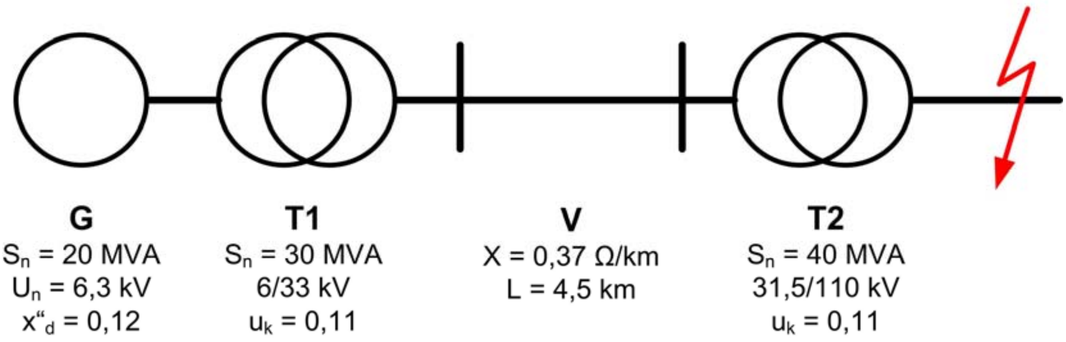
Example 1

Three phase short-circuit is in the figure in the marked place.

Calculate: a) Initial sub-transient short-circuit current
b) Initial sub-transient short-circuit power
c) Peak short-circuit current



Solution:

1) We choose a base power S_v = 110 MVA and a base voltage U_v = 110 kV (any value).

2) We recalculate all reactances to the chosen base power S_v and the voltage in the short-circuit place U_v. This example doesn't have continuing voltage levels therefore we must respect transformer ratios.

Generator:

$$x_g = x_d^{"} \cdot \frac{S_v}{S_{ng}} \cdot \left(\frac{U_{ng}}{U_v}\right)^2 \cdot p_{T1}^2 \cdot p_{T2}^2 = 0{,}12 \cdot \frac{110}{20} \cdot \left(\frac{6{,}3}{110}\right)^2 \cdot \left(\frac{33}{6}\right)^2 \cdot \left(\frac{110}{31{,}5}\right)^2 = 0{,}799$$

Transformer T1

$$x_{T1} = x_k \cdot \frac{S_v}{S_{nT1}} \cdot \left(\frac{U_{nT1}}{U_v}\right)^2 \cdot p_{T2}^2 = 0{,}11 \cdot \frac{110}{30} \cdot \left(\frac{33}{110}\right)^2 \cdot \left(\frac{110}{31{,}5}\right)^2 = 0{,}443$$

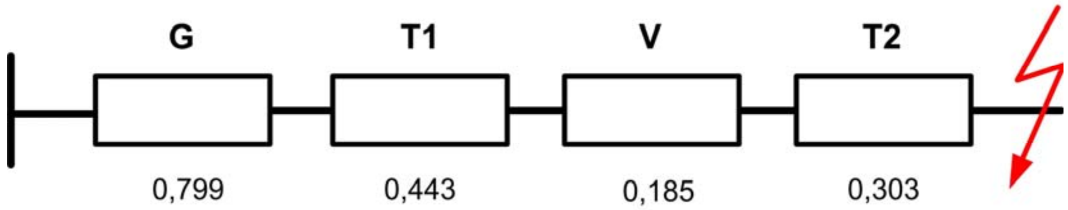
Transformer T2

$$x_{T2} = x_k \cdot \frac{S_v}{S_{nT2}} \cdot \left(\frac{U_{nT2}}{U_v}\right)^2 = 0{,}11 \cdot \frac{110}{40} \cdot \left(\frac{110}{110}\right)^2 = 0{,}303$$

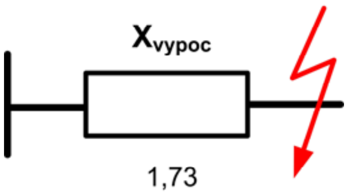
Power line V: (the denominated value recalculation to a relative value and then to S_v and U_v)

$$x_v = x \cdot l \cdot \frac{S_v}{U_v^2} \cdot p_{T2}^2 = 0{,}37 \cdot 4{,}5 \cdot \frac{110}{110^2} \cdot \left(\frac{110}{31{,}5}\right)^2 = 0{,}185$$

3) We draw the equivalent circuit (only positive sequence for 3ph short-circuit)



4) After simplification:



5) We calculate a base current

$$I_v = \frac{S_v}{\sqrt{3} \cdot U_v} = \frac{110}{\sqrt{3} \cdot 110} = 0{,}577\ kA$$

6) Initial sub-transient short-circuit current

$$I_{k0}^{"} = k \cdot \frac{I_v}{X_{vypoc}} = 1{,}1 \cdot \frac{0{,}577}{1{,}73} = 0{,}367\ kA$$

