

MATLAB EXPO

Using Multicore CPU to Speedup Desktop Simulation of Electrical Power System

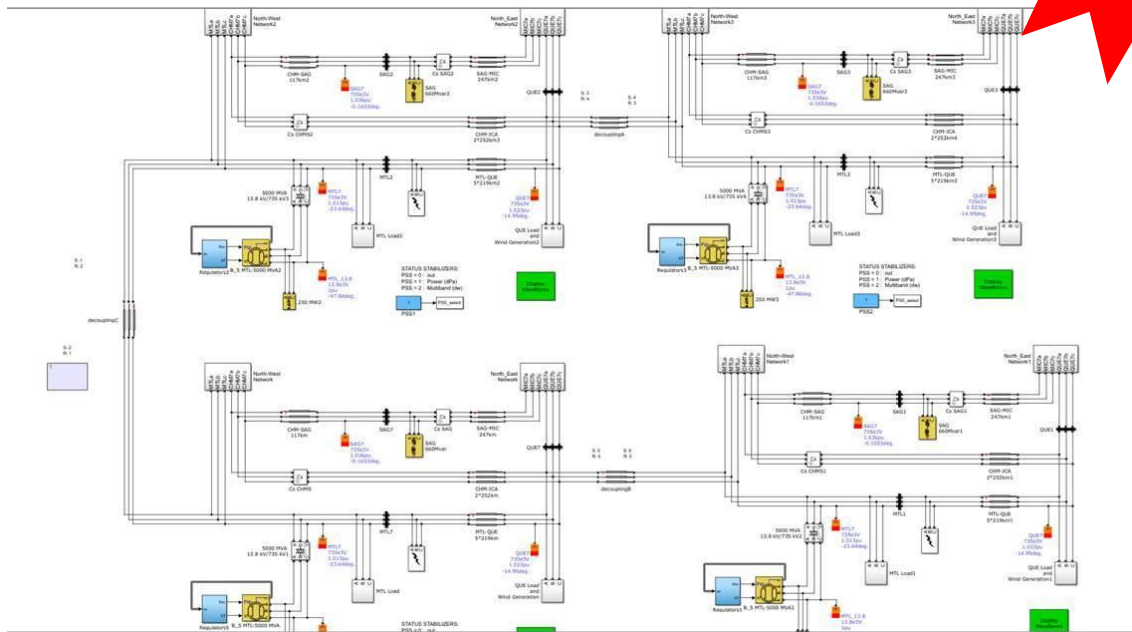
Luke Zhou, MathWorks



Are you doing this?

Very large electrical power grid EMT Simulation

Long duration



Model Scale : 4*29 bus system
Simulation Step Size : 75us
Simulation Stop Time : 4.5s
Simulation Time Cost : 320s

Detailed wind farm simulation with power electronics device

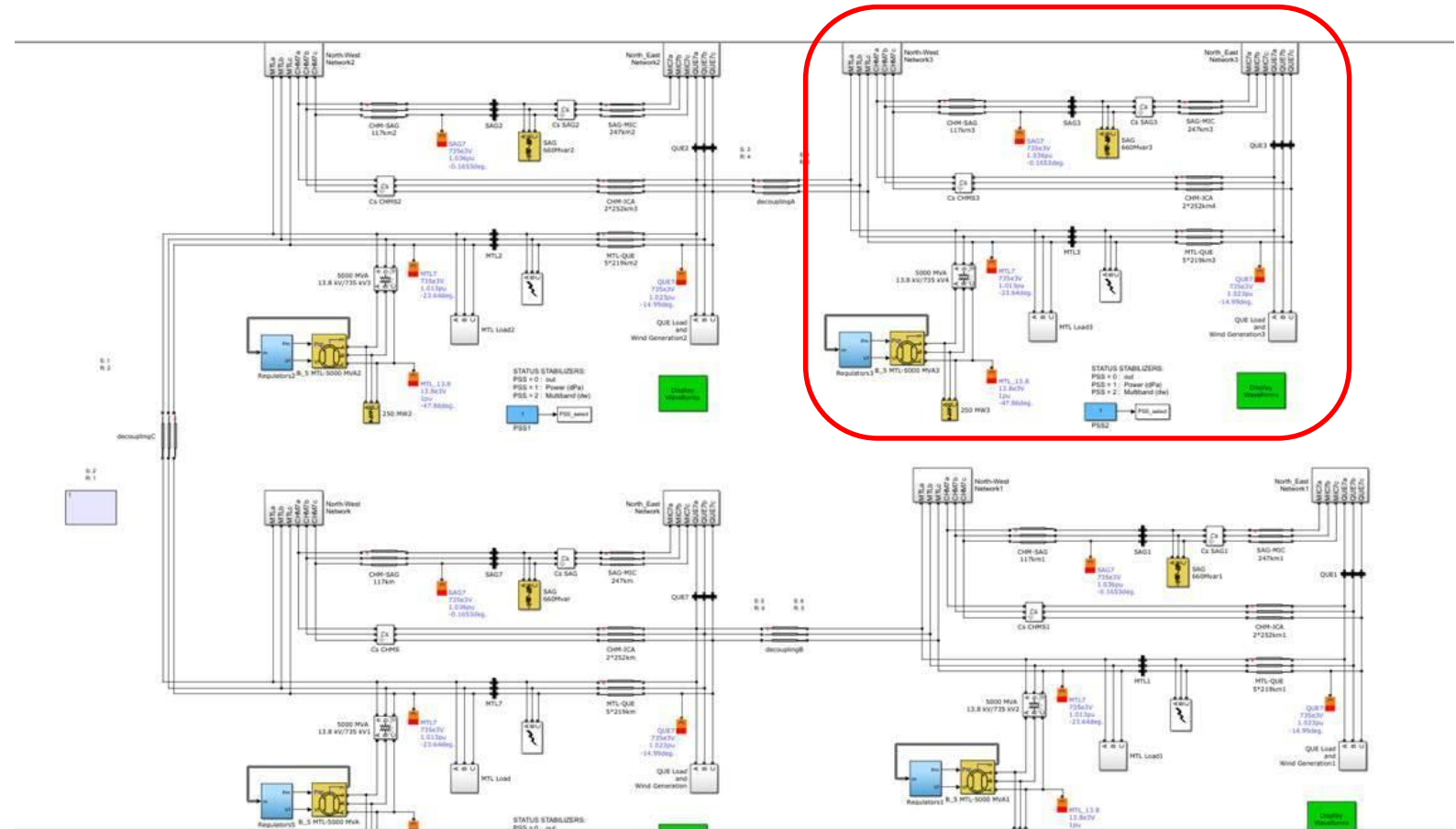
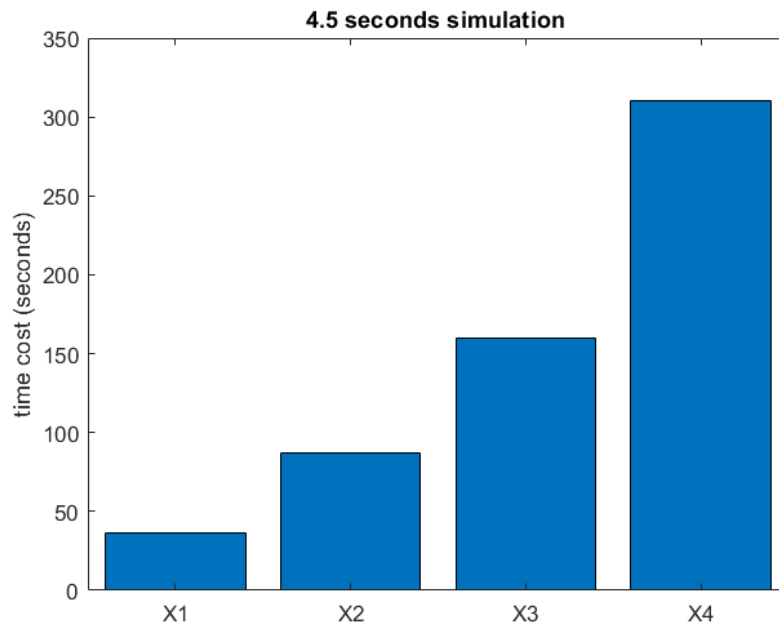
Details



