ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

# Amplificateur opérationnel

## 1.2 Réaction négative

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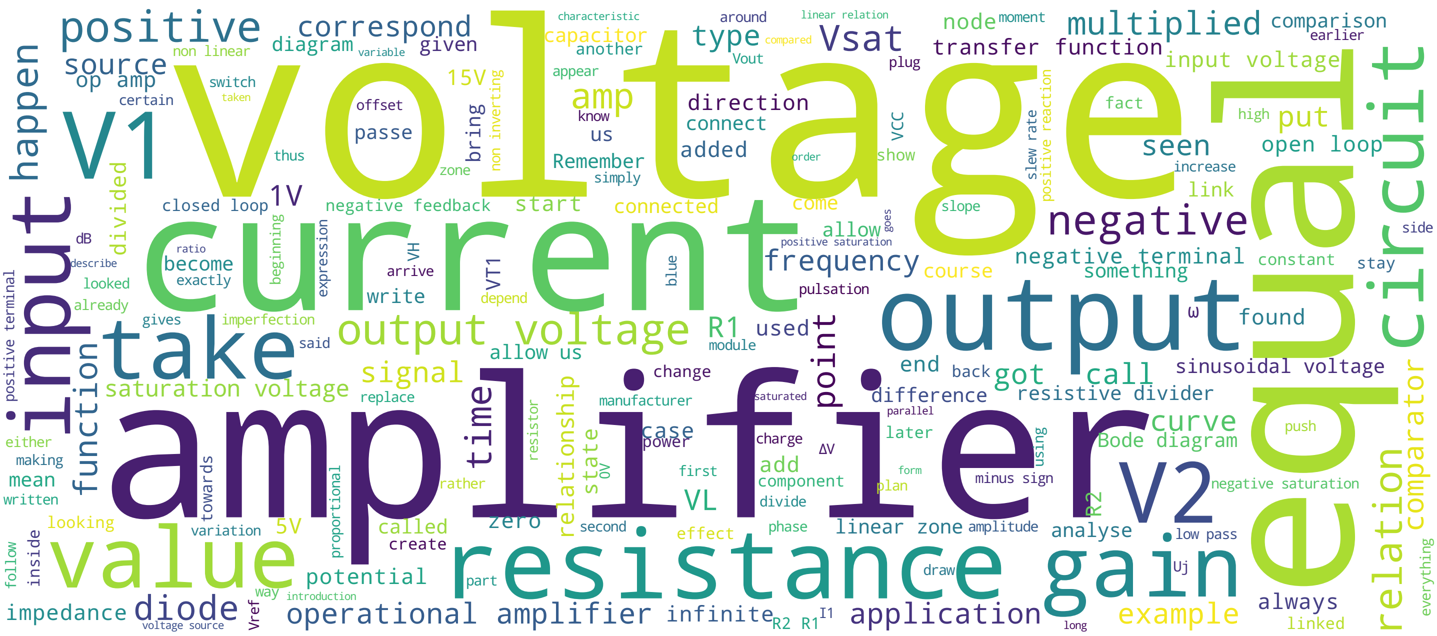
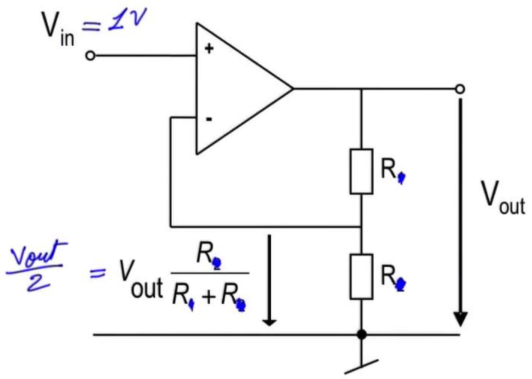



Video

EPFL

# Amplificateur Opérationnel en contre réaction

(AO idéal)




