ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

MÉTHODES EN RÉGIME ALTERNATIF

RÉSOLUTION PAR LES PUISSANCES

LEÇON 18

Électrotechnique I
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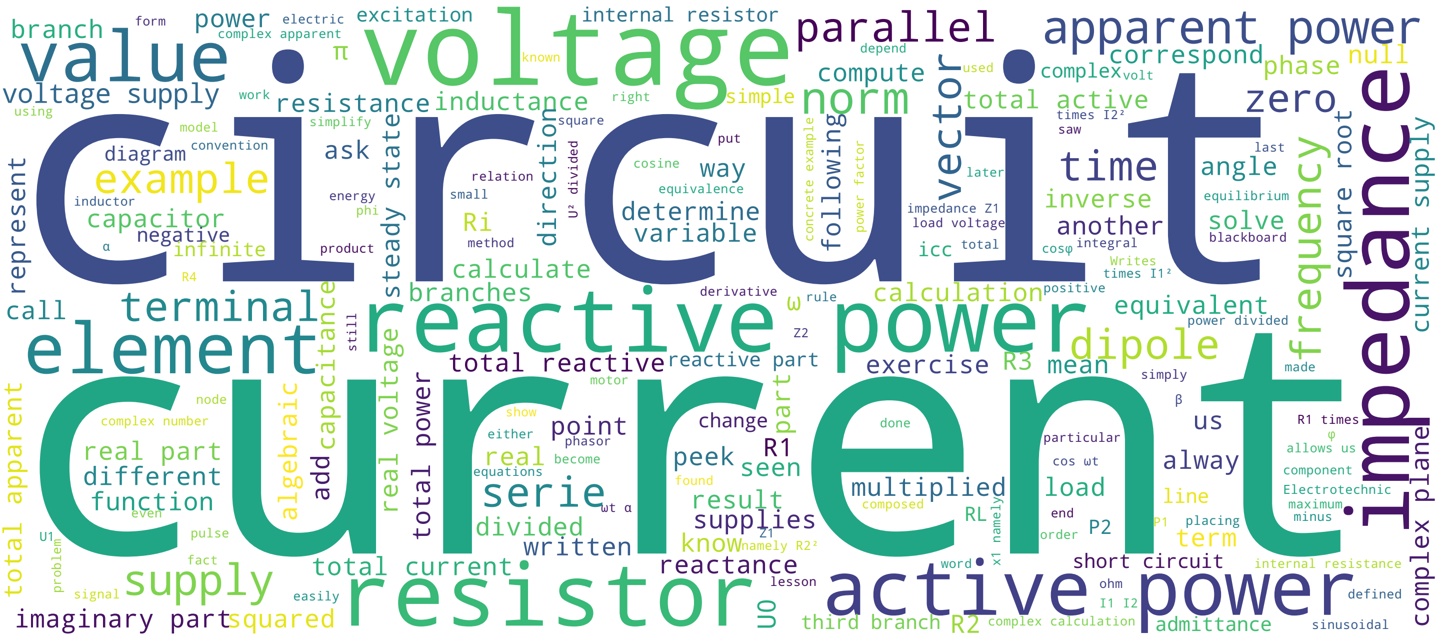
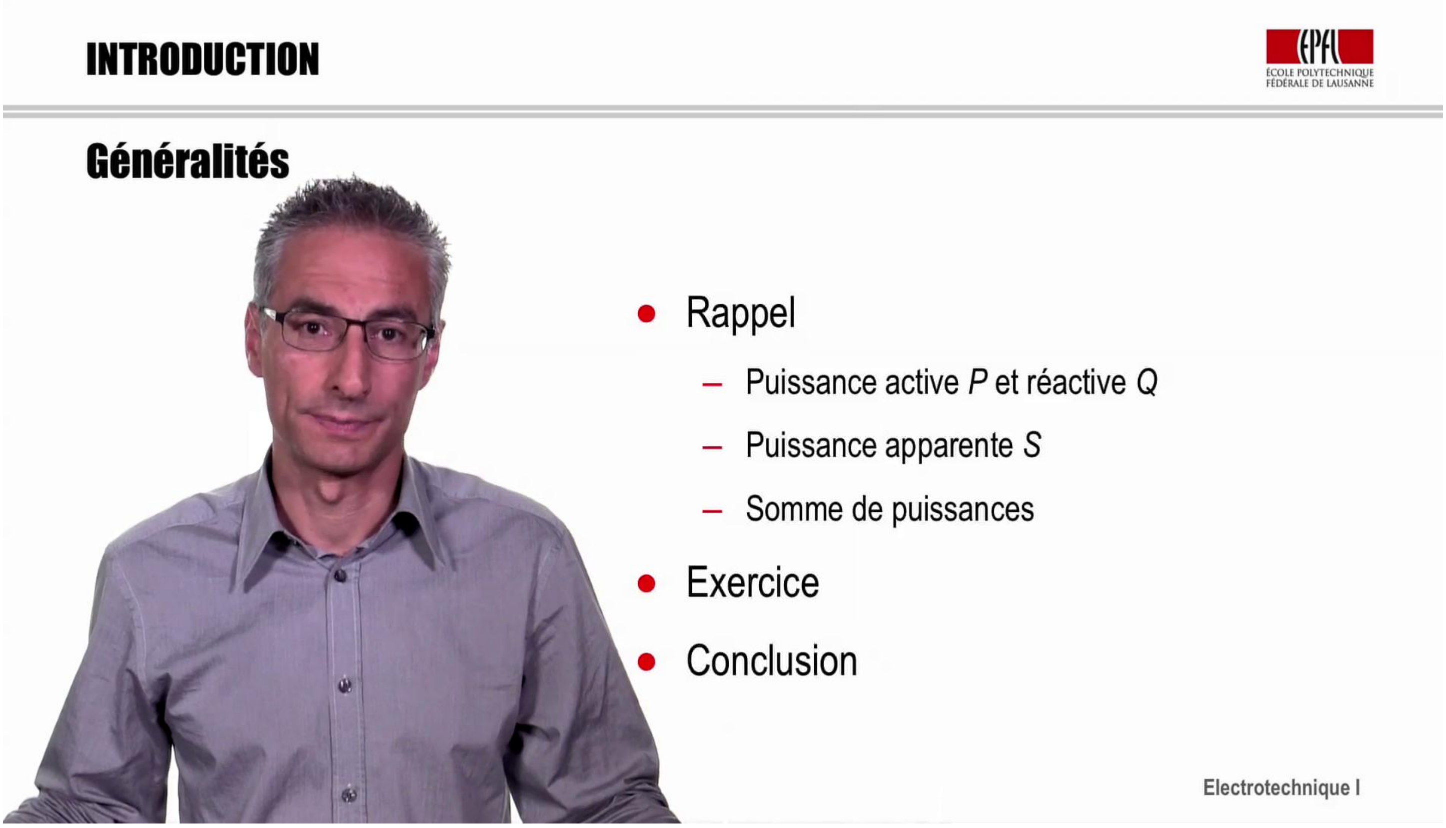


