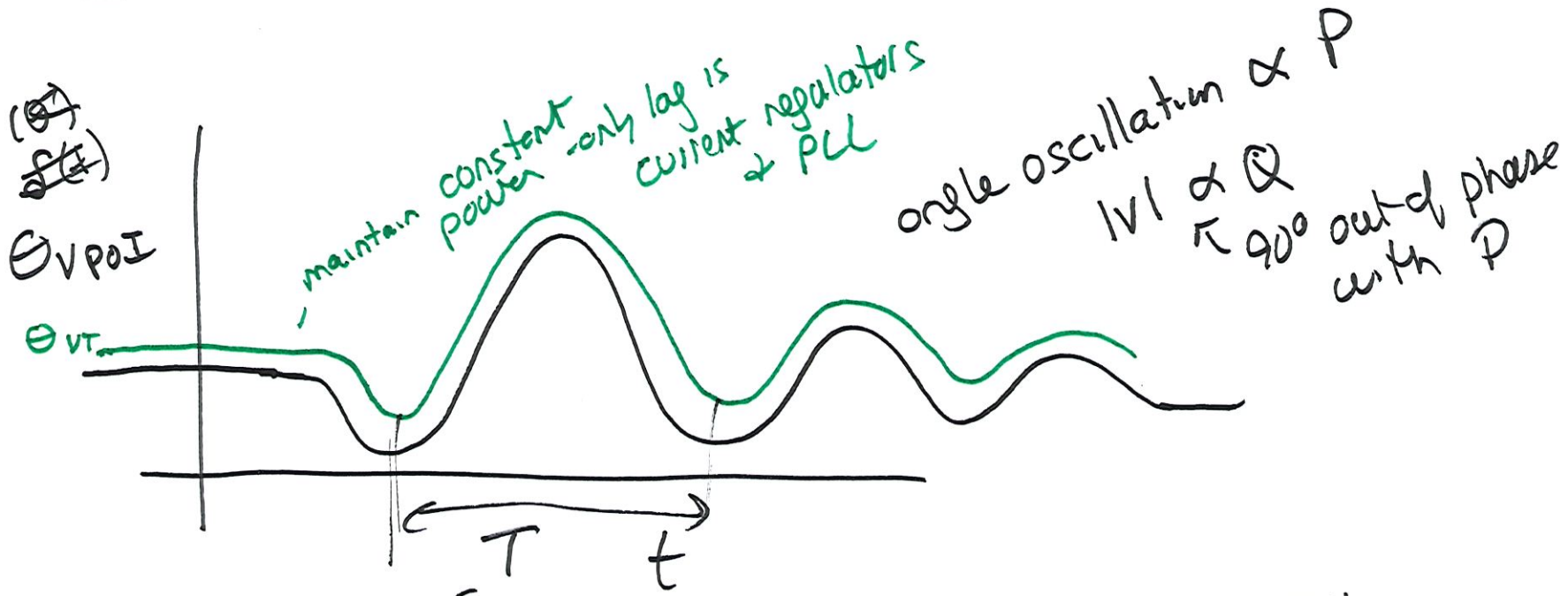
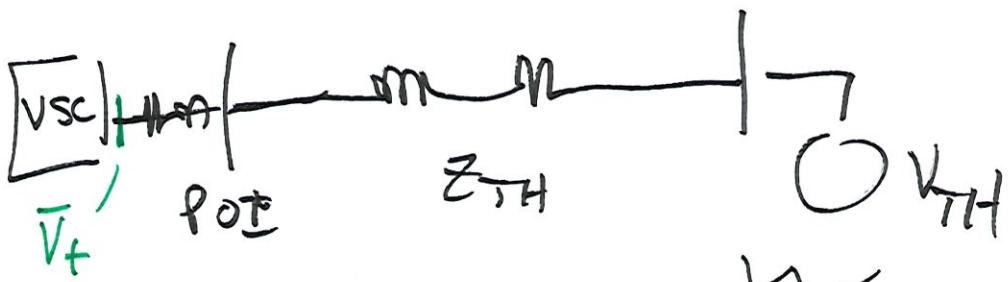
University of Idaho

