HB 219 Worked Example 3.4.2 Fault at 33 kV Concrete or Steel Pole

10 km aerial HV feed, no OHEW.

33 kV source, 20 ohm NER.

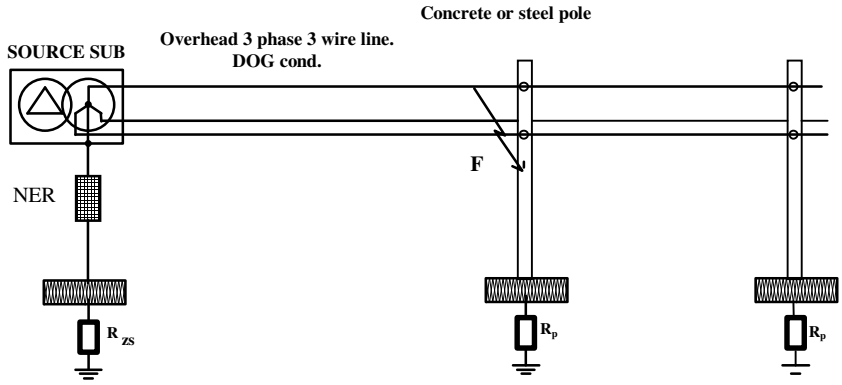


Fig 3.4.2.1 Fault at 33 kV concrete or steel pole

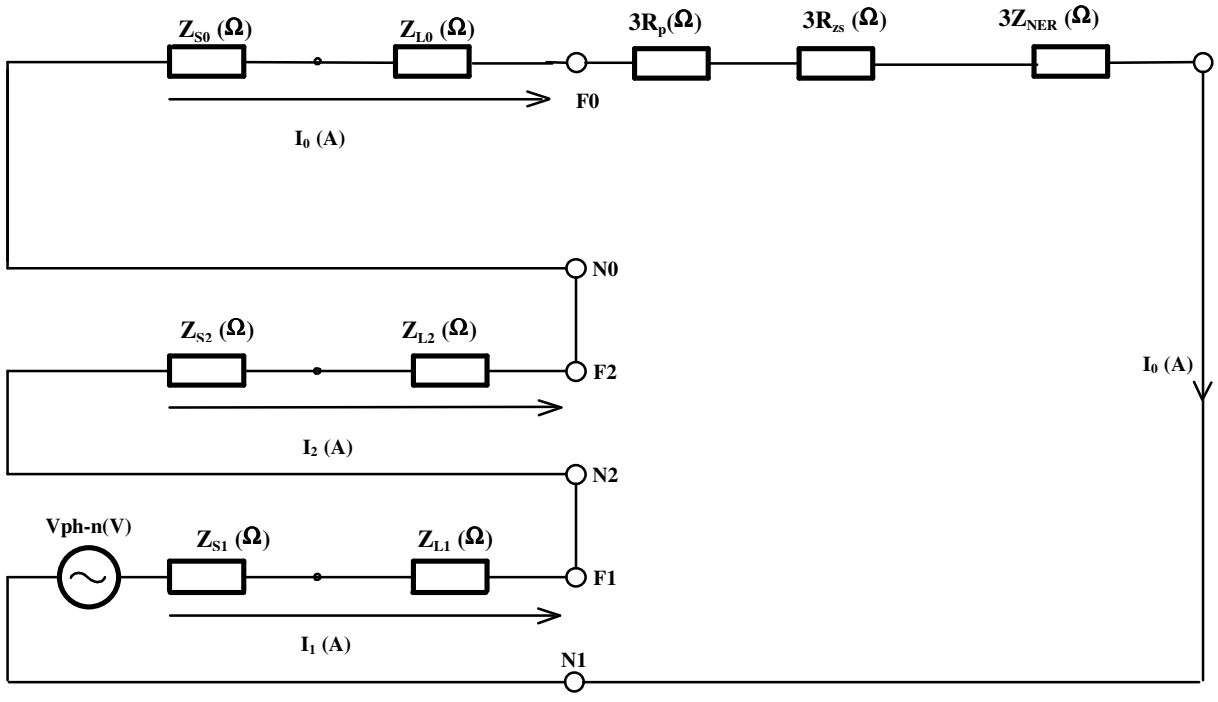


Fig 3.4.2.2 Symmetrical components network for a HV single phase to earth fault at the pole

33 kV SYSTEM DATA

SOURCE VOLTAGE (Volts) & IMPEDANCE (Ohms)

Single phase source voltage V_{ph-n} (Volts) $Vs_1 := \frac{33000}{\sqrt{3}}$ $Vs_1 = 19053$

Single Phase Fault Level S (MVA) $S := 500$

Source impedance calculated from the fault level. Assume source impedance is purely reactive and positive sequence = negative sequence = zero sequence impedance.

Positive sequence source impedance (Ohms) $Z_{S1} := \frac{33^2}{S} \cdot j$ $Z_{S1} = 2.178j$

Negative sequence source impedance (Ohms) $Z_{S2} := Z_{S1}$

Zero sequence source impedance (Ohms) $Z_{S0} := Z_{S1}$

33kV Overhead line impedance

Conductor size: DOG (6/4.72mm aluminium with 7/1.57mm steel)

Length (km) $L := 10.0$

Line sequence impedances (Ohm/km)

Positive sequence line impedance (Ohms/km) $Z_{L1} := 0.2722 + 0.3479j$

Negative sequence line impedance (Ohms/km) $Z_{L2} := Z_{L1}$

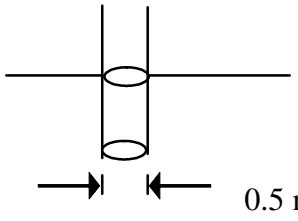
Zero sequence line impedance (Ohms/km) $Z_{L0} := 0.4204 + 1.5748j$

33kV NER AND EARTHING IMPEDANCES (Ohms)

Neutral Earthing Resistor (Ohms) $Z_{NER} := 20$

Zone substation earthing system resistance (Ohms) $R_{zs} := 0.01$

Surface soil resistivity (Ohm-m) $\rho := 10$ Ohm-m



Each pole 2 m deep in soil and 0.5 m dia.

Pole earth resistance (Ohms) $R_p := 0.17 \cdot \rho$ $R_p = 1.700$

The equivalent hemispherical radius (m) $r_E := \frac{\rho}{2 \cdot \pi \cdot R_p}$ $r_E = 0.936$

CALCULATIONS

One Phase to Earth fault on the 33 kV feeder at a conductive pole

Sequence network impedance (Ohms)

$Z_{pos} := Z_{S1} + Z_{L1} \cdot L$ $\quad Z_{neg} := Z_{S2} + Z_{L2} \cdot L$ $\quad Z_{zero} := Z_{S0} + Z_{L0} \cdot L + 3 \cdot R_p + 3 \cdot R_{zs}$

$Z_{pos} = 2.722 + 5.657j$ $\quad Z_{neg} = 2.722 + 5.657j$ $\quad Z_{zero} = 9.334 + 17.926j$

Zero sequence fault current (Amps)

$$I_0 := \frac{Vs_1}{Z_{pos} + Z_{neg} + Z_{zero} + 3 \cdot Z_{NER}}$$

Fault current (Amps)

$I_f := 3 \cdot I_0$ $\quad I_f = 663.0 - 259.2j$ $\quad |I_f| = 711.9$

EPR at the conductive pole (Volts)

$EPR_{pole} := I_f \cdot R_p$ $\quad |EPR_{pole}| = 1210$