Electronique I

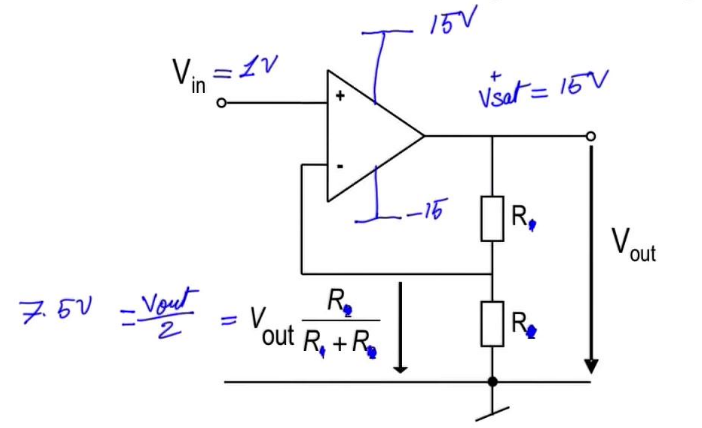
I'm going to take the example of this amplifier with the two resistances such as we have said here, and we're going to see what will happen at the output. So first I'll start by analysing the condition of the amp when I impose a voltage at the input. And I'll take an example where I'll put V(in) equals to 1V. And to simplify the process and to take a practical example, I'm going to try and say that *R* and *R*, therefore I don't have*R1* and *R2*, I have two resistances that are the same, so I'm going to end up with this which will be equal to 1/2. So I'm going to end up with V(out) multiplied by*R* divided twice *R*, then I'll find myself here with something which is equal to V(out) divided by 2. When this amplifier will act with a diagram, so we've taken an ideal amplifier. We plugged in a voltage DC at the constant input equalling to 1V. We put two resistances. So the amplifier will end up in a state at the output, what state? When you take and plug in the amplifier, it will end up in a state of saturation, this is always the case. We will see why later when we analyse the amplifier with its imperfections and you will see, it always starts in a state where V(out) will be at a saturation voltage.

Notes

Summary

0m 04s

(AO idéal)




Electronique I

We can't predict which one it is. It can either be *VCC*+ or *VCC*-. I'm going to take the example where I've a positive supply equal to +15V, and a negative supply equal to -15V. And I'll suppose that the saturation voltage of the positive amplifier, is the state of 15V that I will find again with my amplifier. So this amplifier will first start as soon as I plug it in, it gives me 15V at the output. And a resistive divider. This resistive divider will take a proportion of this voltage. Therefore it'll bring this voltage, it'll multiply it by half. It will divide them by 2. Therefore I'll end up with a voltage here equal to 7,5V here. This 7,5V is connected to the negative terminal of my amplifier. When the positive terminal is equal to 1, what will happen at this moment? Let's imagine that time stopped, that this amplifier, once it's performing this comparison, it left the saturation, it lowered the voltage, and it will carry out a comparison. It will find itself with a voltage on the positive terminal which is equal to 1V and a voltage on the negative terminal which is equal to 7,5V. So it goes without saying that this 7,5V on the negative terminal is superior to this 1V.

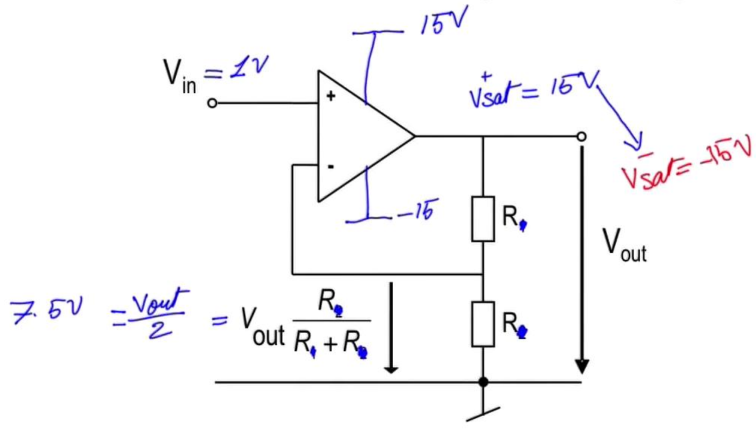
Notes

Summary

1m 24s

# Amplificateur Opérationnel en contre réaction

(AO idéal)