ECE 529
Utility Applications of Power Electronics

Session 34



corresponds to freq of oscillation for 0.5 Hz – 5 Hz



dynamic equivalent (synch machine)
- swing equation

L34 2/A

Approximation for rate of change of frequency

$$\text{ROCOF} = \frac{P_{gen\_sys} - P_{load\_sys}}{2 \cdot H_{system}}$$

Swing equation:

$$P_a = P_m - P_e = \frac{2.H}{\omega_{0_r}} \cdot \frac{d^2\delta}{dt^2} + D\frac{d\delta}{dt}$$

per unit inertia constant - in seconds

$$H_{gen} = \frac{E_{rotor\text{-}rated}}{\text{RATED MVA}} = \frac{\frac{1}{2} J \omega_r^2}{S_{B\,m/c}}$$

J is rotor for generator and masses associated with prime movers

~~Damping~~ Droop

damping

$$T_a = 2H \cdot \frac{d(\Delta\omega)}{dt} - D \cdot \Delta\omega$$

programin into converter controls

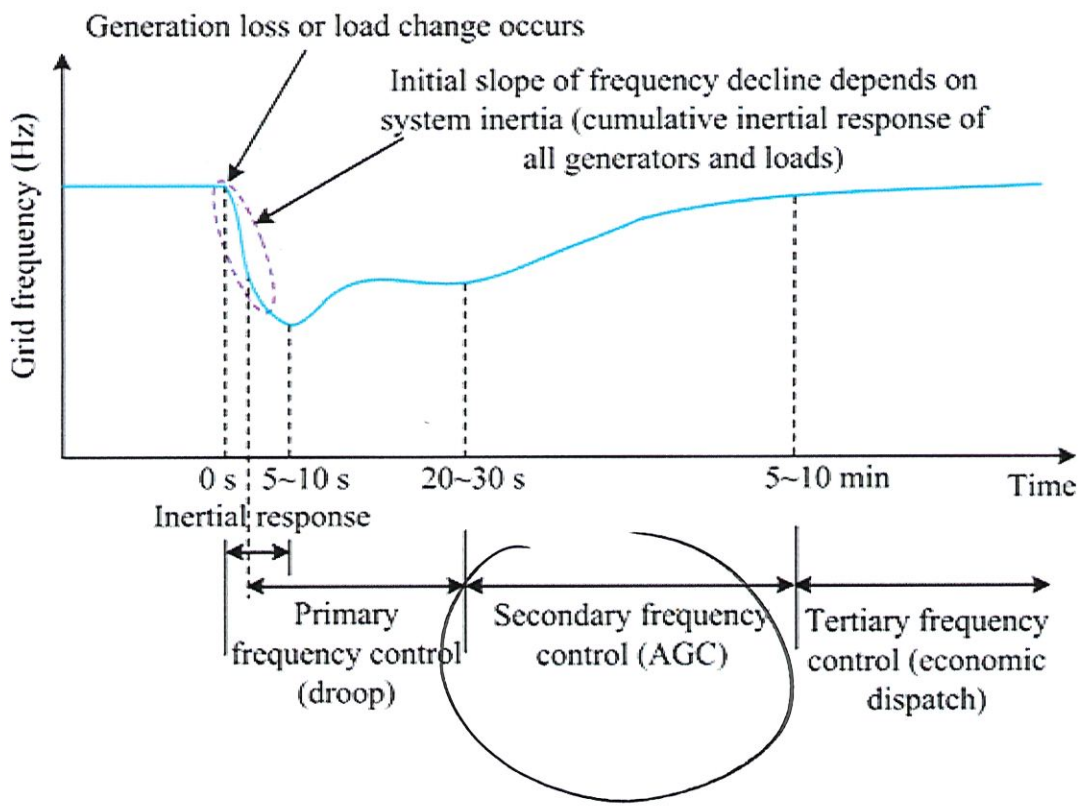
move to a system base - do change of base on MVA..

