**WROCLAW UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**FACULTY OF ELECTRICAL ENGINEERING**

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**Lab1 &2 -Load flow in radial network with DER**

Table of Contents

[1. Objective 2](#_Toc103084457)

[2. Exercise description 2](#_Toc103084458)

[3. Scheme of analyzed power system 2](#_Toc103084459)

[4. Calculation of system parameters for a=61 3](#_Toc103084460)

[5. Input data for a = 61 5](#_Toc103084461)

[6. Load variations results 6](#_Toc103084462)

[6.1 Load variation for 10 kv at the load bus 6](#_Toc103084463)

[6.2 Load variation for 10.5Kv at load bus 8](#_Toc103084464)

[6.3. Using the generator in bus 4 to increase transmission efficiency 10](#_Toc103084465)

[7.Conclusion 12](#_Toc103084466)

# 1. Objective

The aim of this project is to acquire knowledge of the preparation of equivalent parameters of lines, cables and transformers which uses for load flow and voltage analysis for the given radial network in fig.1.

# 2. Exercise description

The given load variation for the given radial Network is 6 motors start (6S)

Induction motor voltage must not be less than 0.8UN and greater than 10.5 KV at the load bus. In each variation, the node load voltage should be changed to obtain the voltage 1.05UN, i.e., 10.5 kV at the feeder point.

# 3. Scheme of analyzed power system

Diagram

Description automatically generated

# 4. Calculation of system parameters for a=61

Text, letter

Description automatically generated

Figure 2: Motor parameter calculation

Text, letter

Description automatically generated

Figure 3: Cable parameter calculation

Text, letter

Description automatically generated

Figure 4: Transformer parameter calculation

# 5. Input data for a = 61

function [nodes,branches,UN,U]=erlfd61

UN=10.0; % nominal voltage of equivalent network

U =10.0; % voltage set at the load bus

%

nodes=[

% Pd(+) - active load at node,

% Pd(-) - active injection at node

% Qd(+) - reactive load at node (inductive),

% Qd(-) - reactive injection at node (capacitive)

% Un\_kV - nominal voltage of equivalent network

% Uk\_st - voltage angle / zero before cload flow computing/

%Node Un\_kV Uk\_st Pd\_MW Qd\_Mvar

% 1 2 3 4 5

1 10.00 0 17.355 44.834

2 10.00 0 0 0

3 10.00 0 0 0

4 10.00 0 0 0

];

%

%

%

branches=[

% k - node number at pi-end, p - node number at pi-begin

% Sp=Pp+jQp--->p\_\_\_\_R\_\_\_\_X\_\_\_\_k----> Sk=Pk+jQk

% Up/Ukp | | Uk/Ukk

% Yp Yk

% | |

% -------------------------------------------

%

% R - resistance, X - reactance

% Yp=G/2+jB/2 - shunt admittance at pi-begin

% Yk=G/2+jB/2 - shunt admittance at pi-end

% NOTE! B>0 for line and B<0 for transformer

% Give G,B w mikrosimens with proper sign:

% (-)minus for transformer,

% (+)plus for line

% Program creates pi-circuit with G/2 and B/2 so give G nad B.

% p k R\_om X\_om G\_mikroS B\_mikroS

% 1 2 3 4 5 6

2 1 0.071111 1.2125 49.161 -876.19

3 2 1.0534 0.6584 0 781.85

4 3 0.9984 0.624 0 741

];

%

return;

# 6. Load variations results

## 6.1 Load variation for 10 kv at the load bus

>> erlf

plikdat =

'erlfd61'

% Calculation stop: 2022- 5- 2 godz. 12h, 41min, 18.75s

Number of pi-circuits npi = 3

Total bus number n = 4

Nominal voltage of equivalent network UN = 10.000 kV

Voltage set at load bus U = 10.000 kV

czwornik 2 - 1

Up\_kV Ukp\_st Pp\_MW dPp\_MW Qp\_Mvar dQp\_Mvar Uk\_kV Ukk\_st Pk\_MW dPk\_MW Qk\_Mvar dQk\_Mvar

15.656 6.6 19.0043 0.0060 72.661 -0.1074 10.000 0.0 17.3550 0.0025 44.834 -0.0438

czwornik 3 - 2

Up\_kV Ukp\_st Pp\_MW dPp\_MW Qp\_Mvar dQp\_Mvar Uk\_kV Ukk\_st Pk\_MW dPk\_MW Qk\_Mvar dQk\_Mvar

