POWERFACTORY

PowerFactory 2021

Technical Reference

Common Impedance

ElmZpu

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POWER SYSTEM SOLUTIONS
MADE IN GERMANY

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1 General Description

1.1 Models

The *Common Impedance* is a per unit impedance model including an ideal transformer. The main usage is for branches used for network reduction. The transformer ratio is equivalent to the nominal voltage of the connected busbars. The transformer includes also a tap ratio (*uratio*), a nominal phase shift (*nphshift*) and an additional phase shift (*ag*). Figure 1.1 shows the model for absolute impedance. Figure 1.2 shows the model for p.u. impedance.

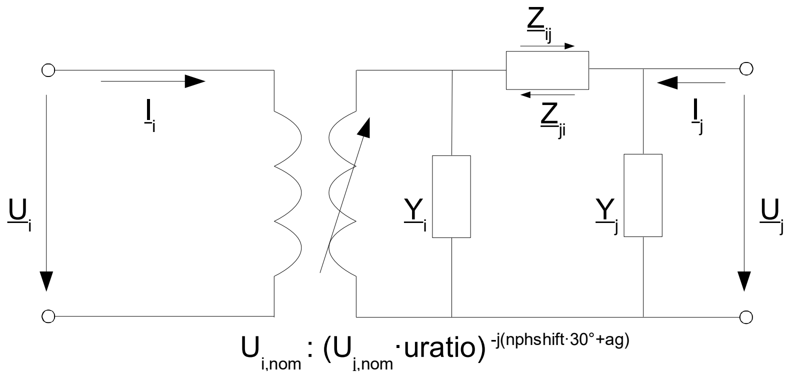

Figure 1.1: Common impedance positive, negative and zero-sequence model in ohm, absolute values

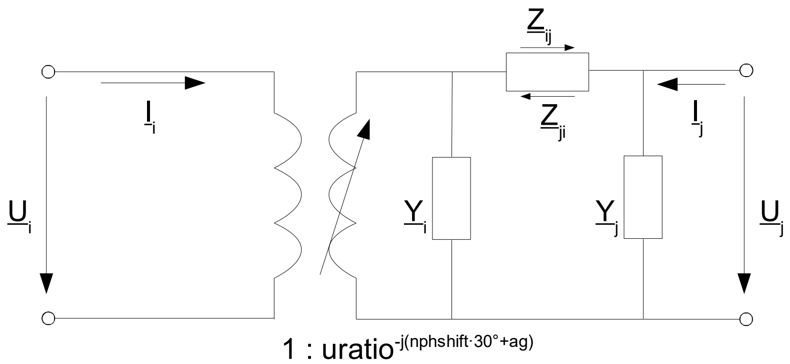

Figure 1.2: Common impedance positive, negative and zero-sequence model in p.u.

$U_{i,nom}$ and $U_{j,nom}$ are the nominal voltage of the connected busbars in kV.

For the single-phase model, the transformer and the shunt admittances are not supported.

1.1.1 Fundamental Frequency Model

The following equations in p.u. are used for the positive sequence:

$$\underline{k} \cdot \underline{u}_i - \underline{u}_j = \underline{z}_{ij} \cdot \left(\frac{\underline{i}_i}{\underline{k}^*} - \underline{y}_i \cdot \underline{u}_i \cdot \underline{k} \right)$$

$$\underline{z}_{ij} \cdot \left(\frac{\underline{i}_i}{\underline{k}^*} - \underline{y}_i \cdot \underline{u}_i \cdot \underline{k} \right) = \underline{z}_{ji} \cdot \left(\underline{i}_j - \underline{y}_j \cdot \underline{u}_j \right)$$

with

$$\begin{aligned}
\underline{k} &= uratio^{-j\frac{pi}{180}(nphshift*30+ag)} \\
\underline{z}_{ij} &= r_{ij}_pu + jx_{ij}_pu \\
\underline{z}_{ji} &= r_{ji}_pu + jx_{ji}_pu \\
\underline{y}_i &= g_i_pu + jb_i_pu \\
\underline{y}_j &= g_j_pu + jb_j_pu
\end{aligned}$$

Both inductive and capacitive impedances are supported. The shunt admittances can only be inductive (capacitive shunt admittance is not supported in EMT studies).