Video

EPFL



Hello, welcome to this new lesson of the Electrotechnics course. Today, we will solve an exercise by the powers method using only partially the complex calculation to determine the impedances, currents and voltages. We will begin with a very brief recall of the notions acquired on the powers and their additivity rules. We will then see a concrete example.

Notes

Summary

0m 04s

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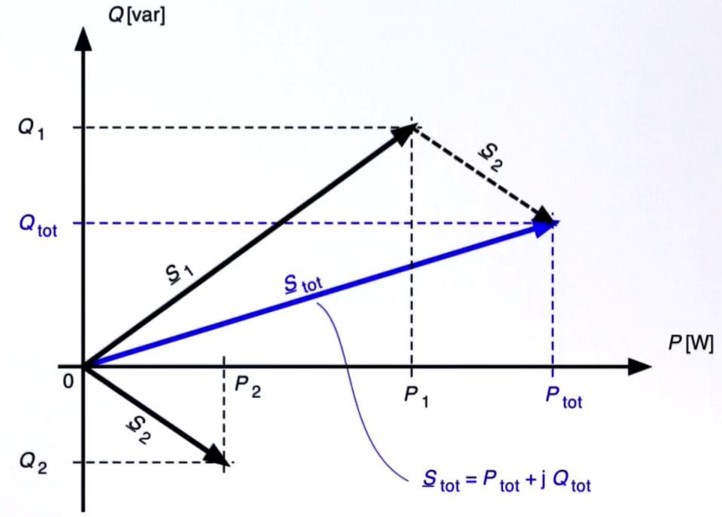
Puissances active, réactive et apparente - Rappel

$$P_{tot} = \sum_j P_j$$

$$Q_{tot} = \sum_j Q_j$$

$$\underline{S}_{tot} = \sum_j \underline{S}j = P_{tot} + \mathrm{j}Q_{tot}$$



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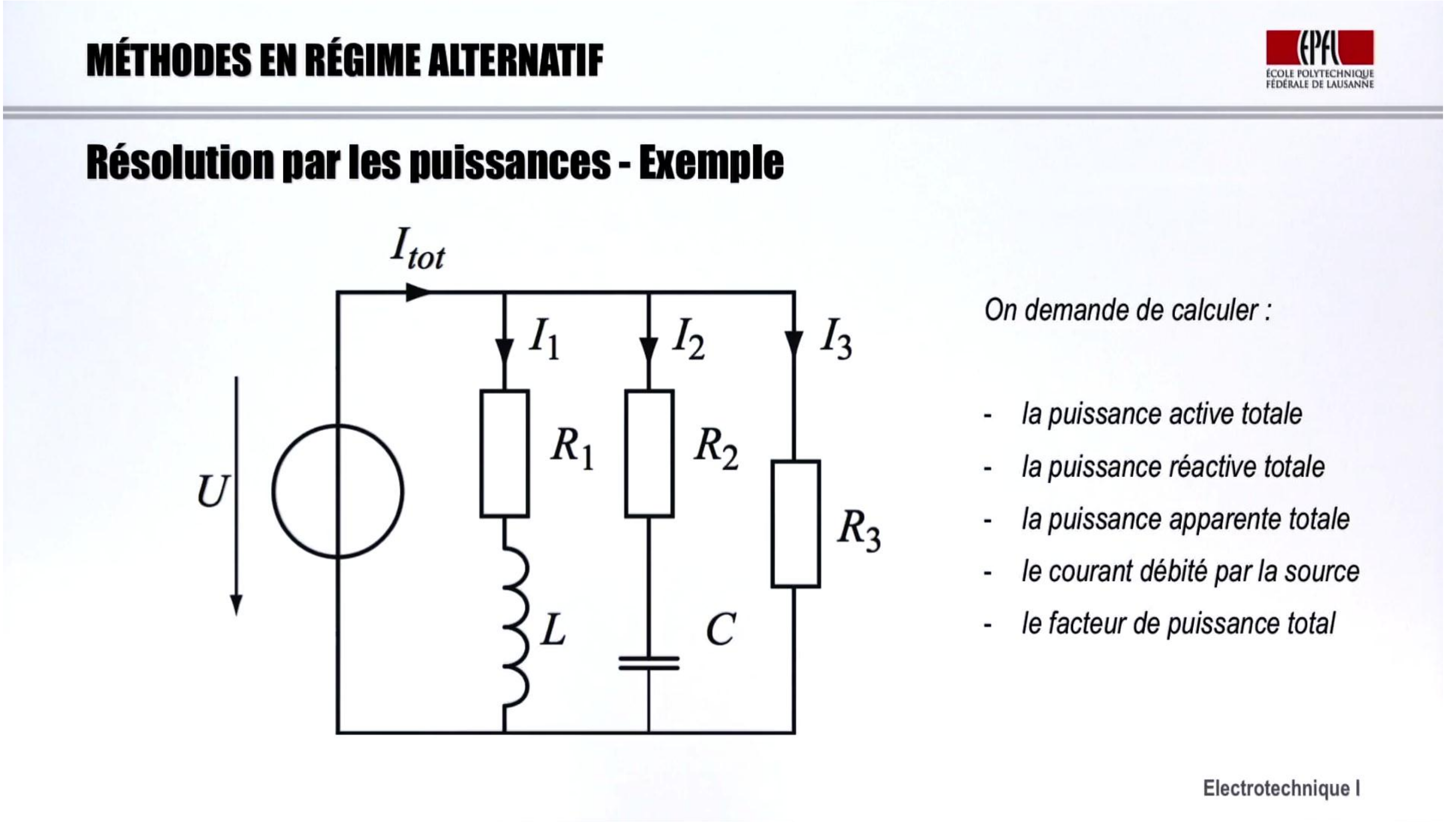
So, as a reminder, the active power P is represented on the real axis of the complex plane and the reactive power Q on the imaginary axis of the same complex plane. The additive rule for a system of several elements says that: the total active power is the sum of powers for each system. same for the total reactive power: it is the algebraic sum of the reactive power units. We can perform this addition algebraically, why? Because these variables are collinear. In this example, we see that we have two systems: the system S1 and the system S2, and each of them consumes an active power, P1 and P2, that we will be able to add; and a reactive power Q1 and Q2. Here, pay attention, Q2 is negative, and we can also add the reactive powers. Concerning the apparent power, we can also add them, but it is vector addition. We see here that the total apparent power, is the sum of the apparent power S1 plus the apparent power S2, vector. And then, we can find the total power, the total active power, as the sum of P1 and P2 : We see that it corresponds to the real part of the complex apparent power, it is that term here. Same for the total reactive power, it is the sum of Q1 and of Q2, Q2 being negative, and it corresponds to the imaginary part of the complex apparent power.