20.399 -5.0 43.1850 0.0000 87.516 -0.1627 15.656 6.6 19.0043 0.0000 72.661 -0.0958

czwornik 4 - 3

Up\_kV Ukp\_st Pp\_MW dPp\_MW Qp\_Mvar dQp\_Mvar Uk\_kV Ukk\_st Pk\_MW dPk\_MW Qk\_Mvar dQk\_Mvar

25.358-11.7 65.9701 0.0000 101.364 -0.2382 20.399 -5.0 43.1850 0.0000 87.516 -0.1542

node UN\_kV U\_kV dU\_% Uk\_st P\_MW Q\_MW

1 10.000 10.000 0.0 0.0 17.3550 44.8340

2 10.000 15.656 56.6 6.6 19.0043 72.6605

3 10.000 20.399 104.0 -5.0 43.1850 87.5155

4 10.000 25.358 153.6 -11.7 65.9701 101.3638

Active losses Pstr = 48.615 MW

Transmission efficiency eta = 26.307 %

End of calculation by erlf.m - see results in file erlfout.m>>

Chart, radar chart

Description automatically generated

Figure 5: Node voltage and current results for 10 KV

## 6.2 Load variation for 10.5Kv at load bus

>> erlf

plikdat =

'erlfd61'

% Calculation stop: 2022- 5- 7 godz. 13h, 41min, 5.06s

Number of pi-circuits npi = 3

Total bus number n = 4

Nominal voltage of equivalent network UN = 10.000 kV

Voltage set at load bus U = 10.500 kV

czwornik 2 - 1

Up\_kV Ukp\_st Pp\_MW dPp\_MW Qp\_Mvar dQp\_Mvar Uk\_kV Ukk\_st Pk\_MW dPk\_MW Qk\_Mvar dQk\_Mvar

15.881 6.1 18.8520 0.0062 70.048 -0.1105 10.500 0.0 17.3550 0.0027 44.834 -0.0483

czwornik 3 - 2

Up\_kV Ukp\_st Pp\_MW dPp\_MW Qp\_Mvar dQp\_Mvar Uk\_kV Ukk\_st Pk\_MW dPk\_MW Qk\_Mvar dQk\_Mvar

20.399 -4.8 40.7736 0.0000 83.488 -0.1627 15.881 6.1 18.8520 0.0000 70.048 -0.0986

czwornik 4 - 3

Up\_kV Ukp\_st Pp\_MW dPp\_MW Qp\_Mvar dQp\_Mvar Uk\_kV Ukk\_st Pk\_MW dPk\_MW Qk\_Mvar dQk\_Mvar

25.104-11.2 61.4238 0.0000 96.006 -0.2335 20.399 -4.8 40.7736 0.0000 83.488 -0.1542

node UN\_kV U\_kV dU\_% Uk\_st P\_MW Q\_MW

1 10.000 10.500 0.0 0.0 17.3550 44.8340

2 10.000 15.881 58.8 6.1 18.8520 70.0475

3 10.000 20.399 104.0 -4.8 40.7736 83.4878

4 10.000 25.104 151.0 -11.2 61.4238 96.0065

Active losses Pstr = 44.069 MW

Transmission efficiency eta = 28.255 %

End of calculation by erlf.m - see results in file erlfout.m>>

Chart, radar chart

Description automatically generated

Figure 6: Node voltage and current results at 10.5 Kv

## 6.3. Using the generator in bus 4 to increase transmission efficiency

In this case unlike the above two cases the generator in bus 4 will operate at power factor 1 (cosfi=1). The input data in this case will look like as shown below

%Node Un\_kV Uk\_st Pd\_MW Qd\_Mvar

% 1 2 3 4 5

1 10.00 0 17.355 44.834

2 10.00 0 0 0

3 10.00 0 0 0

4 10.00 0 14.1 0

Because of this the transmission efficiency increase to a great extent comparing with the other two cases. The result is shown below.