$$H_{sys} = H_{gen} \cdot \frac{S_{B\,m/c}}{S_{B\,sys}}$$

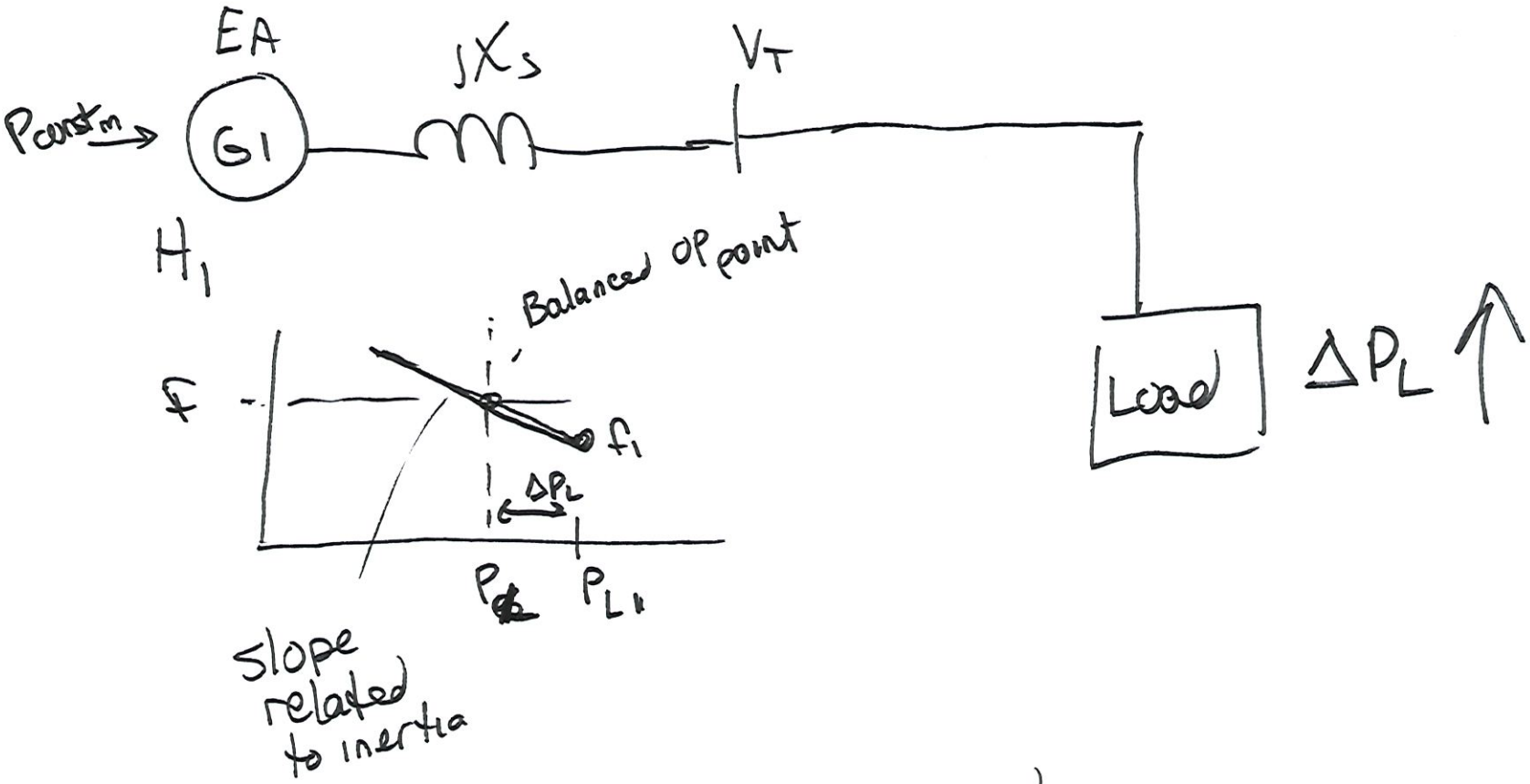
$$H_{TOTAL\_SYS} = H_{g1} + H_{g2} \ldots$$

