ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

THÉORÈMES DE THÉVENIN ET DE NORTON

CIRCUITS ÉQUIVALENTS

LEÇON 8

Électrotechnique I
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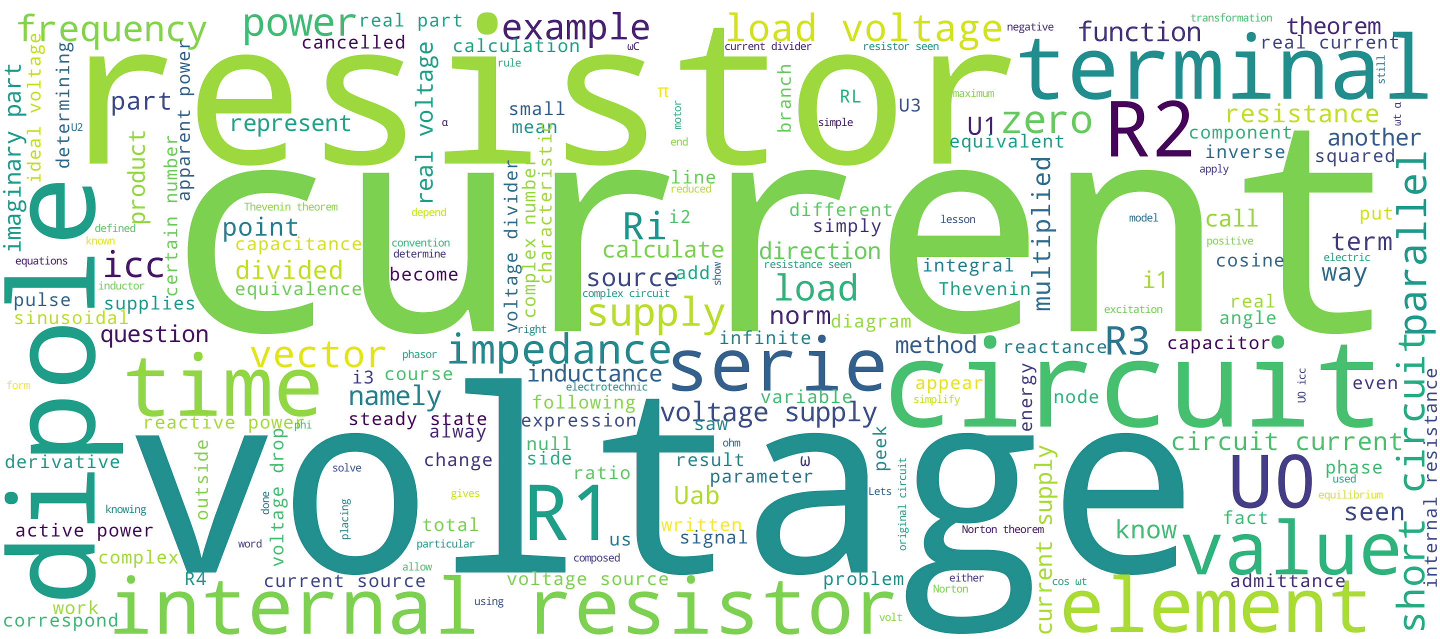
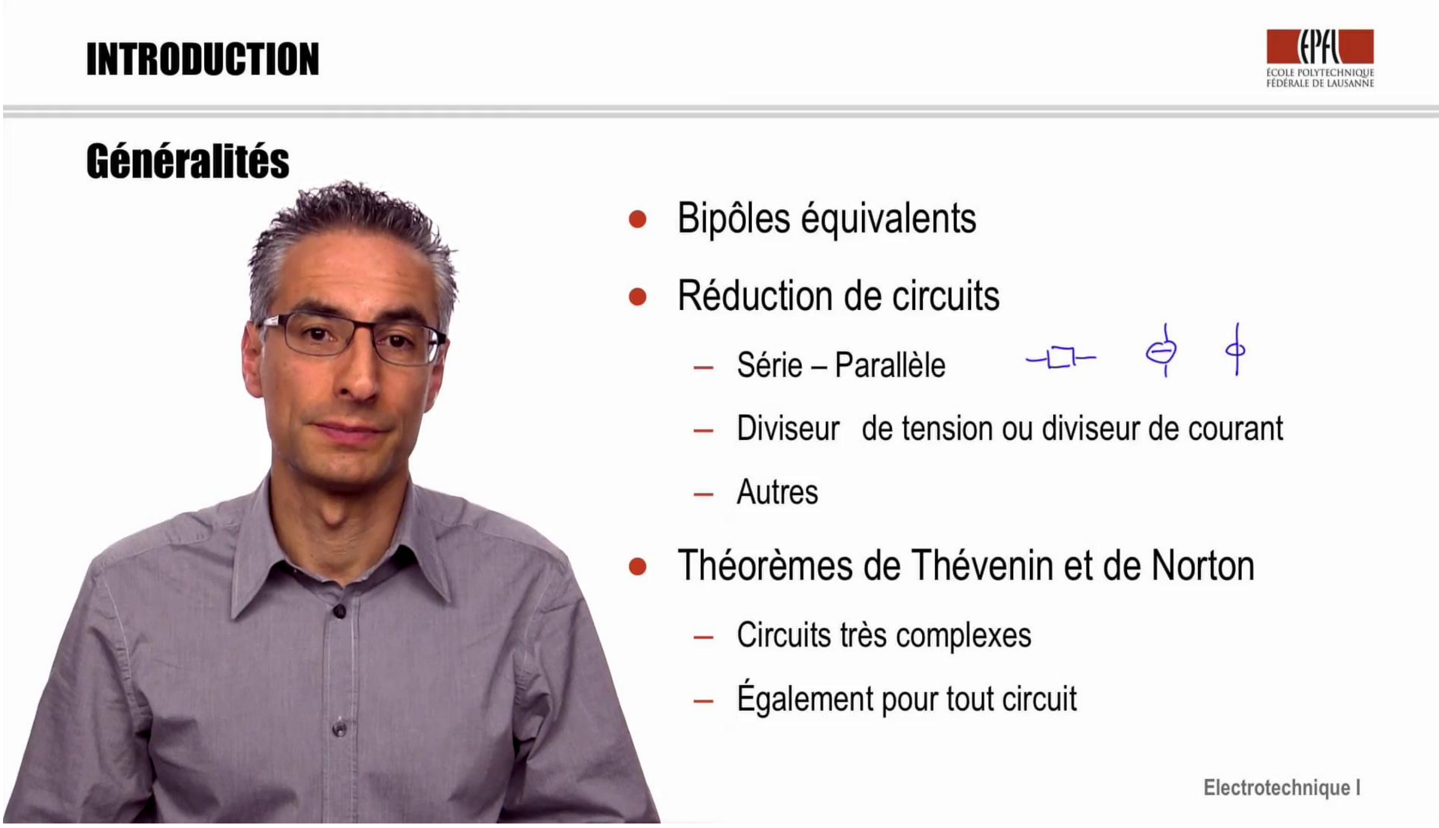


