ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

PRINCIPAUX ÉLÉMENTS DE CIRCUIT

LEÇON 4

Électrotechnique I
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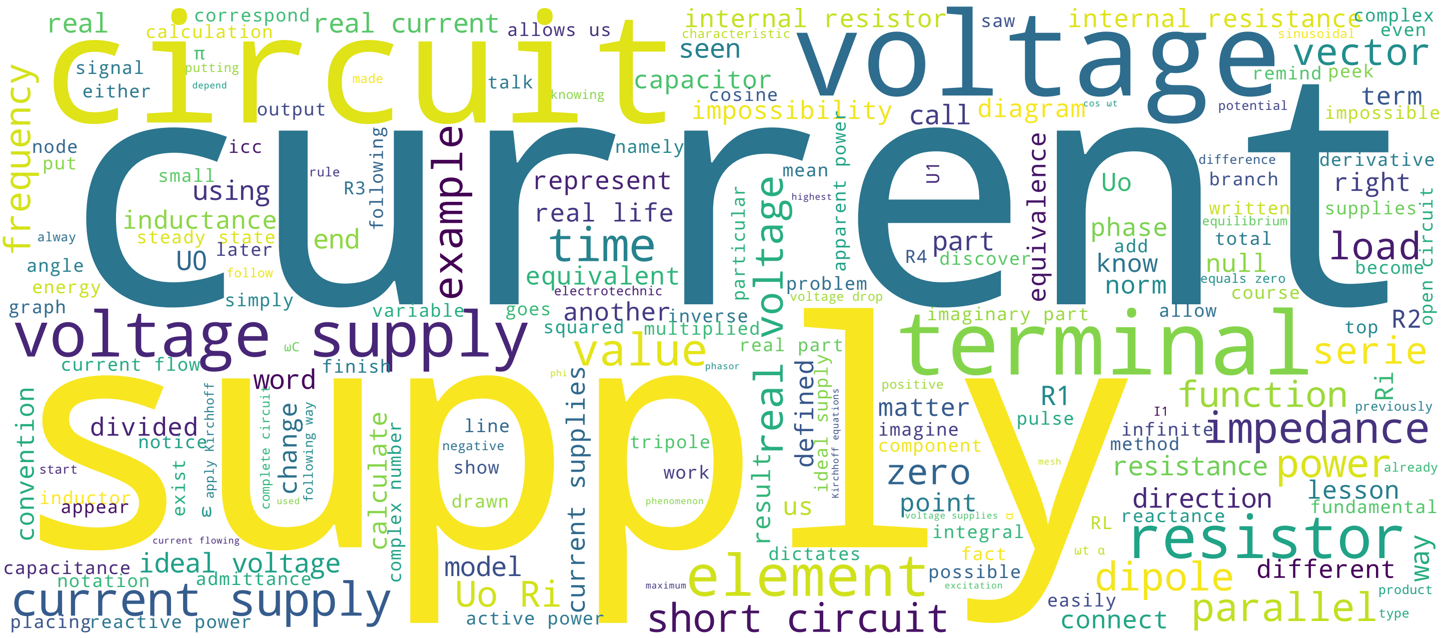
Laboratoire d'Actionneurs Intégrés



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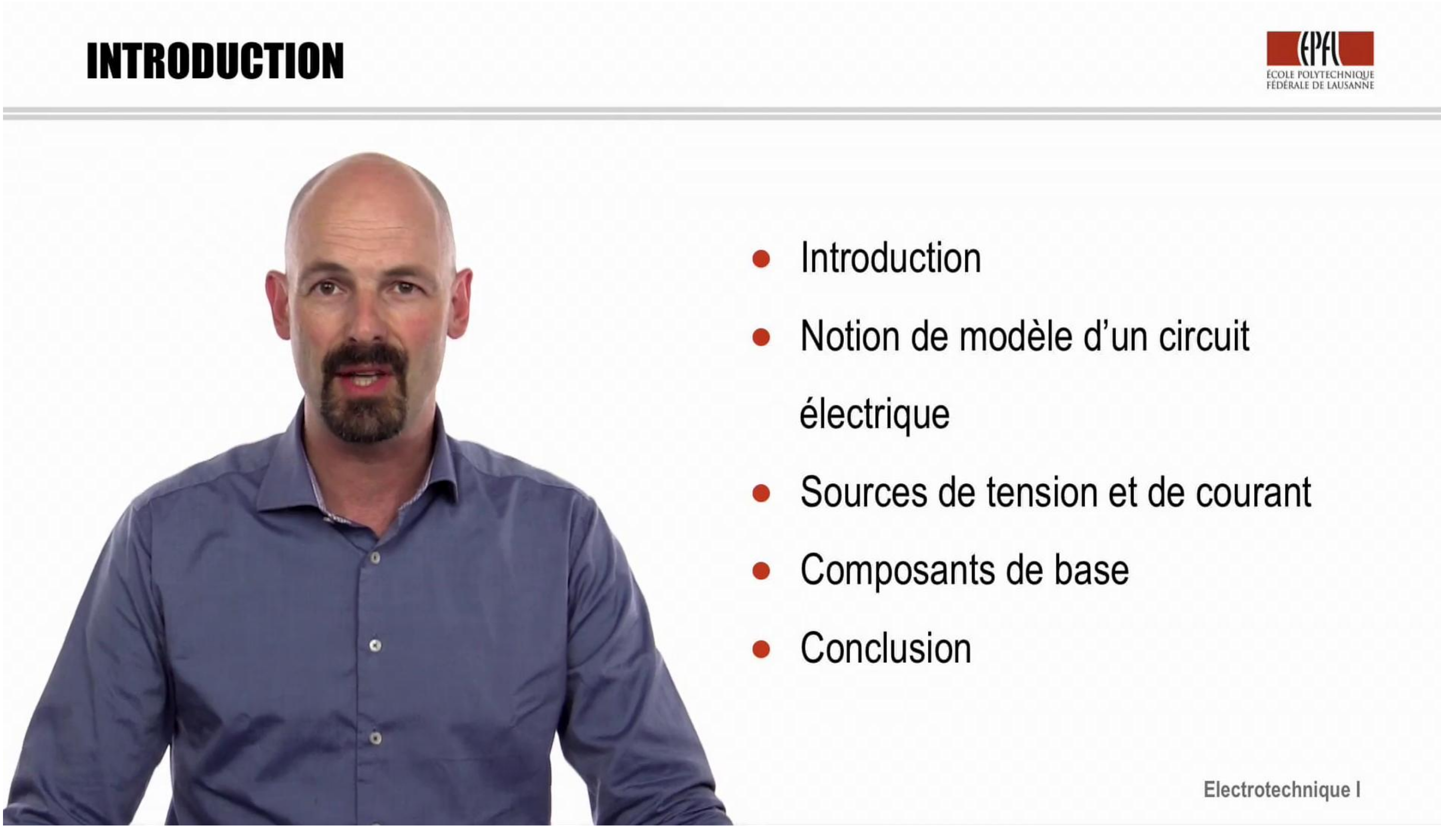
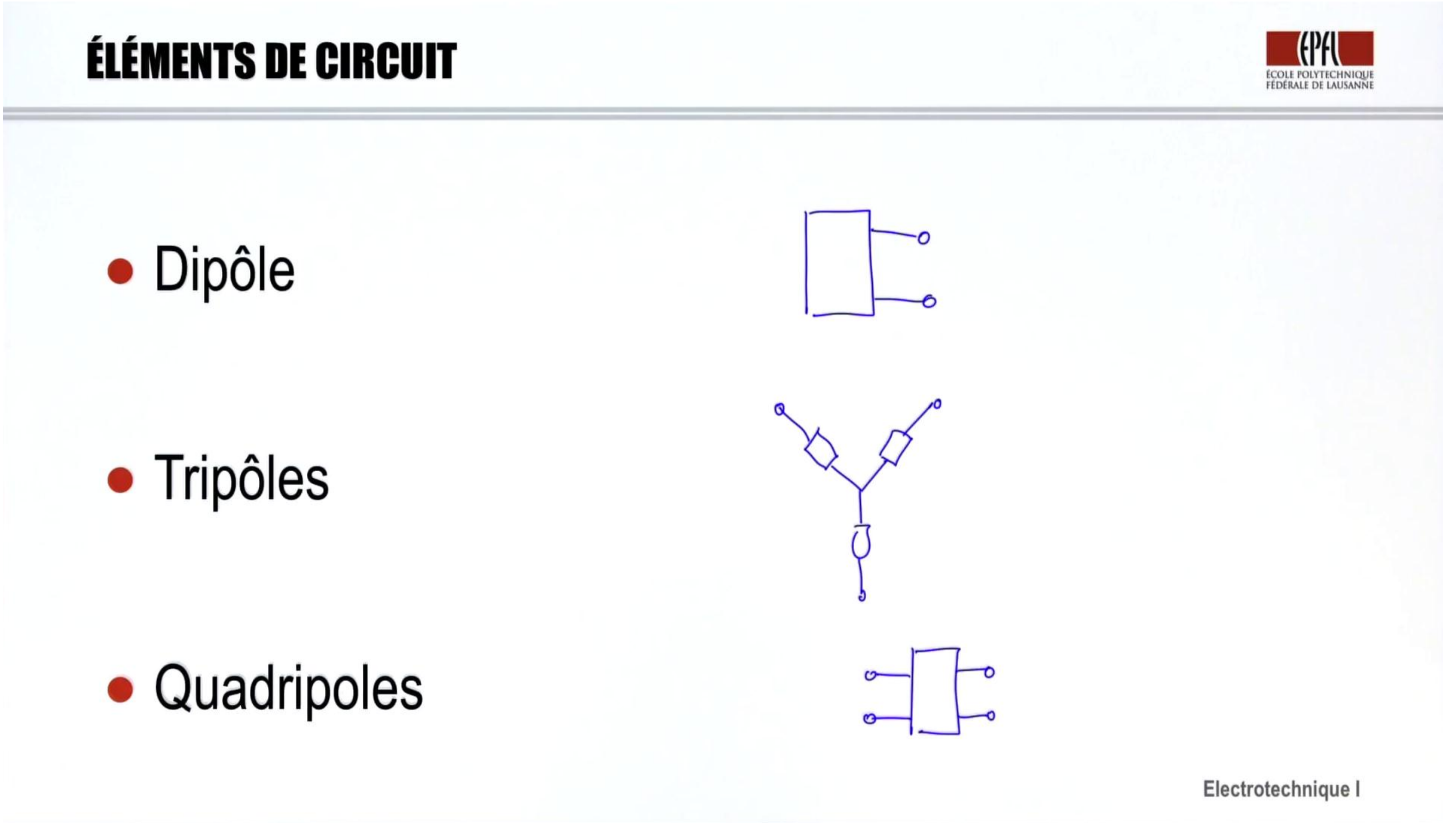