Electronique I

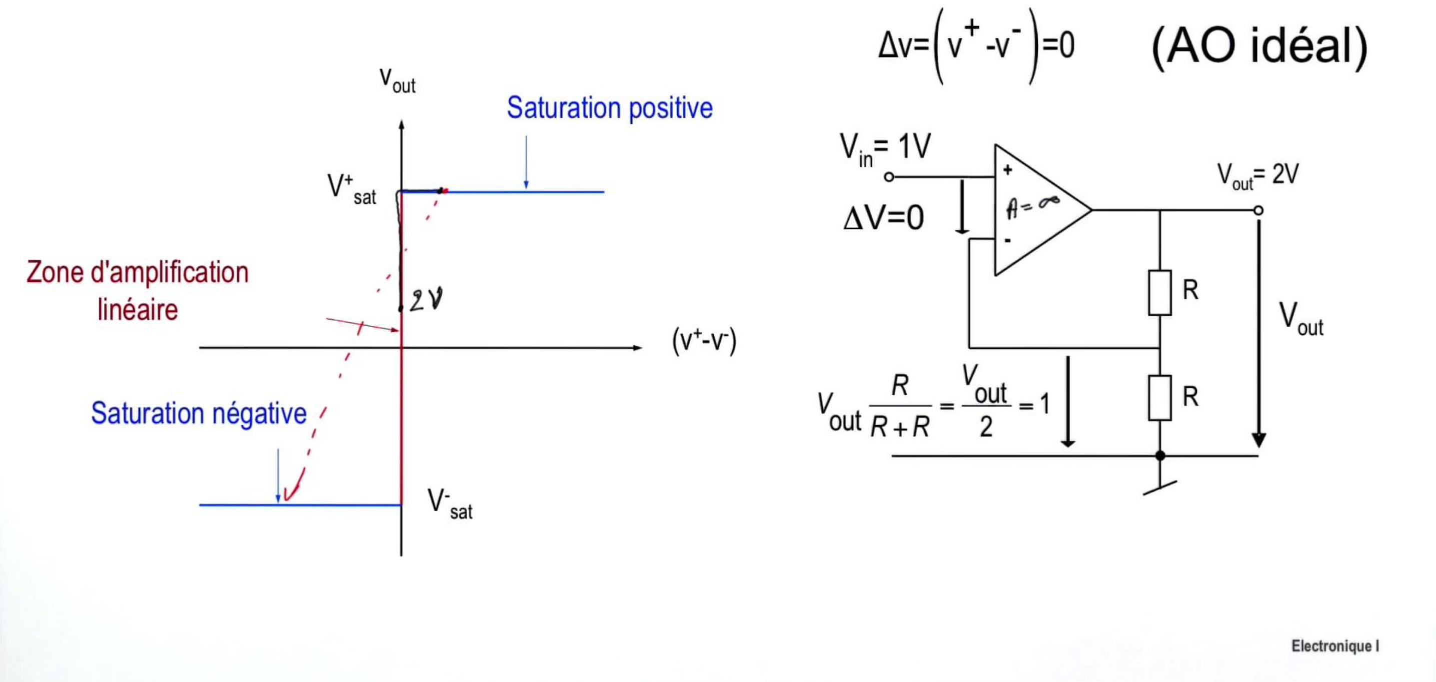
What will the amplifier do? The amplifier will saturate and push the saturation voltage towards the negative saturation voltage. So I'll find myself with this voltage which will tend towards *Vsat-*. And this is what will happen. So its output will look for the -15V. It will look for the negative saturation voltage. And will it be able to do it? Well, we will see this.