Video

EPFL

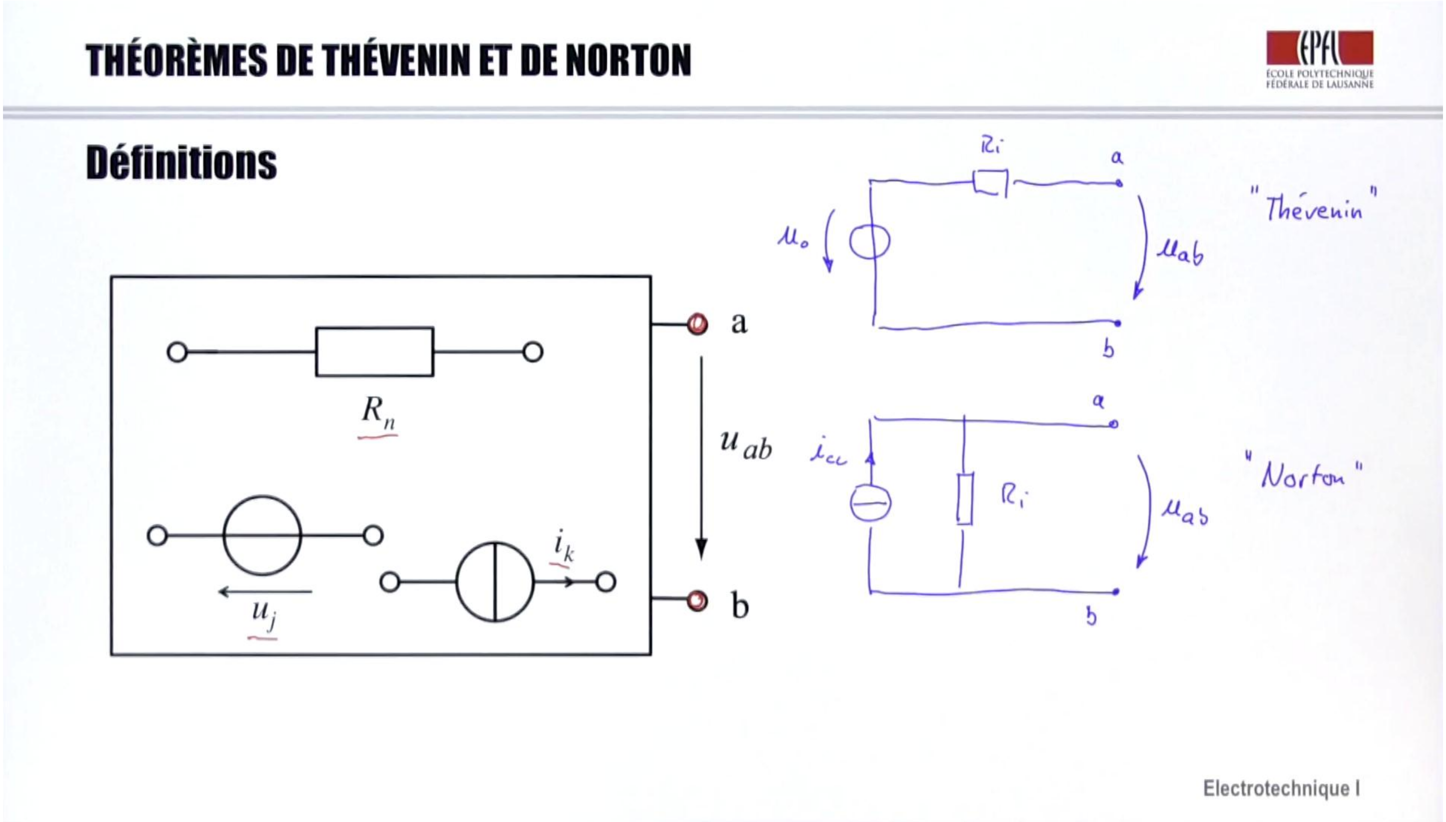


Hello, welcome to this new lesson of the Electrotechnique 1 course. In the framework of electrical circuits, it is rarely needed to know the evolution of the currents and voltages, in every location of the circuit. It is then possible to find a basic equivalent circuit which is simpler but which accurately translates the behaviour of the original circuit. We call equivalent bipoles or dipoles two dipoles that have the same current at all times when they are under the same voltage, or vice versa. A dipole can be reduced to dipole by way of different reductions, provided that they keep the same characteristics. We have seen different possible reductions, such as the Series or Parallel reductions, that apply to resistors, current sources, and voltage sources. We have seen the voltage divider, or the current divider, we will see even other transformations, like the Y-Δ transformation or other methods. In most cases, these reductions and transformations are easily applicable, but of, in particular, complex circuits, we will mostly apply the principle of Thevenin or the theorem of Norton. These two theorems and also valid for more simple circuits. We will now develop these two theorems.

Notes

Summary

0m 04s



Lets consider a dipole that is characterised by a certain number of resistors, a certain number of sources, whether these are voltage sources or current sources, for which we have two terminals, two poles. The respective expression of the Thevenin or Norton theorems say that it is always possible to reduce such a dipole, containing any combination of independent sources and resistor to a dipole that finally contains only one ideal voltage source, *U0*, with, in series, an internal resistor *Ri*. So, this dipole - we put the terminals *a* and *b*- presents a voltage *Uab*, and the extreme simplification of this original circuit, is the theorem of Thevenin. The theorem of Norton says that this dipole can be reduced to a current source, equal to *icc*, in parallel with an internal resistor, the same internal resistor, put in parallel. Once again, the terminals *a* and *b* and the voltage at the side of these terminals, is the expression of the Norton theorem. The equivalence of these dipoles is fulfilled if they have the same no-load voltage, and the same short-circuit current, and so fatally, the same internal resistor, is the equivalence between the real voltage source and the real current source, that we saw in the previous lesson.

