Amplificateur opérationnel

4.2 Amplificateur à gain dépendant de la fréquence

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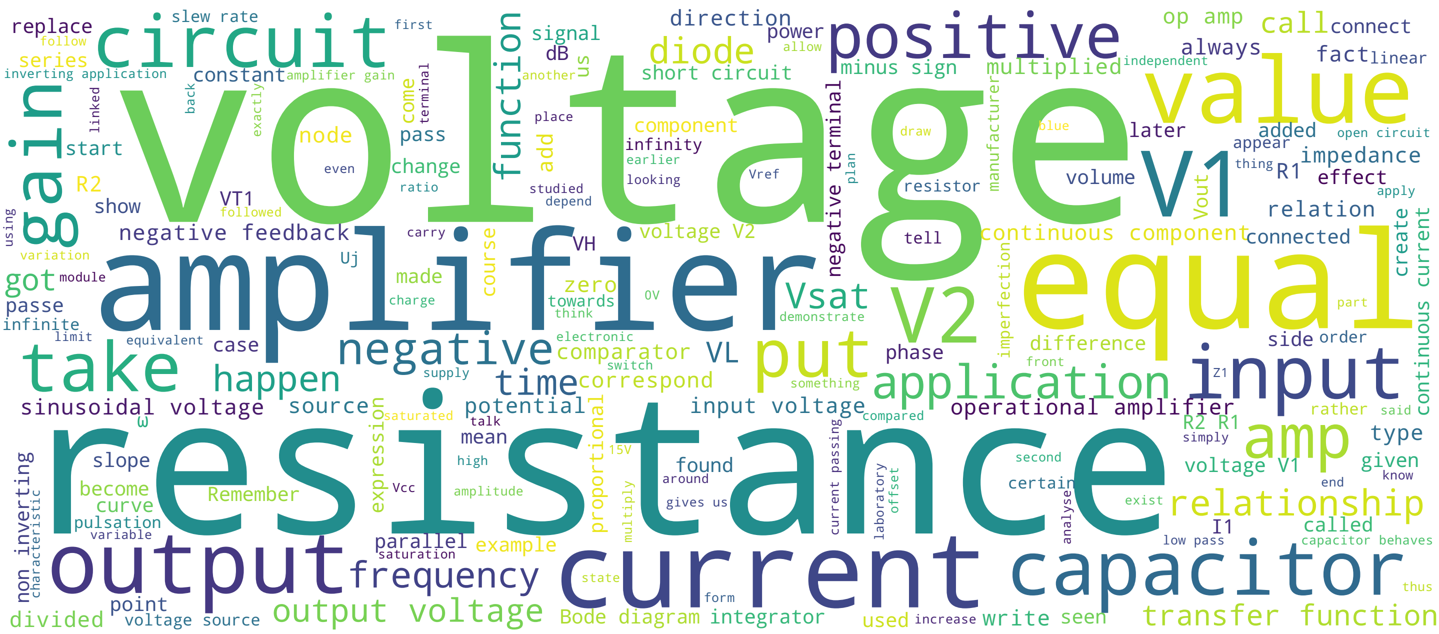
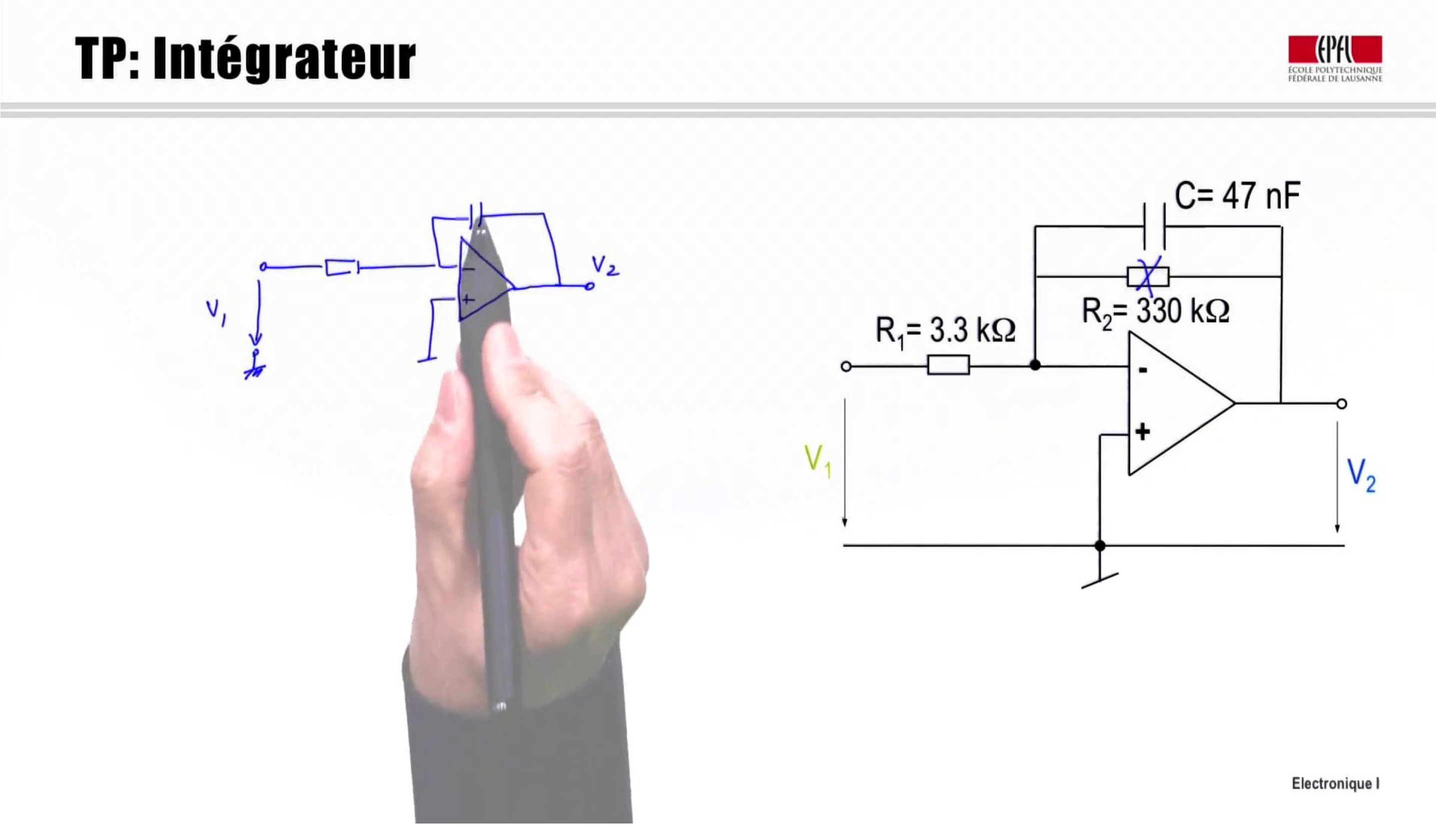


