Fault Location in Resonant-Earthed MV Distribution

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Outline

- Resonant-earthed system
- Fault location strategies
- Sectionalizing the fault
  - Current based fault sectionalizing
- Conclusions
Resonant-earthed system

- The transformer neutral is connected to the earth through Petersen coil.
- The coil is **tuned to minimize the fault current** through the fault location.
- Numerous transient faults become self-extinguishing: **good supply reliability**
Fault location strategies

- **Step 1** is done by the protection system
- **Step 2** has two strategies

**Step 1**
- Find the faulty feeder

**Step 2**
- Distance of the fault location

**Sectionalizing the fault**

Network diagram showing:
- Healthy feeder
- Faulty feeder
- Fault distance
- Faulty section

- **FPI** finds fault
- **FPI** finds no fault

- **FPI** stands for Fault Passage Indicator
Fault location by sectionalizing the fault

Sectionalizing the fault

- Fundamental Frequency
- Zero-sequence method
- Other frequencies
- Injection method

- Only the magnitude of zero-sequence current might not be enough for reliable sectionalization
Sectionalizing the fault (Cont.)

Usually voltage is used as the reference for calculating the current phasors.

Voltage is measured centrally

Requires time synchronization

Voltage is measured locally

Increases the cost

Detection for the fault F1

Detection for the fault F2

\[ I_0 \cos \theta \text{ is plotted where, } \theta = \angle V_0 - \angle I_0 \]
Sectionalizing the fault (Cont.)

- **Current based fault sectionalization (proposed)**
  - The faulty phase is used as a reference to calculate the angle for the other two phases.
  - A resistor is connected parallel to the Petersen coil.
  - The faulty phase information needs to be sent to the FPIs.
  - The newly calculated current quantity is \( x = p \angle 0 + q \angle a + r \angle b \).
  - FPI is located before the fault location if \( \angle x > 0 \).
Sectionalizing the fault (Cont.)

Faulty phase currents (before & after the fault location)

Before
After

Actual Ref.
Load
IRN
I\text{before}
I\text{RN}

\begin{align*}
\Delta & \quad Y \\
\text{Before} & \quad \text{After}
\end{align*}
Sectionalizing the fault (Cont.)

Faulty phase currents (before & after the fault location)

New current phasors (before & after the fault location)
Sectionalizing the fault (Cont.)

New current phasors (before & after the fault location)

Before the fault location

Phase-A

Phase-B

Phase-C

After the fault location

Phase-A

Phase-B

Phase-C
Sectionalizing the fault (Cont.)

- **Testing in a simple system**

Simple 11 kV distribution system with two feeders

- **System information**
  - \( R = 0.17 \, \Omega/\text{km}; \) \( L = 1.21 \, \text{mH/km} \) and \( C = 6 \, \text{nF/km} \)
  - Petersen coil is tuned close to resonant point after fault detection
  - Parallel resistor is 1.8 kΩ
Sectionalizing the fault (Cont.)

- Results
Sectionalizing the fault (Cont.)

- Results
Conclusions

- Increase in the resistive current improves the sensitivity of the current based method
- The method has been studied for the overhead network. It might not work in mixed networks with overhead lines and underground cables
- Sectionalizing the fault often requires large cost involvement
- The Combined implementation of the fault distance calculation and fault sectionalization provides the best outcome.
- However, both of the strategies can exhibit poor performance in different situations
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