



ELECTRIC POWER ENGINEERS

ENERGY ENGINEERING EXPERTS
GENERATION | TRANSMISSION | DISTRIBUTION



OSCILLATION DAMPING FOR THE GRID OF FUTURE

SAM MALEKI, EPE
MARCH 28, 2024

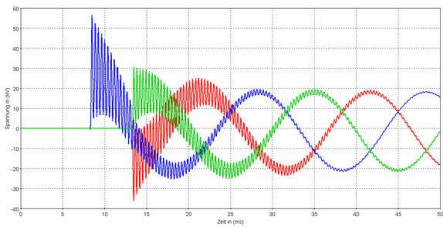


OSCILLATIONS

Very Fast-Transient
(up to several kHz)

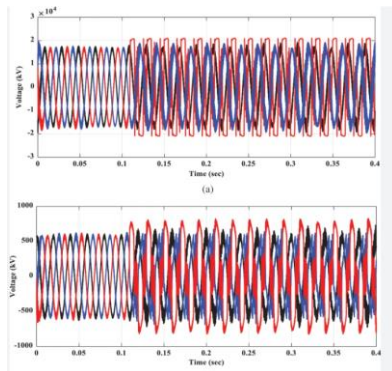


Lightning

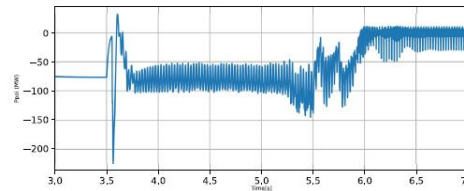


TRV

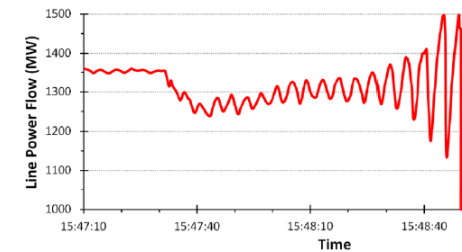
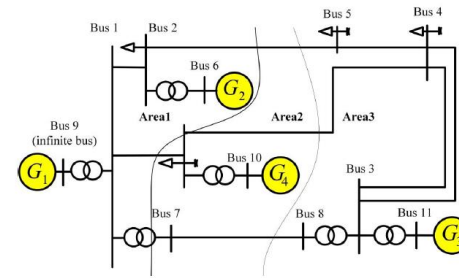
Ferro resonance
(above 60 Hz)



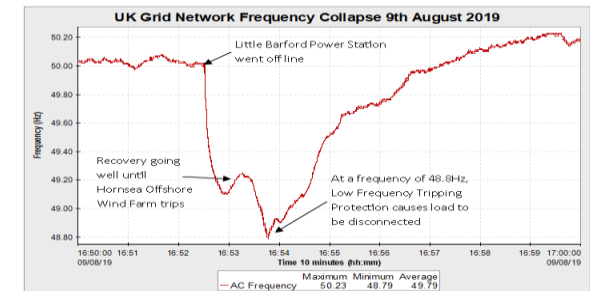
SSR Range
(5-55Hz)



Low Frequency
(0.1-2Hz)



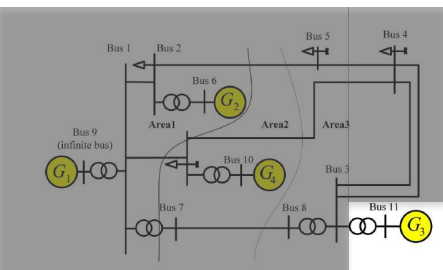
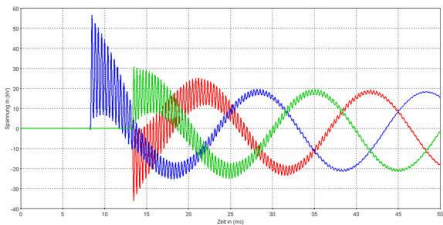
Very Low Frequency
(0.01-0.1Hz)



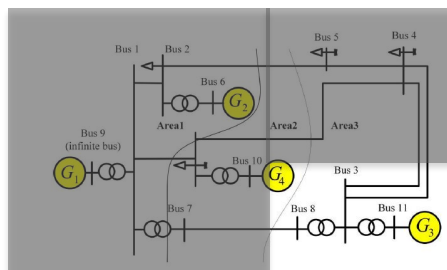
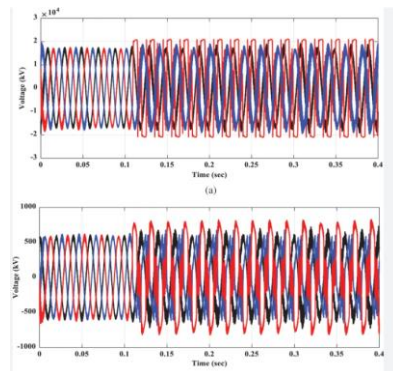


