Summary of Y matrix values from IEC document:

8.4 Nodal admittance and nodal impedance matrices

The nodal admittances and nodal impedance matrices are symmetrical and have the order 14 × 14. The rule for the formulation of the nodal admittance is given in Annex B of IEC 60909-0:2016. The non-diagonal elements are equal for the three variants of the wind power plant. The non-zero elements above the main diagonal are found as follows in 1/Ω:

$\underline{Y}_{1,2} = \frac{1}{\underline{Z}_{\text{TWPK}}} = 0{,}033\,7 - \text{j}\,0{,}672\,3$; $\underline{Y}_{2,3} = \frac{1}{\underline{Z}_{\text{L1}}} = 0{,}6912 - \text{j}\,1{,}035\,3$; $\underline{Y}_{3,4} = \frac{1}{\underline{Z}_{\text{L2}}} = 3{,}2290 - \text{j}\,1{,}8670$

$\underline{Y}_{3,6} = \frac{1}{\underline{Z}_{\text{L4}}} = 4{,}496\,1 - \text{j}\,2{,}599\,6$; $\underline{Y}_{3,10} = \frac{1}{\underline{Z}_{\text{L8}}} = 3{,}738\,8 - \text{j}\,2{,}1618$; $\underline{Y}_{4,5} = \frac{1}{\underline{Z}_{\text{L3}}} = 6{,}458\,0 - \text{j}\,3{,}734\,0$

$\underline{Y}_{6,7} = \frac{1}{\underline{Z}_{\text{L5}}} = 20{,}893\,5 - \text{j}\,12{,}080\,6$; $\underline{Y}_{7,8} = \frac{1}{\underline{Z}_{\text{L6}}} = 8{,}879\,7 - \text{j}\,5{,}134\,2$; $\underline{Y}_{7,9} = \frac{1}{\underline{Z}_{\text{L7}}} = 6{,}4580 - \text{j}\,3{,}7340$

$\underline{Y}_{10,11} = \frac{1}{\underline{Z}_{\text{L9}}} = 14{,}799\,5 - \text{j}\,8{,}557\,1$; $\underline{Y}_{11,12} = \frac{1}{\underline{Z}_{\text{L10}}} = 12{,}247\,9 - \text{j}\,7{,}0817$

$\underline{Y}_{11,14} = \frac{1}{\underline{Z}_{\text{L12}}} = 23{,}679\,3 - \text{j}\,13{,}6913$; $\underline{Y}_{12,13} = \frac{1}{\underline{Z}_{\text{L11}}} = 7{,}175\,5 - \text{j}\,4{,}148\,9$

The diagonal elements of the nodal admittance matrices are listed in Table 11.

Table 11 – The diagonal elements of the nodal admittance matrices for the three variants in 1/Ω

	Variant 3 Wind power plant with five wind power station units WD and five WF
$\underline{Y}_{1,1}$	−0,486 1 + j5,196 4
$\underline{Y}_{2,2}$	−0,724 9 + j1,707 6
$\underline{Y}_{3,3}$	−12,155 1 + j7,663 7
$\underline{Y}_{4,4}$	−9,688 4 + j5,614 9
$\underline{Y}_{5,5}$	−6,459 4 + j3,747 9
$\underline{Y}_{6,6}$	−25,390 9 + j14,694 1
$\underline{Y}_{7,7}$	−36,231 2 + j20,948 8
$\underline{Y}_{8,8}$	−8,881 1+ j5,148 2
$\underline{Y}_{9,9}$	−6,459 4 + j3,747 9
$\underline{Y}_{10,10}$	−18,538 4 + j10,718 9
$\underline{Y}_{11,11}$	−50,726 7 + j29,330 1
$\underline{Y}_{12,12}$	−19,423 4 + j11,230 6
$\underline{Y}_{13,13}$	−7,175 5 + j4,148 9
$\underline{Y}_{14,14}$	−23,679 3 + j13,691 3

***Note all cables except ZL1 are neglected on purpose.**

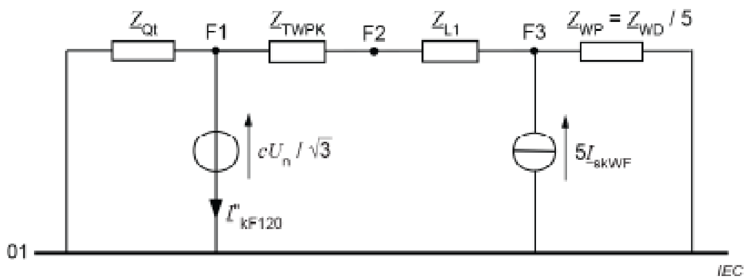

Figure 19 – Equivalent circuit diagram for the calculation of the short-circuit current at the location F1 without the consideration of the internal wind power plant cables (values are related to the 20 kV voltage level), variant 3

The absolute elements of the 3 by 3 nodal impedance matrix in the 20 kV voltage level are:

$$Z = \begin{bmatrix} 0{,}217\,1 & 0{,}197\,6 & 0{,}188\,2 \\ 0{,}197\,6 & 1{,}531\,8 & 1{,}459\,0 \\ 0{,}188\,2 & 1{,}459\,0 & 2{,}080\,6 \end{bmatrix} \Omega$$