Video

EPFL

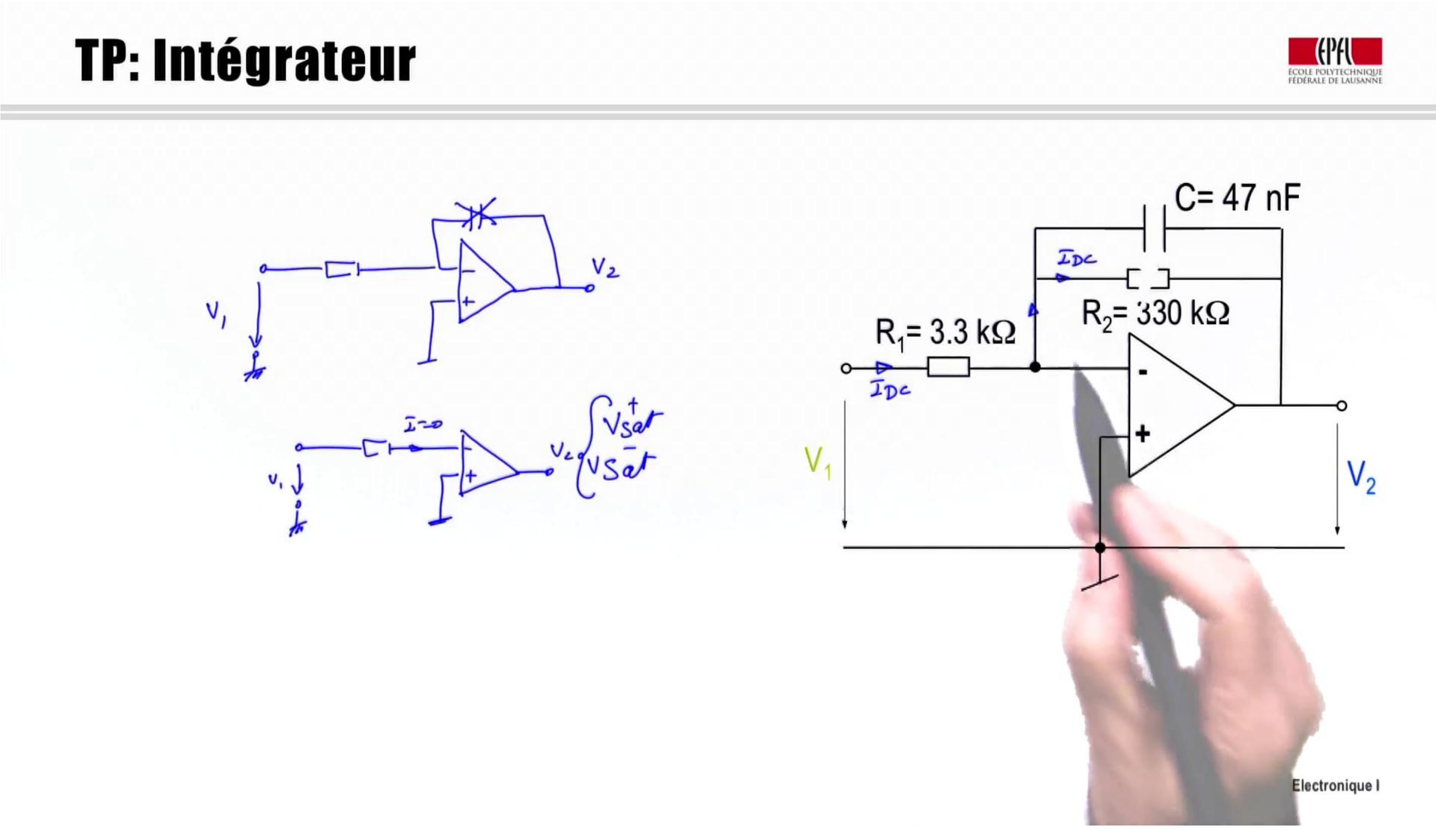


I'm now going to ask you into the laboratory where you can take an ideal op-amp, and to plug it in and power it up, and to choose the values that I have suggested here, a resistance of 330kΩ, a resistance of 3.3 here and a capacitor of 47nF. If I told you that we would make an integrator with this here, why have we added a resistance of 330kΩ in parallel with the capacitor? If that resistance wasn't there, what would happen to the amp? The amp would have, I'll write over this side, it would have a negative feedback capacitor and a resistance, and a voltage input value V1 in relation to the volume. And we're interested in the volume output, V2. Remember that a capacitor will always behave in accordance with the voltage at the terminals with the derivative, the current that's going through it, C times du/dt, gives us the current I. What would happen if somewhere in this voltage V1 there was a continuous component? So, there isn't a sinusoidal power source, but there is a default source that is present, that adds a small continuous component. Remember that the continuous component, the capacitor reacts as in an open circuit to this continuous component, as if the capacitor doesn't exist.