L34 3/9

Grid Forming Converters

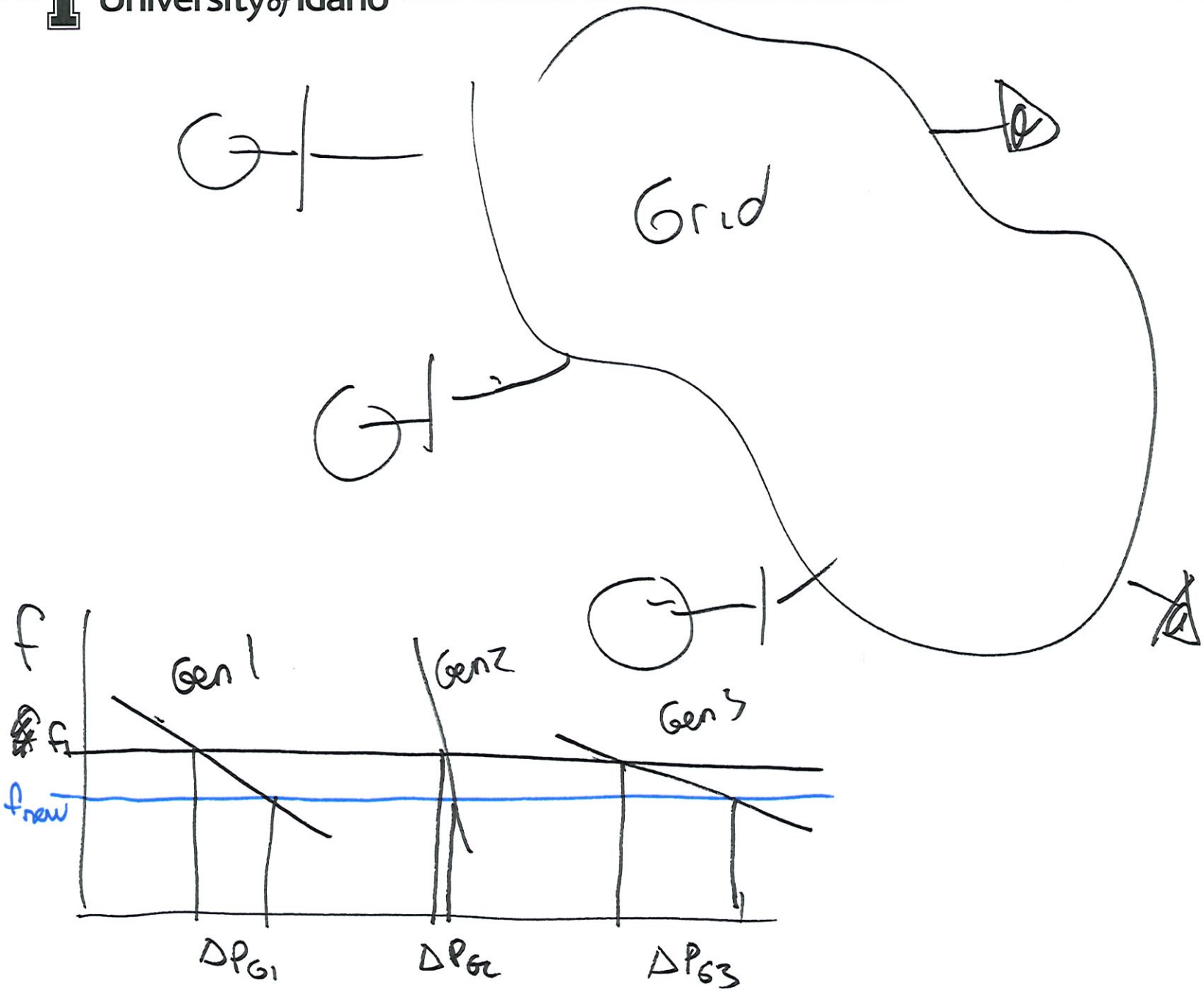


L34 4/9



→ The governor can have a programmed slope → for a nuclear power plant a slope such that no ΔP