Notes

Summary

0m 29s

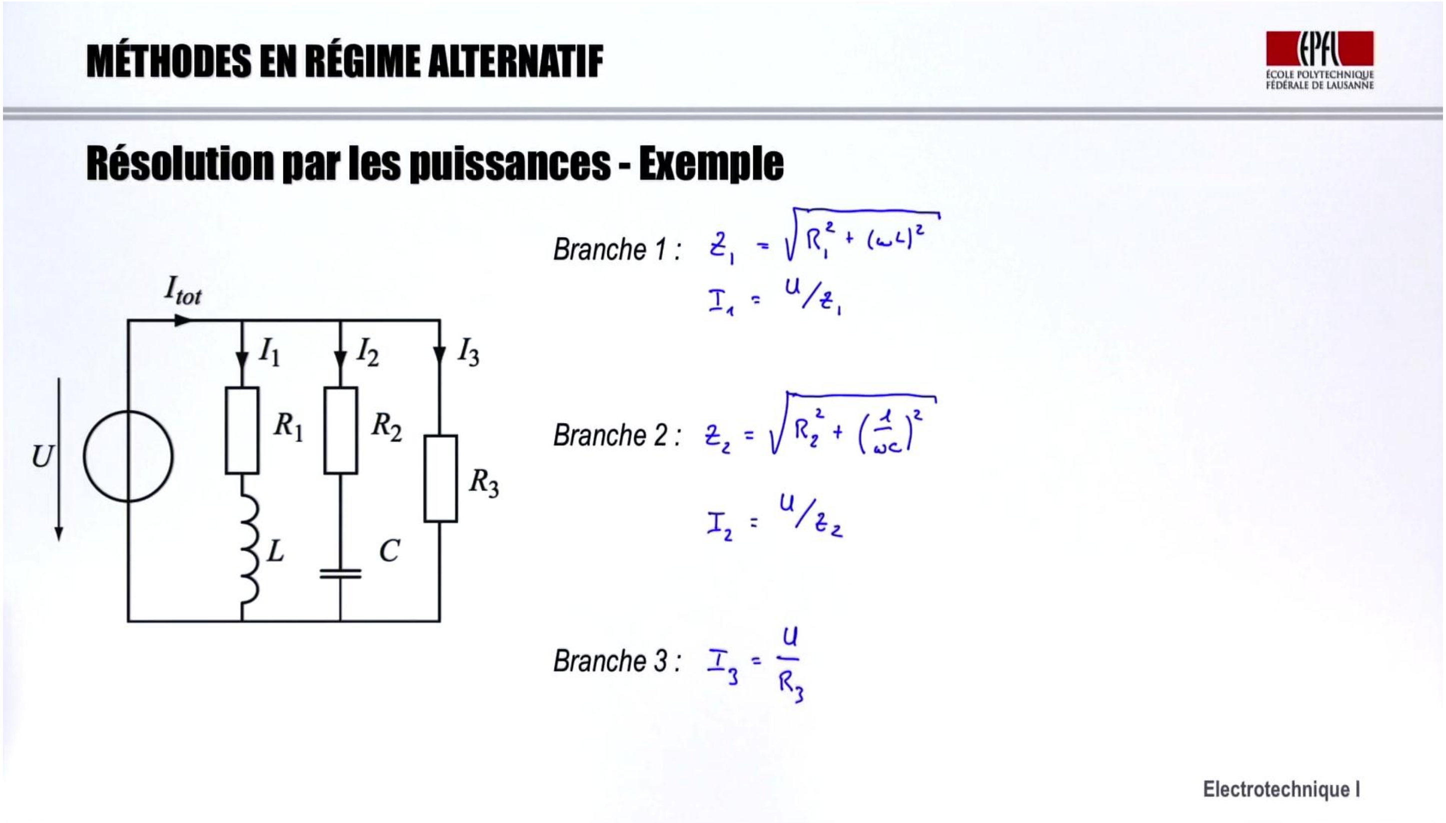


Let's now see a concrete example. We have the following circuit that is composed of an excitation, an alternative voltage U that will feed three branches of a circuit: a branch RL, a branch RC, and a third branch that is only made of a resistor. And in each of these branches, a current will flow I1, I2 and I3, and we ask to compute the total active power of all the circuit, the total reactive power as well, and the total apparent power, and last, we ask the total current delivered by the supply. Finally, we ask also, the total power factor, that is to say, the power factor seen by this supply U.