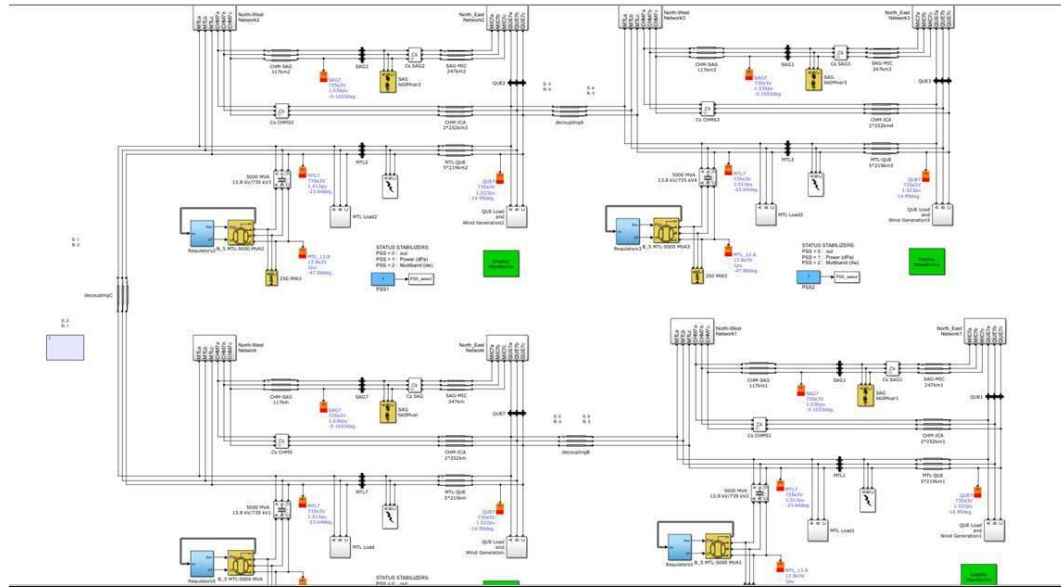
Model Scale : 20 DFIG WT
Simulation Step Size : 1us
Simulation Stop Time : 0.2s
Simulation Time Cost : 1000s

Challenge

- Large Electrical Power Grid simulation costs a lot of computing time.
 - A lot of components
 - Long time simulation



Challenge



- Simulink is single process, so multi-core CPU can't be fully utilized.

Only one core is used during model simulation

CPU Intel(R) Core(TM) i5-10400 CPU @ 2.90GHz

60 秒内的利用率 %

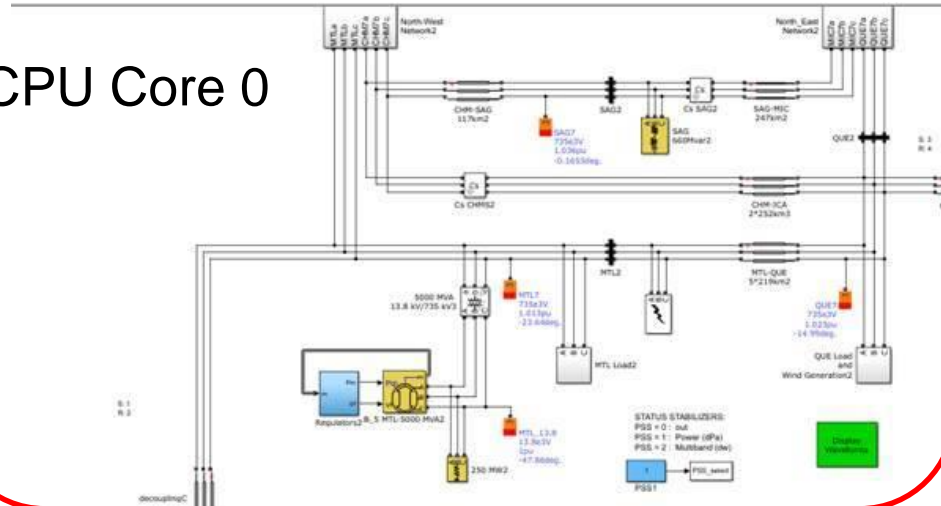
100%



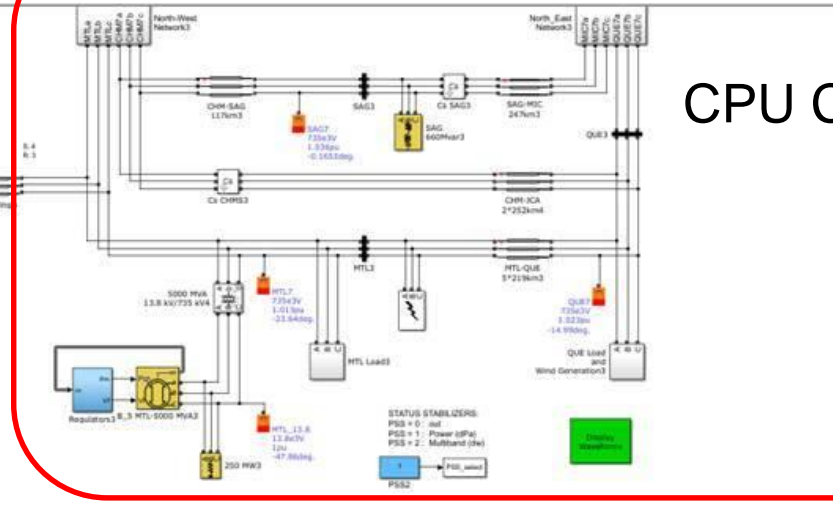
Solution

Parallel Simulation

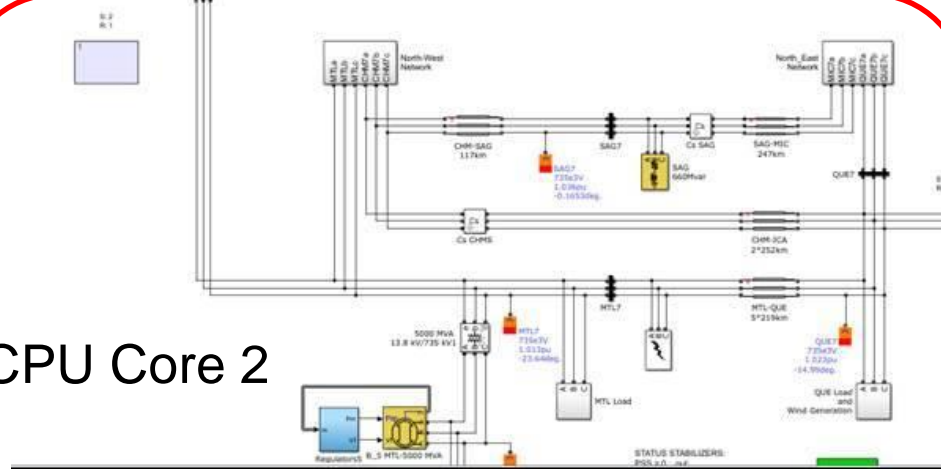
CPU Core 0



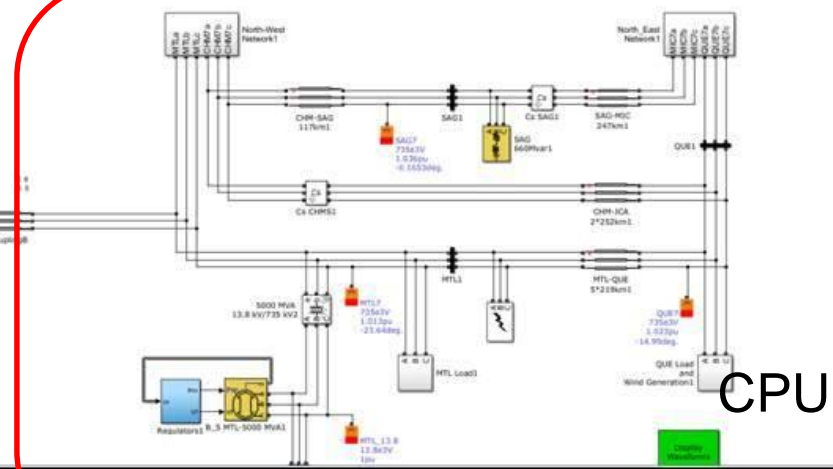
CPU Core 1



CPU Core 2



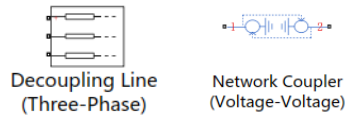
CPU Core 3



Solution

Model decouple

- Decouple physical model with 'Decoupling Line'.

