ECE 404-TD / 504-TD

ST: T&D APPLICATIONS OF VOLTAGE SOURCE CONVERTERS

SESSION no. 25

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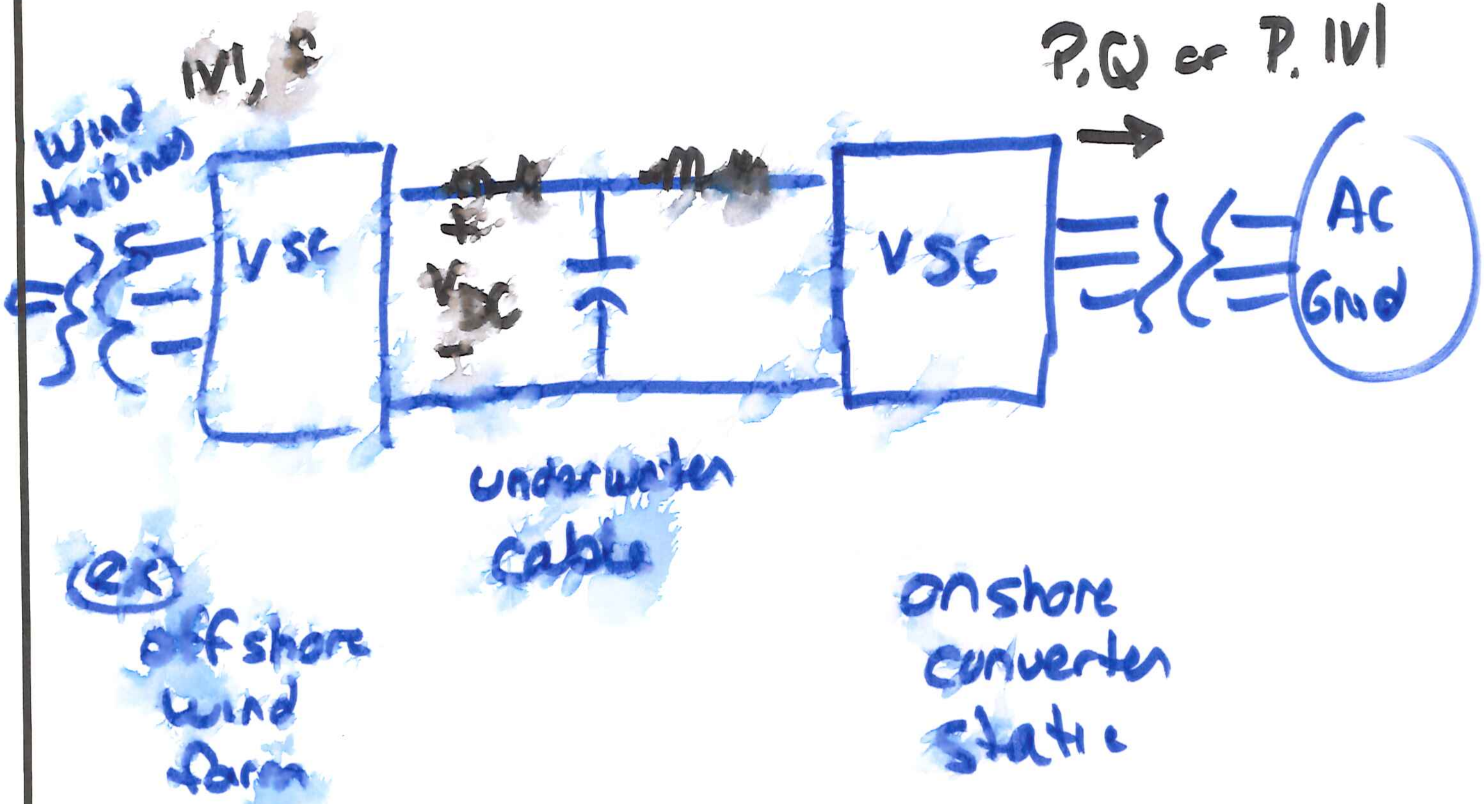
Possible Application - Voltage SC High Voltage DC transmission