OSCILLATIONS

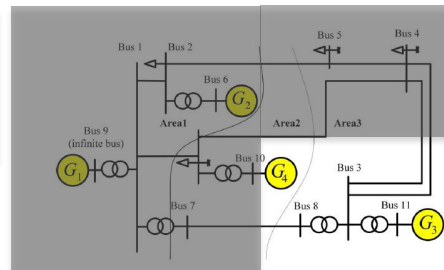
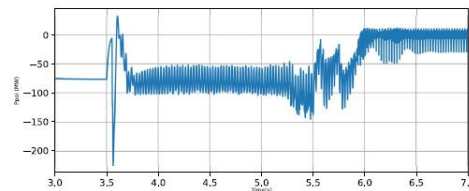
Very Fast-Transient
(up to several kHz)



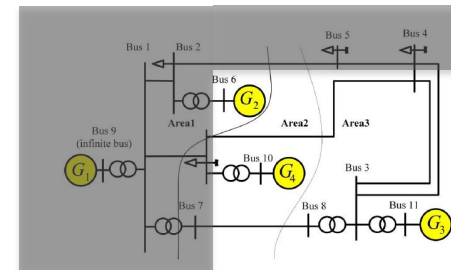
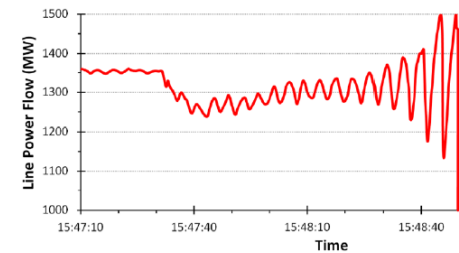
Ferro resonance
(above 60 Hz)



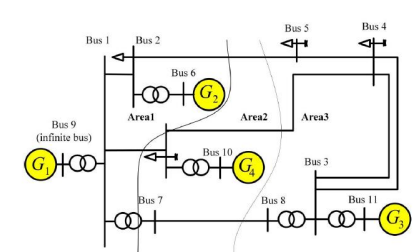
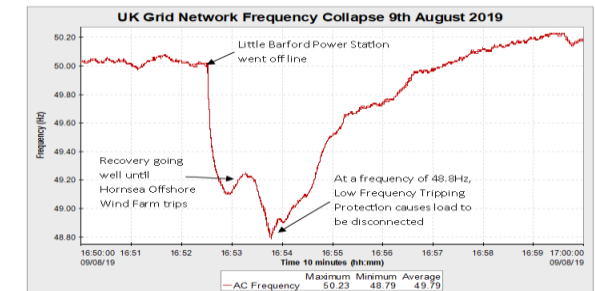
SSO Range
(5-55Hz)



Low Frequency
(0.1-2Hz)



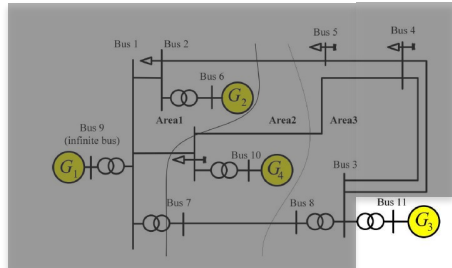
Very Low Frequency
(0.01-0.1Hz)



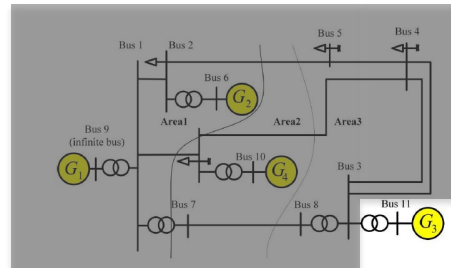


ARE WE MISSING SOMETHING?