Similar equations are valid for the negative and zero sequence. The complex ratio $\underline{k}$ is defined for the negative sequence as:

$$\underline{k} = uratio^{j\frac{pi}{180}(nphshift*30+ag)}$$

and for the zero sequence as:

$$\underline{k} = uratio$$

The corresponding impedance in ohm seen from connection side *i* is calculated according to:

$$\underline{Z}_{ij} = \frac{U_{i,nom}^2}{Sn} \cdot (r_{ij}\_pu + jx_{ij}\_pu)$$

from connection side *j*:

$$\underline{Z}_{ji} = \frac{U_{j,nom}^2}{Sn} \cdot (r_{ji}\_pu + jx_{ji}\_pu)$$

with

$U_{i,nom}$, $U_{j,nom}$ Nominal busbar voltage of side *i* and *j*

Sn Rated power in MVA of common impedance

The zero-sequence impedance can be inserted separately.

The negative-sequence impedance can be inserted separately or set equal to the positive-sequence impedance, if the option *Use same Impedance z2=z1* is enabled. In EMT simulations, the negative-sequence impedance is always considered equal to the positive-sequence impedance.

Further it is possible to insert different impedances for Z_{ij} and Z_{ji} (see option: Use equal Impedances (zij = zji)).

For the short-circuit calculation method IEC/VDE and ANSI it is possible to use different impedances as for the load flow calculation and the *complete* short-circuit method (see option: *Use same impedance as for load-flow*).

1.1.2 EMT simulation

In EMT simulations, the negative-sequence impedance is always considered equal to the positive-sequence impedance. Moreover, capacitive shunt admittances are not supported in EMT studies.

The equations used in EMT simulation depend on the type of impedance (inductive or capacitive). When capacitive, the resistive and capacitive part can either be considered in series (default, *iCapParallel* flag unselected) or in parallel (*iCapParallel* flag selected).

If the reactance is inductive, the following p.u. equations are used for the alpha-beta-gamma components:

$$
\begin{aligned}
\underline{k} \cdot \underline{u}_{\alpha\beta,i} - \underline{u}_{\alpha\beta,j} &= r_{ij\_}pu \cdot \underline{i}_{\alpha\beta,ij} + x_{ij\_}pu \cdot \frac{d\underline{i}_{\alpha\beta,ij}}{dt} \\
k \cdot u_{\gamma,i} - u_{\gamma,j} &= r_{0ij\_}pu \cdot i_{\gamma,ij} + x_{0ij\_}pu \cdot \frac{di_{\gamma,ij}}{dt} \\
\underline{u}_{\alpha\beta,j} - \underline{k} \cdot \underline{u}_{\alpha\beta,i} &= r_{ji\_}pu \cdot \underline{i}_{\alpha\beta,ji} + x_{ji\_}pu \cdot \frac{d\underline{i}_{\alpha\beta,ji}}{dt} \\
u_{\gamma,j} - k \cdot u_{\gamma,i} &= r_{0ji\_}pu \cdot i_{\gamma,ji} + x_{0ji\_}pu \cdot \frac{di_{\gamma,ji}}{dt}
\end{aligned}
$$

If the reactance is capacitive and *iCapParallel* flag is unselected (resistive and capacitive part in series), the following p.u. equations are used for the alpha-beta-gamma components:

$$
\begin{aligned}
\underline{i}_{\alpha\beta,ij} &= -\frac{1}{x_{ij\_}pu} \cdot (\underline{k} \cdot \frac{d\underline{u}_{\alpha\beta,i}}{dt} - \frac{d\underline{u}_{\alpha\beta,j}}{dt} - r_{ij\_}pu \cdot \frac{d\underline{i}_{\alpha\beta,ij}}{dt}) \\
i_{\gamma,ij} &= -\frac{1}{x_{0ij\_}pu} \cdot (k \cdot \frac{du_{\gamma,i}}{dt} - \frac{du_{\gamma,j}}{dt} - r_{0ij\_}pu \cdot \frac{di_{\gamma,ij}}{dt}) \\
\underline{i}_{\alpha\beta,ji} &= -\frac{1}{x_{ji\_}pu} \cdot (\frac{d\underline{u}_{\alpha\beta,j}}{dt} - \frac{d\underline{u}_{\alpha\beta,i}}{dt} - r_{ji\_}pu \cdot \frac{d\underline{i}_{\alpha\beta,ji}}{dt}) \\
i_{\gamma,ji} &= -\frac{1}{x_{0ji\_}pu} \cdot (\frac{du_{\gamma,j}}{dt} - k \cdot \frac{du_{\gamma,i}}{dt} - r_{0ji\_}pu \cdot \frac{di_{\gamma,ji}}{dt})
\end{aligned}
$$