Notes

Summary

0m 04s



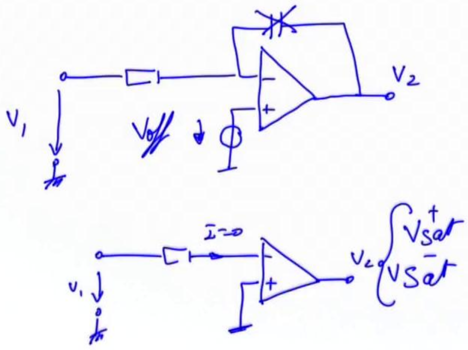
So, if the capacitor doesn't exist, and you'll see, your amplifier looks something like this. And you have a voltage source V1 in relation to the volume. And you have the voltage V2 here. So there's no current passing through here. I equals 0. The continuous current... Anyhow, for the capacitor, the capacitor behaves as in an open circuit. The current doesn't enter the amp. So, we've got a simple comparator schema, so the voltage V1 compares to a 0 potential. So it only needs a tiny continuous component here so that the voltage V2 saturates either to Vsat+, or to Vsat-. So we'd find ourselves with an amplifier that would saturate on one side or the other, if we hadn't put in this resistance. The fact that we have put in a resistance in parallel that equals 330kΩ, so we put in a resistance here, this resistance here will take into account the continuous component. So the continuous component will pass, the continuous current, I'll write down IDC, it will pass through here and, it won't pass into the capacitor, because the capacitor behaves as in an open circuit. So you'll have an amplifier that for a continuous current, will give you a constant gain that will be 330kΩ divided by 3.3.

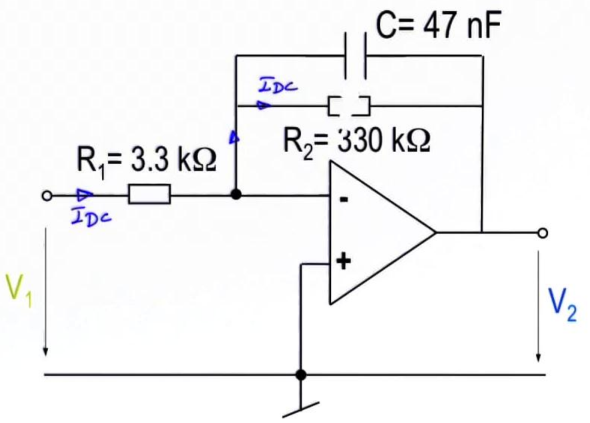
Notes

Summary

1m 49s

TP: Intégrateur





Electronique I

And it's what we are going to try to demonstrate through a practical experiment that we will carry out later on. We need to remember another thing, if you intend to use this amplifier as an integrator, it goes without saying that you should use a sinusoidal voltage. The sinusoidal voltage should be ten times higher than the transfer function pole in order for your amplifier to behave like an integrator. Otherwise, the resistance will always come into effect that we would have put in place to counteract the fact that there was a DC current. There is another thing that you should be aware of, that we'll look at in more detail later on in another chapter, and that's the fact that the amplifier, despite being connected to the volume, has an imperfection that we call the voltage offset. The voltage offset is a default of the amplifier. We haven't spoken about it yet, we'll cover it later on. So, even if the voltage here doesn't have a continuous component, the fact that there is a small offset of some milli-volts added by the amplifier, is enough to provoke the phenomenon that I've just explained, and will push my amplifier into saturation.