Notes

Summary

2m 55s

# Amplificateur Opérationnel en contre réaction



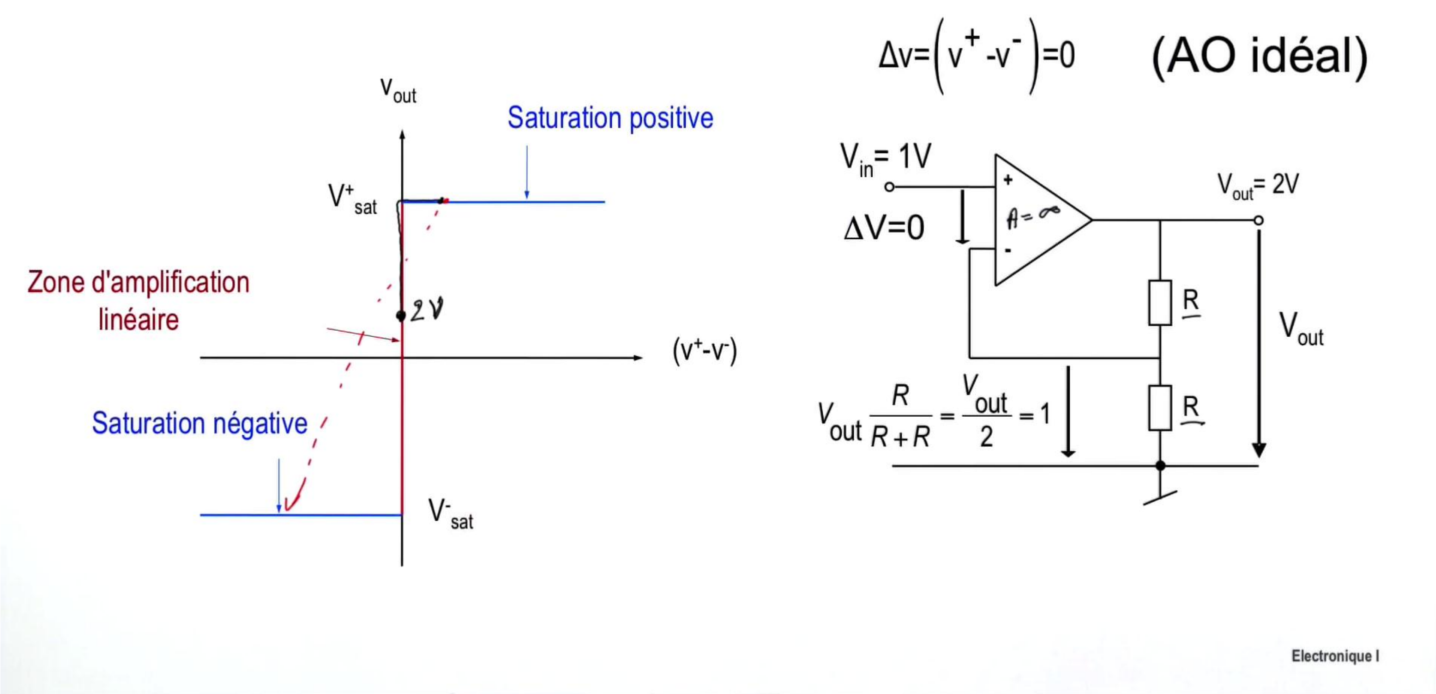

This is what will happen. I'll take the same scenario again. The only relation that links the input to the output and which describes that when the amplifier was at its positive saturation. Remember that we were saying at the very beginning, it ended up at this voltage here. At the input, we had the 1V. At the output, here, we had 7,5V. And the 7,5Vs are supposed to push my amplifier from here, and it will saturate towards the negative voltage. But what is it going to do? It will travel along this curve. So it will, from this voltage here, it will go down to this curve here and will go and look for the saturation voltage. Until where? It will arrive at a point. If this point here corresponds to an output voltage, and this output voltage, it will go through a voltage equal to 2V. And when it reaches this voltage equal to 2V, and if you look at what is written on this diagram here, this diagram describes an absolutely linear relation in which the amplifier could not move anymore. Why? Because everything is verified as mathematical law. The mathematical laws are going to say that its gain $A$ is equal to infinite. If this gain $A$ is equal to infinite and the outcome 2V, 2V divided by infinite will say that $\Delta V$ is equal to 0.