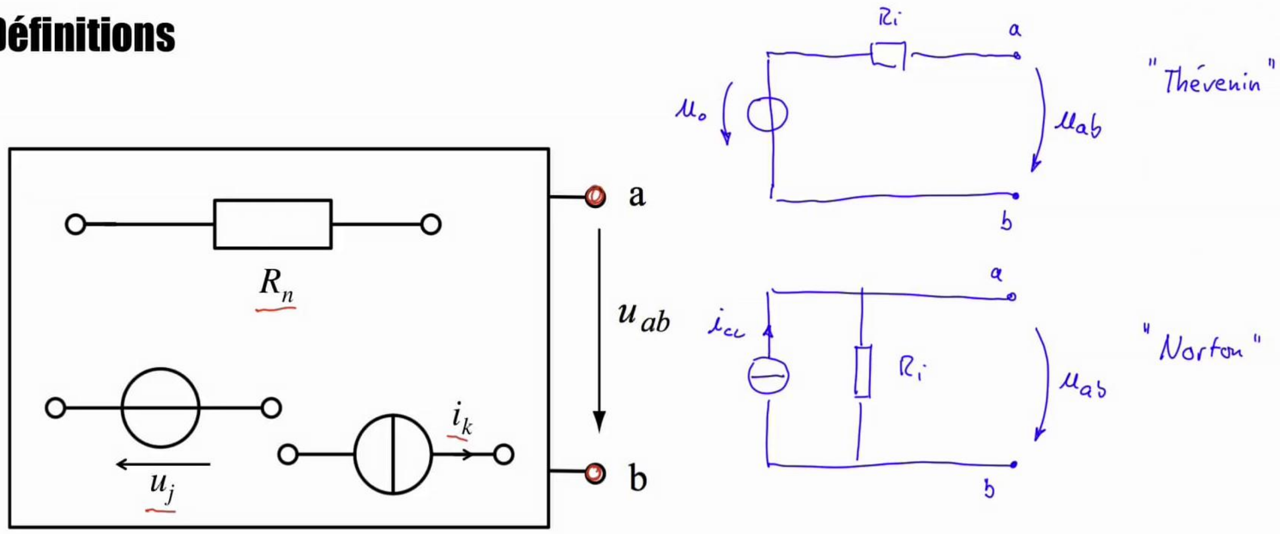
Notes

Summary

1m 26s

THÉORÈMES DE THÉVENIN ET DE NORTON

Définitions



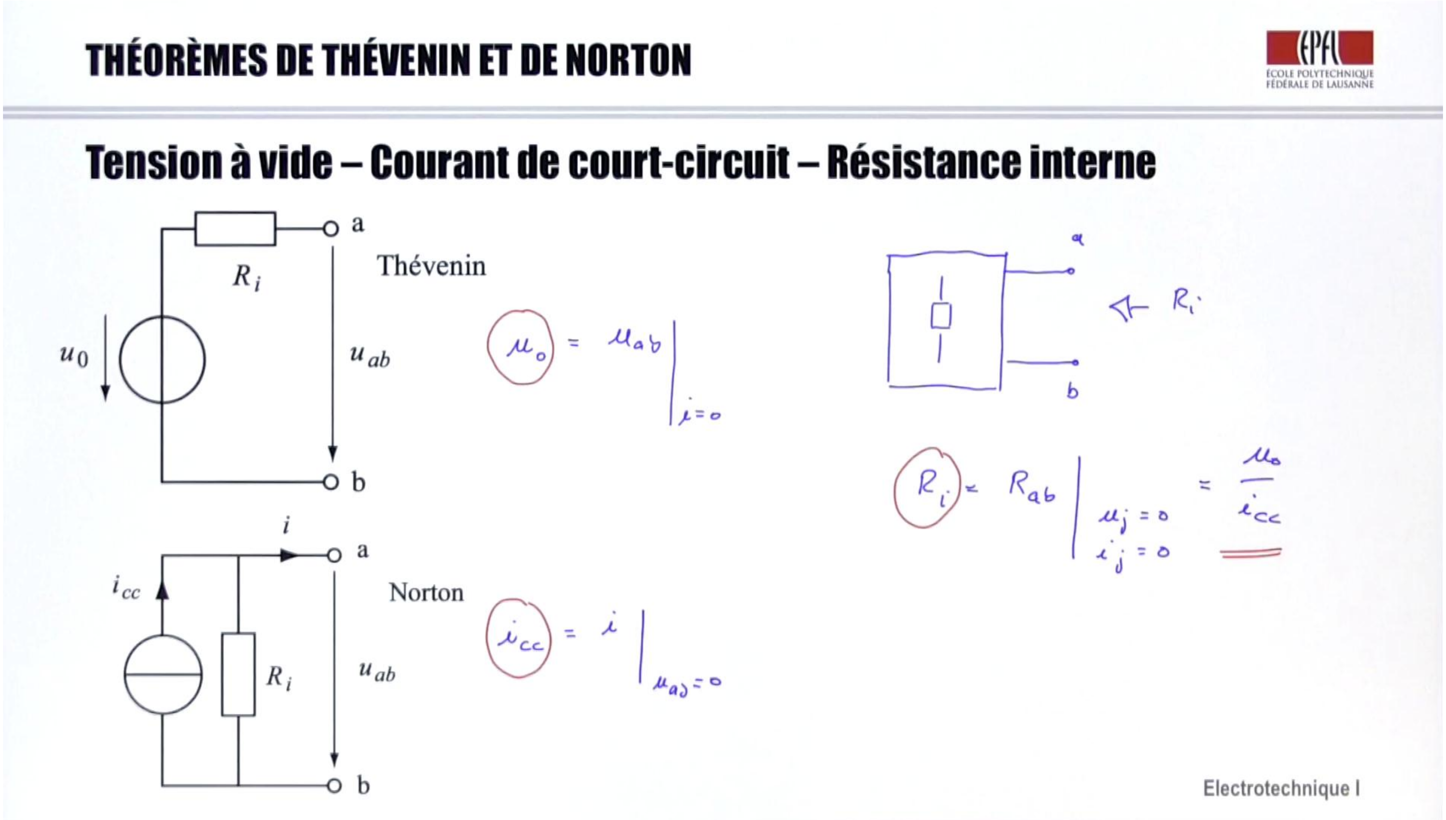
Electrotechnique I

It is now a question of determining these three parameters, the no-load voltage, the short-circuit current and the internal resistor, that, in fact, represent this source, this more complex dipole.