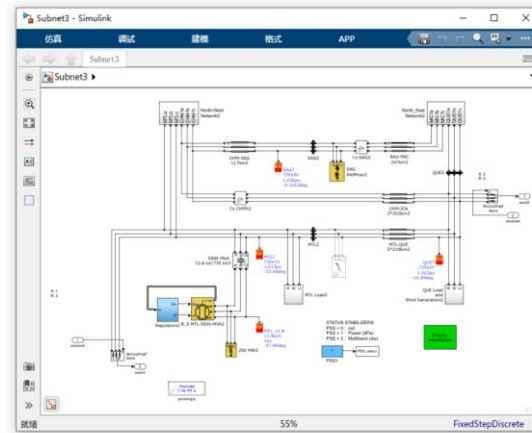


- Put each pieces of model into one model.

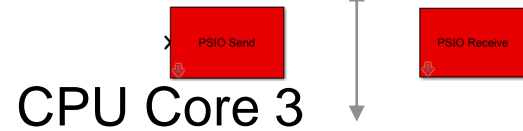
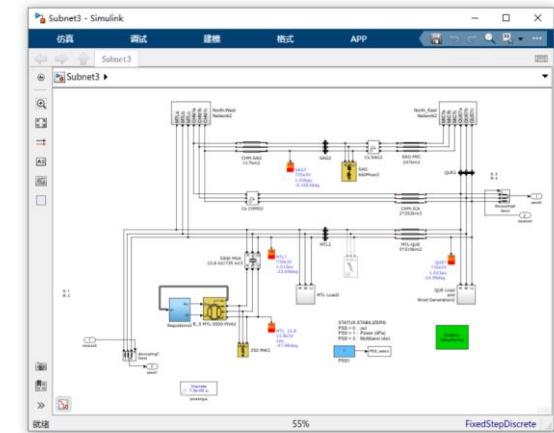
- Build communication channels between models with 'PSIO'.



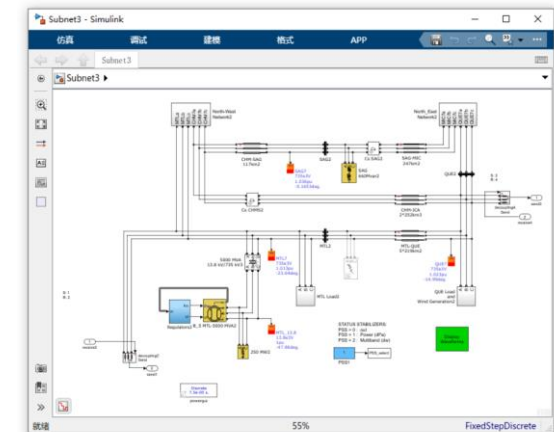
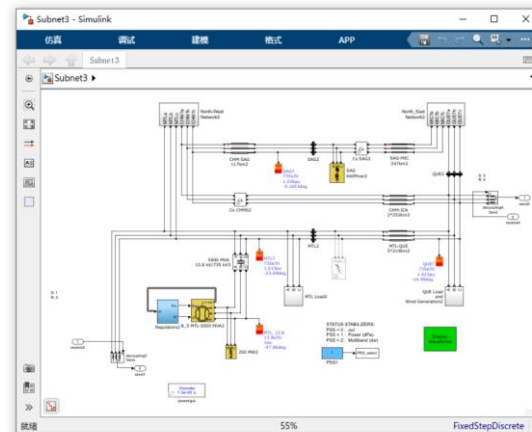
CPU Core 1



CPU Core 2



CPU Core 4



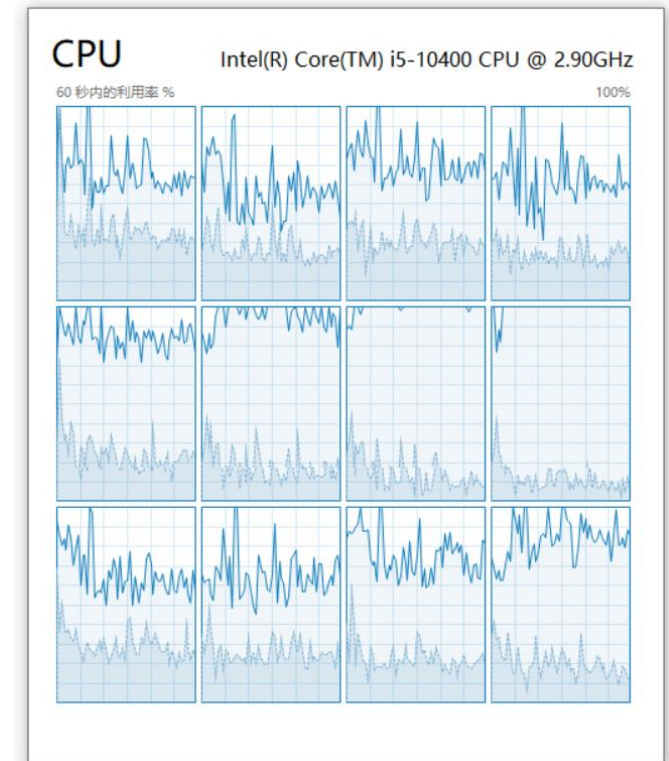
Solution

Using multi-core

- Use Parallel Computing Toolbox start several Simulink processes for Parallel Simulation



→
CPU utilization is much higher



Start Parallel Simulation

Control Panels of Parallel Simulation

The screenshot displays the 'Parallel Simulation' software interface. It is divided into two main sections: 'Controls' and 'Results'.

Controls Panel:

- Buttons:** Initialize, Start Simulation (highlighted with a blue border), Plot, Compare, Import Results, Clear Results.
- Simulation Time (s):** 0.2
- Simulation Mode:** accelerator
- Models:** Select models, Open models
- Model List:** power_wind_dfig_det_serial_x20_p1, power_wind_dfig_det_serial_x20_p2, power_wind_dfig_det_serial_x20_p3, power_wind_dfig_det_serial_x20_p4, power_wind_dfig_det_serial_x20_p5

Results Panel:

Index	Model Name	Variable
1	power_wind_dfig_det_serial_x20...	<labc_grid_conv_p...
2	power_wind_dfig_det_serial_x20...	<P_pu>
3	power_wind_dfig_det_serial_x20...	<Q_pu>
4	power_wind_dfig_det_serial_x20...	<Vabc_grid_conv...
5	power_wind_dfig_det_serial_x20...	<Vdc_V>
6	power_wind_dfig_det_serial_x20...	<wr_pu (IG speed)>
7	power_wind_dfig_det_serial_x20...	<labc_grid_conv_p...
8	power_wind_dfig_det_serial_x20...	<P_pu>
9	power_wind_dfig_det_serial_x20...	<Q_pu>
10	power_wind_dfig_det_serial_x20...	<Vabc_grid_conv...
11	power_wind_dfig_det_serial_x20...	<Vdc_V>
12	power_wind_dfig_det_serial_x20...	<wr_pu (IG speed)>
13	power_wind_dfig_det_serial_x20...	<labc_grid_conv_p...
14	power_wind_dfig_det_serial_x20...	<P_pu>
15	power_wind_dfig_det_serial_x20...	<Q_pu>
16	power_wind_dfig_det_serial_x20...	<Vabc_grid_conv...
17	power_wind_dfig_det_serial_x20...	<Vdc_V>
18	power_wind_dfig_det_serial_x20...	<wr_pu (IG speed)>
19	power_wind_dfig_det_serial_x20...	Vabc_B25 (pu)
20	power_wind_dfig_det_serial_x20...	labc_B25 (pu)
21	power_wind_dfig_det_serial_x20...	<labc_grid_conv_p...
22	power_wind_dfig_det_serial_x20...	<P_pu>
23	power_wind_dfig_det_serial_x20...	<Q_pu>
24	power_wind_dfig_det_serial_x20...	<Vabc_grid_conv...
25	power wind dfig det serial x20...	<Vdc V>