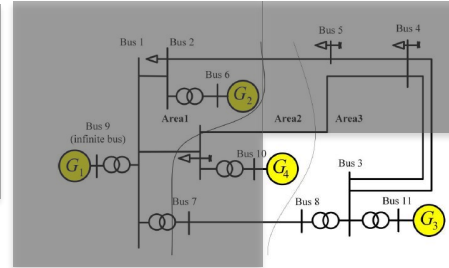
Very Fast-Transient
(up to several kHz)



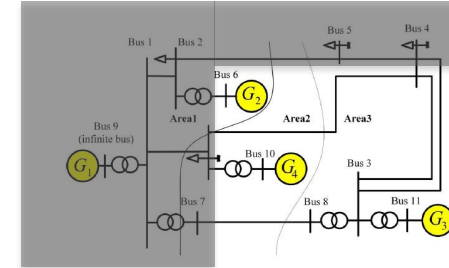
Ferro resonance
(above 60 Hz)



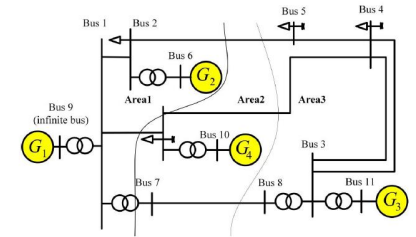
SSO Range
(5-55Hz)



Low Frequency
(0.1-2Hz)



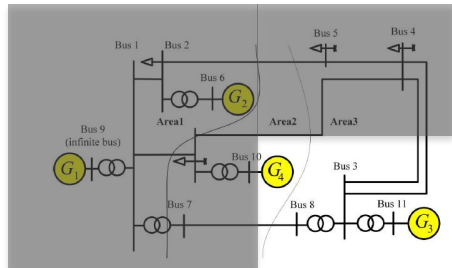
Very Low Frequency
(0.01-0.1Hz)





SUB SYNCHRONOUS OSCILLATION

SSO Range
(5-55Hz)



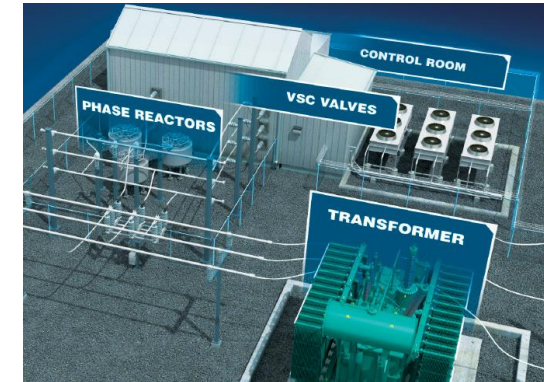
Sub Synchronous Oscillation (SSO)

- Conventional power plant
- Wind power plant
- Solar
- BESS
- Inverter based loads

SSO damping at the inverter side!

- Point of observation is at LV side!
- STATCOM devices and BESS!
200 MW wind → 5 MVAR only!

- Which plant is actually responsible here?!
- Shall the mitigation be done individually, or this should be a joint responsibility?





Low Frequency Oscillation

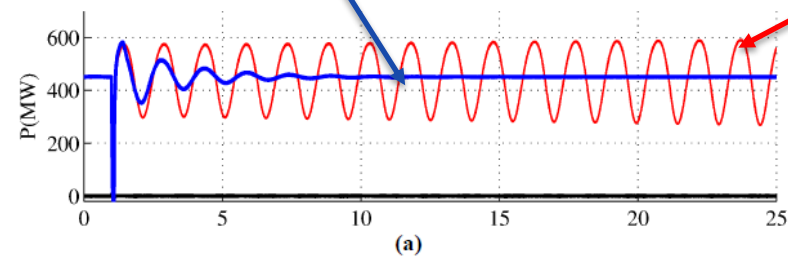
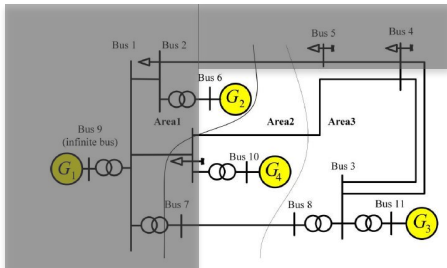
LOW FREQUENCY OSCILLATION



DAMPING (POWER SYSTEM STABILIZER)