Notes

Summary

3m 33s

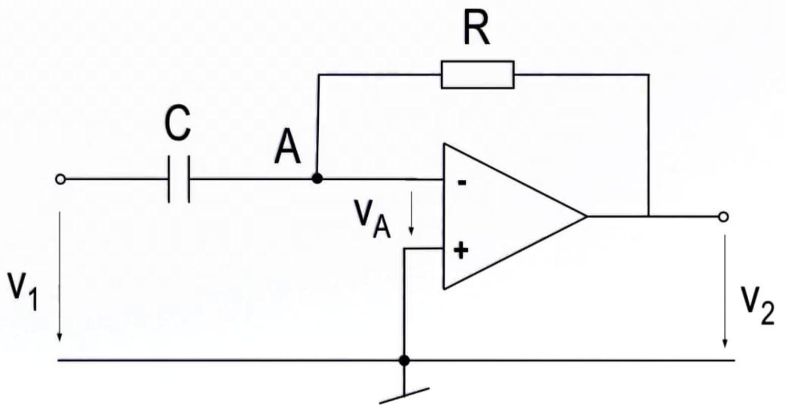
Différentiateur inverseur de tension

- Domaine temporel:

$$V_A = -\Delta v = 0$$

$$\frac{V_2}{R} = -C\frac{dV_1}{dt}$$

$$V_2 = -RC\,\frac{dV_1}{dt}$$



Electronique I

Exactly as if we had made an integrated amplifier, we're going to make an amplifier, an amplifier application, that will make the derivative. I think that here, there's no need to keep repeating the same thing, that's to talk about the voltage V1, and the voltage V2, I think that it's now clear that the same current goes through them both. We have inverted the resistance and the capacitor with an integrated application and we have installed it differently, i.e. the opposite way round, to make a differentiating application. So if you note that the current is the same, and you write the temporal laws in relation to the capacitor and the resistance, you will arrive directly at this relationship that tells you that the same current, flowing through the resistance and the capacitor gives you the relationship, that when you express the voltage V2 in function of the voltage, rather than the value of the voltage derivative V1 because it's the capacitor that is going to come into effect you will land directly on an expression that tells you that the voltage output is proportional to the input voltage derivative multiplied by the constant RC with a minus sign in front.

Notes

Summary

4m 51s

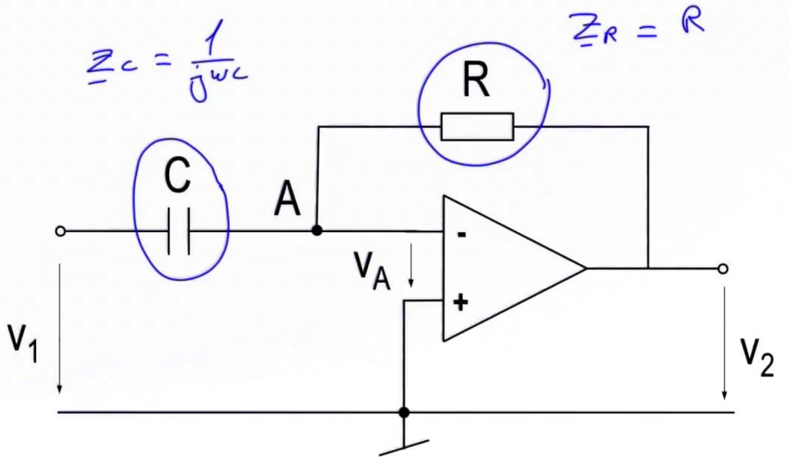
Différentiateur inverseur de tension

- Domaine temporel:

$$V_A = -\Delta v = 0$$

$$\frac{V_2}{R} = -C\frac{dV_1}{dt} = I$$

$$V_2 = -RC\,\frac{dV_1}{dt}$$



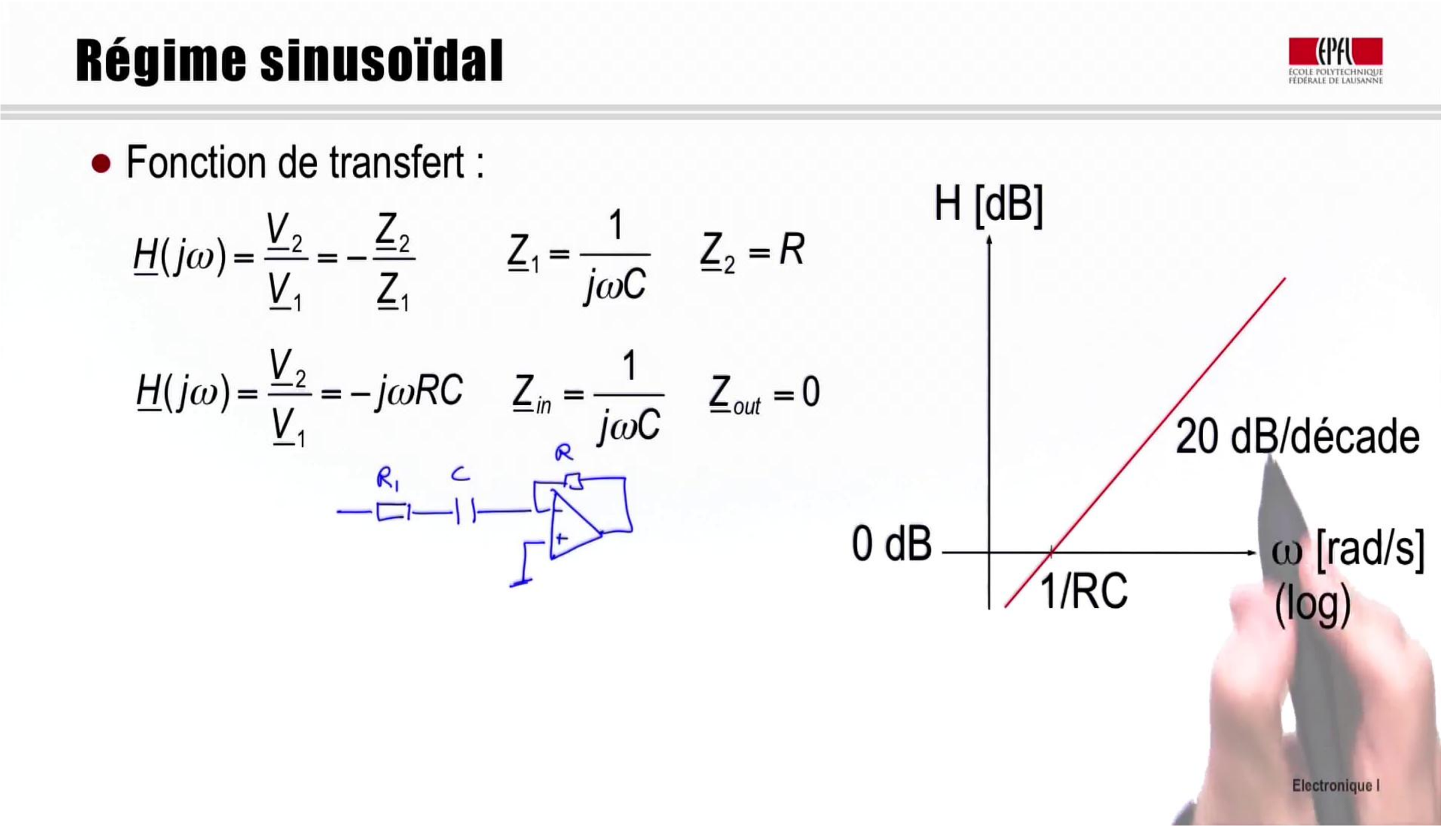
Electronique I

This same application, if you connect a sinusoidal voltage to the input the same as an integrator, we're going to replace the capacitor by its impedance ZC, that equals 1/jωC, and the resistance R by ZR, which is equal to the value of the resistance R, and we're going to make the relationship between this impedance here divided by this impedance here and put that with a minus sign in front, and we're going to find the following expression.