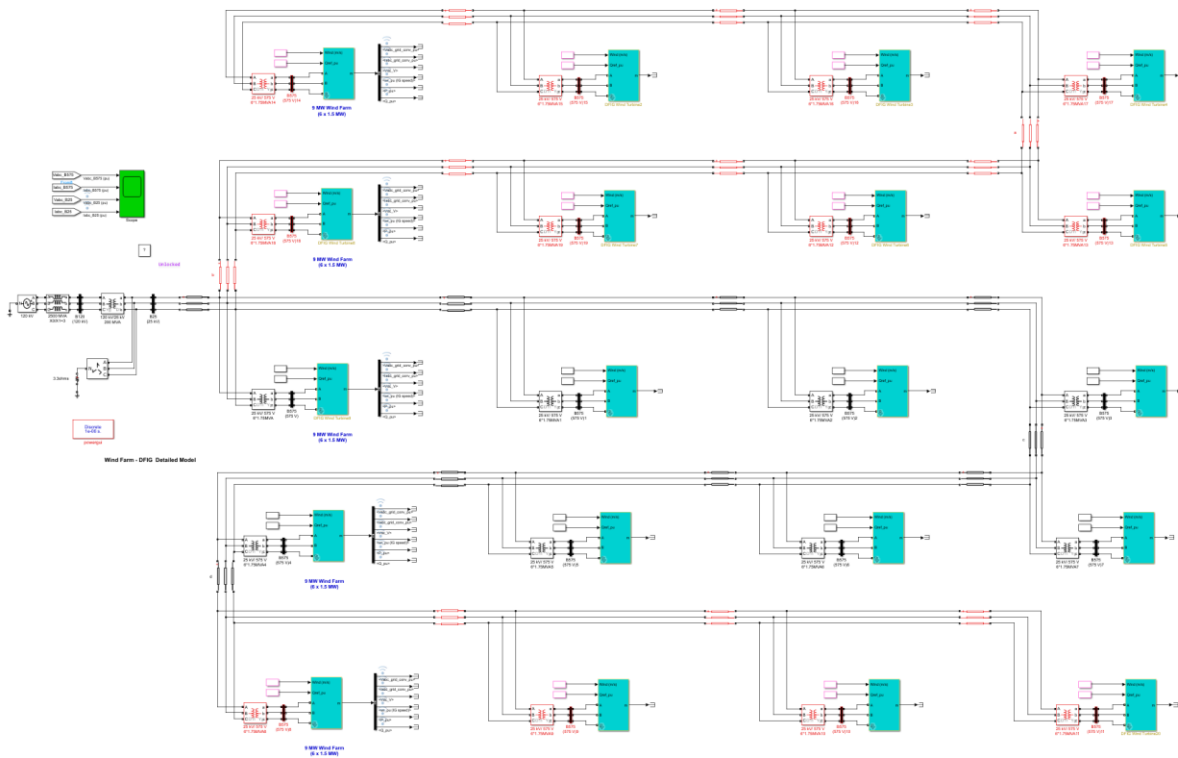
Simulation Result List

Model selection

Simulation Test

Wind Farm Test

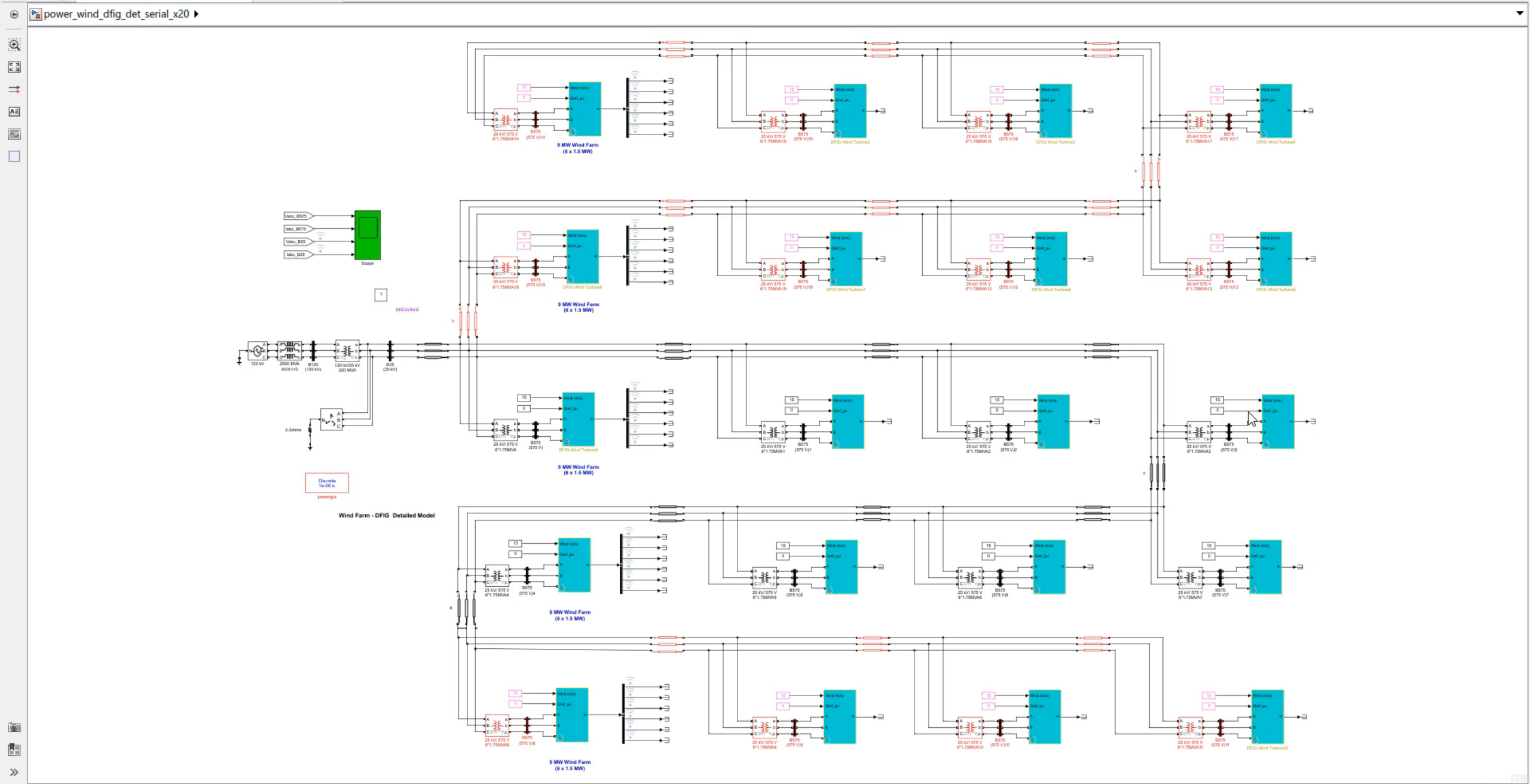
20 DFIG WT's are divided into five models,
A six cores CPU is used for Parallel Simulation