Notes

Summary

3m 28s

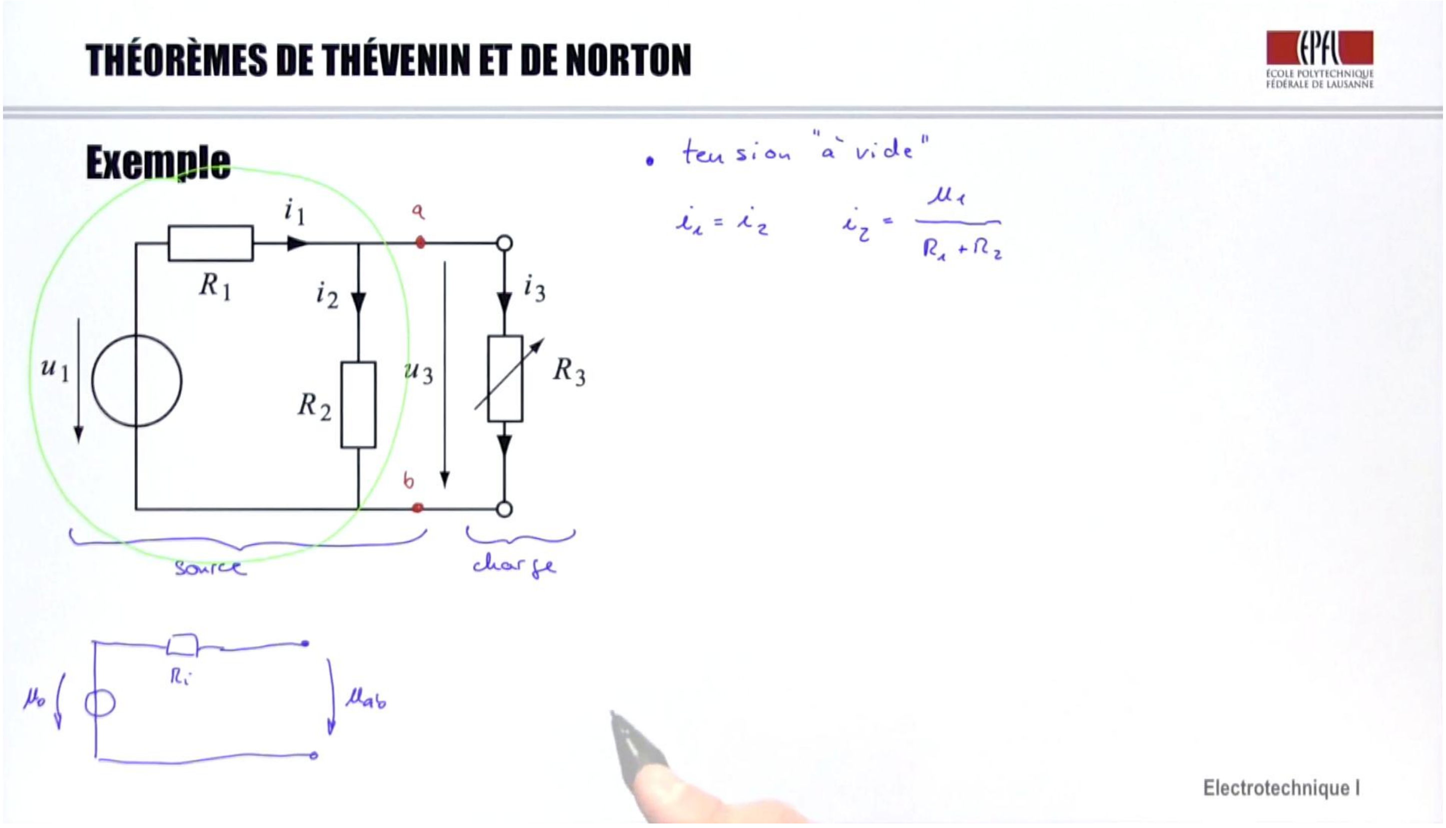


So, let's take these diagrams back, it is now a question of determining the no-load voltage *U0*, which is, in fact, the voltage *Uab*, from the original voltage, when the current is equal to zero. It is now still a question of representing or determining the current *icc*, which is the current between the terminals *a* and *b*, when the dipole is short-circuited, namely when the voltage *Uab* is equal to zero. The internal resistor is the resistance seen from outside the dipole, when all the sources are cancelled. I represent the dipole here, the terminals *a* and *b*, the internal resistor seen from outside the dipole, *Ri*, it is the resistance between the terminals *ab*, when all the sources are cancelled out, namely all the *uj* are equal to zero, and all the *ij* are also equal to zero, and we have seen that this internal resistor is the ratio of *U0* over *icc*. By knowing these three parameters between *U0*, *icc*, *Ri*, we completely determine the source, knowing that *Ri* is equal to the ratio of *u0* over *icc*.

