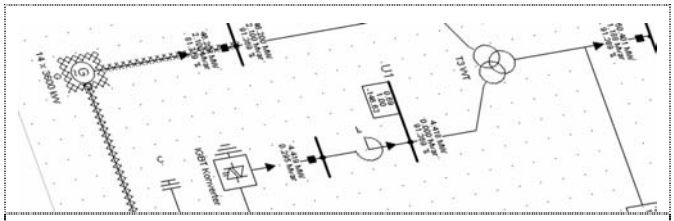


DIgSILENT Technical Documentation

Data conversion for 4-wire line model

DIgSILENT GmbH
Heinrich-Hertz-Strasse 9
D-72810 Gomaringen
Tel.: +49 7072 9168 - 0
Fax: +49 7072 9168- 88
http://www.digsilent.de
e-mail: mail@digsilent.de

Data conversion for 4-wire line model

Published by
DIgSILENT GmbH, Germany

22 Dezember 2005

Table of Contents

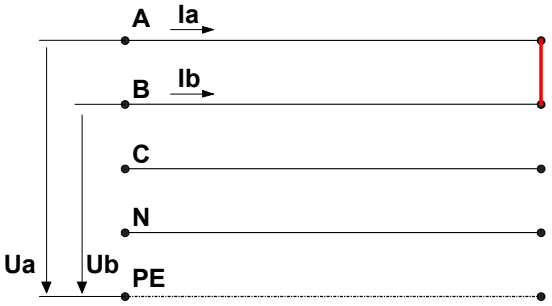
1 Unbalance 4-wire line equations:

$$\begin{bmatrix} Ua \\ Ub \\ Uc \\ Un \end{bmatrix} = \begin{bmatrix} Zs & Zm & Zm & Zpn \\ Zm & Zs & Zm & Zpn \\ Zm & Zm & Zs & Zpn \\ Zpn & Zpn & Zpn & Zn \end{bmatrix} \cdot \begin{bmatrix} Ia \\ Ib \\ Ic \\ In \end{bmatrix} \quad (1)$$

$$Zs = \frac{1}{3}(Z0 + 2 \cdot Z1) \quad (2)$$

$$Zm = \frac{1}{3}(Z0 - Z1) \quad (3)$$

1.1 Measurement between phase A and phase B wire



Phase-phase measurement

Using equation (1)

$$Ua = Zs \cdot Ia + Zm \cdot Ib$$
$$Ub = Zm \cdot Ia + Zs \cdot Ib$$

and

$$Ia = -Ib$$

$$Ua - Ub = 2Ia \cdot (Zs - Zm\cdot)$$

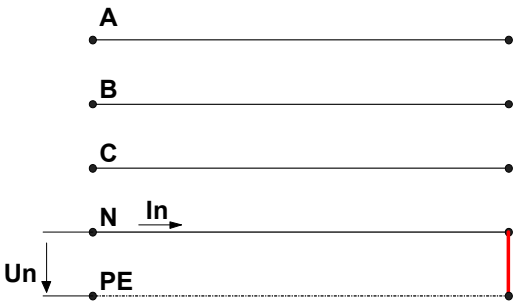
With equation (2) and (3)

$$\frac{Ua - Ub}{Ia} = 2 \cdot Z1$$

The positive sequence impedance Z1 will be received as the result of the phase to phase measurement.

Input data in PowerFactory: R1, X1 (Z1)

1.2 Measurement between neutral and PE (earth) wire



Neutral –PE measurement

Using equation (1) with Ia=Ib=Ic=0:

$$Un = Z(N - PE) \cdot In$$

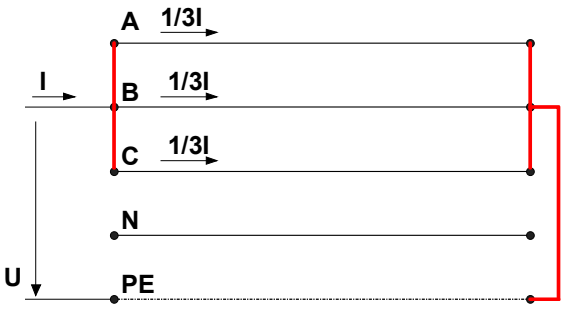
$$\frac{Un}{In} = Z(N - PE) \text{ with } Z(N - PE) = Zneutral + Ze$$

The Z(N-PE) impedance will be received as the result of the neutral – ground (PE) measurement.