Full Model



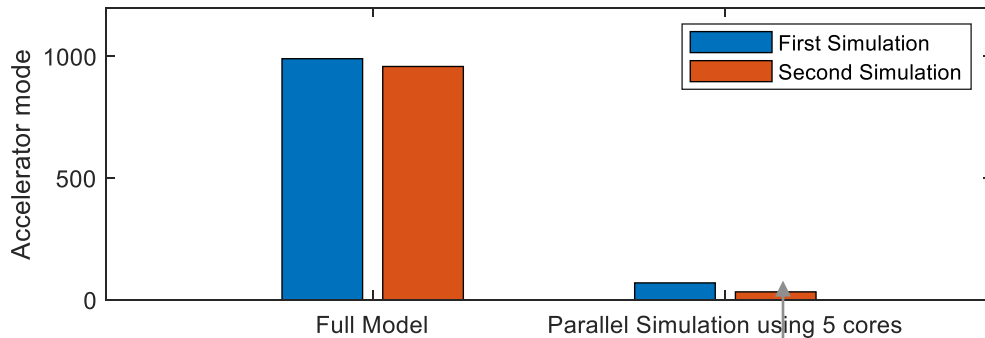
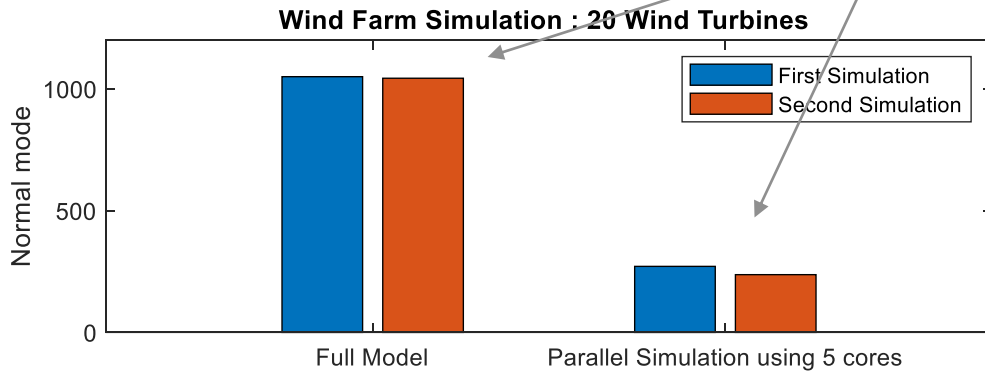
Parallel Models