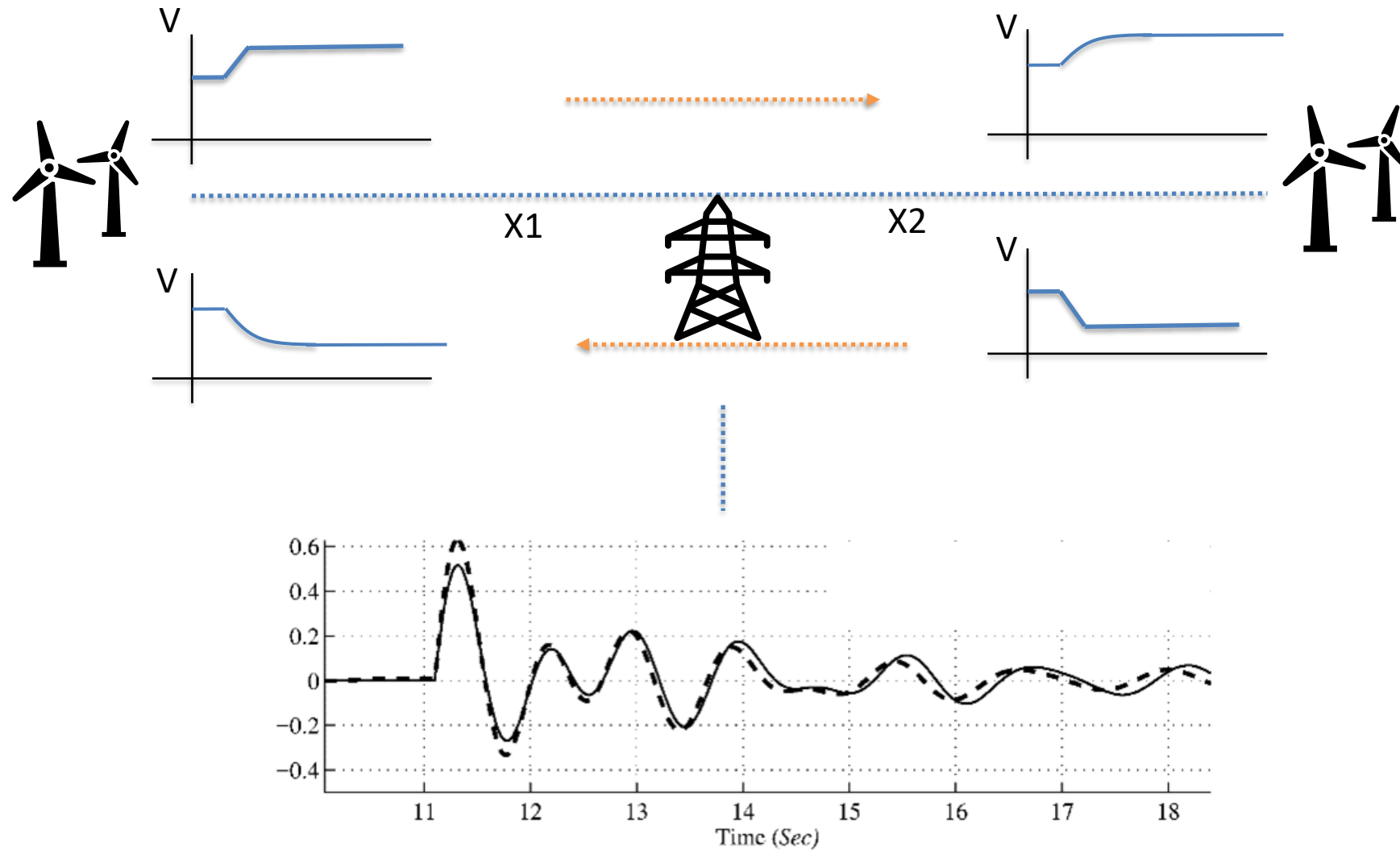
Low Frequency
(0.1-2Hz)

Here we are not talking about inertia rather we want are discussion the damping!





WHY DO WE SEE LOW FREQUENCY OSCILLATION?





WE DON'T NEED STABILIZER!



Power
System
Stabilizer

AVR

Governor

Nothing!