7) Initial sub-transient short-circuit power

$$S_{k0}^{"} = \sqrt{3} \cdot U_v \cdot I_{k0}^{"} = \sqrt{3} \cdot 110 \cdot 0{,}367 = 69{,}9\ MVA$$

Or:

$$S_{k0}^{"} = k \cdot \frac{S_v}{X_{vypoc}} = 1{,}1 \cdot \frac{110}{1{,}73} = 69{,}9\ MVA$$

6a) Initial sub-transient short-circuit current

$$I_{k0}^{"} = \frac{S_{k0}^{"}}{\sqrt{3} \cdot U_{sv}} = \frac{69{,}9}{\sqrt{3} \cdot 110} = 0{,}367\ kA$$

8) Peak short-circuit current

$$I_{km} = k \cdot \sqrt{2} \cdot I_{k0}^{"} = 1{,}7 \cdot \sqrt{2} \cdot 0{,}367 = 0{,}882\ kA$$

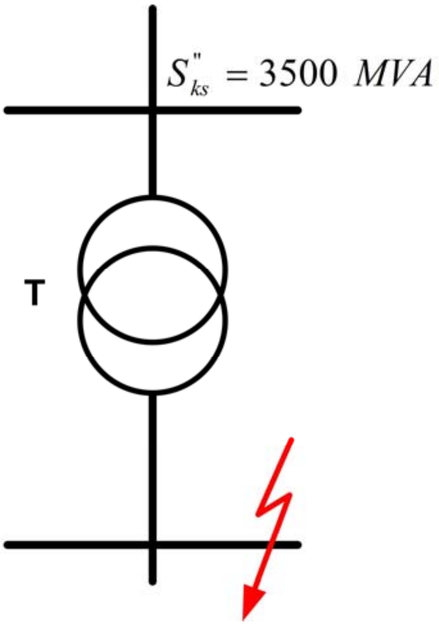
factor k = 1,7 for HV systems

Example 2

Calculate initial sub-transient short-circuit power during three-phase short-circuit behind a transformer S_{nT} = 15 MVA, u_k = 10%, 115/10,5 kV. Transformer is connected to the power grid with initial sub-transient short-circuit power $S_{ks}^{"}$ = 3500 MVA. If short-circuit occurs on the grid terminals, the grid contribution to the initial sub-transient short-circuit power is:

$$S_{ks}^{"} = \frac{S_v}{x_s} = 3500\ MVA$$

We choose the base power $S_v = S_{nT}$. Power grid reactance is:



$$x_s = \frac{S_v}{S_{ks}^{"}} = \frac{15}{3500} = 0{,}00428$$

Transformer reactance

$$x_t = u_k = 0{,}1$$

Calculation

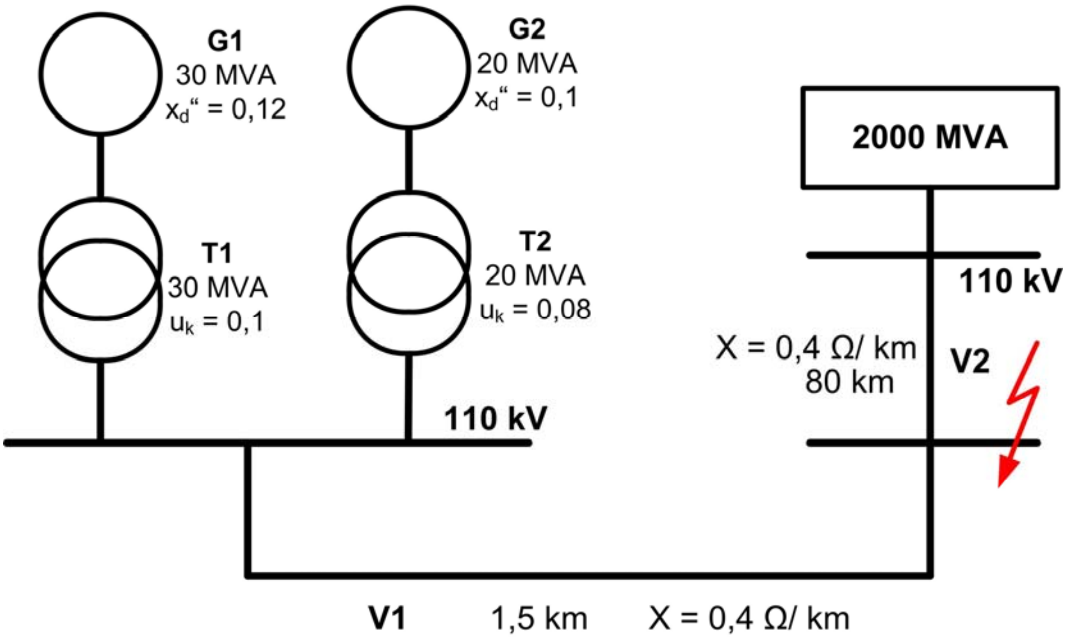
$$x_{vyp} = x_s + x_t = 0{,}00428 + 0{,}1 = 0{,}10428$$

Initial sub-transient short-circuit power

$$S_{ks}^{"} = \frac{S_v}{x_{vyp}} = \frac{15}{0{,}10428} = 143{,}8\ MVA$$

Example 3

Calculate initial sub-transient short-circuit current and power in case of three phase short-circuit.



