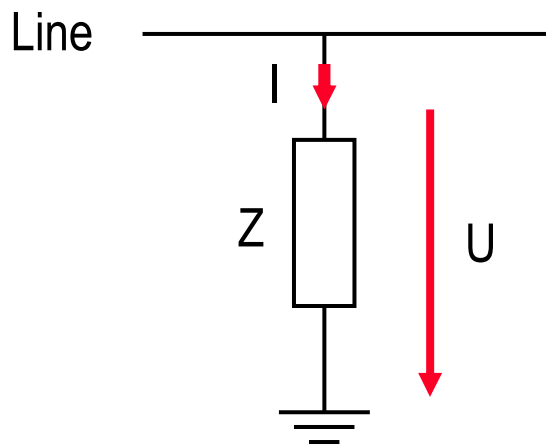


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## Some basics on shunt reactor losses (1)

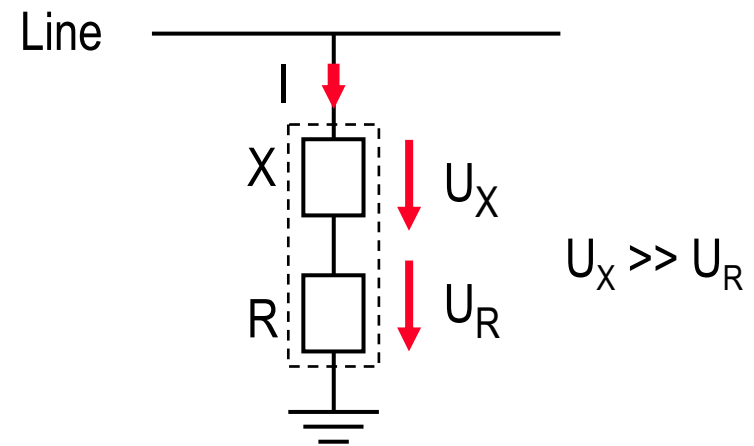
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Power  $S$ :  $S = U^2 / Z = I^2 Z$

Losses  $P$ :  $P = I^2 R$

Power Factor  $PF$ :  $PF = P / S$



Power  $S$ :  $S = U_X^2 / X = I^2 X$

Losses  $P$ :  $P = U_R^2 / R = I^2 R$

Power Factor  $PF$ :  $PF = P / S$

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## Some basics on shunt reactor losses (2)

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Design tolerance for impedance and losses is reflected in standard:

impedance:  $\pm 5\%$

losses:  $+ 6\%$

losses are currently related to rated current and therefore independent of any impedance tolerances.

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Under discussion: loss relation to Power Factor.

Reason: Utilities are most interested in efficiency of their grid which is related to PF.

Consequence: losses depend additionally on the impedance tolerance

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## Example – current situation (1)

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1~ shunt reactor designed  
and tested with

$S = 100 \text{ MVAr}$   
 $U = 100 \text{ kV (const.)}$   
 $I = 1 \text{ kA}$   
 $Z = 100 \Omega$   
 $P = 100 \text{ kW}$   
 $PF = 0.001 = 0.1\%$

1~ shunt reactor tested with  
- 5% impedance

$S = 105.26 \text{ MVAr}$   
 $U = 100 \text{ kV (const.)}$   
 $I = 1.0526 \text{ kA}$   
 $Z = 95 \Omega$   
 $P = 110.79 \text{ kW}$   
 $PF = 0.00105 = 0.105\%$

1~ shunt reactor tested with  
+ 5% impedance

$S = 95.24 \text{ MVAr}$   
 $U = 100 \text{ kV (const.)}$   
 $I = 0.9524 \text{ kA}$   
 $Z = 105 \Omega$   
 $P = 90.7 \text{ kW}$   
 $PF = 0.00095 = 0.095\%$

Because of tolerance of impedance the losses can differ from about 90 to 110 kW, if measured losses match exactly the calculated losses at rated current.

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## Example – current situation (2)

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1~ shunt reactor tested with  
+ 6% loss

$$S = 100 \text{ MVAr}$$

$$U = 100 \text{ kV (const.)}$$

$$I = 1 \text{ kA}$$

$$Z = 100 \ \Omega$$

$$P = 106 \text{ kW}$$

$$PF = 0.00106 = 0.106\%$$

1~ shunt reactor tested with  
- 5% impedance and +6% loss

$$S = 105.26 \text{ MVAr}$$

$$U = 100 \text{ kV (const.)}$$

$$I = 1.0526 \text{ kA}$$

$$Z = 95 \ \Omega$$

$$P = 117.44 \text{ kW}$$

$$PF = 0.00111 = 0.111\%$$

1~ shunt reactor tested with  
+ 5% impedance and + 6% loss

$$S = 95.24 \text{ MVAr}$$

$$U = 100 \text{ kV (const.)}$$

$$I = 0.9524 \text{ kA}$$

$$Z = 105 \ \Omega$$

$$P = 96.15 \text{ kW}$$

$$PF = 0.00101 = 0.101\%$$

Because of tolerance of impedance and tolerance of losses the losses can differ from about 96 kW to 118 kW.

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## Example – proposed definition with max. permissible PF

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1~ shunt reactor designed  
and tested with

$S = 100 \text{ MVAr}$   
 $U = 100 \text{ kV (const.)}$   
 $I = 1 \text{ kA}$   
 $Z = 100 \Omega$   
 $P = 100 \text{ kW}$   
 $PF = 0.001 = 0.1\%$

1~ shunt reactor tested with  
- 5% impedance

$S = 105.26 \text{ MVAr}$   
 $U = 100 \text{ kV (const.)}$   
 $I = 1.0526 \text{ kA}$   
 $Z = 95 \Omega$   
 $P = 105.26 \text{ kW}$   
 $PF = 0.001 = 0.1\%$

1~ shunt reactor tested with  
+ 5% impedance

$S = 95.24 \text{ MVAr}$   
 $U = 100 \text{ kV (const.)}$   
 $I = 0.9524 \text{ kA}$   
 $Z = 105 \Omega$   
 $P = 95.24 \text{ kW}$   
 $PF = 0.001 = 0.1\%$

Because of tolerance of impedance the losses can differ from about 95 kW to 105 kW if a maximum Power Factor has to be guaranteed.

In case a PF tolerance of +6% is permissible the loss range would be about 101 kW to 111.6 kW.

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# Conclusion

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## Impacts of loss definition via Power Factor

- loss guarantee would depend on impedance tolerance and loss tolerance itself
- permissible loss range becomes slightly smaller
- calculation would need a higher accuracy
- new definition might result in some confusion
- new definition would be not any longer in accordance with IEC