Notes

Summary

3m 40s

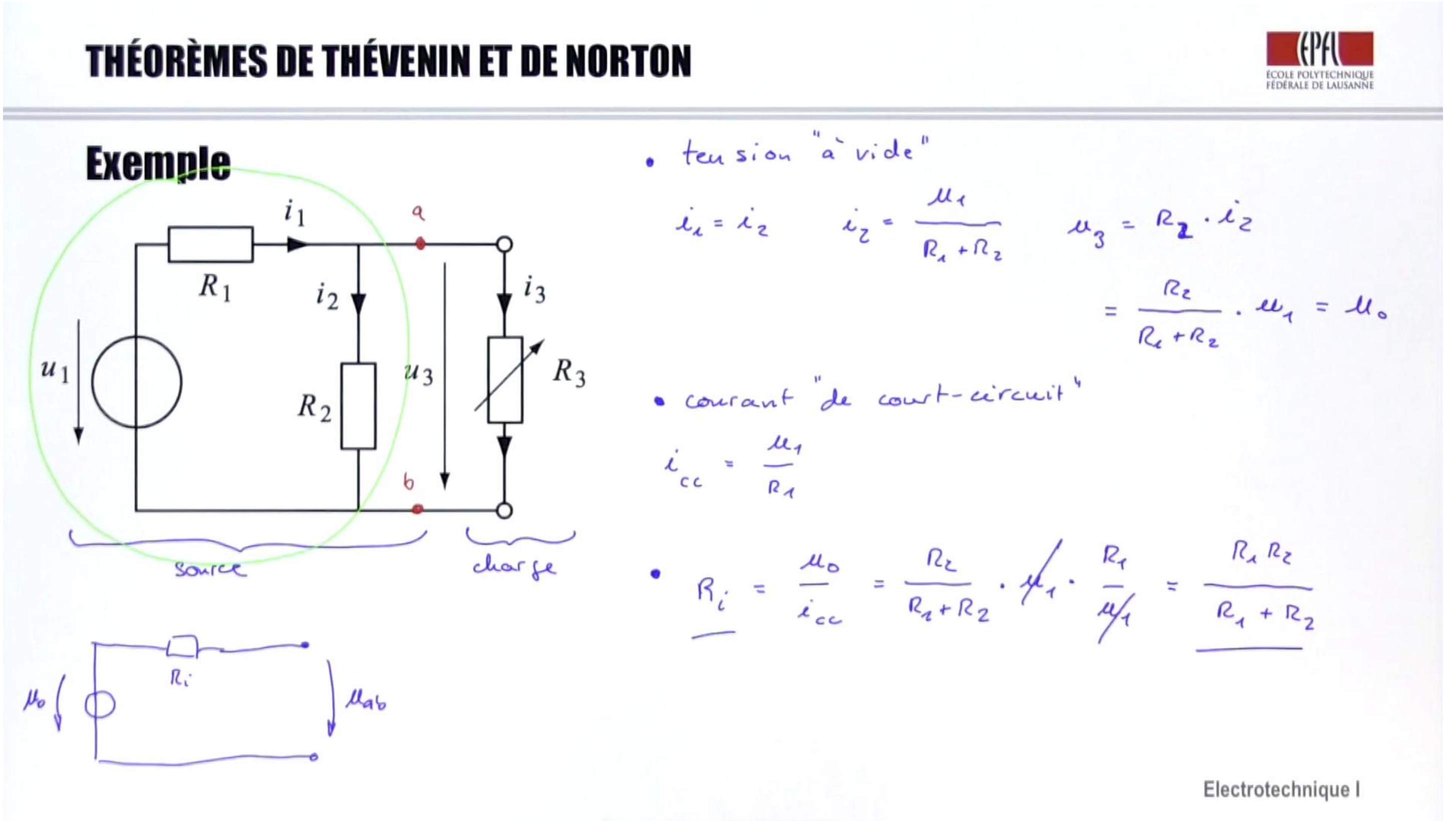


Lets now pass to a concrete example. We consider this circuit, which is composed of a source and a load, we define the dipole *ab* between these two terminals *a* and *b*. This is then the source, this is the charge, and this dipole here can be simplified into the following dipole, by the Thevenin theorem, a no-load voltage in series with an internal resistor. It now a question of calculating this no-load voltage *Uab*, and to calculate the short-circuit current. For the no-load voltage... the no-load voltage is the dipole voltage when the resistor *R3* doesn't exist, the circuit is open. We can then write the following equation, firstly, the current *i1* is equal to the current *i2*, so there is only one loop in the circuit, and so *i1* or *i2* is equal to the source *U1*, divided by the sum of these two resistors *R1* and *R2*, since they are in series. Finally, the voltage that appears between the points *a* and *b* in no-load, also correspond to the voltage drop at the terminals of the resistor, namely that *U3* is equal to *R2 times i2* and this is equal to *R2* divided by *R1 plus R2*, multiplied by *U1*, and this is the no-load voltage.