1) Base power and voltage:

S_v = 30 MVA, U_V = 110 kV

2) Reactances recalculation to the base power and voltage in the short-circuit place

generator G1: $x_{G1} = 0{,}12$

generator G2: $x_{G2} = x_d^{"} \cdot \frac{S_v}{S_{nG2}} = 0{,}1 \cdot \frac{30}{20} = 0{,}15$

transformer T1: $x_{T1} = 0{,}1$

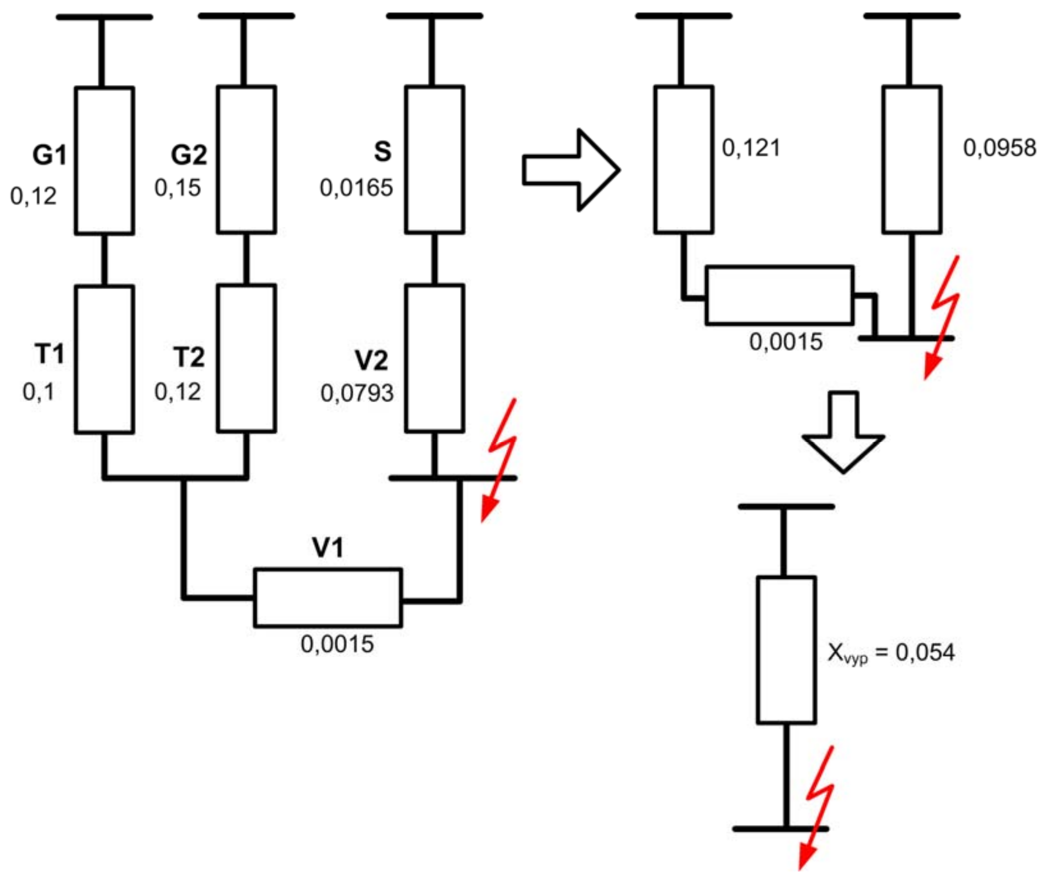
transformer T2: $x_{T2} = u_k \cdot \frac{S_v}{S_{nT2}} = 0{,}08 \cdot \frac{30}{20} = 0{,}12$

power line V1: $x_{V1} = x \cdot l \cdot \frac{S_v}{U_v^2} = 0{,}4 \cdot 1{,}5 \cdot \frac{30}{110^2} = 0{,}0015$

power line V2: $x_{V2} = X \cdot l \cdot \frac{S_v}{U_v^2} = 0{,}4 \cdot 80 \cdot \frac{30}{110^2} = 0{,}0793$

power grid: $x_S = 1{,}1 \cdot \frac{S_v}{S_{k0S}^{"}} = 1{,}1 \cdot \frac{30}{2000} = 0{,}0165$

3) equivalent circuit



4) initial sub-transient short-circuit power

$$S_{k0}^{"} = k \cdot \frac{S_v}{x_{vyp}} = 1{,}1 \cdot \frac{30}{0{,}054} = 611{,}1\ MVA$$

5) initial sub-transient short-circuit current

$$I_{k0}^{"} = \frac{S_{k0}^{"}}{\sqrt{3} \cdot 110} = 3{,}207\ kA$$