Notes

Summary

3m 26s

# Amplificateur Opérationnel en contre réaction



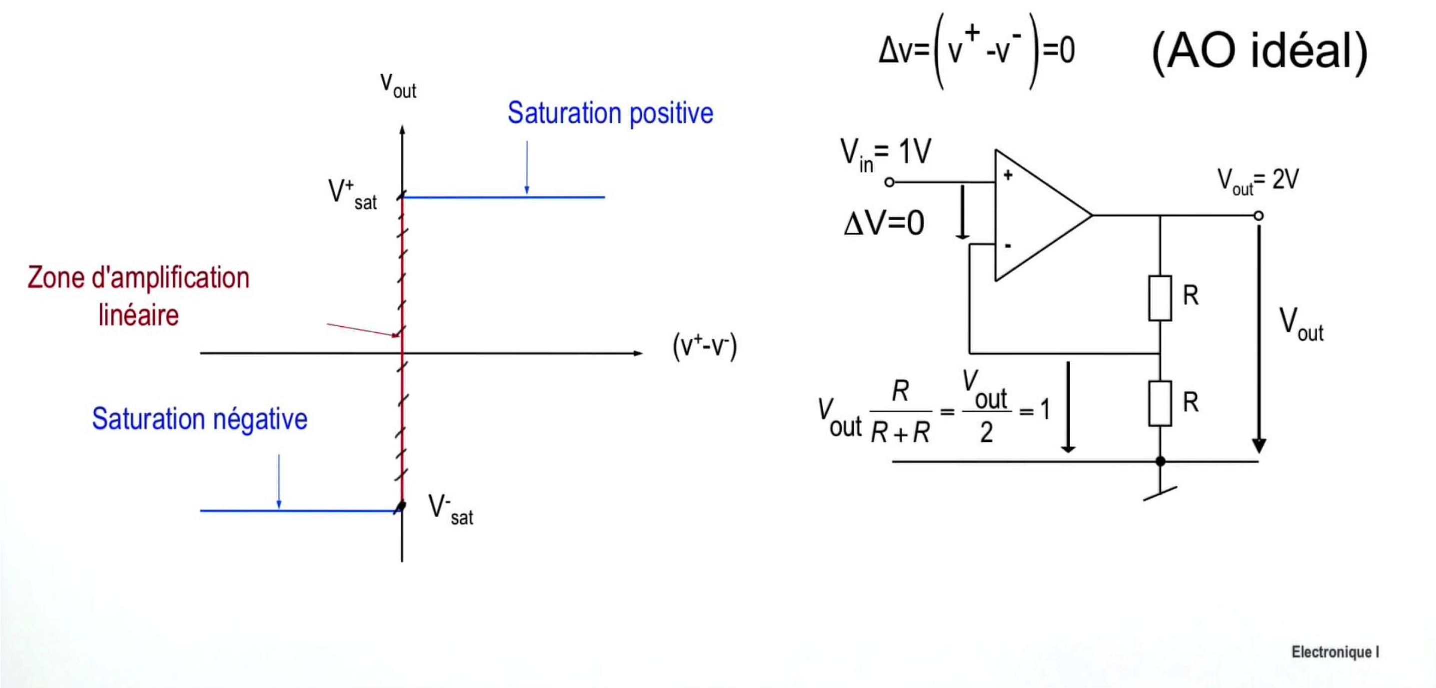

If $\Delta V$ is equal to 0, then this voltage here is equal to this voltage here. Let's check if it's true. Well yes, of course. We took an example $R$ and $R$, so it divides the output voltage by 2 and at the moment where it's leaving the saturation voltage while looking for its negative voltage saturation, so for it, it looked for the instability towards the *Vsat-*, it found itself at a point, it couldn't go out of the impasse. We have a relation between the input and the output which perfectly verifies that relation which says, for the amplifier itself, that voltage is equal to this one, that is 1V here and 1V there. This voltage there links it to an output voltage, which is equal to 2V. This voltage here is linked up to this one by the resistive divider which brings me back to V(out) multiplied by 1/2 is equal to 1V, so it will stay stuck in this point here and it is in its linear zone. So an amplifier is found, even if in the beginning it came from here or from there, it's going to end up stuck in the linear zone because the relation of circuit when we added the resistive divider links the output voltage to the input voltage by an absolutely linear law that which is written here.