Input data in PowerFactory: Neutral impedance (Rn, Xn)

$$Zn = Z(N - PE)$$

1.3 Measurement between phase and PE (earth) wire



Phase – PE (earth wire) measurement

Using equation (1) with In = 0

$$U = 1/3 \cdot (Zs \cdot I + Zm \cdot I + Zm \cdot I)$$

With equation (2) and (3):

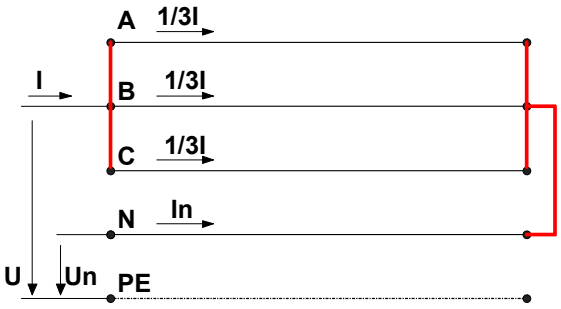
$$U = 1/3 \cdot Z0 \cdot I$$

$$Z0(PH - E) = Z0 = \frac{3 \cdot U}{I}$$

Input data in PowerFactory: Zero-sequence impedance (R0, X0)

$$Z0 = Z0(PH - E)$$

1.4 Measurement between phase and neutral wire



Phase – neutral measurement

Using equation (1):

$$U = 1/3 \cdot (Zs \cdot I + Zm \cdot I + Zm \cdot I) + Zpn \cdot In$$
$$Un = 1/3 \cdot I \cdot (Zpn + Zpn + Zpn) + Zn \cdot In$$

With:

$$In = -In$$

$$U = 1/3 \cdot (Zs \cdot I + Zm \cdot I + Zm \cdot I) - Zpn \cdot I$$
$$Un = 1/3 \cdot I \cdot (Zpn + Zpn + Zpn) - Zn \cdot I$$

With equation (2) and (3):

$U = 1/3 \cdot Z0 \cdot I - Zpn \cdot I$ and $Un = I \cdot (Zpn - Zn)$

Subtraction of both equations:

$$Z0(PH-N) = \frac{3 \cdot (U - Un)}{I} = Z0 - 6 \cdot Zpn + 3 \cdot Zn$$

Zn from measurement neutral to ground, Z0 from measurement phase to ground (PE)

$$Zpn = \frac{Z0 + 3 \cdot Zn - Z0(PH-N)}{6} \quad (4)$$

Input data in PowerFactory: Phase-neutral coupling impedance (Rpn, Xpn)

1.5 Data conversion without N-PE measurement

If the measurement between the neutral and the PE (earth) wire does not exist the following simplification can be assume:

Phase – neutral wire measurement:

$$Z0(PH-N) = Z1 + 3 \cdot Zneutral \quad (5)$$

Phase – PE (earth) wire measurement:

$$Z0(PH-E) = Z1 + 3 \cdot Ze \quad (6)$$

The neutral – PE (earth) wire measurement is:

$$Z(N-E) = Zneutral + Ze$$

With equation (5) and equation (6)

$$Z(N-E) = Zn = \frac{Z0(PH-N) + Z0(PH-E) - 2 \cdot Z1}{3} \quad (7)$$

Using equation (4), (5) and (6)

$$Zpn = Ze = \frac{Z0(PH-E) - Z1}{3} \quad (4)$$

Input data in PowerFactory:

Zero-sequence impedance (R0,X0)

$$Z0 = Z0(PH-E)$$

Neutral impedance (Rn, Xn)

$$Zn = \frac{Z0(PH-N) + Z0(PH-E) - 2 \cdot Z1}{3}$$

Input data in PowerFactory: Phase-neutral coupling impedance (Rpn, Xpn)

$$Zpn = \frac{Z0(PH-E) - Z1}{3}$$