L34 SA



Grid forming or grid firming converter control

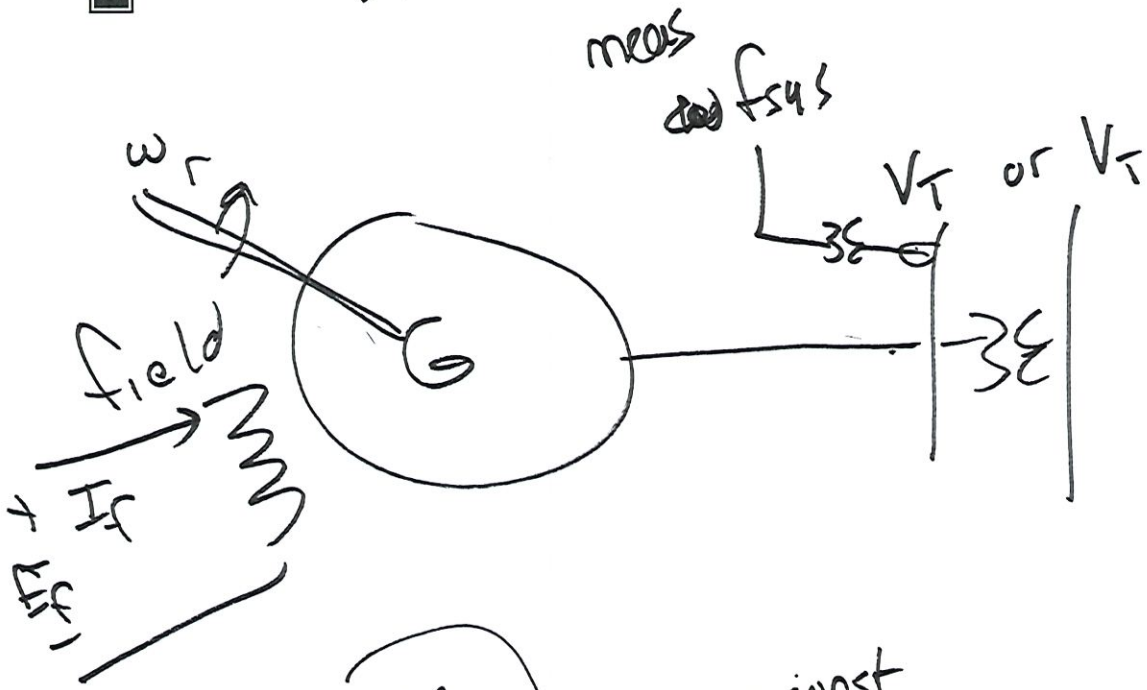
→ develop control response that models desired behavior

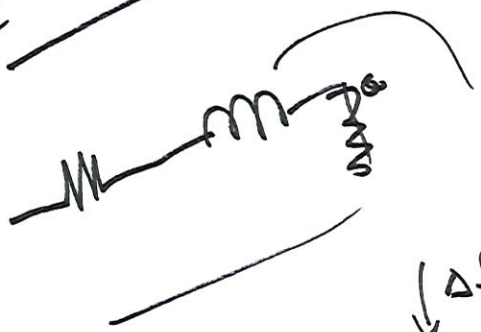
→ Damping

S/G

- damper bars (cycles)
- PSS (1/2 sec to seconds)