Notes

Summary

6m 06s

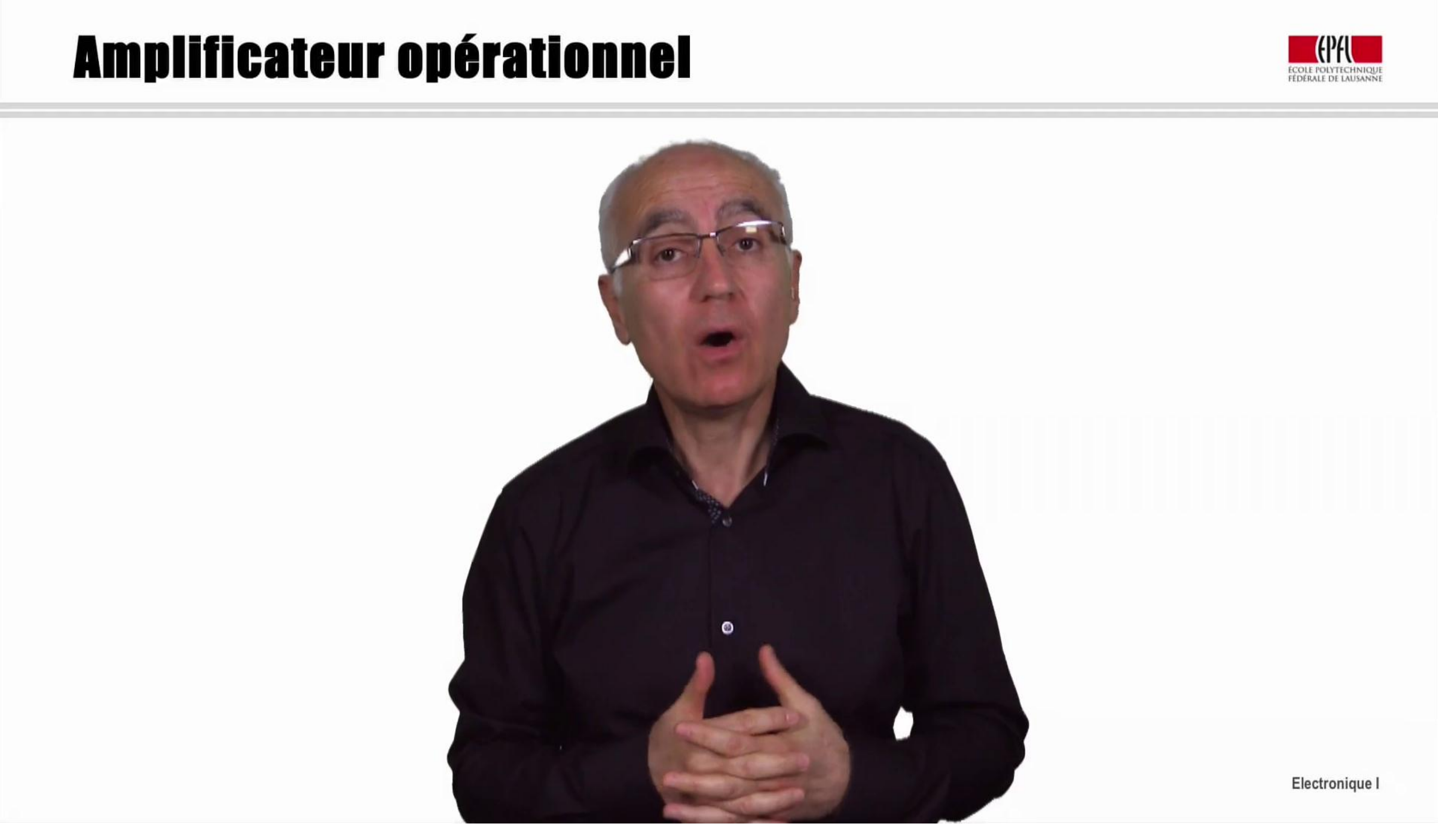


The transfer function value H equals -Z2/Z1, with Z2 is a resistance and Z1 is a capacitor, will give you a transfer function equal to -jωRC. When we apply that to a Bode diagram module, it's a slope of 20dB/décade that passes the point that equals 1/RC. So, this same application, when used in practice, we always tend to put... so, remembering that the application with the resistance that comes with negative feedback R, and we have a capacitor at the input and this application, to avoid having a continuous component that arrives directly on the negative terminal, we put a resistance in series with the capacitor. Remember that in an integrated application, we find the capacitor here, and we had put a resistance in parallel so that the continuous current passes through the resistance rather than through the capacitor. And here, at very high frequency, when the capacitor behaves like a short circuit, when ω reaches infinity, so that we are somewhere along way on the pulsation axis. So, we still would like to limit the amplifier's gain so that the output voltage doesn't saturate.

Notes

Summary

6m 44s



So we're going to put a resistance in series with the capacitor so that the capacitor, when it's the equivalent of a short circuit, because ω reaches infinity, so Z reaches 0 for the capacitor, it's the equivalent of a short-circuit, and we'll have a gain that is the relationship of R divided by R1. We began with a general introduction as to what is an operational amplifier. We used the amplifier as if