Notes

Summary

5m 13s

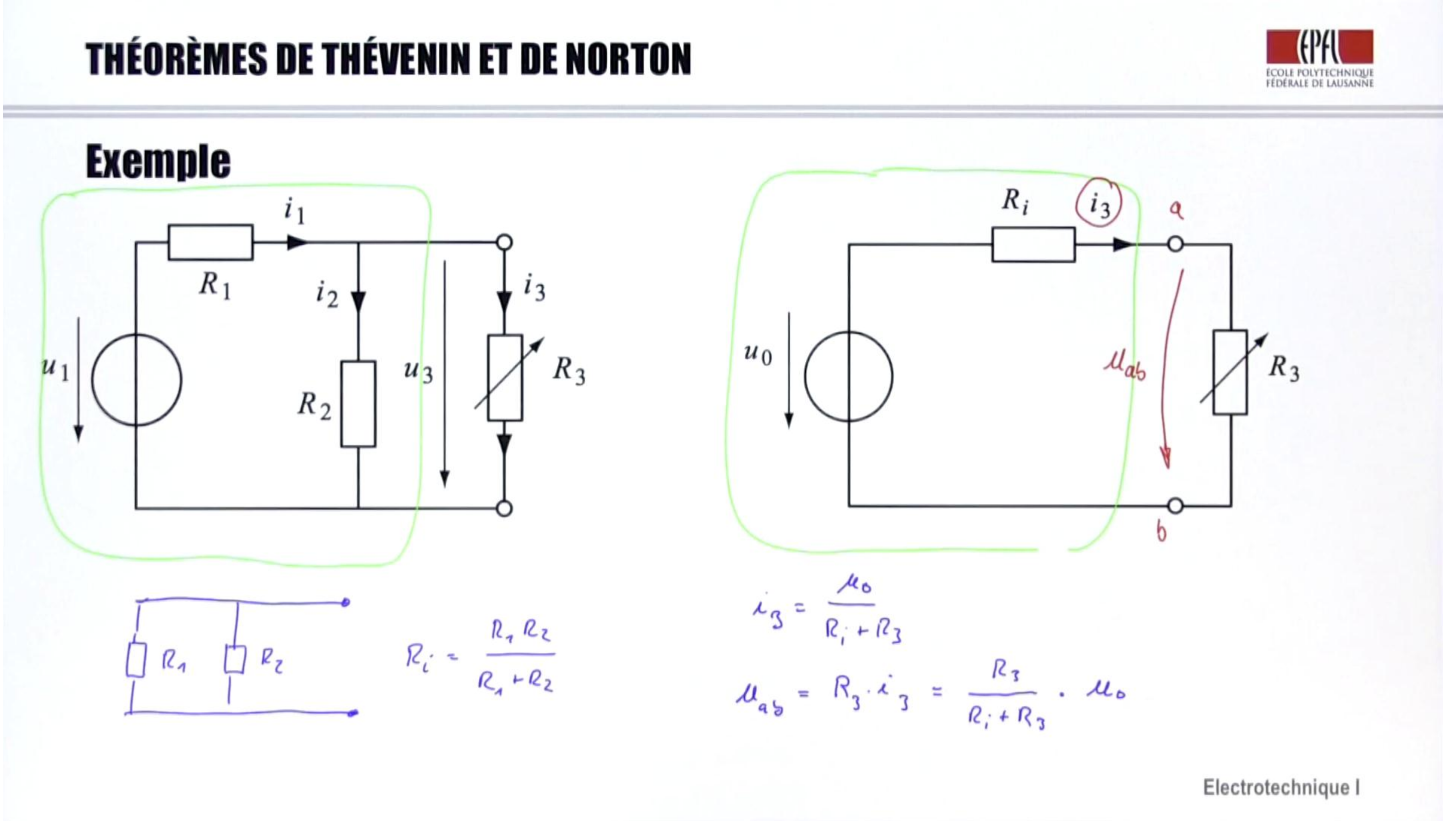


Lets calculate now the short-circuit current. It is the current passing through the terminals *a* and *b*, when we short-circuit them, namely when we replace the resistor *R3* by a null resistor. We simply find that *icc* is equal to *U1* over *R1*, since the short-circuit cancels out, here, the effect of the resistor *R2*. We have then determined the no-load voltage and the short-circuit current, we can now determine the internal resistor of the circuit, the dipole, the internal resistor is the ratio of *U0* over *icc*, and it is equal to, *U0* is *R2* over the sum of these two resistors, multiplied by *R1*, and multiplied by 1 over *icc*, namely *R1* over *U1*, which finally gives for the internal resistor, the product of *R1* times *R2* over the sum of *R1* plus *R2*.

Notes

Summary

7m 12s



Here is our original dipole which is here, replaced by the simplified dipole, found with Thevenin's theorem. We can assure ourselves that the internal resistor seen from outside, *Ri* which is the resistance seen when all the sources are cancelled out, well, *R1* in parallel with *R2* is equal to the product of *R1.R2* over the sum of *R1 plus R2*. Now that we have completely determined the three parameters *U0*, *icc* and *Ri*, we can express the current *i3* and the voltage *U3*, or *Uab*, in function of the resistor *R3*, we know that the current *i3* is equal to *U0* over the sum of *Ri* plus *R3*, and the output voltage *Uab* or *U3*, is equal to the product of *R3* times *i3*, which is equal to *R3* over *Ri* plus *R3*, multiplied by *U0*. We recognise here the expression of the voltage divider.

Notes

Summary

8m 35s

CONCLUSIONS

- Simplifications simples, souvent applicables
- Circuits complexes, Théorème de Thévenin et Théorème de Norton
- Autres méthodes

Electrotechnique I

There, the simple simplifications are often applicable, but for complex circuits or sub-circuits, we can usefully apply the theorems of Thevenin and Norton: they guarantee the dipole equivalences. Later, we will see more methods for circuit transformations.

Notes

Summary

10m 11s