Notes

Summary

2m 22s

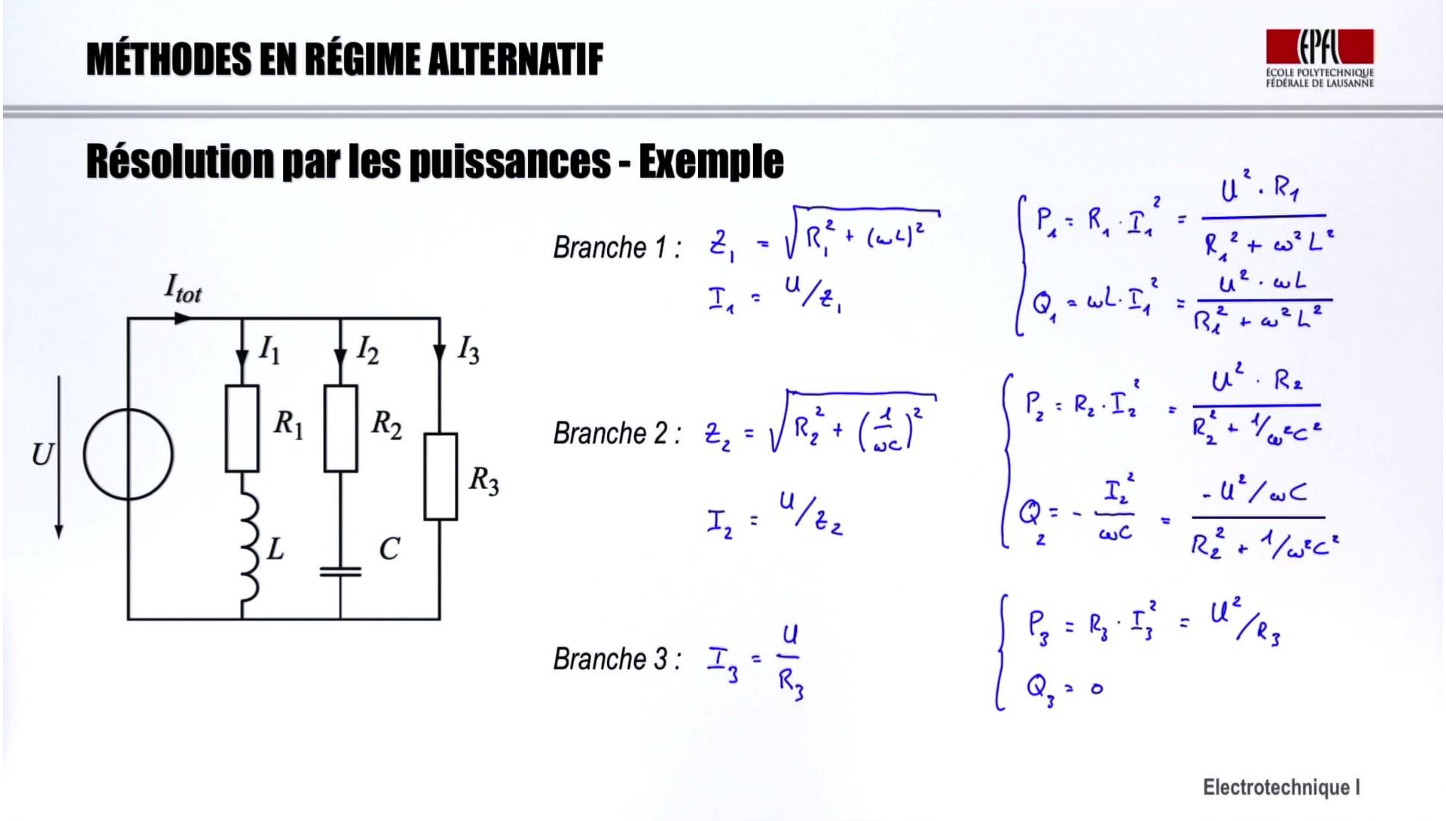


In order to solve that exercise, we will compute the three currents I1, I2, I3 in each branch and we will compute the norm of the current; why? Because, to determine the active power, we only need to know : I; to square it, multiply it by R to get that active power. same for the reactive power that is equal to x multiplied by I². To determine the current, we still need to know the impedance Z1, this impedance Z1 is given by: Pythagoras R1² plus x1, namely, ω.L squared. This, is the value of the norm of the impedance. The norm of the current will then be equal to U divided by Z1. Same for the branch n°2. The impedance's norm, Z2 is equal to the square root of the real part squared namely, R2² of the impedance Z2 plus the imaginary part it's then a capacitor it's 1/ωC squared. And then, the norm of the current I2 is given by U/Z2. Finally, for the third branch, it is simpler because we have only one resistive part, we have the current I3 given by U / Z3 or R3. The imaginary part is null. Therefore, we can now compute all the active and reactive powers for each of the three branches.