Notes

Summary

4m 57s

# Amplificateur Opérationnel en contre réaction



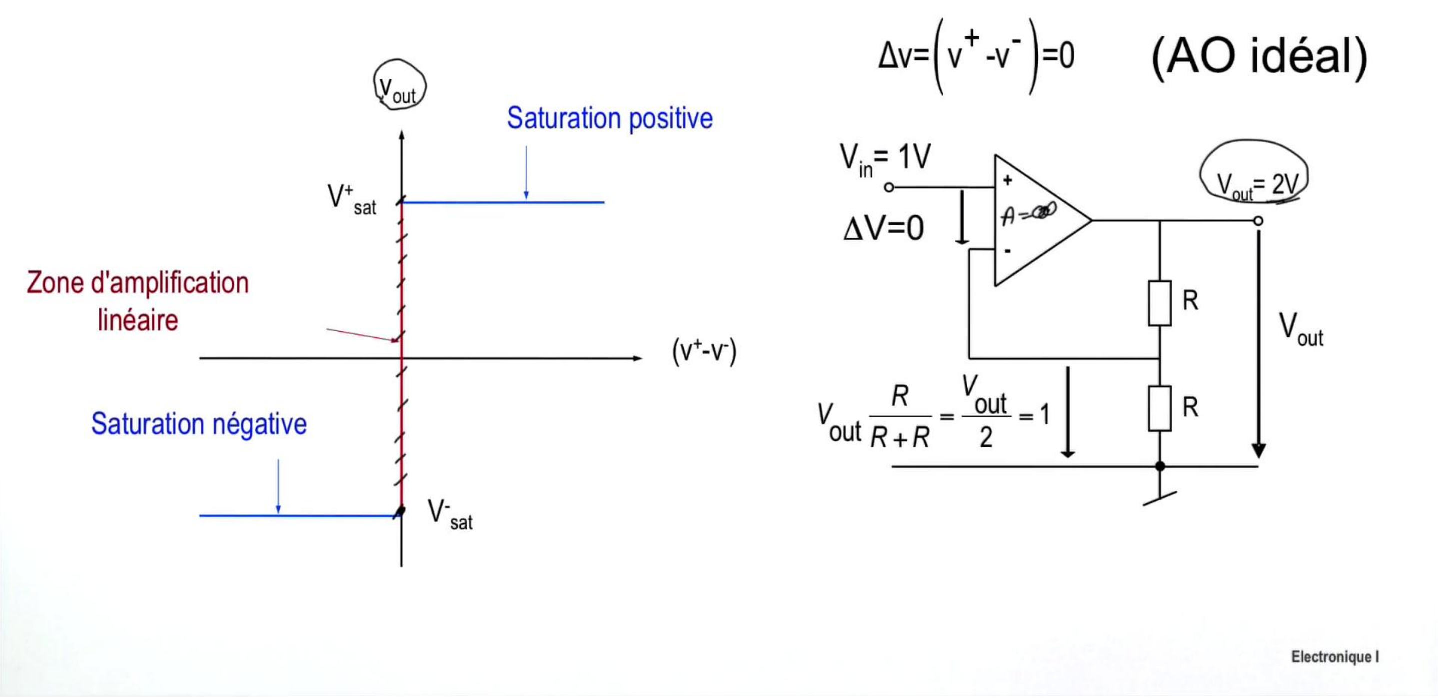

So this voltage will tell us that the output voltage V(out), it is absolutely equal to V(in) which is multiplied by *(1+R/R)* which is this relation that you see here. Your amplifier is found therefore by the resistive divider equal to *y* is equal *A* times *x*. So it's a linear relation and it'll stay in the linear zone. Let's analyse again what'll happen in a linear zone. In this zone that is shown which is linear from here to here, it's a zone where all the points that belong here all correspond to a state *V+* is equal to *V-*. Therefore so long as the amplifier links up its output voltage to its voltage *V+* and *V-* which corresponds to a point that is found here, these types of relations will always stay in relation between...