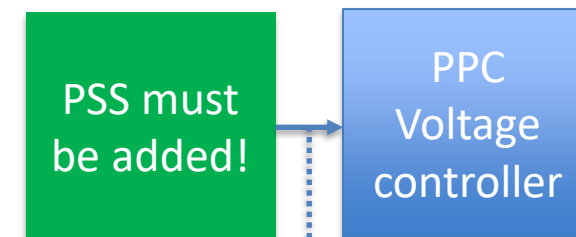
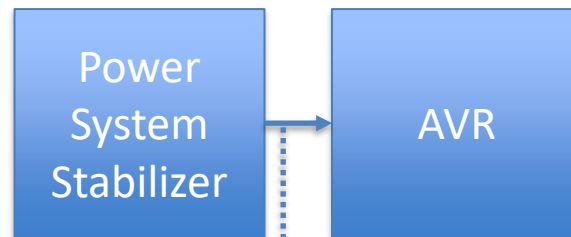
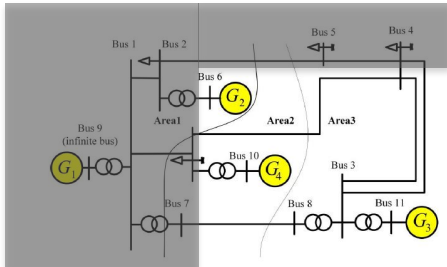
PPC
Voltage
controller

PPC PFR
function

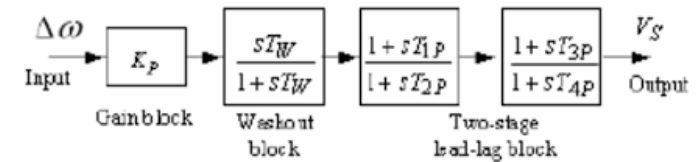
