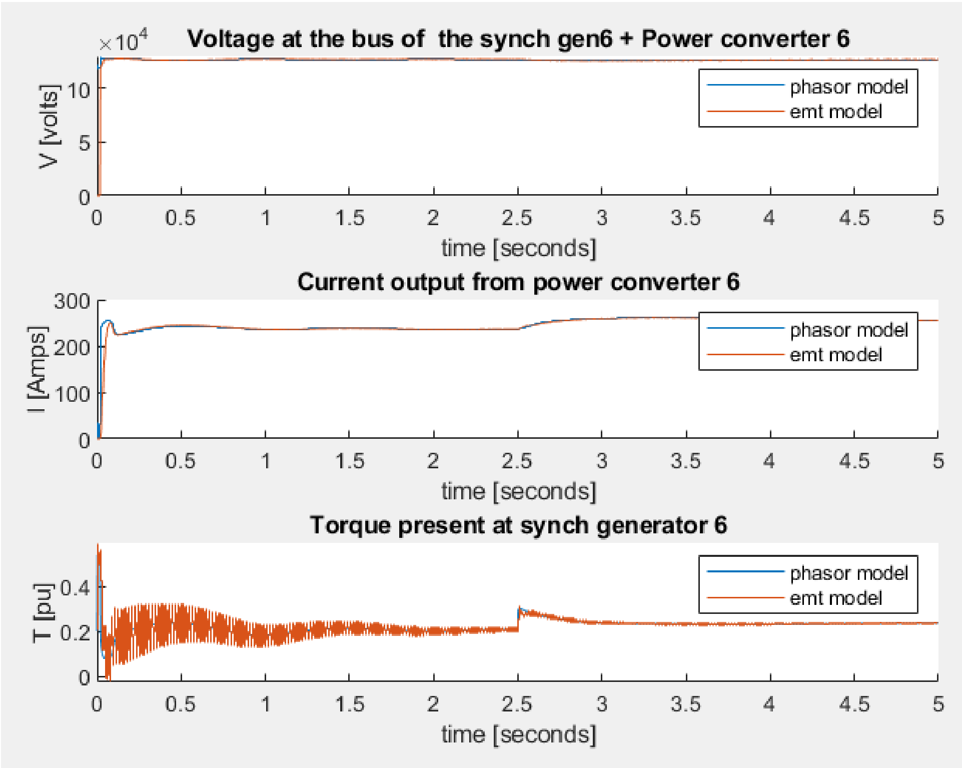

Figure 12: Voltage Current and Torque (from synchGen6) measured in bus 6

2.2 Increasing simulation time

Increasing the Phasor's model execution step to Ts=150us made again the simulation to finish at only 10% of previous runtime with negligible loss of information.

