HVDC Control

Control Principles

- Two independent control inputs at each terminal
  - Firing angle $\rightarrow$ fast
  - AC voltage $\rightarrow$ slow (LTC)
- Synchronized firing with PLL
- Fast control loop for firing commands
- Somewhat slower for regulator
Control Principles

• One terminal controls DC voltage (fast)
• One terminal controls DC current (slower)
  • Current order from higher order power command
• Communication enhances performance
• Required for start up or major changes
  • Power flow reversal

Static Characteristics

• Alpha min for rectifier
  • Disturbance
• Gamma min at inverter
  • Commutation failure
• VDCOL
Measurements

- DC voltage and current
- AC voltage
- Remote end current or voltage
- Operator commands

Station Control

- Bipole power order
- Frequency control/limits
- AC voltage control
- Reactive power
Bipole Control

- Pole power orders
- Power limits
- Pole balancing

Pole Control

- Pole power
- Firing angles, limits
- Phase limits
- Static characteristics
- Tap changer
- SSR damping
- Power Swing damping
- Pole protection
Power Control

- Operator sets power demand
- Compare to measured control
- Set current or voltage order
  - Within limits
- Can integrate offset to power order with frequency slope characteristic
- Can add power modulation control
- SSR damping

DC Faults with LCC

- DC faults
  - One end will not feed the fault
  - Use converter control to reverse voltage polarity
    - Reverses current direction
    - Starves Fault
  - Smoothing reactor slows rate of rise of current
- AC faults
  - Load rejection
  - Commutation failure
### Multiterminal HVDC Systems

- Multiterminal Connection Options
- Controls
- Mixing LCC and VSC
  - Full bridge MMC
  - DC/DC converters