Hello and welcome to this lesson dedicated to the main elements of a circuit and in particular, dedicated to voltage and current supplies which will be the primordial elements to supply energy to our different circuit elements. We will, after the introduction, see the notations of circuit models, see how these voltage and current supplies can be defined. We will then study the different basic components and, finally, in this lesson, how we can model a complete circuit.

Notes

Summary

0m 03s

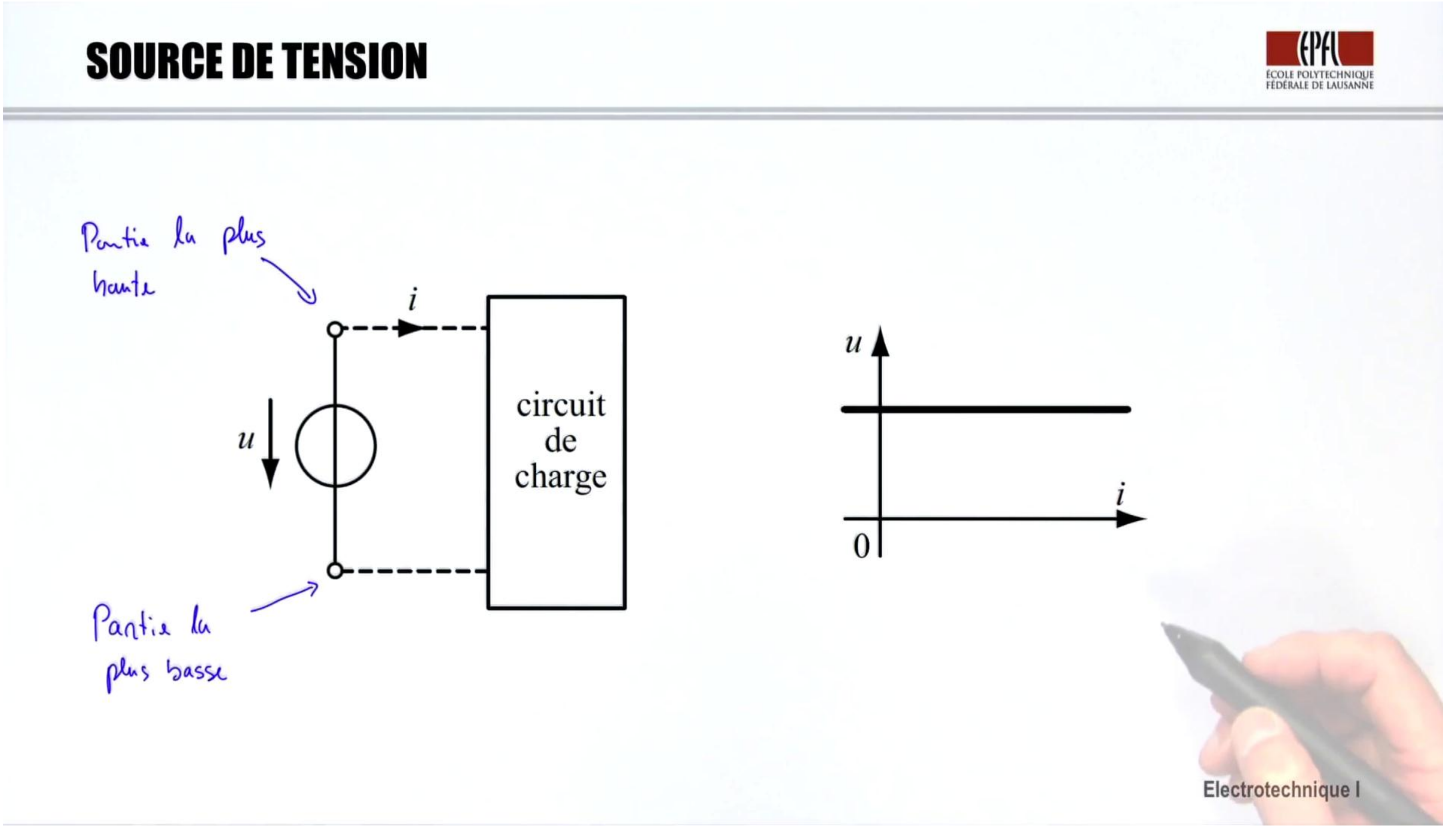


First of all, we will define a relatively simple notion : the "dipole"; respectively "tripole" and "quadripole". What is a dipole ? It's a component which will have two terminals. Hence, we can model or draw it easily. It's a "bloc", like this, on which there are two terminals. This can be an element such as a resistor, a capacitance, an inductance... It can also be a supply. The tripole, by evidence related to the definition of the dipole, is an element which will have 3 terminals. We can mainly find it in three-phase circuits when the components linked to the three-phase system will include three impedances. So, for example, a circuit which we will observe in the later lessons, with three terminals. So here, for example, is a tripole. And finally, a quadrupole, which will have - this is a little more complicated - four terminals that enter the quadrupole, rarer, but also possible with a "two entrances/ two exits" circuit or vice versa, that we will write or define as a quadrupole.

