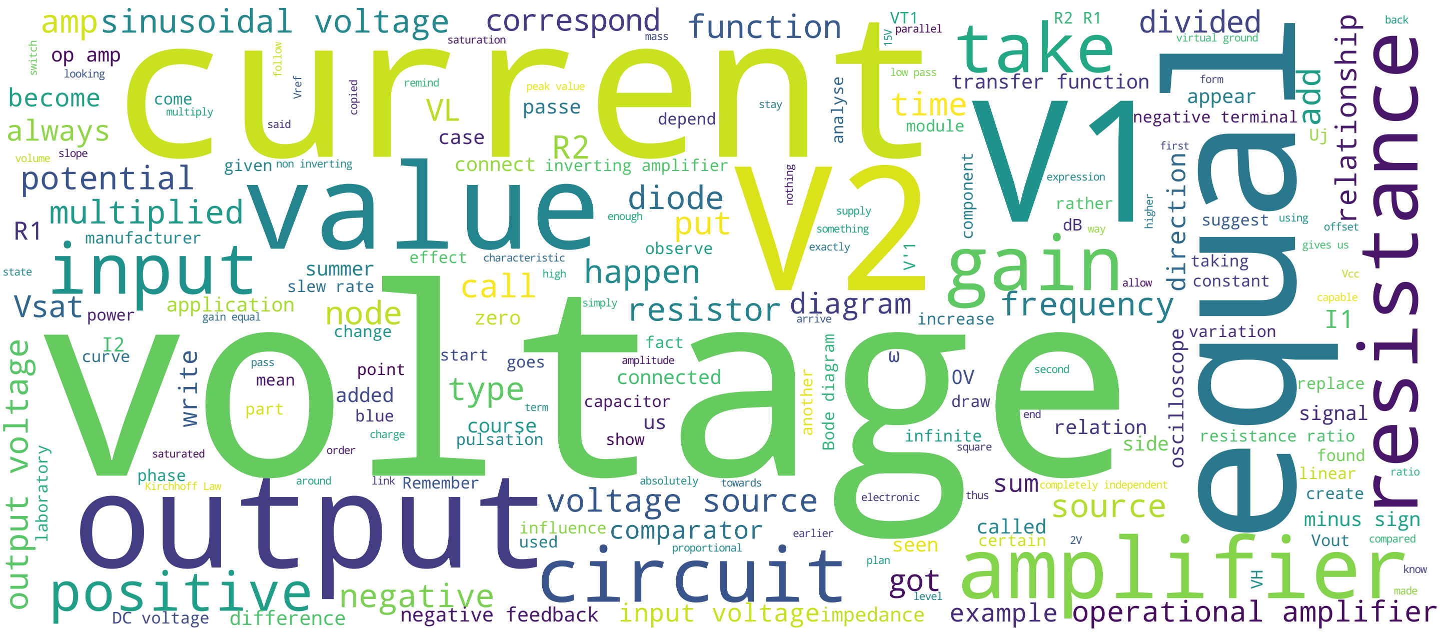
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Amplificateur opérationnel