Notes

Summary

3m 16s



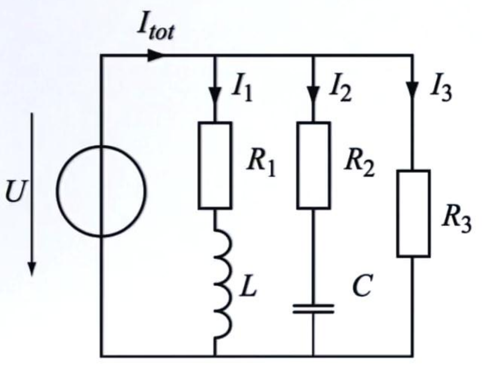
We have that P1, is equal to R1 times $I1^2$, which is equal to R1 times the current squared, that is to say, we will develop this term, U^2 divided by Z squared then it is $R1^2$ plus $\omega^2 L^2$, times the resistance R1. For the reactive power in this branch, it is always equal to, x1 times $I1^2$, then, x it's ωL multiplied by $I1^2$. And it is equal, after development, to the current I1, U^2 over Z squared, times x1, namely ωL. For the active power in the second branch, we have that P2 is equal to R2 times $I2^2$, the norm of I2 squared, and is equal to I^2, namely U^2 divided by Z^2, that is to say; $R^2 + 1 / \omega^2 C^2$, times R2. For the reactive power, it is x the reactive part of the branch, namely, negative. minus one over ωC times $I2^2$. And this is equal to $-U^2 / \omega C$ divided by the norm squared, of Z2, namely $R2^2 + 1/\omega^2 C^2$. Finally, for the third branch, the active power is equal to R3 times $I3^2$, it is equal to $U^2/R3$. And the reactive part is equal to zero, because there is no reactance in this branch.

Notes

Summary

5m 16s

Résolution par les puissances - Exemple



Puissance active totale :

$$P_{tot} = \sum_{j=1}^{3} P_j = \frac{U^2 R_1}{R_1^2 + \omega^2 L^2} + \frac{U^2 R_2}{R_2^2 + 1/\omega^2 C^2} + \frac{U^2}{R_3}$$

Puissance réactive totale :

$$Q_{tot} = \sum_{j=1}^{3} Q_j = \frac{U^2 \omega L}{R_1^2 + \omega^2 L^2} - \frac{U^2/\omega C}{R_2^2 + 1/\omega^2 C^2}$$

Puissance apparente totale, courant total et facteur de puissance :

$$S_{tot} = \sqrt{P_{tot}^2 + Q_{tot}^2} \quad ; \quad I_{tot} = \frac{S_{tot}}{U} \quad ; \quad \cos\varphi = \frac{P_{tot}}{S_{tot}}$$