Notes

Summary

6m 15s

# Amplificateur Opérationnel en contre réaction

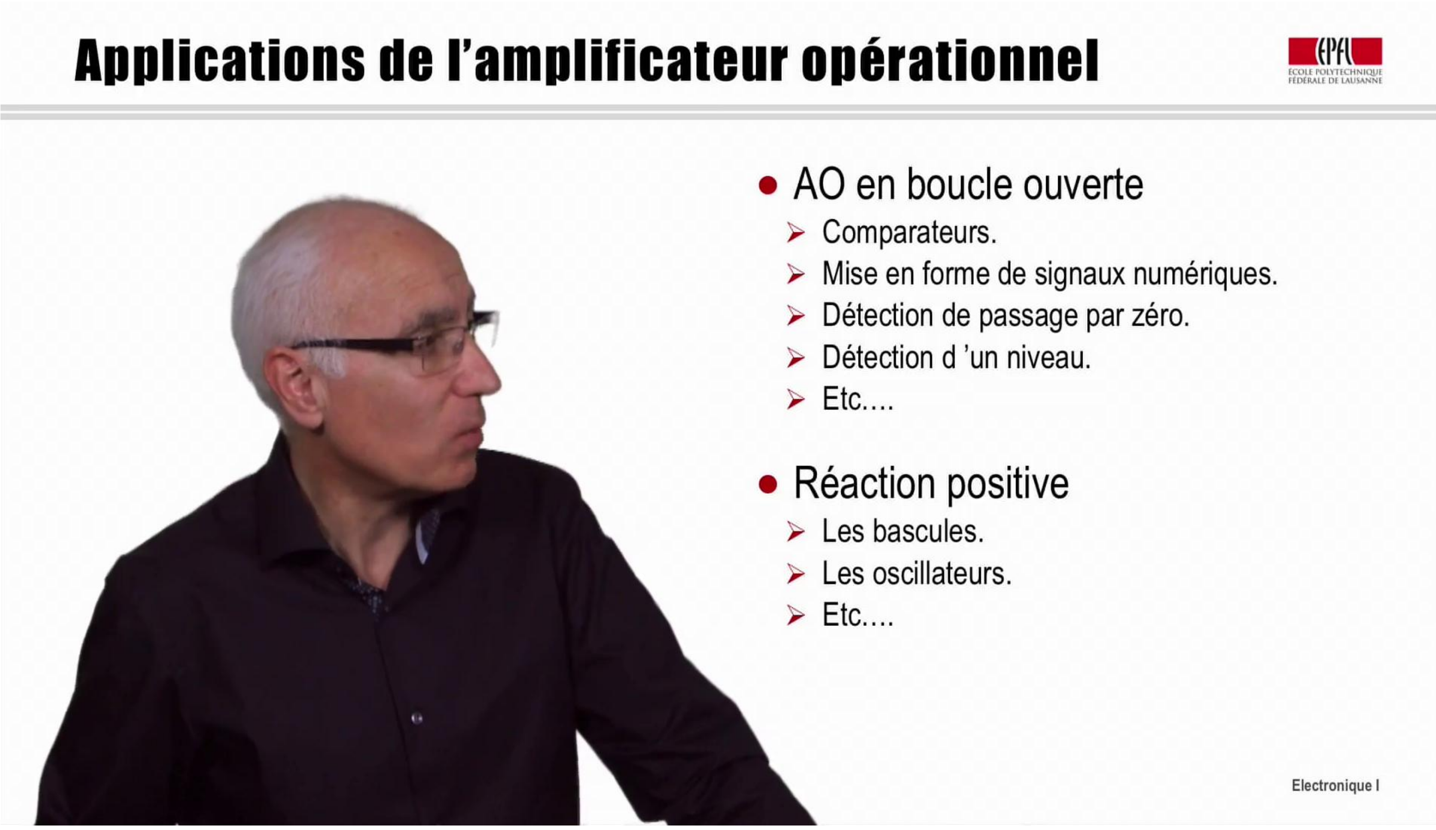



connecting the voltage V(in) to V(out) and we can say for any value of V(in): as long as the amplifier is neither on the positive saturation, nor the negative saturation, it is in a counter-reaction, this means we take a proportion of the output voltage, we bring it back to the input after having multiplied by a certain constant, and it has an equality which determines that when its gain here inside, and it's completely the case, its gain is equal to infinite, its gain absolutely equals to infinite, it'll guarantee us that $\Delta V$ equals to 0 so any point of this curve here confirms this relation and your amplifier will stay here inside and we call that an operational amplifier in negative reaction.