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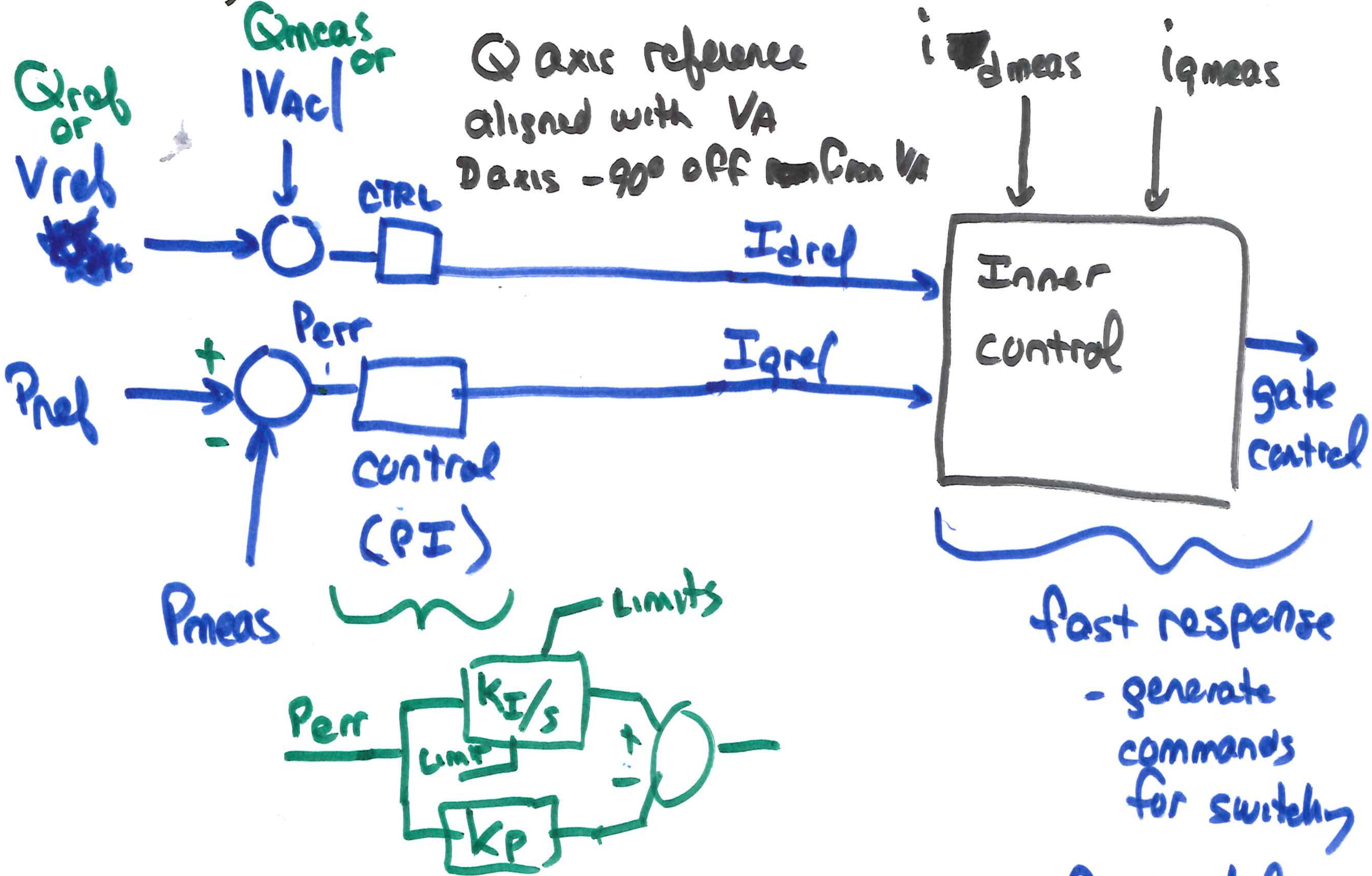
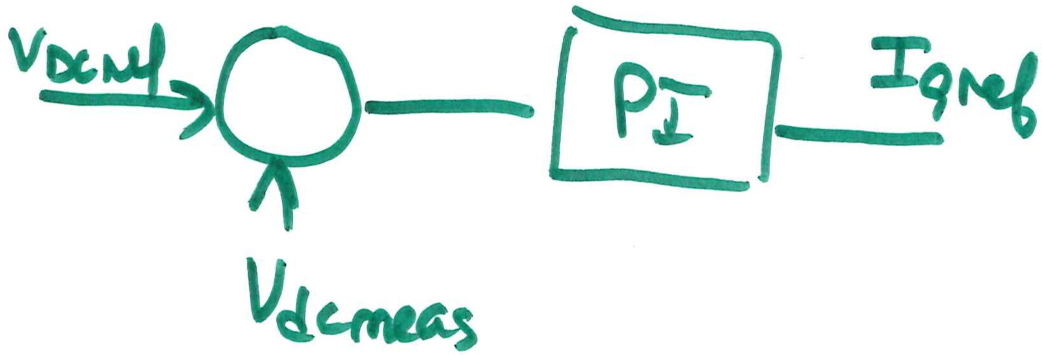
Q axis reference aligned with VA
D axis -90° off from VA



fast response
- generate commands for switching
- fundamental frequency cycle or less

for converter controlling V_{dc}



→ replaces Power control at a converter

→

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Supplemental outer loop controls