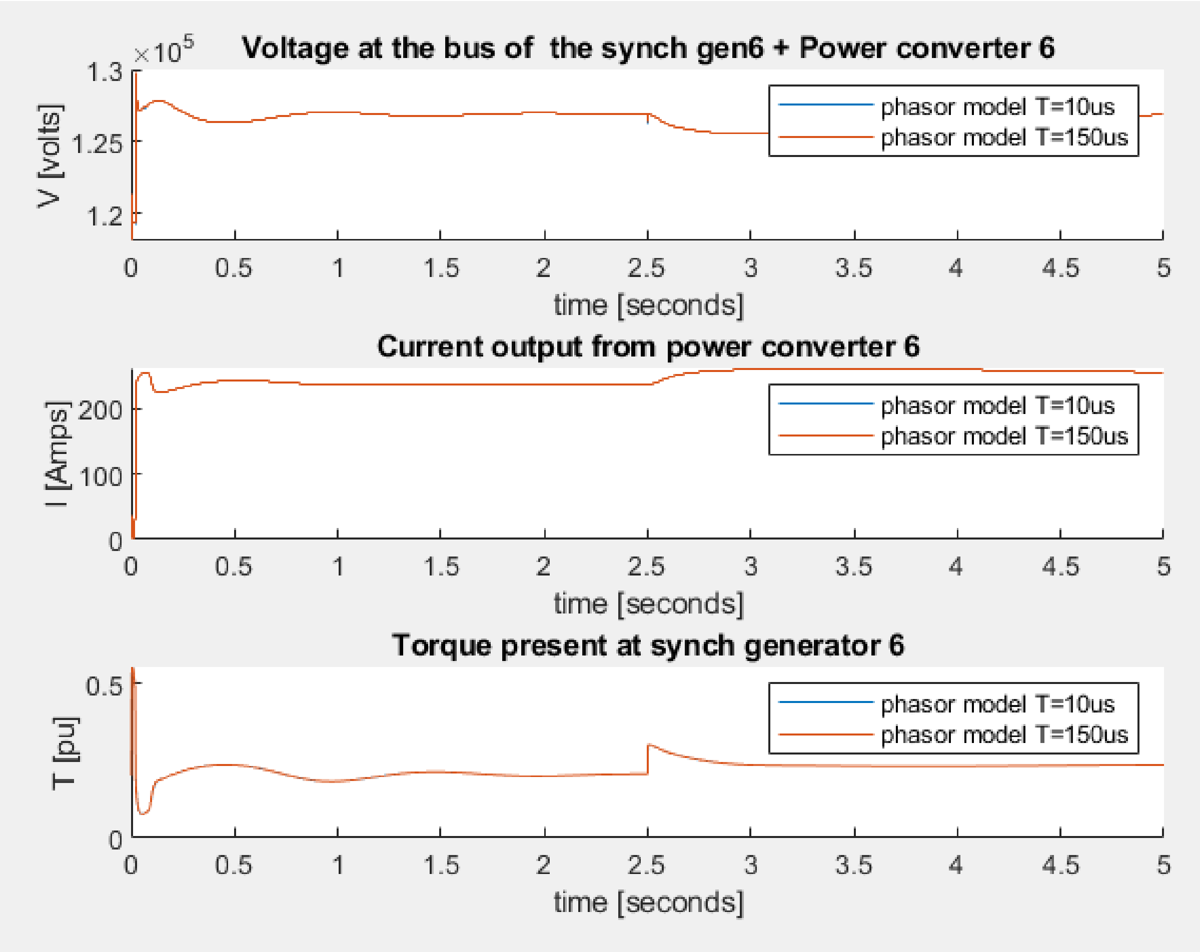

Figure 13: Compared phasor models ith different Ts values

As already acknowledged in previous points, Phasor simulation (Increased Ts sim step) is a great candidate for very time consuming and complex (even parametric) simulations, if we were to partially neglect the importance of precise dynamics. Figure 14

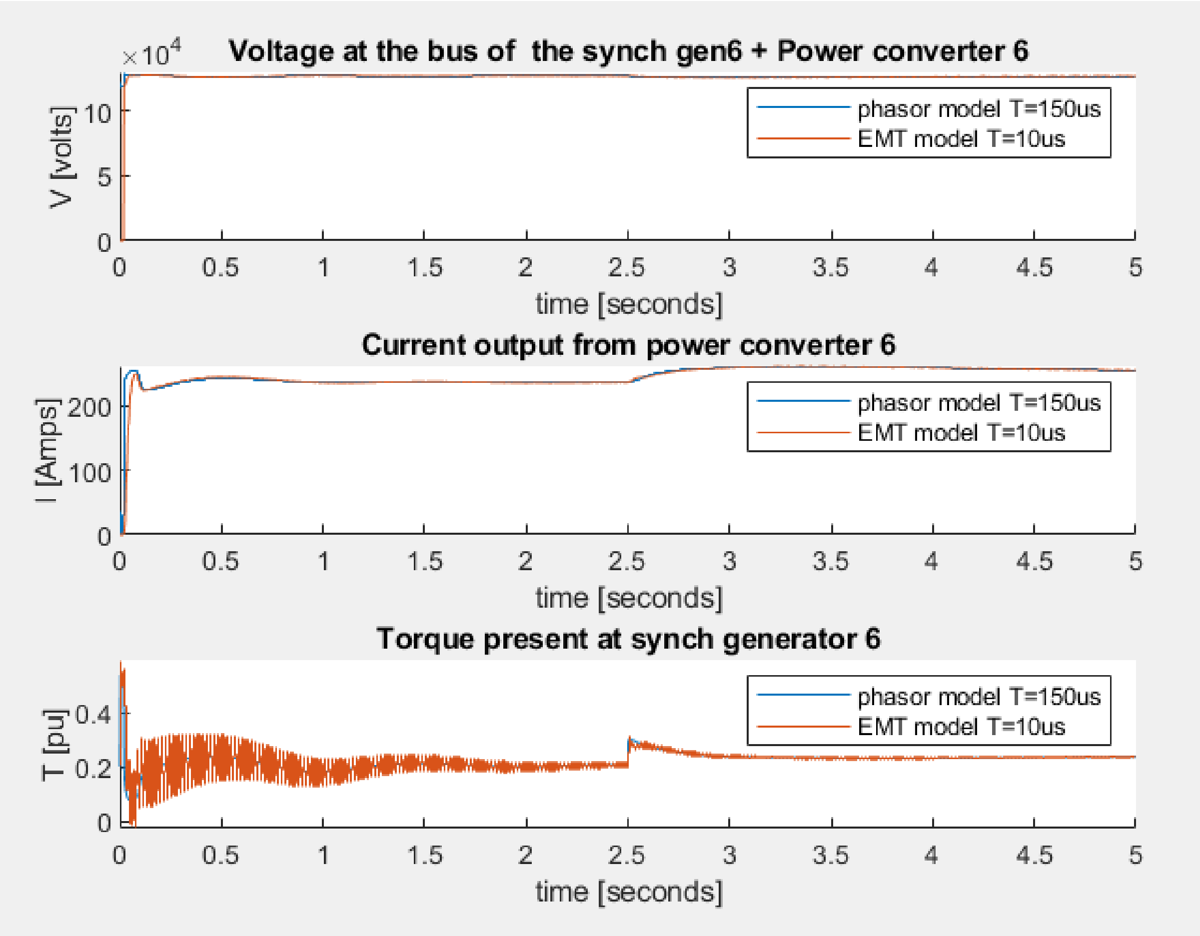

Figure 14: same as Figure 12 but now wih phasor Ts=150us

3 Code

Code available in **this Github repo**