Notes

Summary

0m 31s

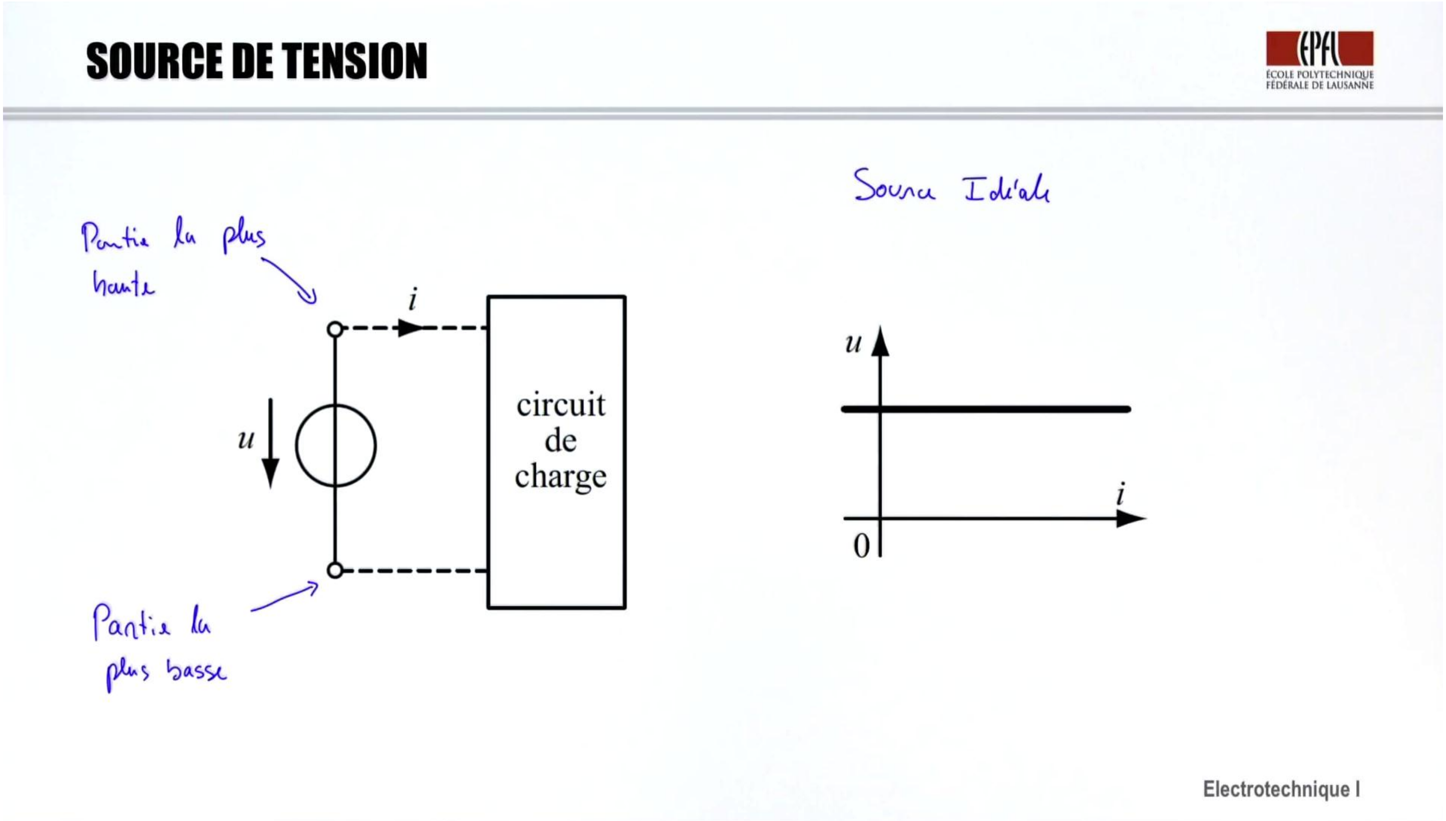


The first element that we will define, fundamental when defining an equivalent model of an electric circuit : the voltage supply. The voltage supply is, by convention, drawn in the following way, in other words a circle crossed by two vertical lines and two terminals. So we typically have here a dipole, drawn with an arrow from up to down : the voltage. We then have, here at this terminal, the ground or neutral or the lowest part in the difference of potential. We will then write : the lowest end. And on the other hand, at the top, the part with the highest potential, and by definition, in the supply, with the conventions that we've seen during the first lessons of this MOOC, when the voltages goes from the highest to lowest point, the current flows from bottom to top as shown in this diagram. We then have here a load circuit, in other words, we connect to this voltage course a resistor, capacitor, or any other element, or a combination of these different elements, and on your right, you have a graph which allows you to notice the current that this supply is outputting as a function of the voltage.