Simulation Result

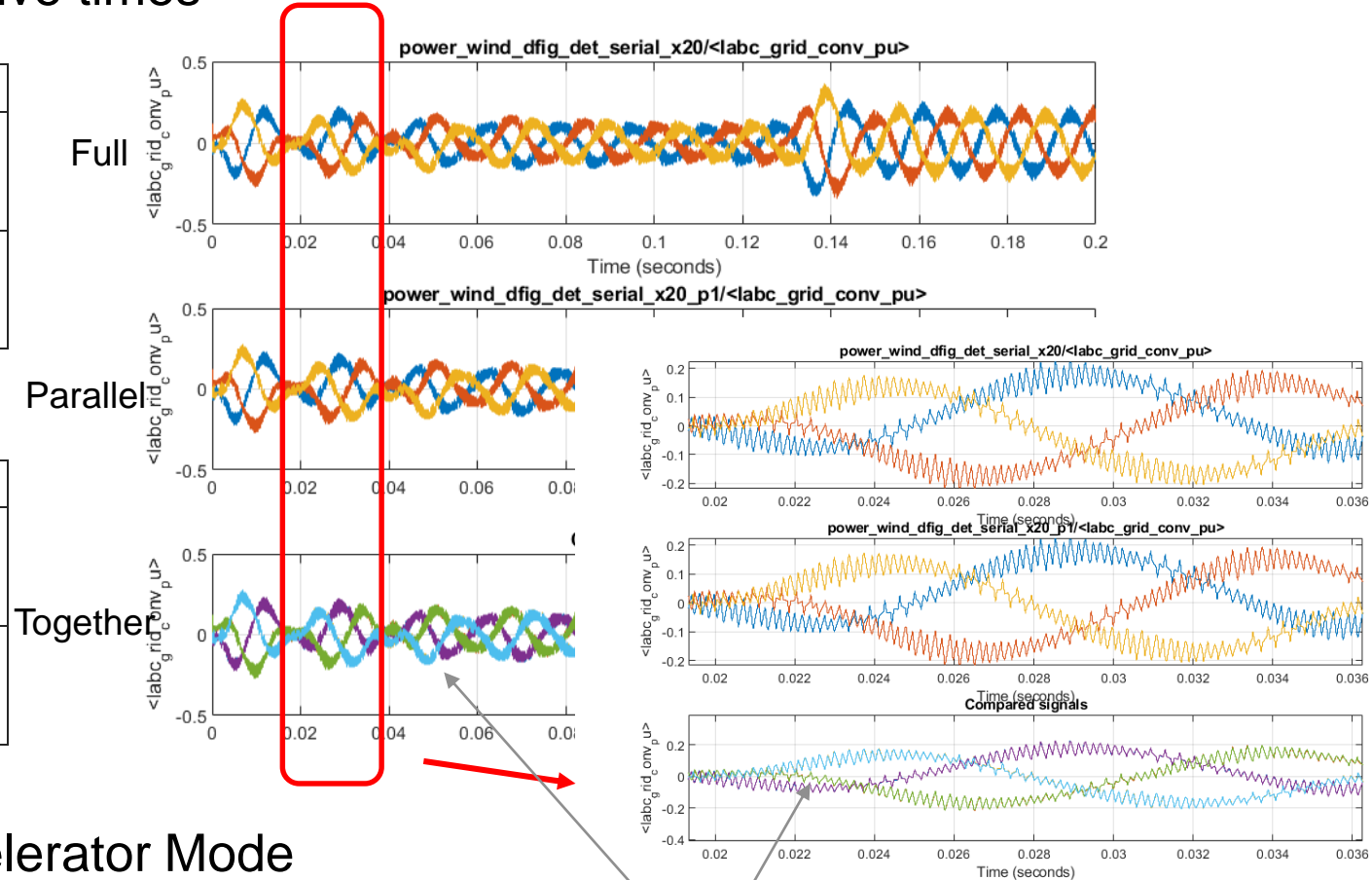
Wind Farm Test

Simulation Time Cost Near Five times



Much Faster in Accelerator Mode

Wind Turbine Current Comparison Between Full model and Parallel Models

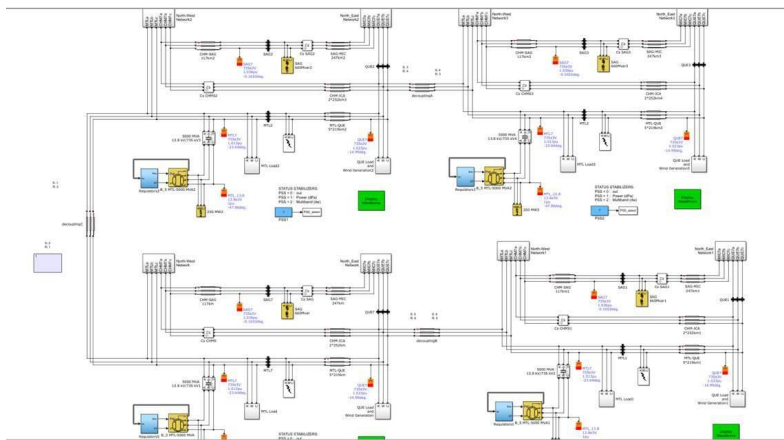
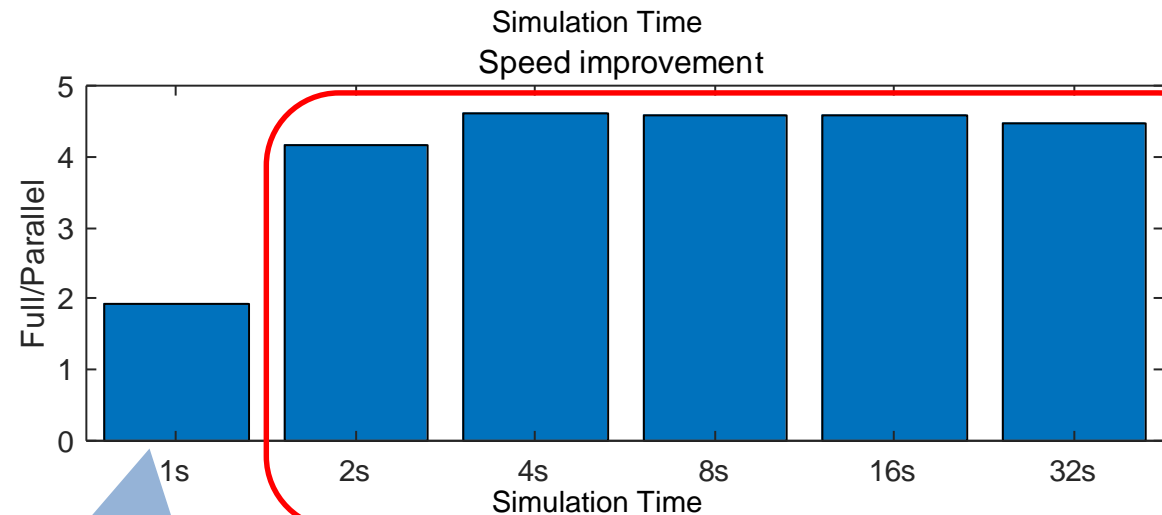
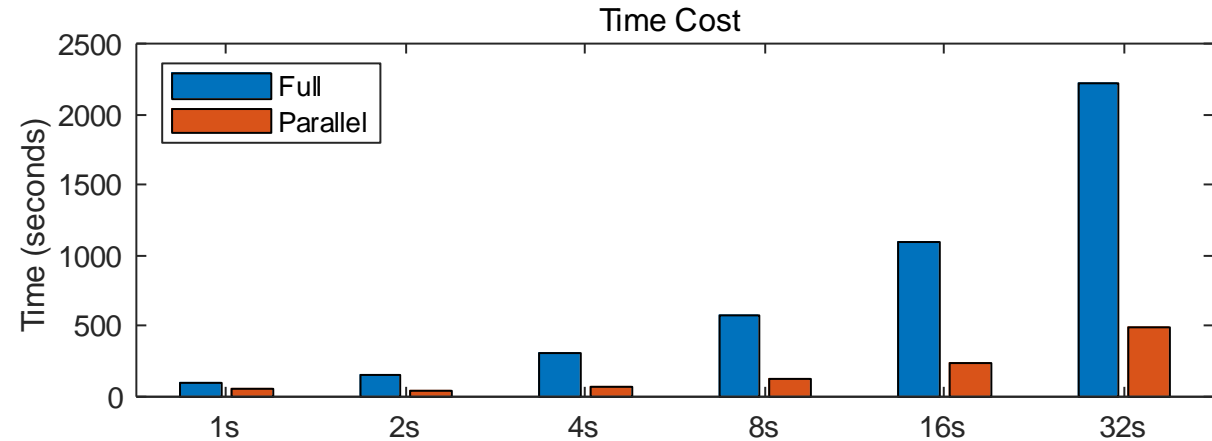


20 DFIG WTs are divided into five models,
A Six Cores CPU is used for Parallel Simulation

Simulation Result

Electrical power grid : Simulation Speed Improvements

- Full is original model, which whole electrical grid in one model
- Parallel is four models run parallelly in CPU
- Parallel is more than four times faster than Full
- Long time simulation have better improvement
- PCT initialization cost some time for 1s case