The partial short-circuit currents without the influence of the wind power station units WF becomes with $Z_{\mathrm{kF}i} = Z_{ii}$ (i = 1…3):

$$I''_{\mathrm{kF1WFO}} = \frac{cU_\mathrm{n}}{\sqrt{3}\cdot Z_{\mathrm{kF1}}}\cdot\frac{U_\mathrm{nQ}}{U_\mathrm{n}}\cdot\frac{1}{t_\mathrm{rTWP}^2} = \frac{1{,}1\cdot 20\,\mathrm{kV}}{\sqrt{3}\cdot 0{,}217\,1\,\Omega}\cdot\frac{110\,\mathrm{kV}}{20\,\mathrm{kV}}\cdot\left(\frac{20\,\mathrm{kV}}{110\,\mathrm{kV}}\right)^2 = 10{,}637\,\mathrm{kA}$$

$$I''_{\mathrm{kF2WFO}} = \frac{cU_\mathrm{n}}{\sqrt{3}\cdot Z_{\mathrm{kF2}}} = \frac{1{,}1\cdot 20\,\mathrm{kV}}{\sqrt{3}\cdot 1{,}531\,8\,\Omega} = 8{,}292\,\mathrm{kA}$$

$$I''_{\mathrm{kF3WFO}} = \frac{cU_\mathrm{n}}{\sqrt{3}\cdot Z_{\mathrm{kF3}}} = \frac{1{,}1\cdot 20\,\mathrm{kV}}{\sqrt{3}\cdot |2{,}080\,6\,\Omega} = 6{,}105\,\mathrm{kA}$$

The partial short-circuit currents of the five wind power station units WF for short circuits at F1 to F3 are:

$$I''_{\mathrm{kF1WF}} = \frac{Z_{13}}{Z_{11}}\cdot 5\cdot I_\mathrm{skWF}\cdot\frac{1}{t_\mathrm{rTWP}} = \left|\frac{\underline{Z}_\mathrm{WP}}{\underline{Z}_\mathrm{TWPK}+\underline{Z}_\mathrm{L1}+\underline{Z}_\mathrm{WP}}\right|\cdot 5\cdot I_\mathrm{skWF}\cdot\frac{1}{t_\mathrm{rTWP}} = 0{,}406\,7\,\mathrm{kA}\cdot\frac{1}{5{,}5} = 0{,}073\,9\,\mathrm{kA}$$

$$I''_{\mathrm{kF2WF}} = \frac{Z_{23}}{Z_{22}}\cdot 5\cdot I_\mathrm{skWF} = \left|\frac{\underline{Z}_\mathrm{WP}}{\underline{Z}_\mathrm{L1}+\underline{Z}_\mathrm{WP}}\right|\cdot 5\cdot I_\mathrm{skWF} = 0{,}446\,8\,\mathrm{kA}$$

$$I''_{\mathrm{kF3WF}} = \frac{Z_{33}}{Z_{33}}\cdot 5\cdot I_\mathrm{skWF} = 0{,}469\,1\,\mathrm{kA}$$

Revised Y Matrix_2

$Z_{QtIECOhm} = 0.022 + 0.219i$ $\quad XFMRZ\_IEC_{ohm} = 0.074 + 1.484i$ $\quad \frac{Z_{WD\_ohm}}{5} = 1.424 + 14.239i$

$Z_{L1\_L1B\_Cables\_Ohm} = 0.446 + 0.668i$

$$Y_{11} := -1 \cdot \left(\frac{1}{Z_{QtIECOhm}} + \frac{1}{XFMRZ\_IEC_{ohm}} \right) = -0.486 + 5.196i$$

$$Y_{12} := \left(\frac{1}{XFMRZ\_IEC_{ohm}} \right) = 0.034 - 0.672i$$

$$Y_{13} := 0$$

$$Y_{21} := Y_{12}$$

$$Y_{22} := -1 \cdot \left(\frac{1}{XFMRZ\_IEC_{ohm}} + \frac{1}{Z_{L1\_L1B\_Cables\_Ohm}} \right) = -0.725 + 1.708i$$

$$Y_{23} := \left(\frac{1}{Z_{L1\_L1B\_Cables\_Ohm}} \right) = 0.691 - 1.035i$$

$$Y_{31} := 0$$

$$Y_{32} := Y_{23}$$

$$Y_{33} := -1 \cdot \left[\frac{1}{\frac{(Z_{WD\_ohm})}{5}} + \frac{1}{Z_{L1\_L1B\_Cables\_Ohm}} \right] = -0.698 + 1.105i$$

$$Y := \begin{pmatrix} Y_{11} & Y_{12} & Y_{13} \\ Y_{21} & Y_{22} & Y_{23} \\ Y_{31} & Y_{32} & Y_{33} \end{pmatrix} \qquad Zmat := Y^{-1}$$

$$Zmat_{Mag} := \begin{pmatrix} |Zmat_{0,0}| & |Zmat_{0,1}| & |Zmat_{0,2}| \\ |Zmat_{1,0}| & |Zmat_{1,1}| & |Zmat_{1,2}| \\ |Zmat_{2,0}| & |Zmat_{2,1}| & |Zmat_{2,2}| \end{pmatrix} = \begin{pmatrix} 0.2171 & 0.1976 & 0.1882 \\ 0.1976 & 1.5318 & 1.459 \\ 0.1882 & 1.459 & 2.0806 \end{pmatrix}$$