Notes

Summary

1m 52s

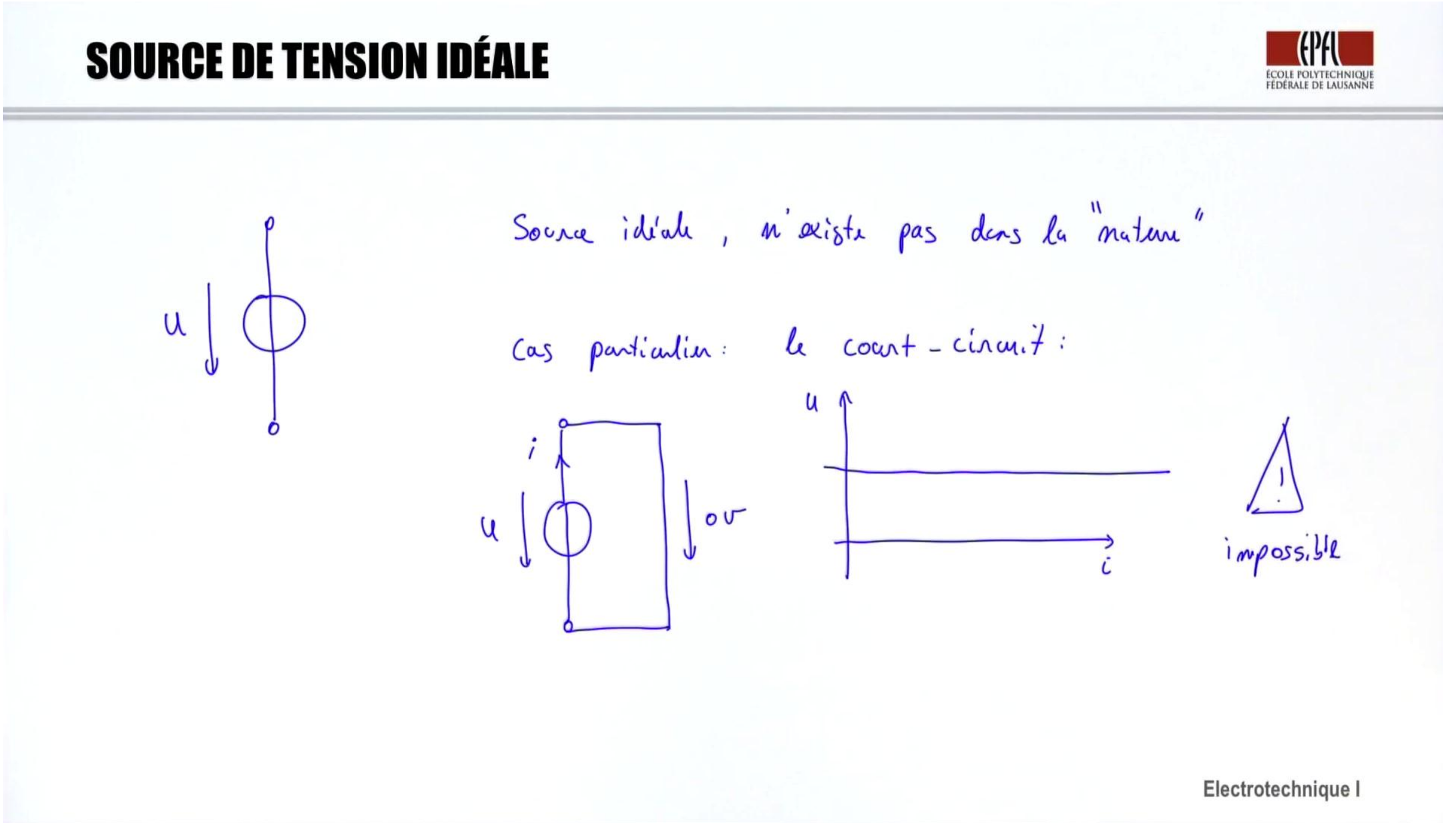


We discover then a phenomenon, or, let us say, the strange characteristics of this supply, which is that this supply produces the same voltage - it is constant - no matter the amount of current it outputs. It is obvious that such a thing does not exist in nature. It is impossible, no matter the current outputted by this supply, to, in the end, be able to have a strictly constant voltage. Hence, this is a supply which we will call ideal. It does not exist, we could say, quote, "in real life". Thus, it does not represent a proper model of the voltage supply that we can find in the art, like a battery, battery cells, or a normal power supply. This supply will, in fact, have its voltage change with the outputted current.

Notes

Summary

3m 23s

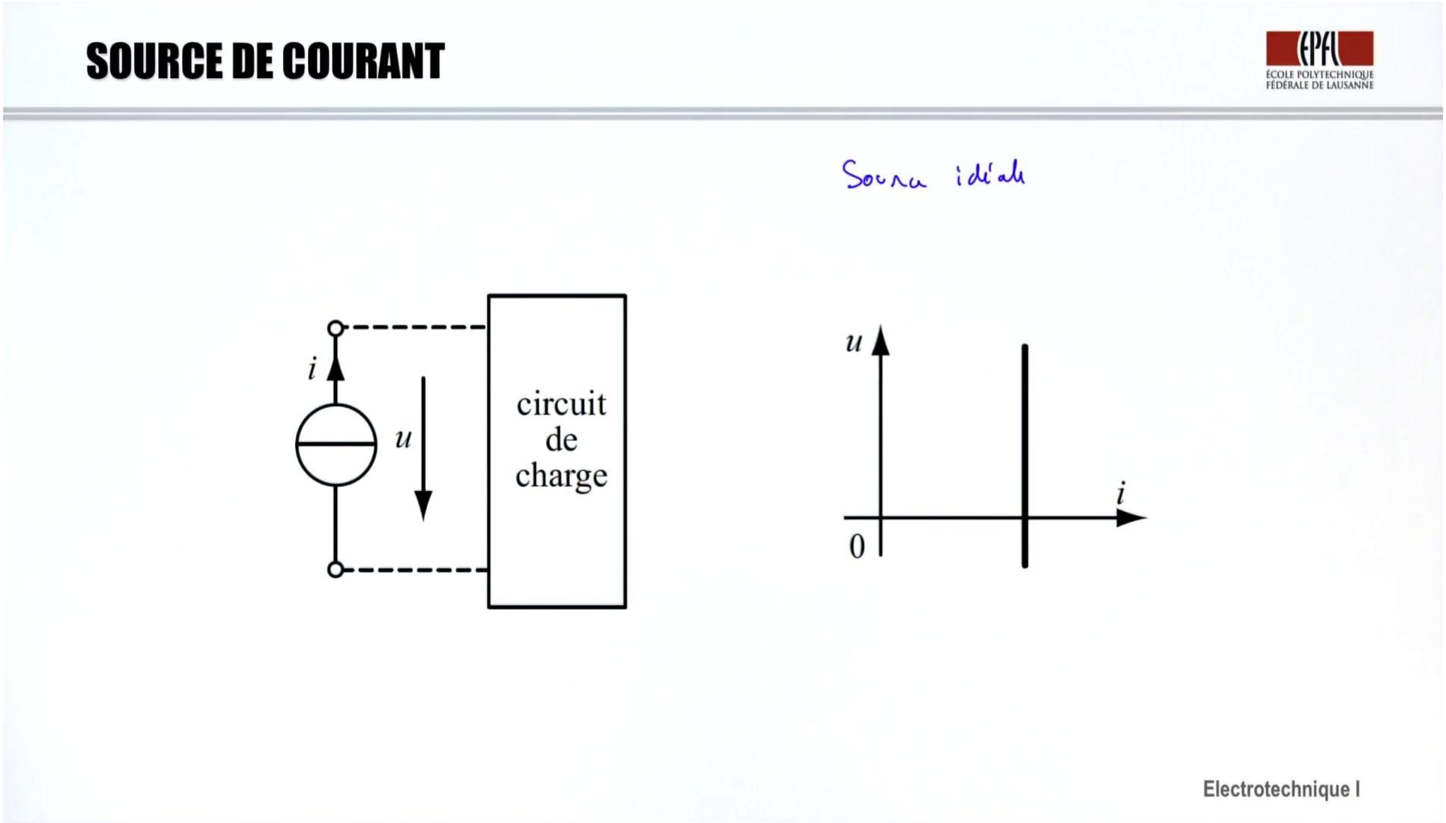


So we will define this ideal voltage supply, in the following way, We have a voltage with two terminals. We know that this supply is ideal. [dictates] "It does not exist in real life" But it will be immensely helpful for the modelling of the real one, or we shall call it real voltage supply, when we will talk about it soon. An important element is, in fact, the short-circuit. A special, or particular, case : [dictates] the short-circuit What is a short-circuit ? Well, let us take a supply, a voltage, U, an outputted current as such and we will connect this supply to a wire and thus, we short-circuit our supply. Well in this case, the current - since I'm using the previous graph - I have a nondescript voltage no matter the current, and this current is supposedly always identical to U. But, this is impossible since, if I make a short-circuit the voltage that I have here is zero volts. And we can already see here a first problem and thus we see the impossibility of having this type of supply in real life.