If the reactance is capacitive and *iCapParallel* flag is selected (resistive and capacitive part in parallel), the following equations are usedfor the alpha-beta-gamma components:

$$
\begin{aligned}
\underline{y}_{ij} &= \frac{1}{\underline{z}_{ij}} = g_{ij}\_pu + jb_{ij}\_pu \\
\underline{y}_{0ij} &= \frac{1}{\underline{z}_{0ij}} = g_{0ij}\_pu + jb_{0ij}\_pu \\
\underline{y}_{ji} &= \frac{1}{\underline{z}_{ji}} = g_{ji}\_pu + jb_{ji}\_pu \\
\underline{y}_{0ji} &= \frac{1}{\underline{z}_{0ji}} = g_{0ji}\_pu + jb_{0ji}\_pu \\
\underline{i}_{\alpha\beta,ij} &= g_{ij}\_pu \cdot (\underline{k} \cdot \underline{u}_{\alpha\beta,i} - \underline{u}_{\alpha\beta,j}) + b_{ij}\_pu \cdot (\underline{k} \cdot \frac{d\underline{u}_{\alpha\beta,i}}{dt} - \frac{d\underline{u}_{\alpha\beta,j}}{dt}) \\
i_{\gamma,ij} &= g_{0ij}\_pu \cdot (k \cdot u_{\gamma,i} - u_{\gamma,j}) + b_{0ij}\_pu \cdot (k \cdot \frac{du_{\gamma,i}}{dt} - \frac{du_{\gamma,j}}{dt}) \\
\underline{i}_{\alpha\beta,ji} &= g_{ji}\_pu \cdot (\underline{u}_{\alpha\beta,j} - \underline{k} \cdot \underline{u}_{\alpha\beta,i}) + b_{ji}\_pu \cdot (\frac{d\underline{u}_{\alpha\beta,j}}{dt} - \underline{k} \cdot \frac{d\underline{u}_{\alpha\beta,i}}{dt}) \\
i_{\gamma,ji} &= g_{0ji}\_pu \cdot (u_{\gamma,j} - k \cdot u_{\gamma,i}) + b_{0ji}\_pu \cdot (\frac{du_{\gamma,j}}{dt} - k \cdot \frac{du_{\gamma,i}}{dt})
\end{aligned}
$$

where

$$
\begin{aligned}
\underline{i}_{\alpha\beta,ij} &= \frac{\underline{i}_{\alpha\beta,i}}{\underline{k}^*} - (g_i\_pu \cdot \underline{k} \cdot \underline{u}_{\alpha\beta,i} + b_i\_pu \cdot \underline{k} \cdot \frac{d\underline{u}_{\alpha\beta,i}}{dt}) \\
i_{\gamma,ij} &= \frac{i_{\gamma,i}}{k} - (g_{0i}\_pu \cdot k \cdot u_{\gamma,i} + b_{0i}\_pu \cdot k \cdot \frac{du_{\gamma,i}}{dt}) \\
\underline{i}_{\alpha\beta,ji} &= \underline{i}_{\alpha\beta,j} - (g_j\_pu \cdot \underline{u}_{\alpha\beta,j} + b_j\_pu \cdot \frac{d\underline{u}_{\alpha\beta,j}}{dt}) \\
i_{\gamma,ji} &= i_{\gamma,j} - (g_{0j}\_pu \cdot u_{\gamma,j} + b_{0j}\_pu \cdot \frac{du_{\gamma,j}}{dt})
\end{aligned}
$$

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