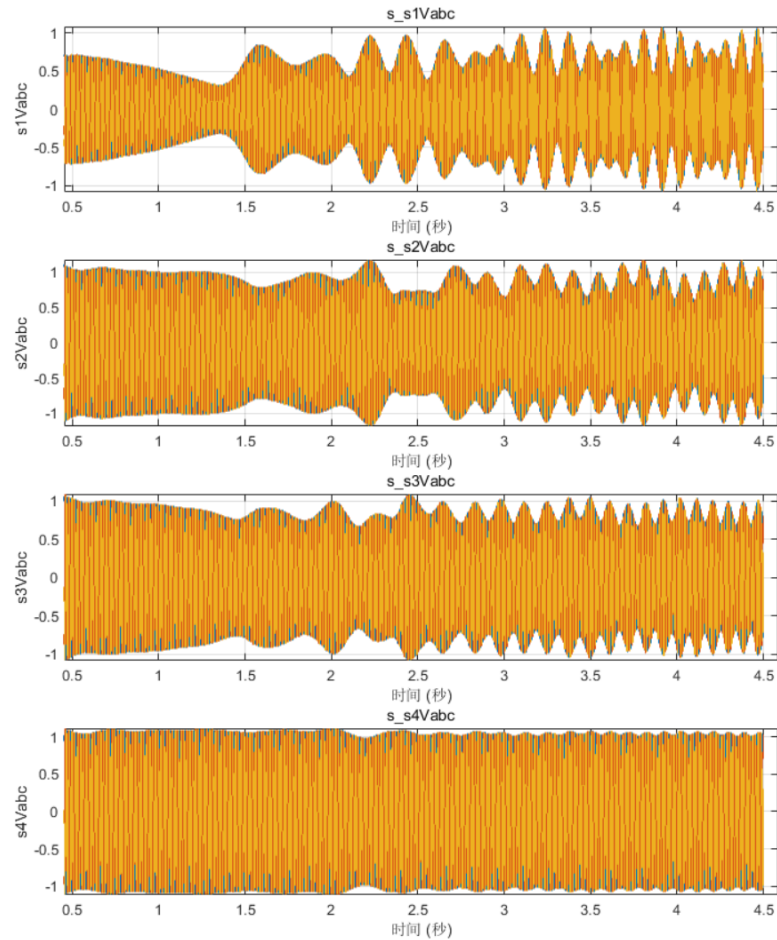
PCT initialization

Improvement Proportional to the number of cores

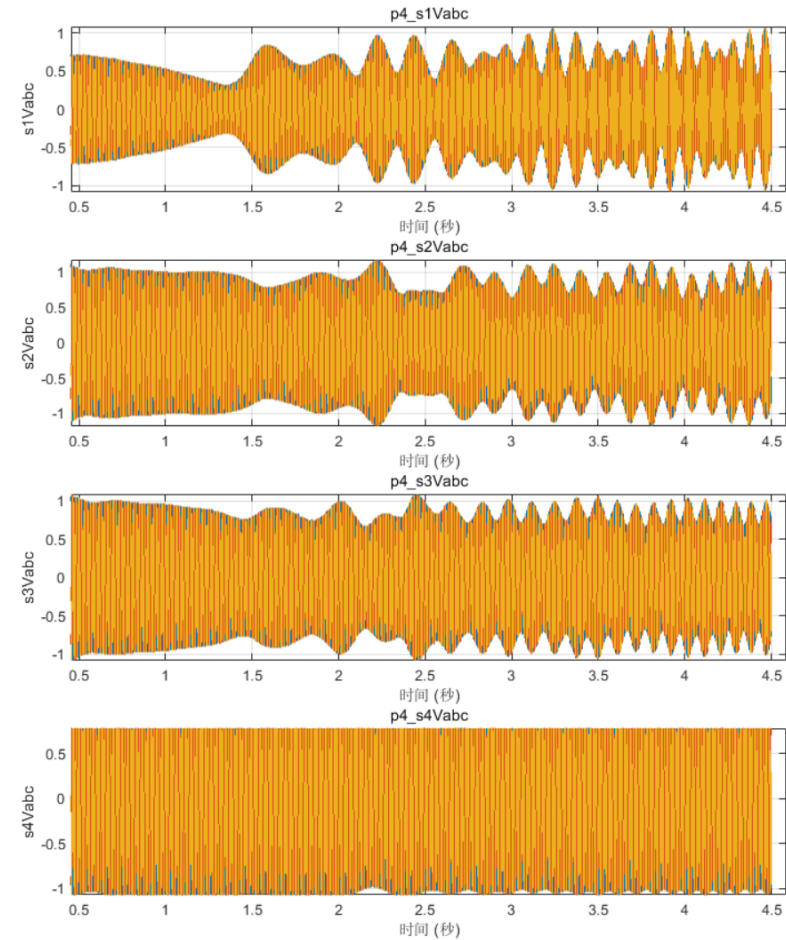
Simulation Result

Electrical power grid : Voltage compare

Full model



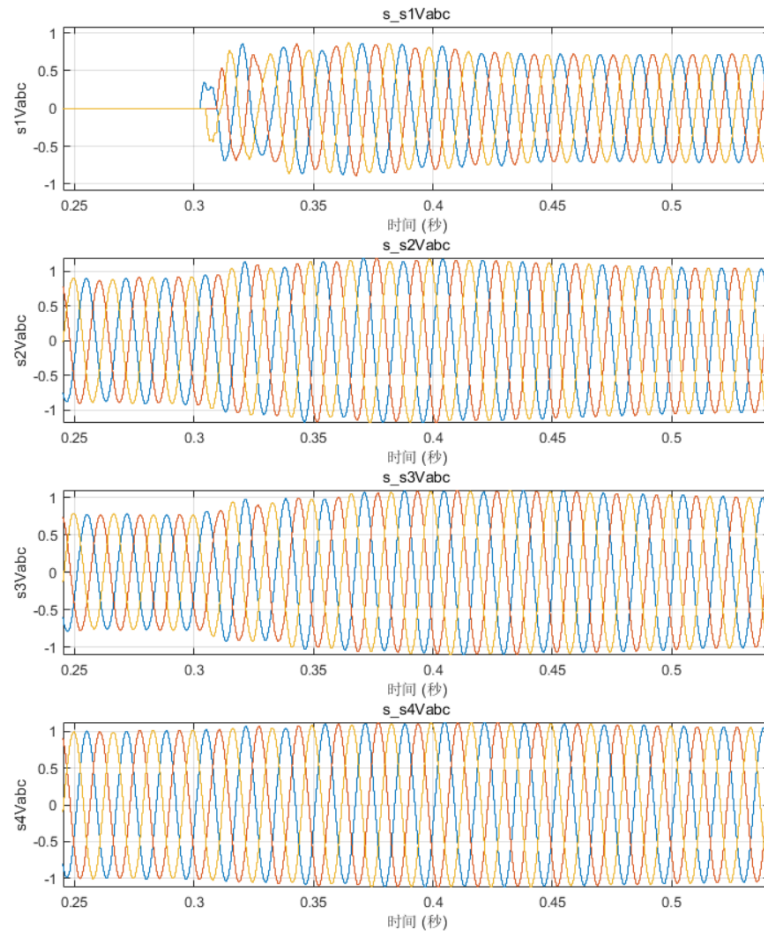
Parallel 4 models



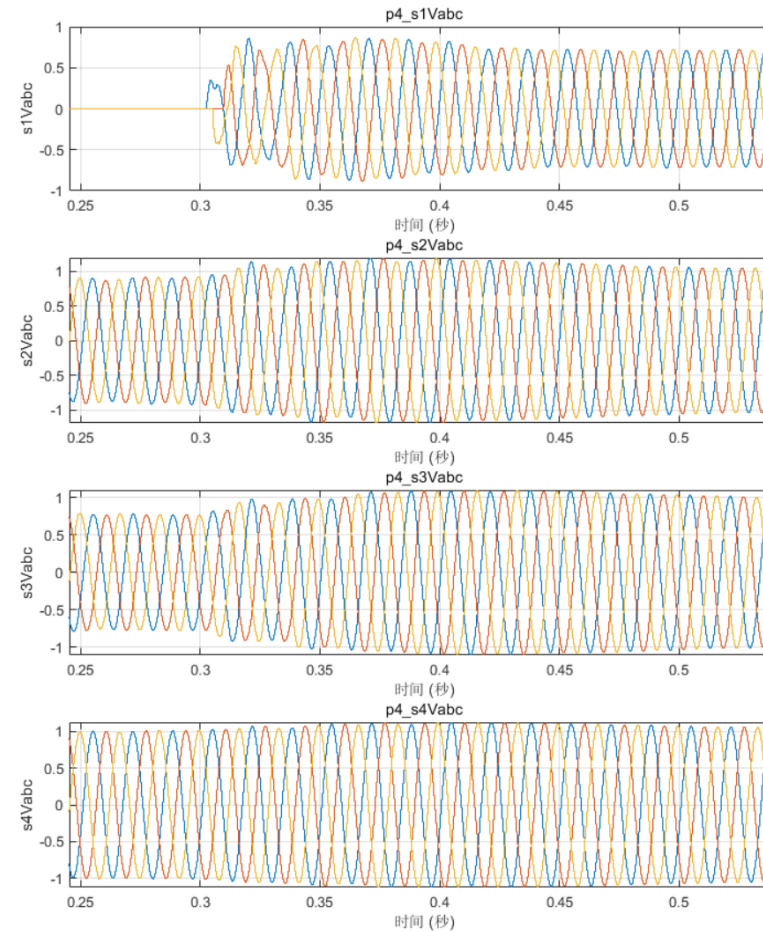
Simulation Result

Electrical power grid : Voltage compare

Full model

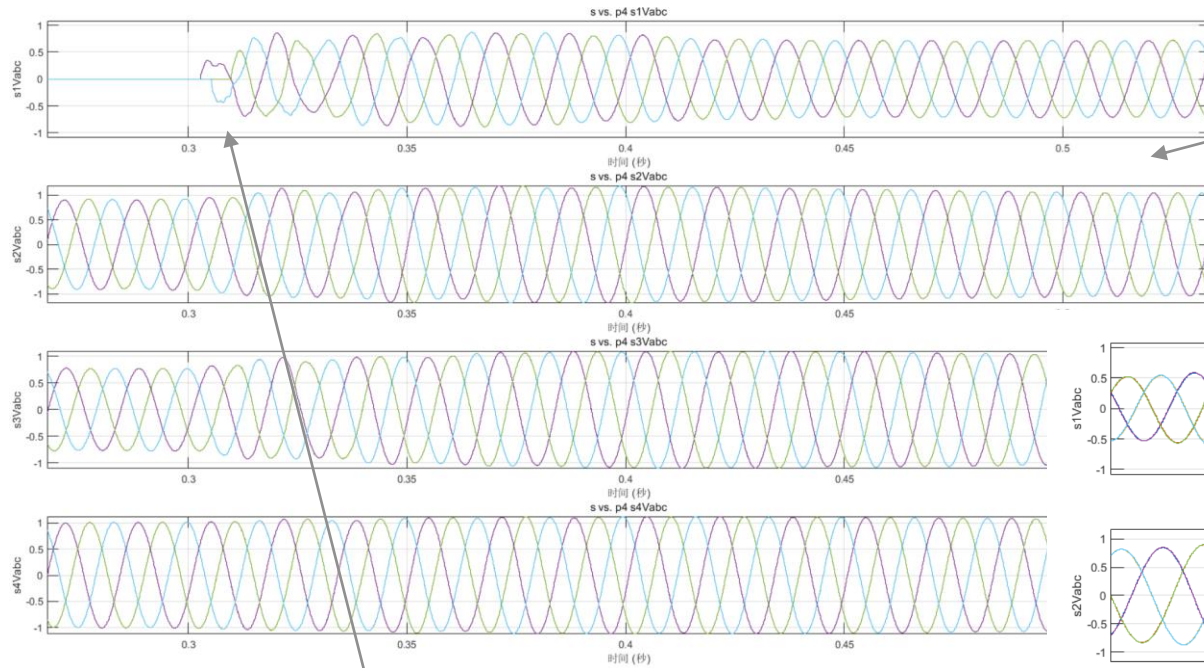


Parallel 4 models



Simulation Result

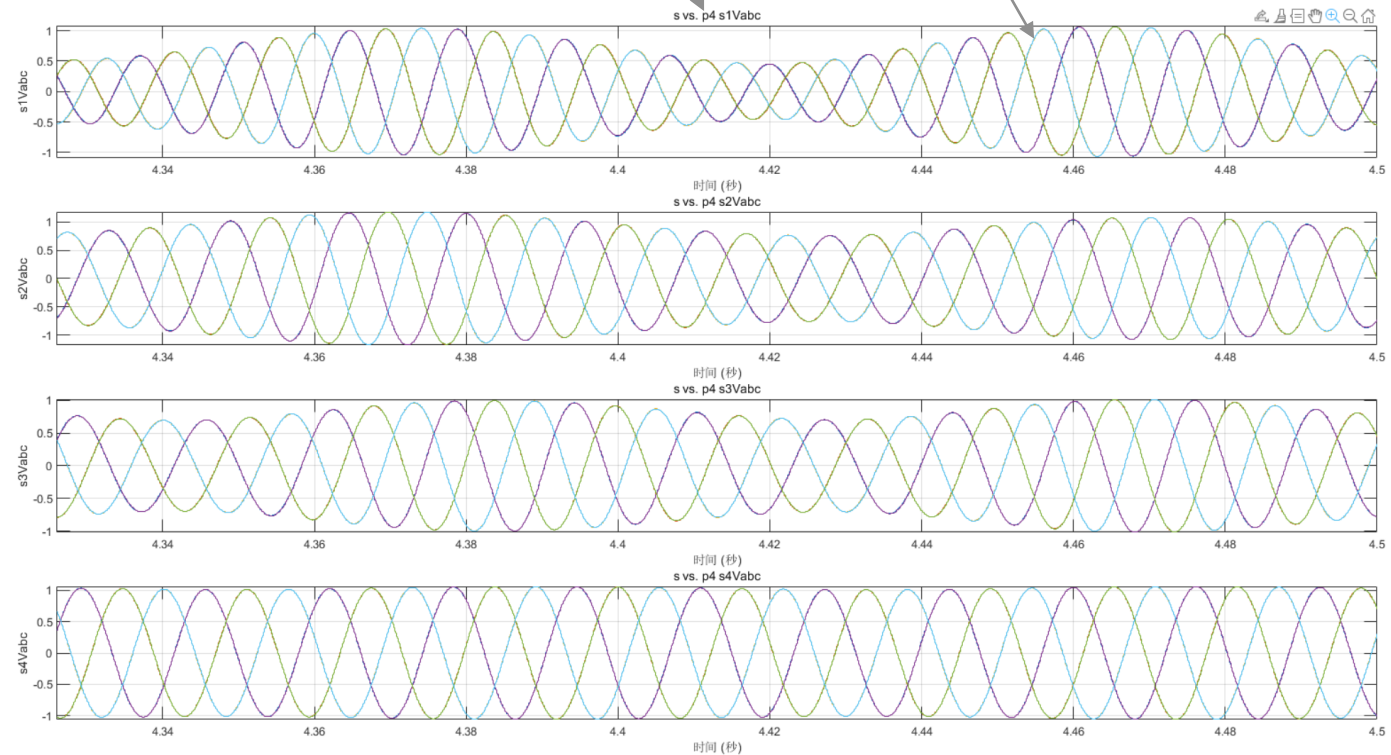
Electrical power grid : Voltage compare



Transition time

Full model and parallel model results in one plot
The curves overlap

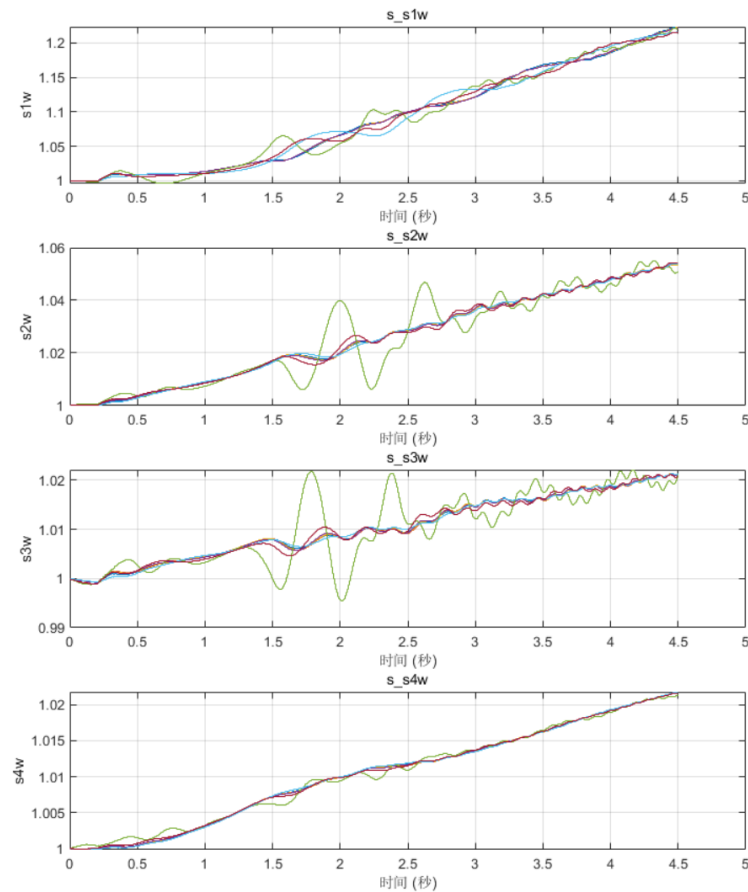
Long time



