Cable Fault Location on long HVAC and HVDC Cable Systems

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Challenges in cable fault location on HVAC and HVDC cable systems

- Cable fault location (CFL) is a process
- Different types of possible cable faults (CF) asks for various number of test methods
- Today's base of experience is still limited
- Characteristics of CF can change with time and during the test
- Big influence of laying conditions and HVAC system design

► All CFL methods have limitations and needs to be adopted to specific environment of HVAC and HVDC cable systems
Prelocation of cable faults

- **Time Domain Reflectometry (TDR)**
  - CFL up to 500km cable length possible with good TDR equipment
  - Well proven on low-resistance faults
  - Correction methods for damping and dispersion important for long cables
  - Documented reference fingerprint traces are very helpful
Prelocation of cable faults

- **Arc Reflection Method (ARM)**
  - Limited to ca. 40 km cable length
  - Method is well proven on high-resistance faults (makes them low-ohmic)
  - Inductive HV filter design provide a good ARC stabilization and multiple TDR traces are used for selection of the best trigger point.
Prelocation of cable faults

- ICE and DECAY
  - Well proven on high resistance faults with certain DC withstand voltage
  - Strongly dependent on cable fault condition
  - Surge Generator up to 80 kV with high energy used
  - Limited for fault distances up to 30 km due to physics

![Diagram of fault location process]

Fault → Fault Identification → Prelocation → Cable Tracing → Pinpointing → Cable Identification → Repair
Prelocation of cable faults

- **Burning methods**
  - Fault conditioning with high voltage and high current to achieve low ohmic status
  - 40kV/25kVA burning transformer well proven in combination with TDR on difficult faults
  - Provides a TDR capability up to 500 km cable length
Prelocation of cable faults

- **Bridge Method**
  - Highly dependent on cable design -> AC cables with Graaf Method
  -> DC cables with Murray Method (correction of different cable parameter needed)
  - Reliable cable data crucial for precise prelocation
  - Long distance fault location possible
  - Voltage drop method provide easier application of Murray Method

![Diagram of Graaf Method](image1)

![Diagram of Murray Method](image2)

Fault ➔ Fault Identification ➔ Prelocation ➔ Cable Tracing ➔ Pinpointing ➔ Cable Identification ➔ Repair
Cable tracing on HVAC and HVDC cables

- **Audio frequency**
  - 200W Transmitter with D-Class Amplifier and various frequencies
  - Special inductive coupling system for low frequencies
  - Normal Receiver used on Land Cables and Shallow Water
  - Special Audio Frequency Receiver installed on ROV for deep water application
Pinpointing of cable faults on HVAC and HVDC cables

- **Acoustic location**
  - Noise cancelation technology important
  - Combined analysis of acoustic and magnetic impulse most promising method
  - Installation inside ducts and pipes makes pinpointing challenging on land cables
Safety Issues

• Safe discharge in case of charged cables

  • In case of fault confirmation with DC voltage and no breakdown
  • In case of surging and no discharge at the fault place
  • Discharge energy: \( P = \frac{U^2 C}{2} \)

Example: 100 km cable length with app. 25 \( \mu F \) capacitance
  DC voltage for fault confirmation 130 kV
  -> in case of no breakdown/flash over - > the Energy of \( 422 \text{ kJ} \) must be discharged safely