Notes

Summary

4m 19s

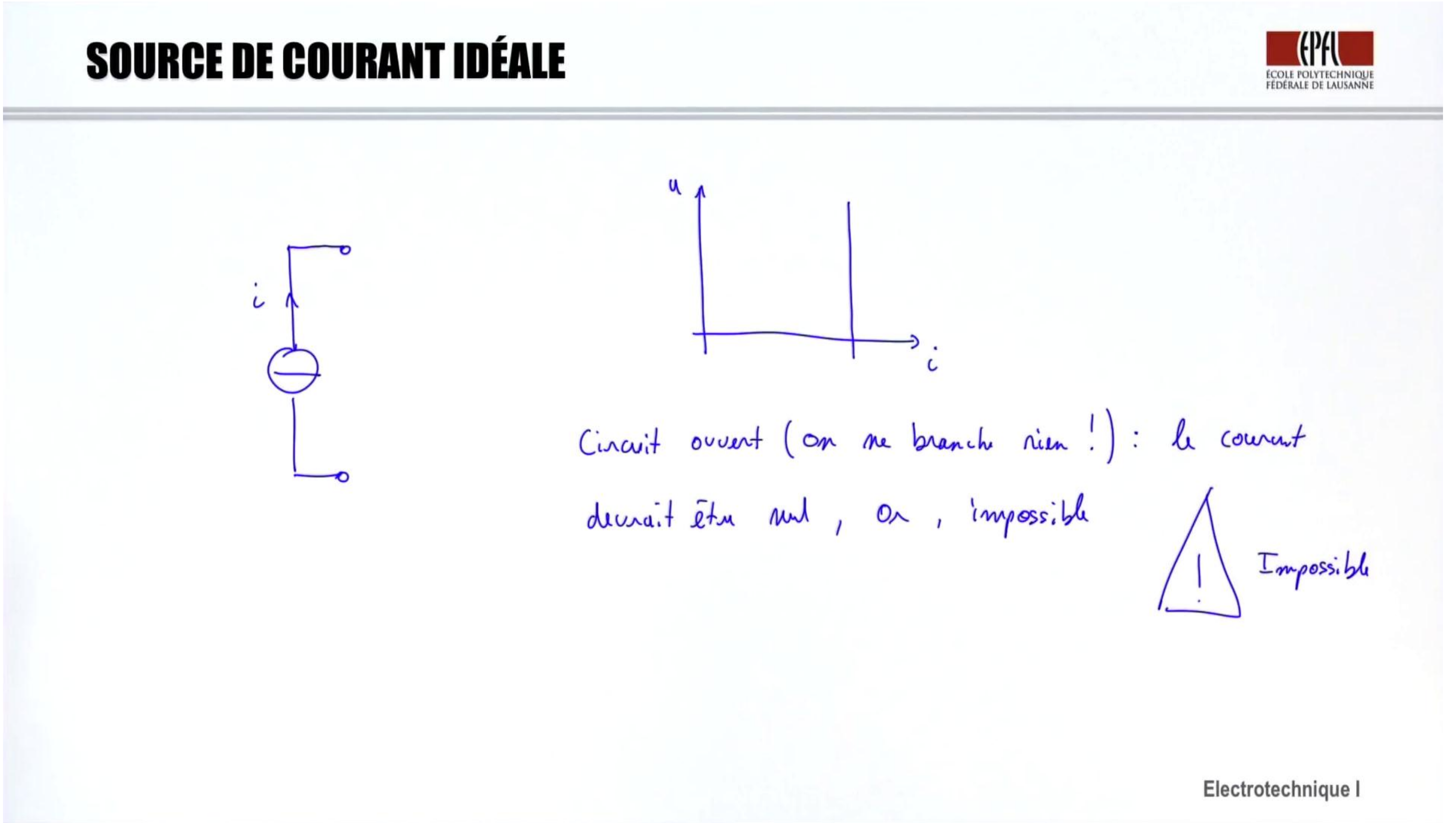


We can do the same with the current supply. It's even more difficult to imagine since the current supply is not a usual element in practice, in the usage of electricity, we often mention voltage supplies but rarely current supplies. We shall see later on, while studying the theorems of Thevenin and of Norton that, in the end, it's two way to model the same thing. But the idea of the current supply is to have an object defined as once again, as a circle, but this time not with a vertical line but with a horizontal one and a current flow, defined by the supply itself and at the terminals, then, will appear a voltage. To this current supply we will also be able to define - or connect, sorry - a load circuit. and you have here, once again on your right, a voltage - current graph. The current is defined by the supply and we can see that no matter the current drawn from the load, once again, the voltage will adapt here. It's once again, like previously, an element impossible to have in real life. So we shall call this current supply an ideal supply : that does not exist in real life.

Notes

Summary

6m 01s

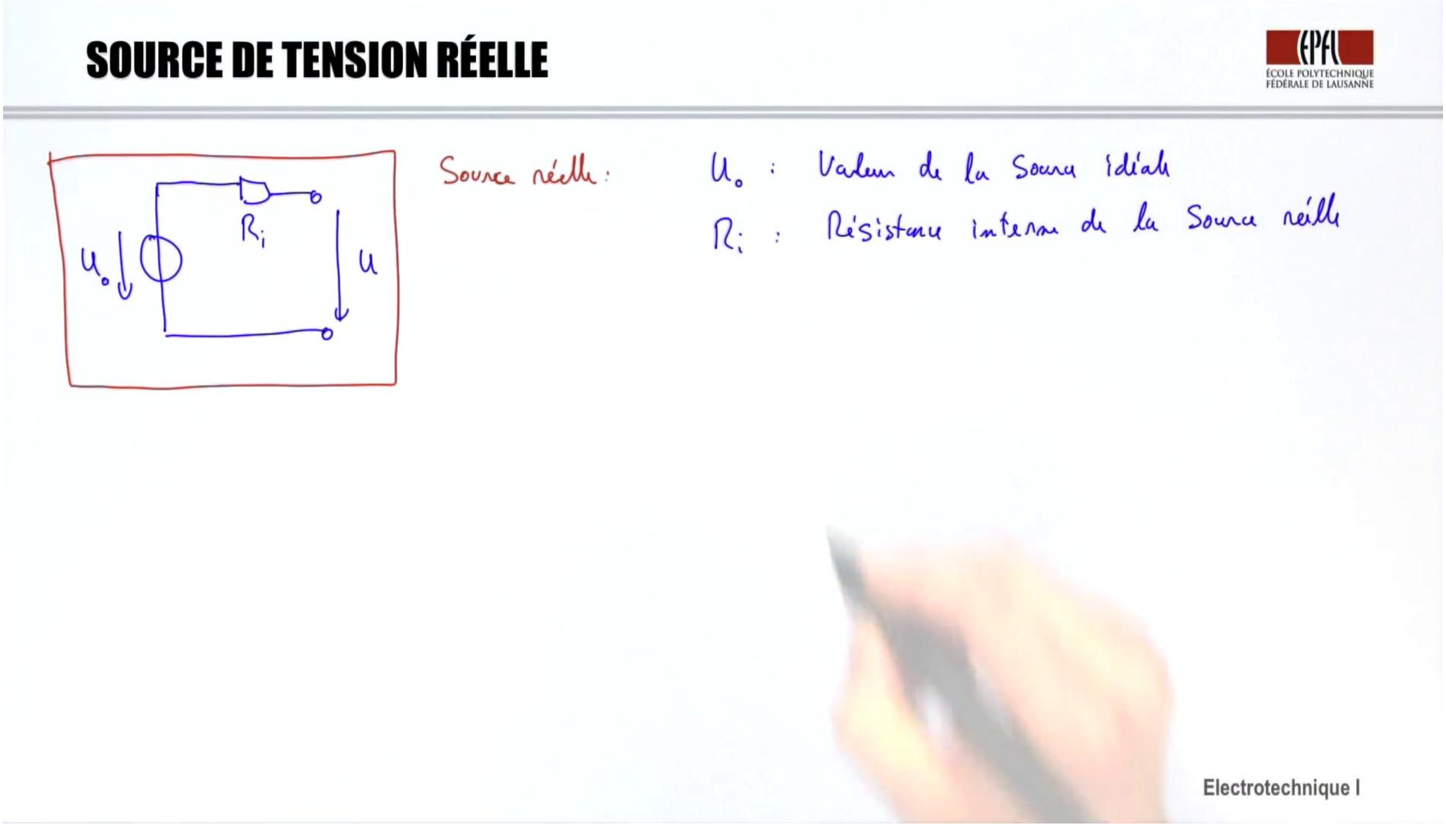


So, to redo the same diagram, we have here a current supply with a current i, I have this dipole and let's imagine that I connect... Better, I do not connect this supply to anything at all. By definition, it not possible to have any current flowing. However, we just saw in the previous diagram that the current is drawn, no matter what I connect here to the terminals of the supply. Thus, an open circuit, or in other words, we don't connect anything : [dictates] The current should be null. But it is impossible, here, using our definition of this current supply. Thus, we once again have, here this impossibility and we will need to model differently the real current supply that we will encounter.

