ECE 529

UTILITY APPLICATIONS OF
POWER ELECTRONICS

SESSION no. 46
**AC Fault Behavior**

- Controls will have a huge impact
- Converter topology some effect
  - Most topologies are ungrounded
  - Transformer may be Yg-D (delta faces converter)
    - Some variation with vendors

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**Inner Controls**

- Most schemes use inner current regulators
  - Fact acting, protect devices from excess currents
  - Possibly 2 sets, one each for pos and neg sequence

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*HVDC Controls*  
Spring 2019
Impact of Inner Controls

- Converter will limit current for ac faults
  » Same current for variety of fault locations
  » A little different in older schemes
- Doesn’t vary much with converter topology
- Generally fairly balanced currents
- Try to support local voltage
  » Current at leading power factor
- Some reports of impact on distance protection

Impact on Distance Protection

- Source: L. He, C.C. Liu, “Effects of HVDC Connection for Offshore Wind Turbines on AC Grid Protection,” 2013 IEEE PES General Meeting
**DC Fault Behavior**

- Converter topology poses problem
- Diodes form uncontrolled path
  - Known since 1980's
- Pole to pole versus pole to ground

**Clearing DC Faults**

- To date, no systems use DC breakers for this problem
- Siemens proposed IGBTs in old HVDC plus designs
- Full bridge based MMCs can block dc fault currents
  - Doubles device count and increases losses
  - So schemes use half-bridges
- Rely on ac side breakers to interrupt dc fault current – point to point systems
CIGRE-B4
(Study Committee)
c-cigre.org
AC System Impact

- AC system will see dc fault current
  - Will most often look like phase to phase fault
  - Possibly 3 phase depending on breaker response time
- Followed by load (or source) rejection since dc power transfer will go to zero
  - Will not see temporary overvoltages as with LCC

Circuit Interruption Options

- Multiterminal HVDC Grids will need DC breakers
  - Possibly as little as 2 ms response needed
- Lack of DC breakers (at least fast ones)
  - BPA test, metallic earth return breakers
  - IGBTs in line (point to point better)
    - Drawbacks: ratings, losses and they don’t truly “open” and “isolate”
  - Recent developments HVDC breakers
Power

Pure Electronic Transformer

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\begin{align*}
\frac{V}{\sqrt{2}} & \div \frac{V}{\sqrt{2}} - 3 \& 3 - \frac{V}{\sqrt{2}} & \div \frac{V}{\sqrt{2}} \\
\end{align*}
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