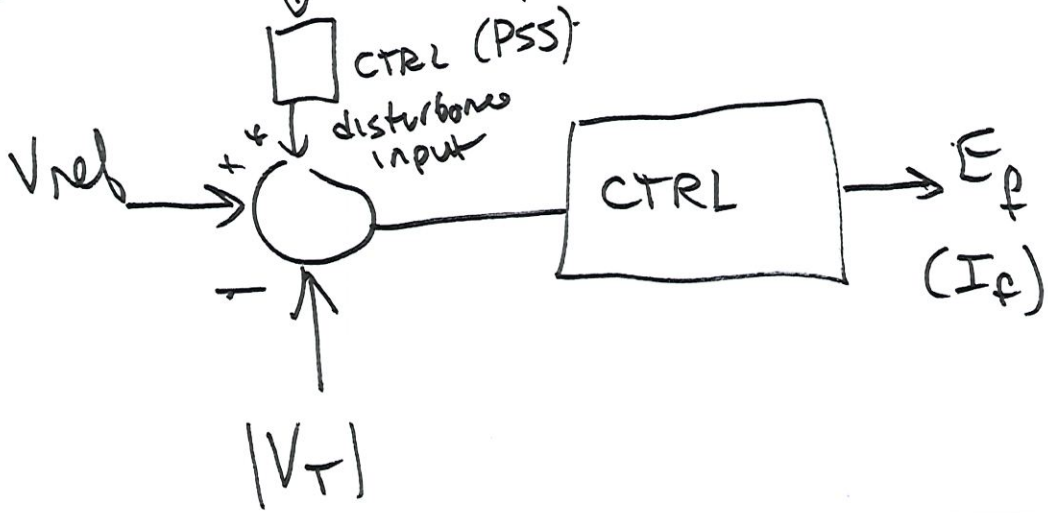
University of Idaho





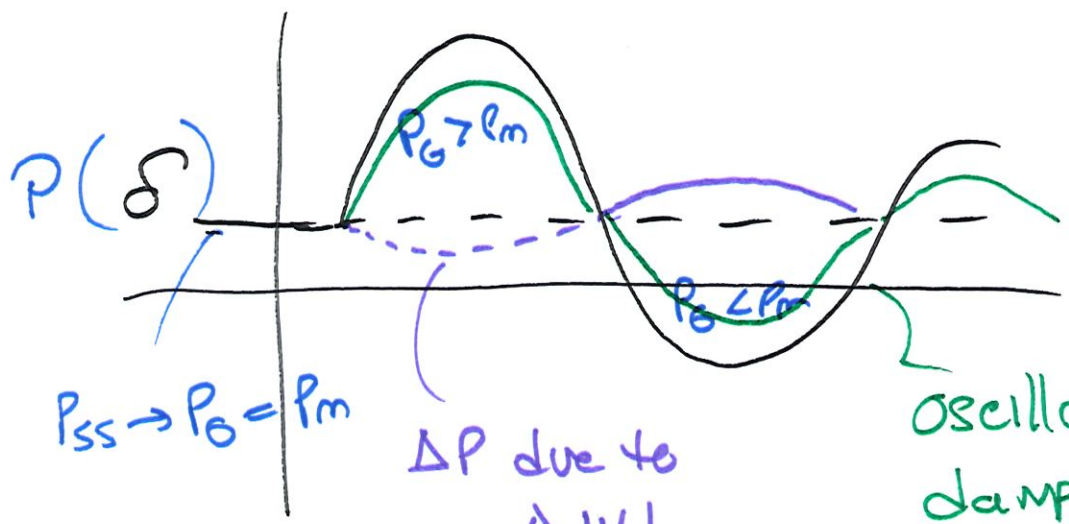
RL tim const
~ 0.5 - 1sec

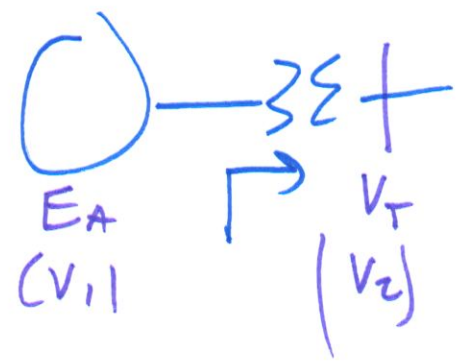
Power System Stabilizer - indirect damping of angle/power oscillations



$$P \cong \frac{|V_1||V_2|}{X} \sin(\underbrace{\theta_1 - \theta_2}_{\delta})$$

VOM $|V_1| - \Delta V_1$





L34 9/9

- voltage magnitude (reactive power) damping can be programmed into converter
  - → Flexible AC Transmission Systems (FACTS) devices over 40 years.
  - → can also program into generators (Inverter based gens)
- Real power damping it is far more effective → vary real power to improve overall system response ← STORAGE