Multiple SFCLs for Fast Fault Detection

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A future power system...

Highly meshed

Low fault currents

All faults detected and isolated rapidly

Optimal zone isolated, without communications
How?

• Multiple Superconducting Fault Current Limiters (SFCLs)
Resistive SFCLs

- Fast-acting
- Resettable
- Allows interconnection
- Eases voltage transients
- Fail-safe
- Recovery time (minutes)

Effects on protection

Cost ~ SFCL Load

1. Fault occurs

2. SFCL "quenches"

3. Peak fault current halved
SFCL transient reaction

- Inverse current-time characteristic
- Use same parameters for each SFCL
Fault detection example

- Closer to fault, larger fault current

SFCL 1
SFCL 2
SFCL 3
SFCL 4
SFCL 5
SFCL 6
Load L1
Load L2

Limits all sources of fault current

Minimal zone disconnected
Applications

• Applies for all (low-Z) fault types
• Ideal for meshed systems, with DG
  – Eliminates fault level concerns
• Integration with superconducting transmission cables
• Best suited to cables sections, not overhead lines
• Can change operating current threshold using temperature
What’s the catch?

- Needs many SFCLs
- All SFCLs must have the same characteristic
- Must select superconductor properties carefully
- Each bus must have $\geq 3$ fault current sources
- Needs protection for high-impedance faults
  – but can reduce time settings
Summary

• A solution for future, interconnected grids
• Compelling benefits:
  – Very fast-acting
  – No high fault currents
  – Permits interconnection
• But potentially very expensive in practice
• Merits consideration for any new grid