it was a circuit or a negative feedback application where the resistances made the negative feedback loop of the amplifier, which demonstrated that the gain is independent of the frequency. So we can create a gain with this type of amplifier and we made two applications. The so-called inverting application from which we extracted different characteristics, such as virtual volume. We did this with a summing application. We followed on with the non-inverting application and the non-inverting application is an application that has an input that corresponds to infinity, an input impedance equals to infinity, a positive gain. We followed on with some applications notably we made an application that allowed us to make a negative impedance. We also did the voltage buffer.

Notes

Summary

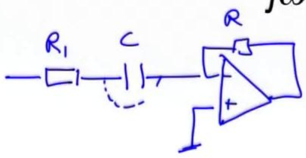
8m 14s

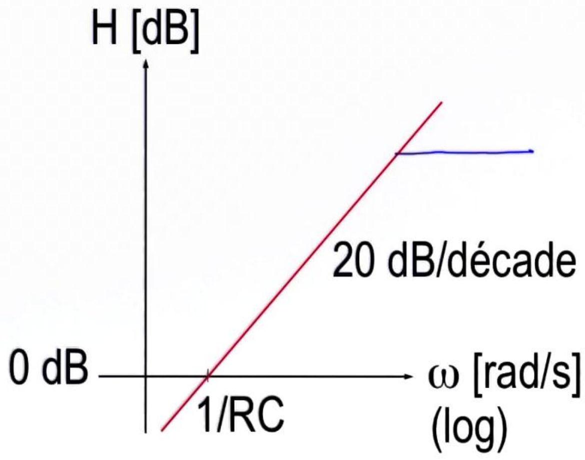
Régime sinusoïdal

- Fonction de transfert :

$$\underline{H}(j\omega) = \frac{\underline{V}_2}{\underline{V}_1} = -\frac{\underline{Z}_2}{\underline{Z}_1} \qquad \underline{Z}_1 = \frac{1}{j\omega C} \qquad \underline{Z}_2 = R$$

$$\underline{H}(j\omega) = \frac{\underline{V}_2}{\underline{V}_1} = -j\omega RC \qquad \underline{Z}_{in} = \frac{1}{j\omega C} \qquad \underline{Z}_{out} = 0$$





Electronique I

To finish off, we studied the integrator function and the derivative function to demonstrate that the op-amp applications can be about components that are frequency dependant and that it allows us to modify the amplifier's gain in function to the voltage input frequency.

Notes

Summary

9m 35s