Notes

Summary

7m 14s

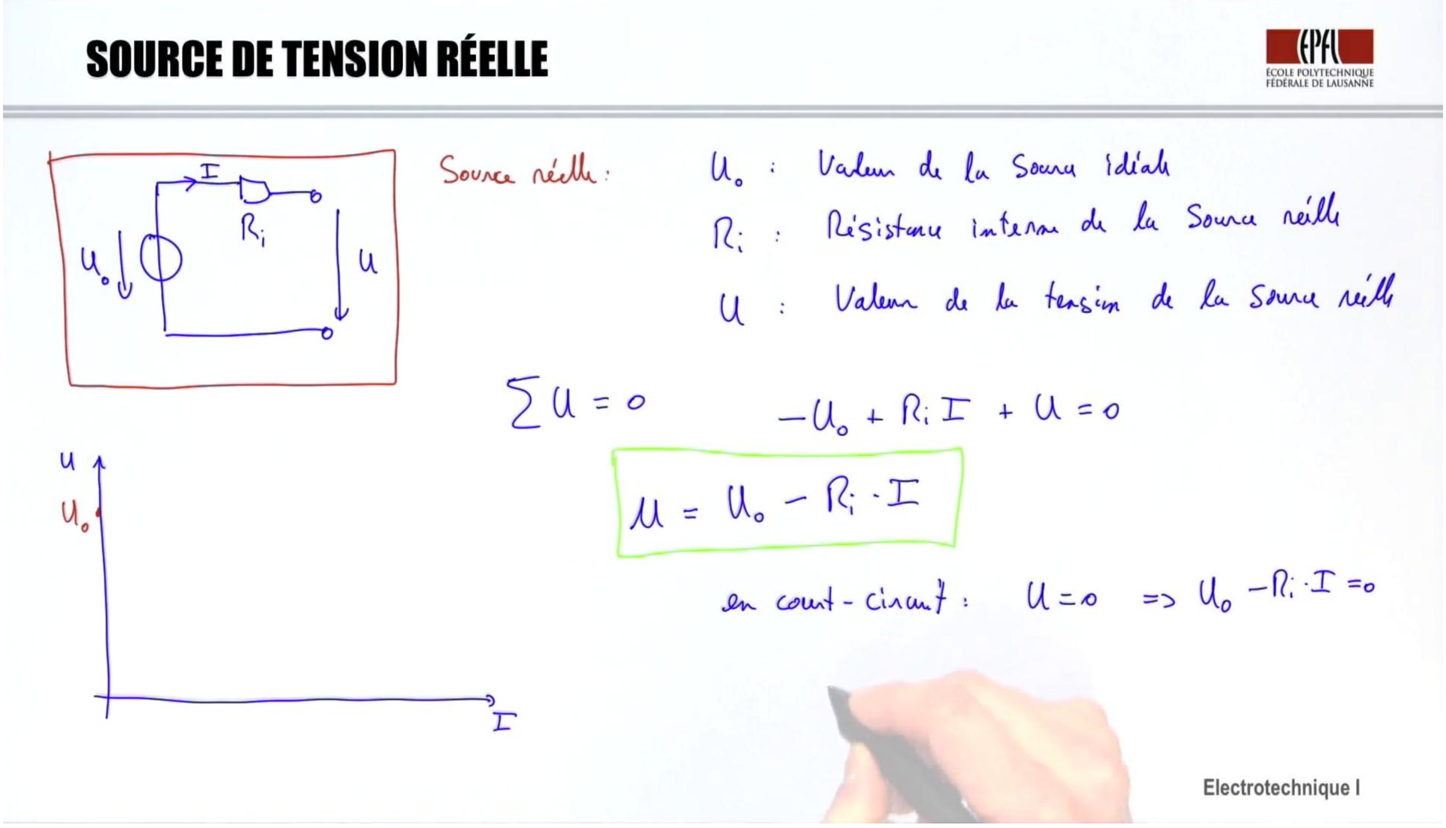


So, in the end, how to change this ideal voltage supply into a real voltage supply that corresponds to what we have in the art ? Well, easily, by adding a resistor following the ideal voltage supply. I will show you the result. So we have, first of all, our supply of voltage U followed by a resistor that we will call Ri. Why Ri ? Because it's the internal Resistance of the supply. Here is our new dipole which characterizes here, in all, this will be my real supply. So we will try to convince ourselves of it to be sure that we've made the right choice. So first of all we will write, here, a Uo at the supply to properly say that this supply Uo is the ideal voltage supply. While using this supply, we will never have this Uo voltage at the terminals of the U circuit, and this U supply which will be the real voltage that the user we will see from the supply. So we define : first of all Uo will be [dictates] the value of the ideal supply Ri will be, as we've mentioned previously, by definition [dictates] the internal resistance of the ideal supply. And finally, U will be [dictates] the value of the voltage of the real supply.