Notes

Summary

7m 21s

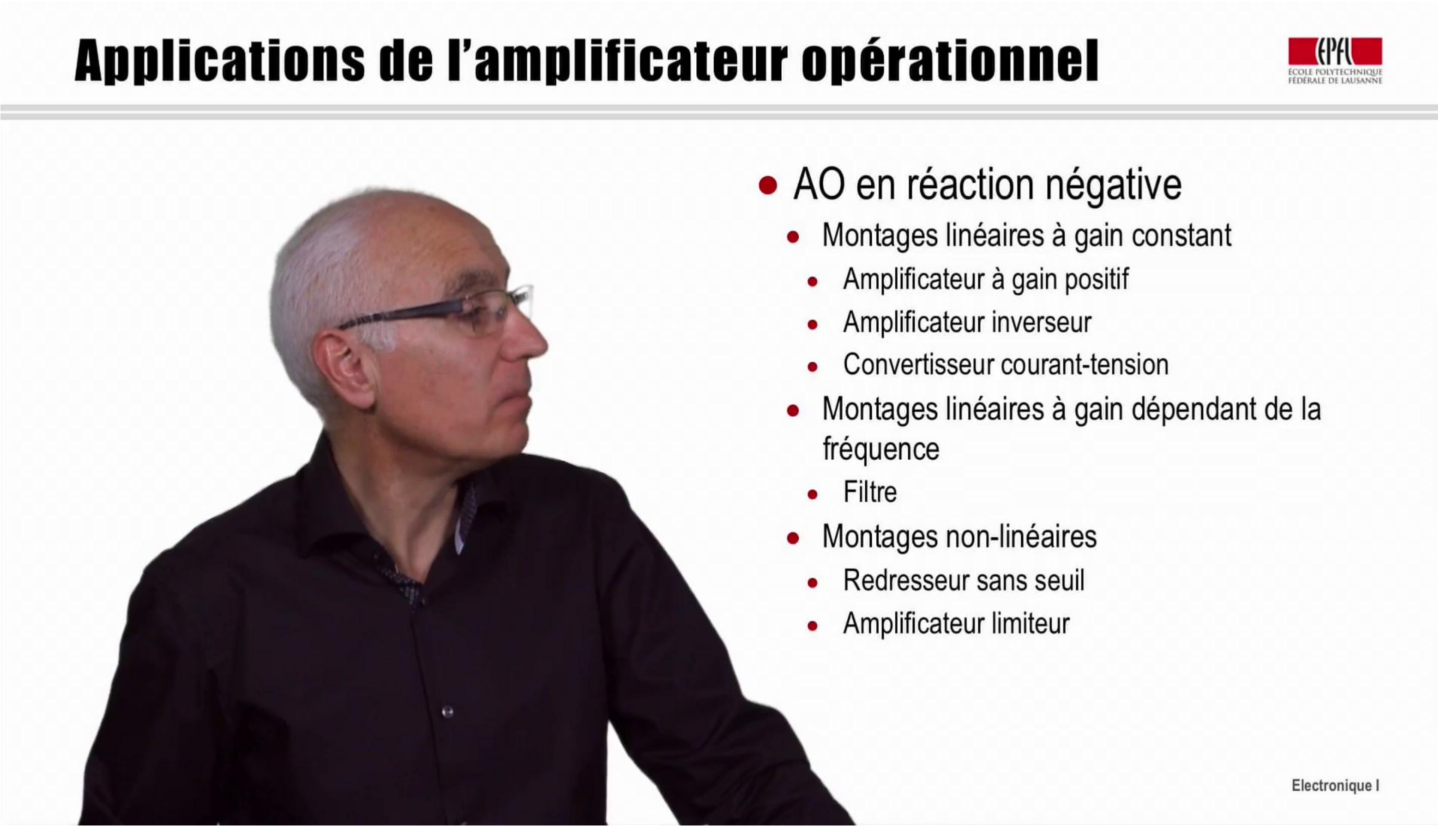



And so, we've just seen so far that an amplifier can be used in an open loop. We have given a demonstration of how an amplifier when we add a resistive divisor, it could be used in a closed loop. And we'll start to make several circuits which use the amplifier just to cover the functions which allow to integrate or perform electronic functionalities, whether it's in an open loop in positive reaction or in a closed loop. I'll start by showing you the qualities of electronic applications that are related to what we call an amplifier in open loop. So an amplifier in an open loop could be used as a comparator, we've seen it already. It would allow us to shape digital signals. It would allow us to make path detections by zero. We also looked at it as a presentation of an amplifier simply by plugging in a signal on the positive or negative input and making the comparison. It allows to make a level detection and many, many other applications which have an analog input and whose output is digital. Now the positive reaction, is something we'll see later, is how we use the amplifier to make a flip-flop or an oscillator or many other functions where the output and input are absolutely non-linear but of which the relation between the input and the output would allow to operate the capacity of the amplifier to stay with a voltage *Vsat+* or *Vsat-*.

Notes

Summary

8m 07s




The applications of the amplifier now in a closed loop. These applications are absolutely of an impressive quantity because they would allow us to make all the linear functions in the electronics area. Let's see as an introduction what we could do with an amplifier when we use the output brought back on the negative terminal by a division through resistances or impedances. That would allow us to see applications such as everything that is linked to the making of an amplifier, an audio amplifier, this is a signal which comes from a micro that gets amplified by an amplifier and sent back to the output. The gain can be positive or negative. We can make current-voltage converters, therefore receiving a signal which is a current at the input and converting it in voltage at the output. We can make many functions linked to the frequency, so making filters. And we'll finish after with non-linear circuits, such as rectifiers without threshold or limiters amplifiers. And there you go with this we just finished an introduction for the operational amplifier and we've seen that by putting the operational amplifier in a closed loop, therefore adding two resistances which bring a portion of the output voltage on the negative terminal, we obtain with this an amplifier which has a gain, it's a positive gain and always superior to 1.

Notes

Summary

9m 46s