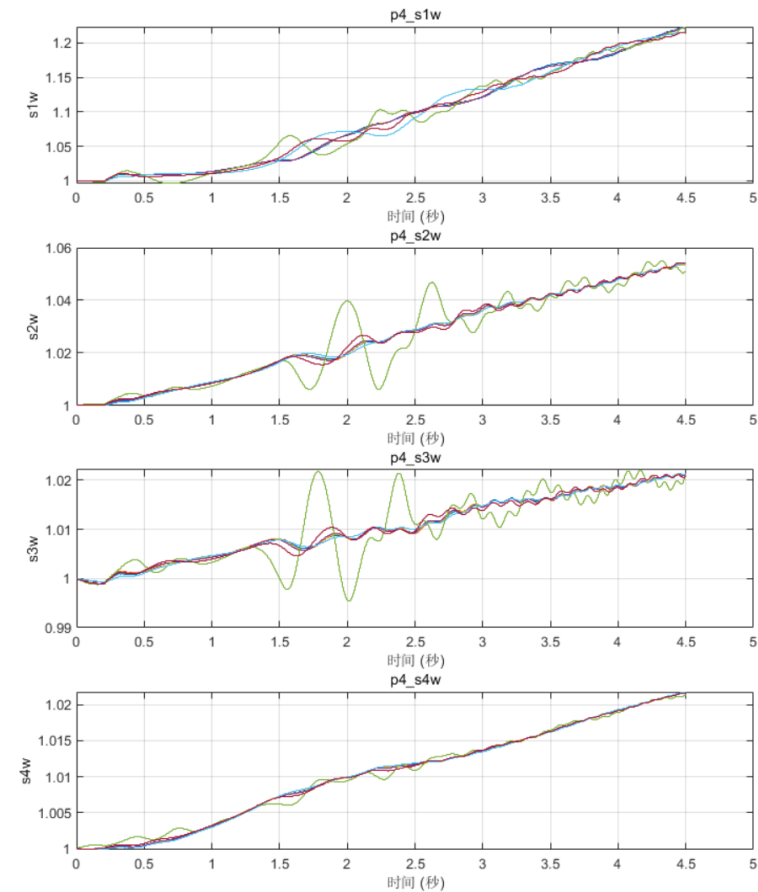
Simulation Result

Electrical power grid : Rotor Speed

Full model



Parallel model



Conclusion

- Large electrical grid, long time test and detailed new energy simulation cost a lot of time.
- Parallel Simulation can significantly speed up simulation, and keep result accuracy
- Speed Improvement is proportional to the number of cores in Normal Mode
- With Accelerator mode simulation can be much faster than Normal Mode
- Parallel Simulation suits for both long duration and small step detailed simulation
- Use Parallel Simulation Control Panel to run model and check result

MATLAB EXPO

Thank you



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