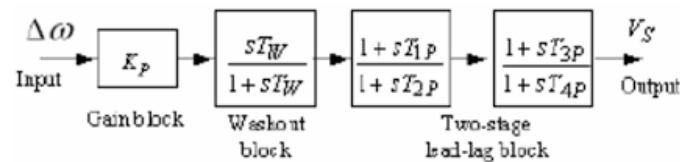


IS PPC REALLY SLOW?!

Low Frequency
(0.1-2Hz)

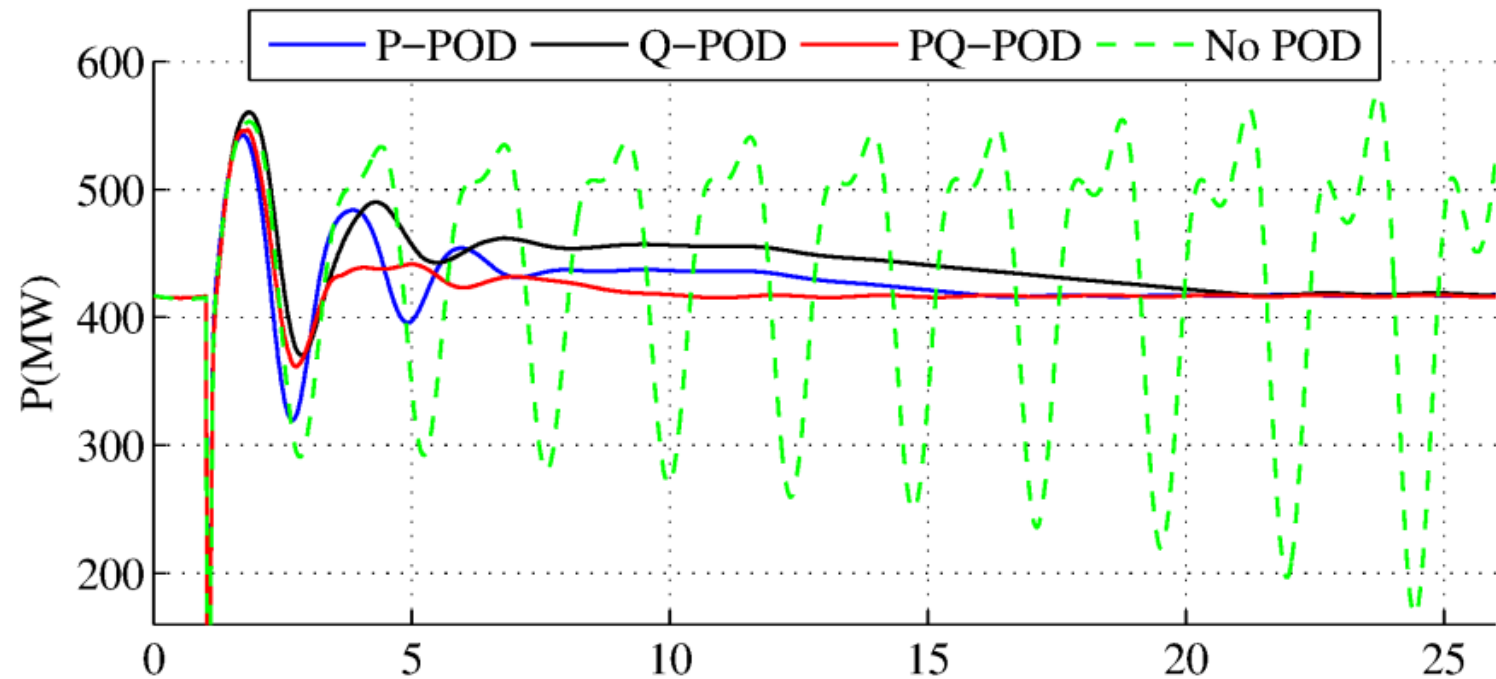
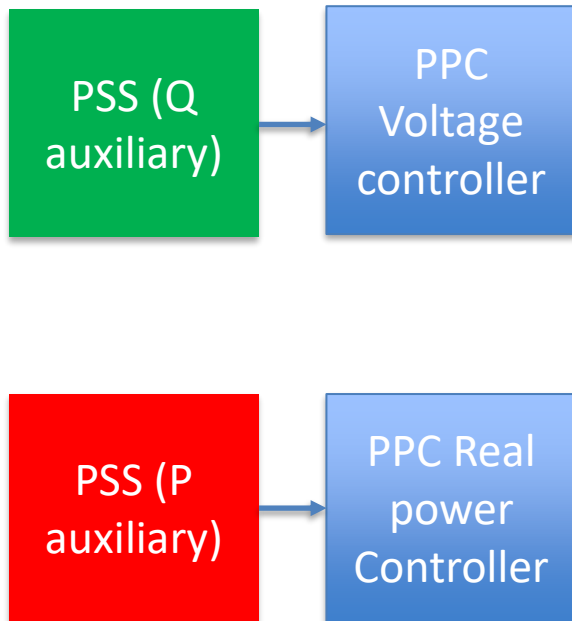