Notes

Summary

8m 20s

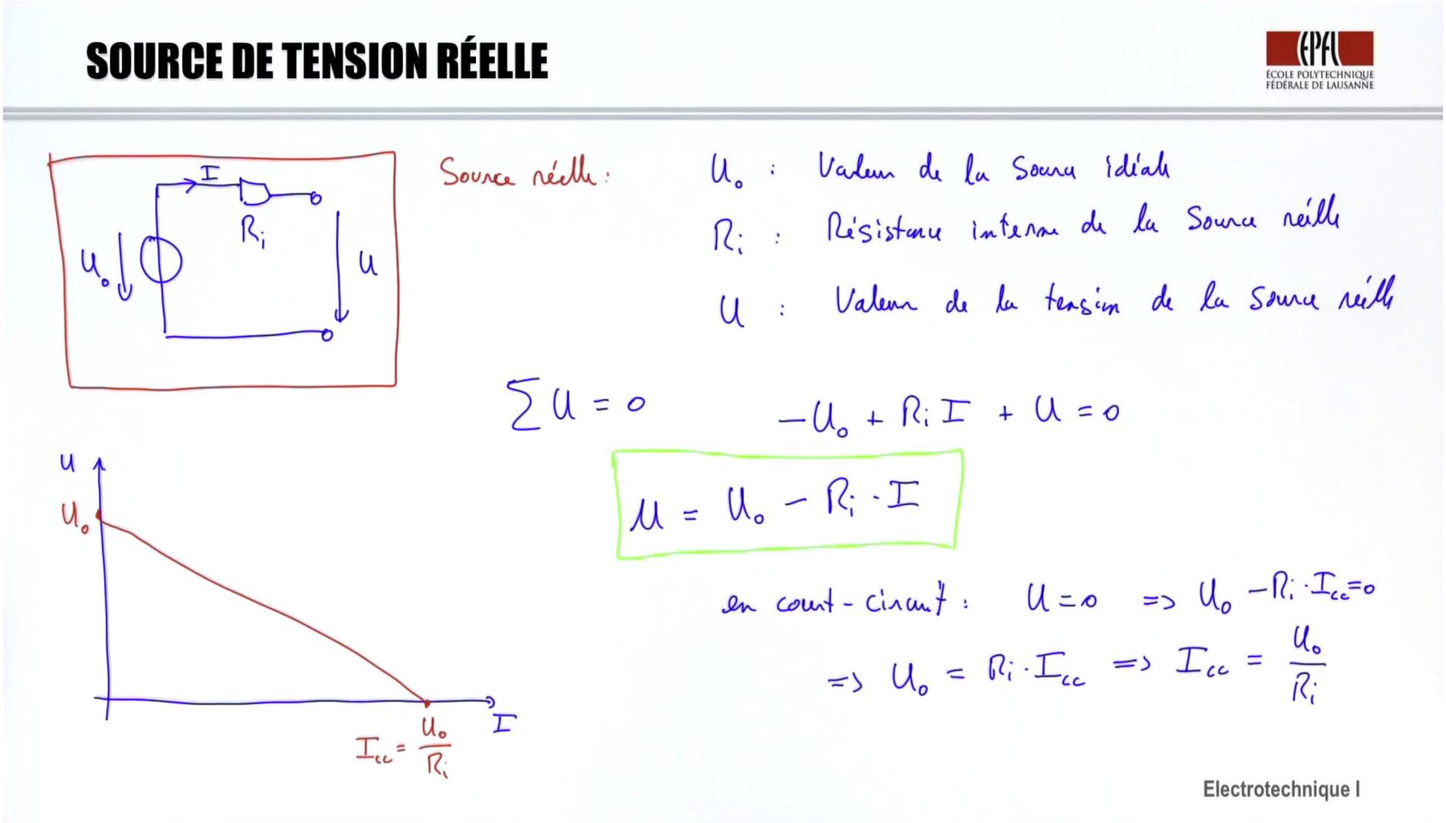


Thus, if we apply Kirchhoff to this small simple element by using U, Uo and the voltage drop at the terminals of the resistor Ri, we can write, knowing that the sum of voltages will be null, by going around clockwise, we have -Uo + Ri x I. I will write I upper-case by using the convention that, here, we have a continuous, or direct, current and with an I that is like this. Thus - Uo + Ri x I + U = O. If we put all of this back together, we have that the real voltage supply U is equal to Uo - Ri x I This, by definition, is the real voltage supply. So I mentioned earlier that there was an impossibility in the ideal voltage supply. Let's try to see, now, if we managed to properly model it, we should no longer find any impossibility. So we will make a small graph of this voltage supply with here, again, U and I. First of all, we can notice that when I is null, U equals Uo. So at first, we will find ourselves, for example, here. At the end, in other words when U equals zero in a short circuit we have that U equals zero. Thus, we have Uo - Ri x I equal to zero. and thus Uo = Ri x I and finally, this short-circuit current, I will add CC in subscript, is equal to Uo / Ri.

Notes

Summary

10m 13s

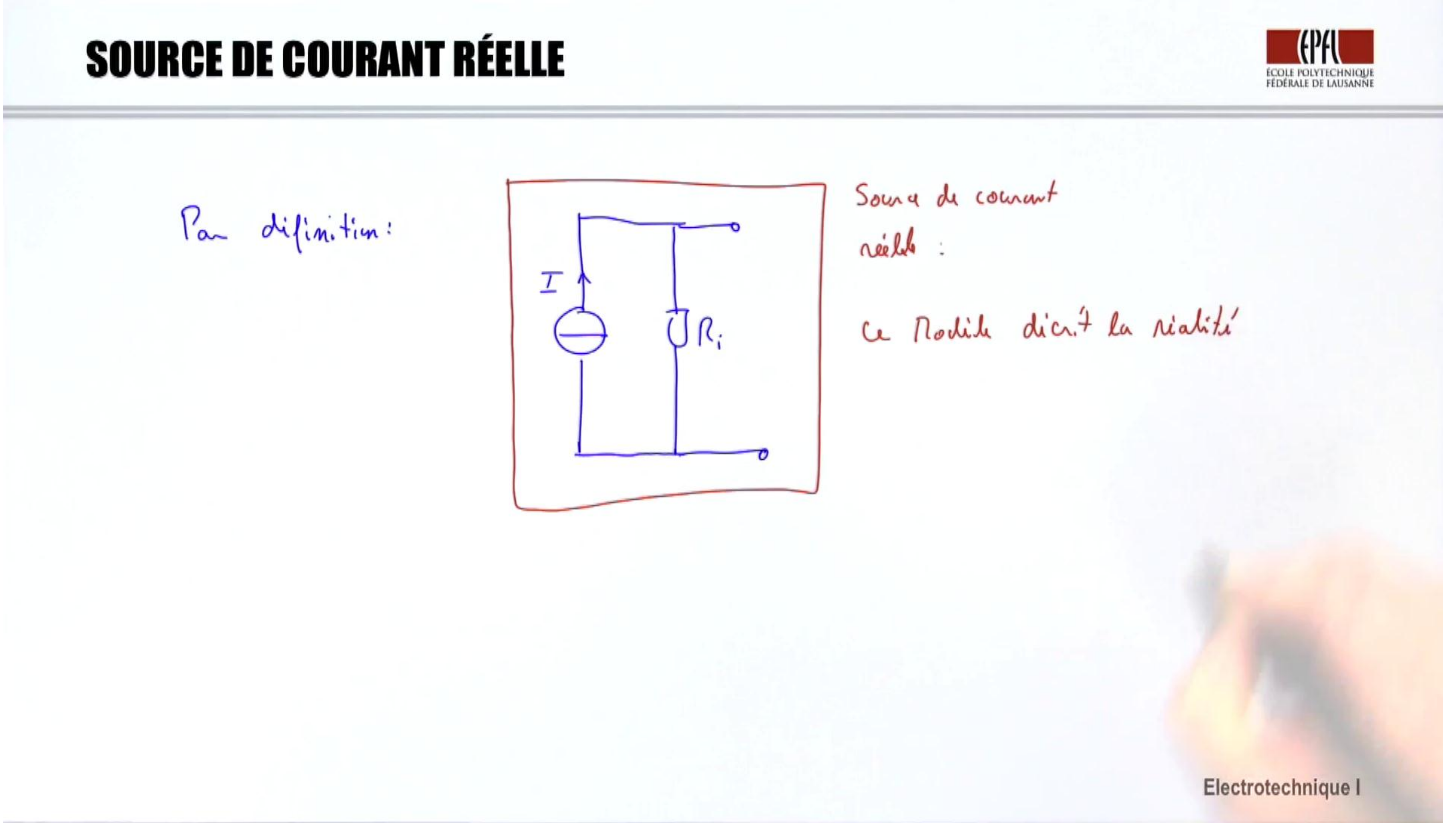


This Uo / Ri can be, for example here, Uo / Ri is my particular short-circuit current and between the two I have a line which allows me to define the characteristics of the ideal voltage supply. And you can see that it corresponds, relatively differently, since instead of having a horizontal line with a permanent voltage no matter the current, I have a voltage that diminishes as a function of the current rise until, finally, a value, where this voltage at the terminals of the real voltage is equal to zero. In this case, the supply is completely short circuited. and the short-circuit current, in other words, the maximum current that this supply can output is Uo / Ri. Thus we've defined here a model that corresponds rather correctly and faithfully to what we can find in reality.