>> erlf

plikdat =

'erlfd61'

% Calculation stop: 2022- 5- 4 godz. 9h, 31min, 22.93s

Number of pi-circuits npi = 3

Total bus number n = 4

Nominal voltage of equivalent network UN = 10.000 kV

Voltage set at load bus U = 10.500 kV

czwornik 2 - 1

Up\_kV Ukp\_st Pp\_MW dPp\_MW Qp\_Mvar dQp\_Mvar Uk\_kV Ukk\_st Pk\_MW dPk\_MW Qk\_Mvar dQk\_Mvar

15.881 6.1 18.8520 0.0062 70.048 -0.1105 10.500 0.0 17.3550 0.0027 44.834 -0.0483

czwornik 3 - 2

Up\_kV Ukp\_st Pp\_MW dPp\_MW Qp\_Mvar dQp\_Mvar Uk\_kV Ukk\_st Pk\_MW dPk\_MW Qk\_Mvar dQk\_Mvar

20.399 -4.8 40.7736 0.0000 83.488 -0.1627 15.881 6.1 18.8520 0.0000 70.048 -0.0986

czwornik 4 - 3

Up\_kV Ukp\_st Pp\_MW dPp\_MW Qp\_Mvar dQp\_Mvar Uk\_kV Ukk\_st Pk\_MW dPk\_MW Qk\_Mvar dQk\_Mvar

25.104-11.2 61.4238 0.0000 96.006 -0.2335 20.399 -4.8 40.7736 0.0000 83.488 -0.1542

node UN\_kV U\_kV dU\_% Uk\_st P\_MW Q\_MW

1 10.000 10.500 0.0 0.0 17.3550 44.8340

2 10.000 15.881 58.8 6.1 18.8520 70.0475

3 10.000 20.399 104.0 -4.8 40.7736 83.4878

4 10.000 25.104 151.0 -11.2 75.5238 96.0065

Active losses Pstr = 44.069 MW

Transmission efficiency eta = 41.649 %

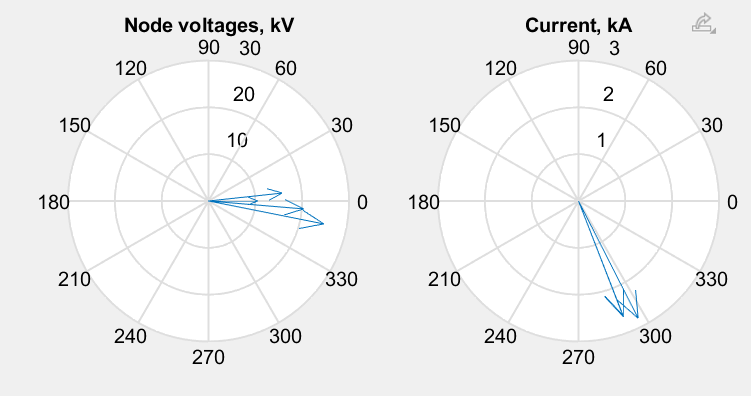
End of calculation by erlf.m - see results in file erlfout.m>> 

Figure 7: Node voltage and current results when Generator in bus 4 operates

# 7.Conclusion

Three different cases are selected to perform this task at the given load as listed below.

* The first case is performed at 10Kv at the load bus. At this voltage level, the active power losses is 48.615 MW, transmission efficiency is 26.307 %, and supply voltage is 25.358Kv
* The second case is performed for 10.5Kv load bus. At this voltage level, the active power losses is 44.069 MW and transmission efficiency is 28.255 %, and supply voltage is 25.104Kv
* The third case is performed at 10.5Kv with the generator in bus 4 operating to increase the transmission efficiency. While the active power losses is still the same (44.069 MW) because the generator is operating at power factor 1, but the transmission efficiency is this time 41.649 %. Which is big improvement compared with the above two cases in which the generator was not operating.

Although the goal is to reach 10.5 Kv at the feeder point, this is not possible due to the very high reactive power requirements of the motors. All 6 motors are starting in this case, which requires 17.355 Mw real and 44.834 Mvar reactive power. This very high reactive power requirement shows that a very high voltage is required to increase transmission efficiency and reduce active losses. However, we cannot arbitrarily increase the voltage in the load bus, since this requires a high supply voltage, which is above the rated voltage.

In summary, as the voltage in the load bus increases the transmission efficiency increases and the active power loss decreases. Moreover, the transmission efficiency increases when the generator in bus 4 operates at good power factor as it is demonstrated in case 3.