Almost the same delay
(max 0.1 sec 10Hz)!



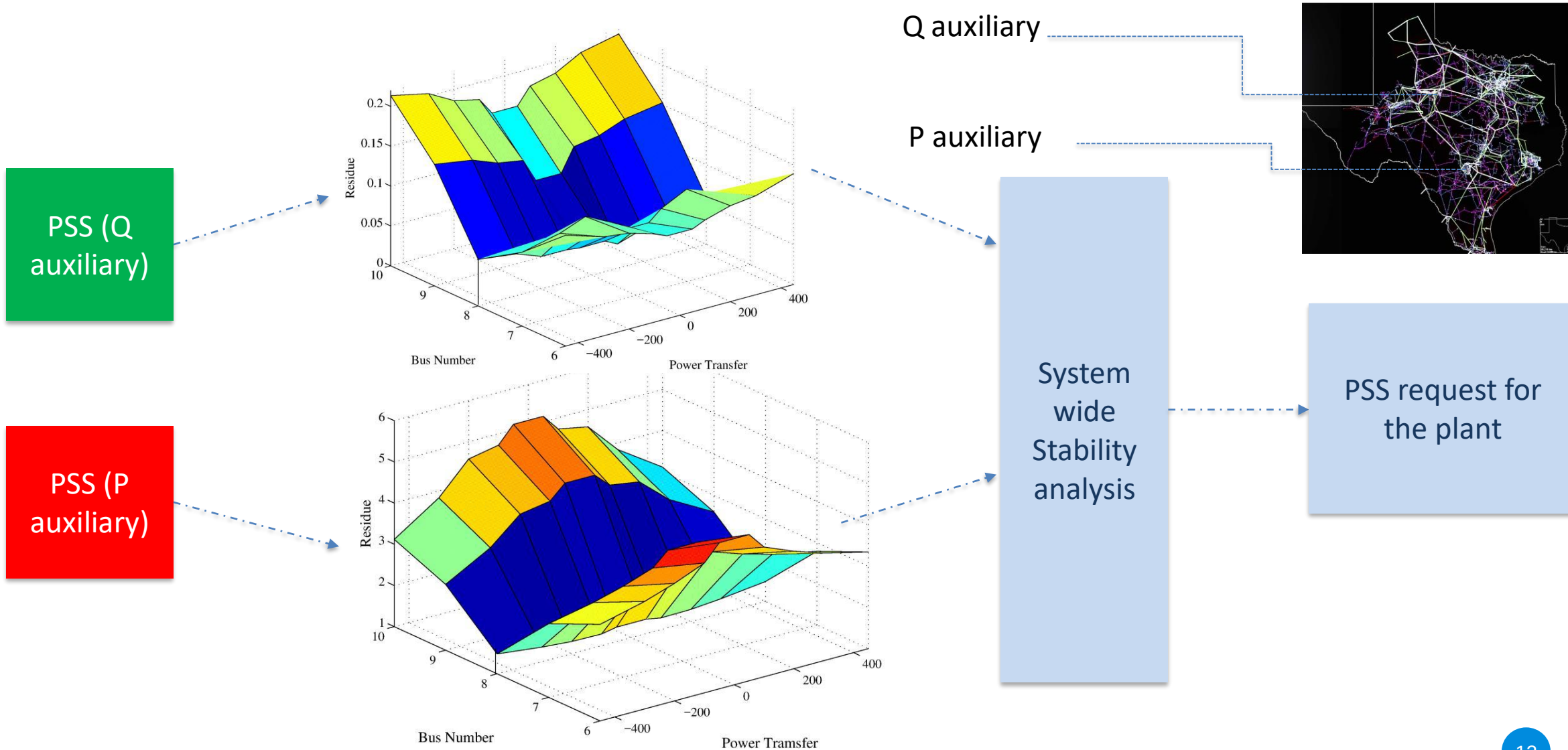


BOTH REACTIVE AND REAL POWER!



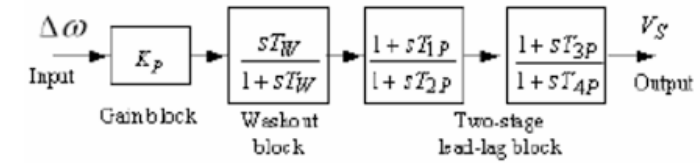
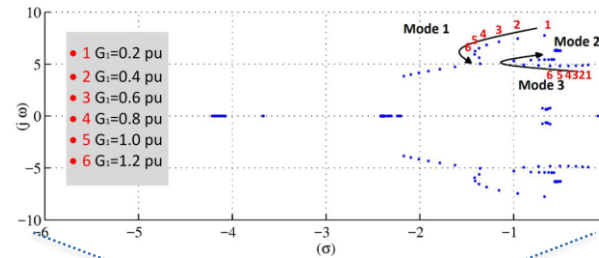


LOCATION EFFECT/ RESIDUE ANALYSIS





LOCATION EFFECT/ RESIDUE ANALYSIS



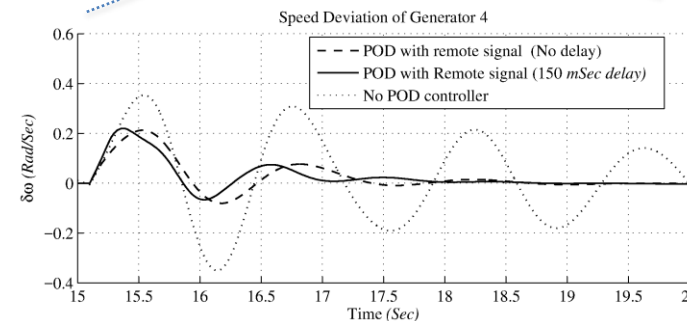
System wide
Stability
analysis

PSS request for
the plant

Small Signal
Analysis

MOD test
5% voltage step
change

Fine tuning based
on system short
circuit level
(lowest & Highest)





LOAD DYNAMIC EFFECT ON SYSTEM STABILITY

Constant load model (*system with high short circuit level*) Composite load model (*system with low short circuit level*)