→ Power oscillation damping

- grid connected converters
- low frequency oscillation due to disturbance
  → modulate P (or Q) to damp disturbance

→ subsynchronous resonance damping

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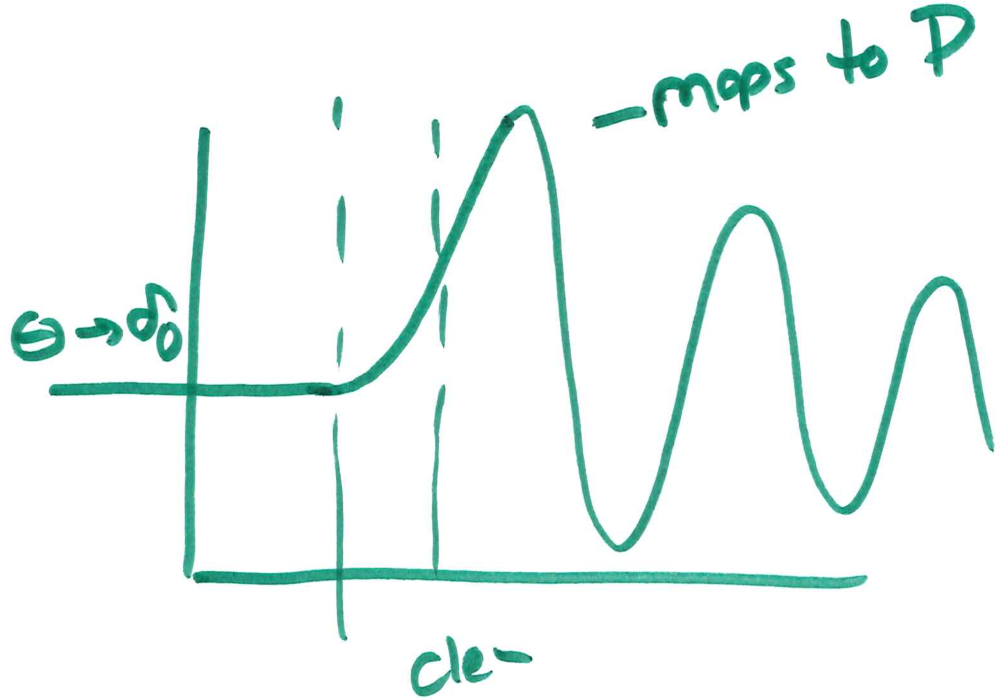

Q (M) will oscillate with
90° shift

Model converters for

1. system studies
2. control design

Options: (1) fully detailed switching model

- model all of the devices
- model turn on/turn off behavior

→ Impractical

- system dynamics of interest are much slower than device turn-on/turn off

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(2) Simplified switching models

- Ideal switches or quasi ideal

→ model 1 devices instead of series string

- don't model turn-on/turn off behavior in detail

- don't model diode in detail

- Not necessarily model all converter modules

Time steps 1 ns - 50 nsec

EMTP-like programs ATP, EMTDC RTDS

- Don't model system startup in detail
- Doesn't represent losses very well
  - approximations
    1. Add a series voltage drop
    2. Add a series resistor (small) to represent resistive part of forward drop

(3) Add a voltage dependant current source on dc link for switching losses

for most system studies neglecting losses has a small impact

- full ~~swing~~ ~~switing~~ switching models are a late stage model for studies
  - Non-switching models
    1. Power flow models
       regulated P, |V|
       or P, Q or whatever control goals are
       - with limits added

(2) Stability studies

- add outer control loops
  - some of the averaged dynamics of converter

(3) Fault studies

→ voltage source with current control/limits

or

current source

Possible phase shift to leading current ←

④ Transient studies / control dcv

→ Fundamental component models
or
– Averaged models

equivalent AC voltage source
+
equivalent dc current source