Notes

Summary

12m 15s

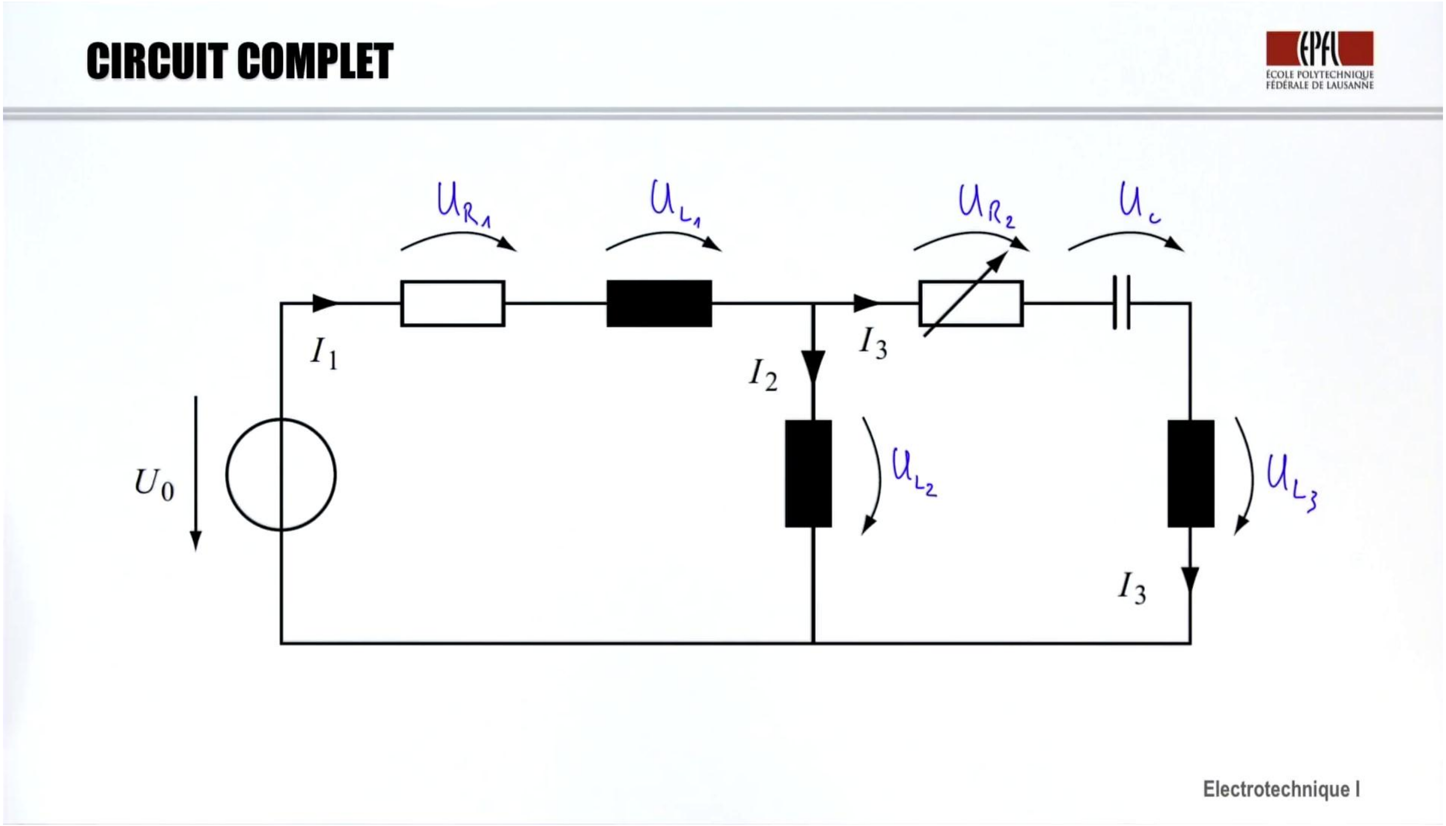


This real voltage supply that we have just defined, we can do the same thing with the current supply which will then become a real current supply and by definition this real current supply, will be, similarly, a current I, transformed by the addition in parallel of an internal resistance. Here again, this element, or this bloc, becomes a real current supply. Here also, the impossibility that was there, earlier, in open circuit, allows us to perfectly, correctly model this phenomenon since by not having anything connected here to this supply the current outputted by the supply I will simply flow through the internal resistor. It's the way to properly model this real current supply. We will also see in in the later chapters, that this real voltage supply and this real current supply have an equivalence, can be equal, and this equivalence, we will discover that it is present if this internal resistor is the same for the voltage supply and the current supply. Thus, this model describes reality.

Notes

Summary

13m 19s

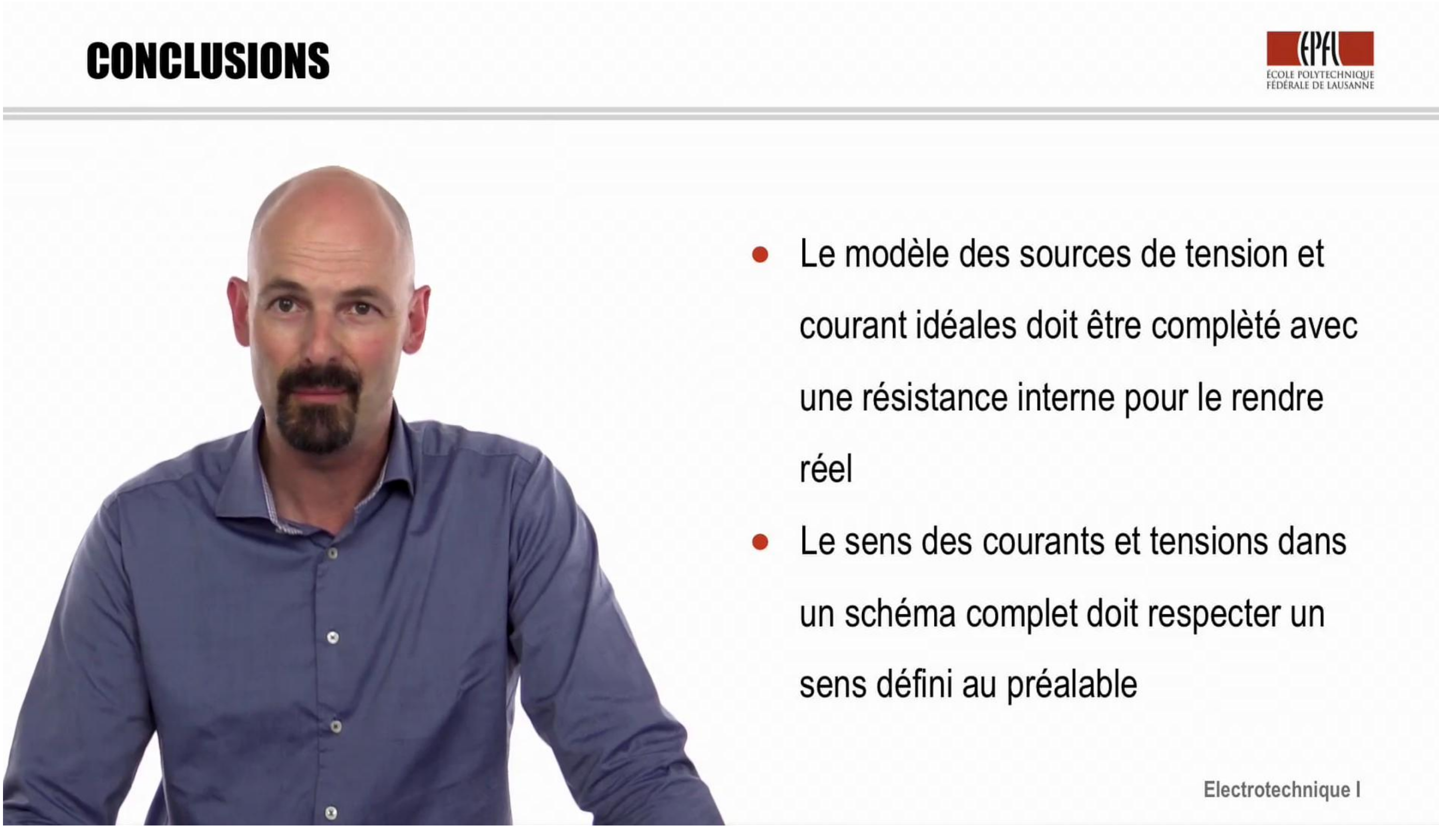


This brings me to the last element that I wanted to talk to you about in this lesson, it's how to model a complete circuit, with the elements of this circuit and with a voltage supply like Uo here. Once again, I will remind you of the notations and definitions linked to what we have agreed upon as a convention of signs. We've agreed that with the supply that goes from the highest to lowest potential, the current flows in the opposite direction. And in the elements, the voltage for example, at the terminals of this resistor is in the same direction as the current. Similarly here, the voltage at the terminals of the inductor. We have here the current, so the voltage at the terminals of this inductor will, again -we will write in subscript L1, L2 - here we have again Ur, but we will write " 2 ". We have here the U of a capacitor. And finally, the voltage here for the third inductor, L3. This finally allows us, with the help of simple conventions and with proper writing, to apply Kirchhoff's equations. But it is fundamental for that to have a unified convention which allows us to not reverse things from one mesh to another, which would absolutely falsify the resulting equations, when we are using Kirchhoff's equations.

Notes

Summary

14m 42s



To finish and to conclude, I would like to remind you that the models for the ideal voltage and current supplies must, in the end, be completed, as we've seen, with an internal resistance to render it real. So either by putting a serial resistor for the voltage supply or by placing a parallel one for current supplies. Then, the direction of currents and voltages in a complete diagram as we've seen just here, at the end, must follow a predefined direction. You can also define this direction yourself. There isn't a right or wrong direction, what is needed is to have a single way of doing things from start to finish when analysing your circuit. Thank you.

Notes

Summary

16m 03s