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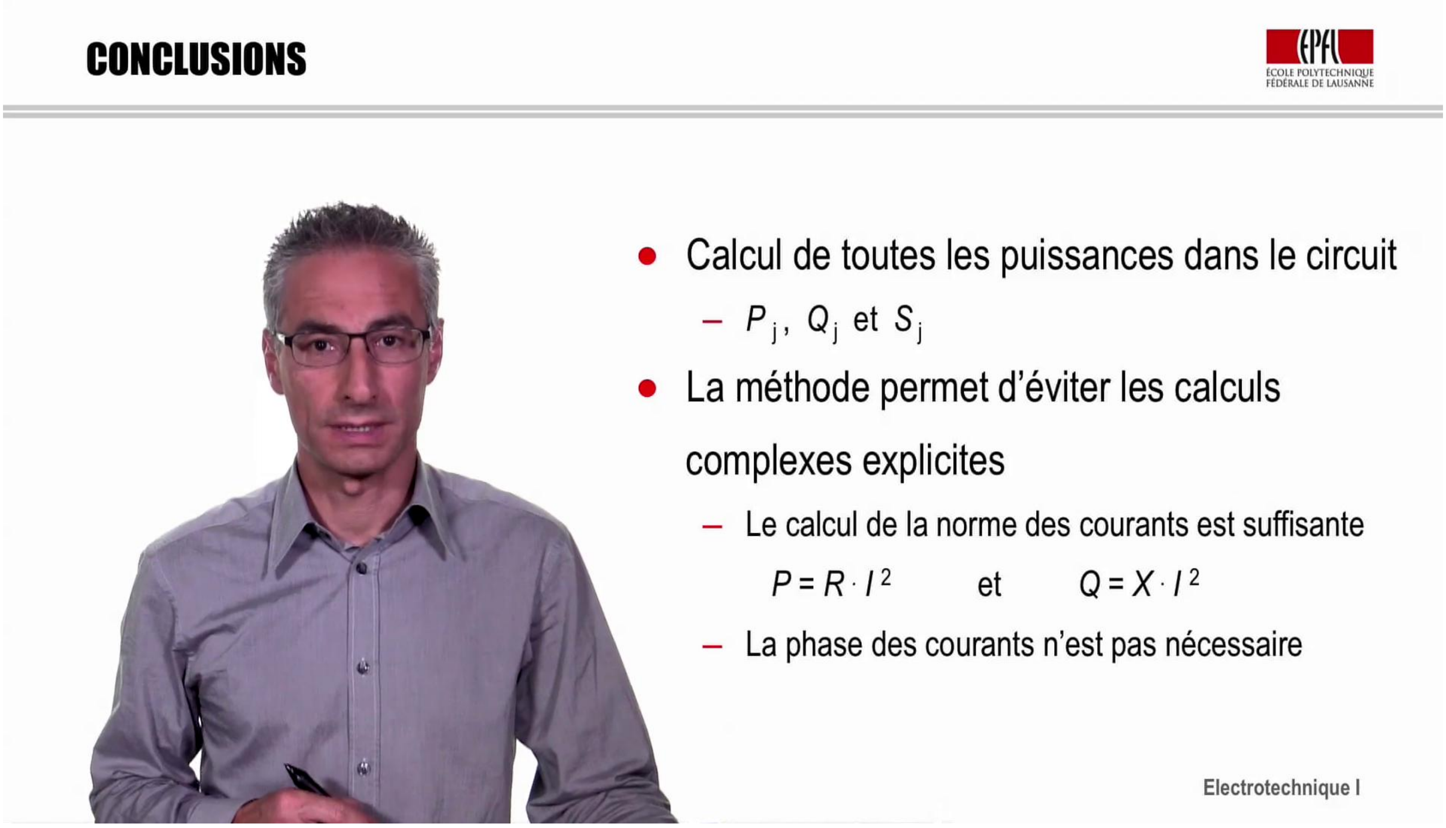
The total active power consumed by the circuit is given by the relation that the total power is the sum of all the active powers, and it is equal to : [Writes on the blackboard] This is the result. For the total reactive power, we can also sum all the reactive powers of the circuit. and it is equal to : [Writes on the blackboard] Here is the result for the total reactive power. Now, it is very simple by Pythagoras, to extract the apparent power from the circuit. It is given by the square root of $Ptot^2 + Qtot^2$. This result allows us to determine very easily the norm of the total current knowing that the apparent power is U times I, therefore, the current Itot is equal to the total apparent power divided by U. We see at that level that we have managed to determine the norm of the total current without performing the vector sum of three unit currents. and, we arrive at the last question of the exercise. We have to calculate the global cosφ of the circuit. And it is given, we have seen it before, by the total active power divided by the total apparent power. We could determine the value of cosφ by computing the equivalent impedance of the five impedances, and we would found the same result, the same cosφ, but probably the calculation is longer.

Notes

Summary

8m 01s



That's it, we have computed all the powers in the circuit: - The active power P which is the algebraic sum of all the active powers of the elements. - The reactive power Q which is also the algebraic sum of all the reactive powers of all the elements. - And the apparent power S which is, this time, the vector sum of all the apparent powers in the circuit. The method avoids the explicit complex calculations, only the norm of the currents is sufficient; Why? Because the powers are calculated only with the norm of the current with the active power, it's RI²; the reactive power it's x times I². The phase of the currents and the impedances, it is not necessary to calculate it. Thank you for your attention.

Notes

Summary

10m 37s