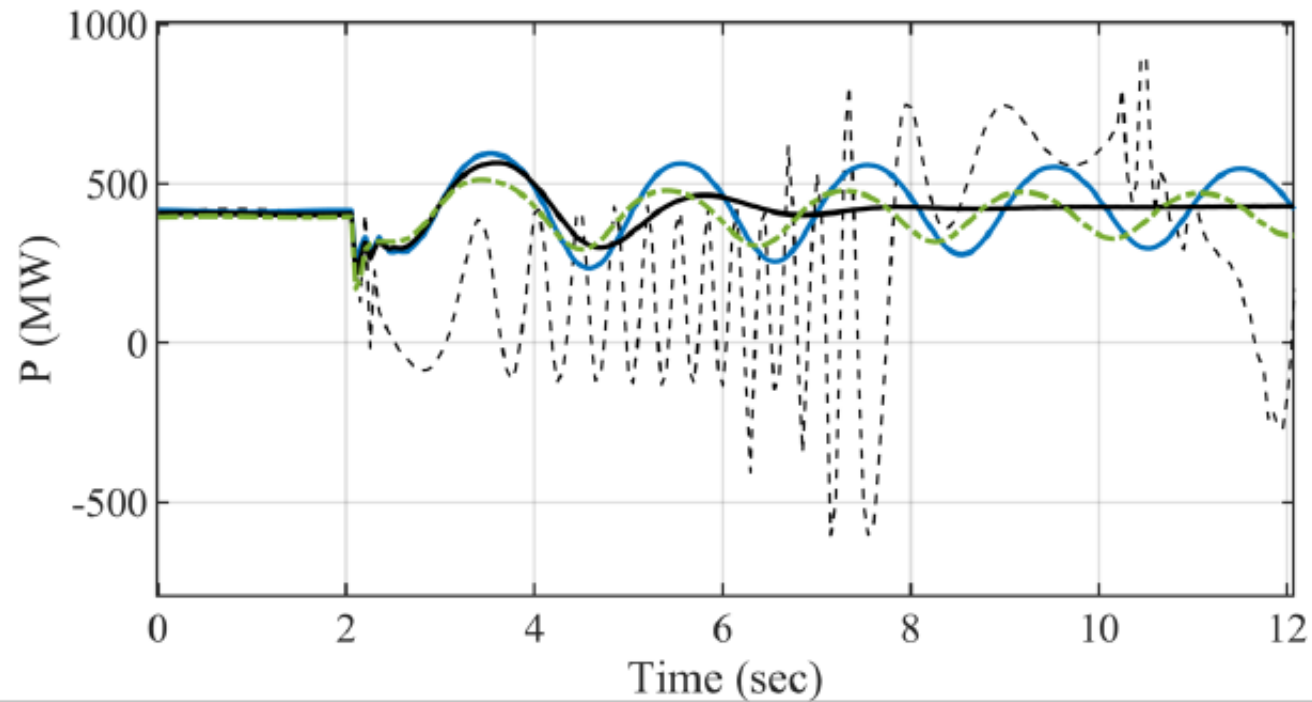


Inverter based load model

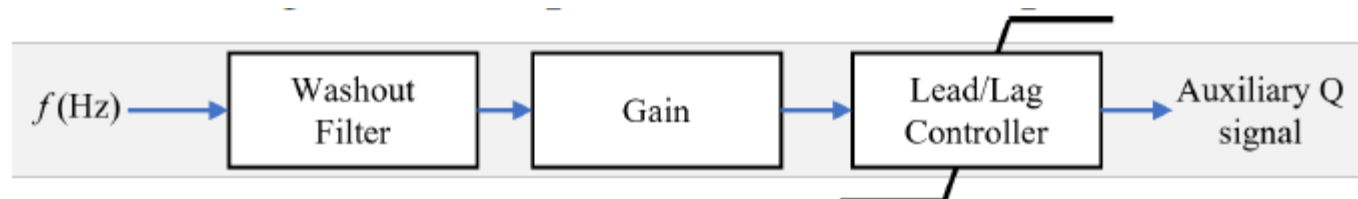
- System short circuit
- Phase lock loop
- Controller units



POD CONTROL MODES FOR LOADS

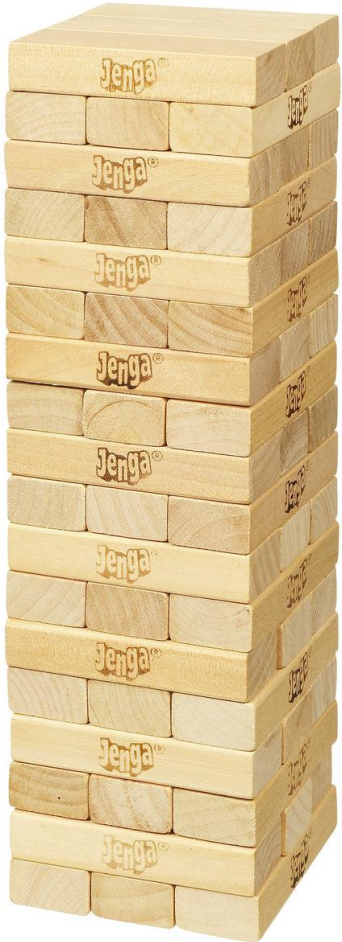


- 50% voltage control
- No composite load
- 50% composite load (Q Control)
- 50% composite load (POD)





CONCLUSION



Please add Power System Damper to IBR generation and inverter-based facilities!



THANK YOU!

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