2.3 Montage inverseur indépendant de la fréquence

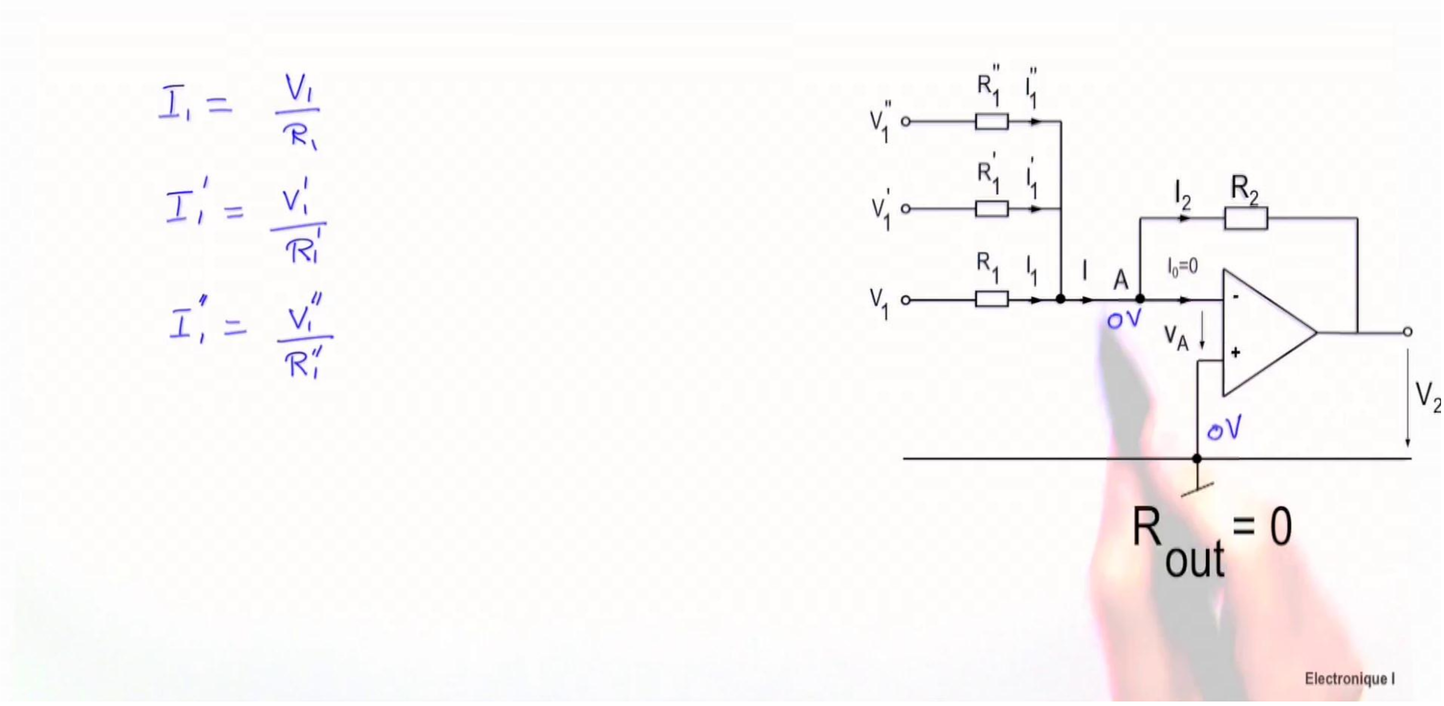
Prof. Maher Kayal
Electronics Laboratory-ELAB



Video

EPFL

Sommateur de tensions



Here is the diagram that I would like to show you, which is what we call a voltage summer. You'll see here that we have an inverting amplifier and we have created a virtual ground. This virtual ground is essential to the use of this amp when it is in a linear area. So the potential here, is the same as it is here. And if I put a resistor here, or a potential of 0V, I will still find myself with a potential of 0V. When we look what happens here, I can write all these resistors that you're seeing, from a *V1* voltage source, a *V'1* voltage source, a *V''1* voltage source or we could easily write that the current *I1* is simply equal to the voltage *V1* divided by the resistor *R1*, the same for the current *I'1* which is equal to *V'1* divided by the resistor *R'1*. It's the same for the current *I''1* which is equal to *V''1* divided by the resistor *R''1*. But what's really interesting here is that the potential is completely independent, it's controlled from this side. This area here imposes the duplication from the negative feedback of the level, or rather the potential of 0V towards this node here.

Notes

Summary

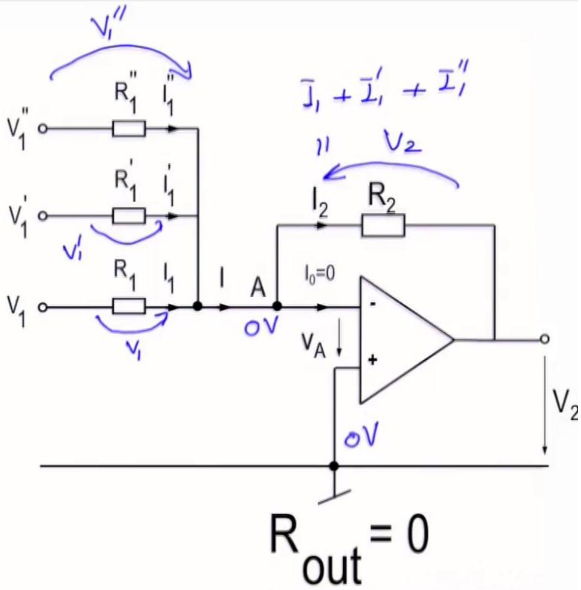
0m 05s

Sommateur de tensions

$$I_1 = \frac{V_1}{R_1}$$

$$I_1' = \frac{V_1'}{R_1'}$$

$$I_1'' = \frac{V_1''}{R_1''}$$



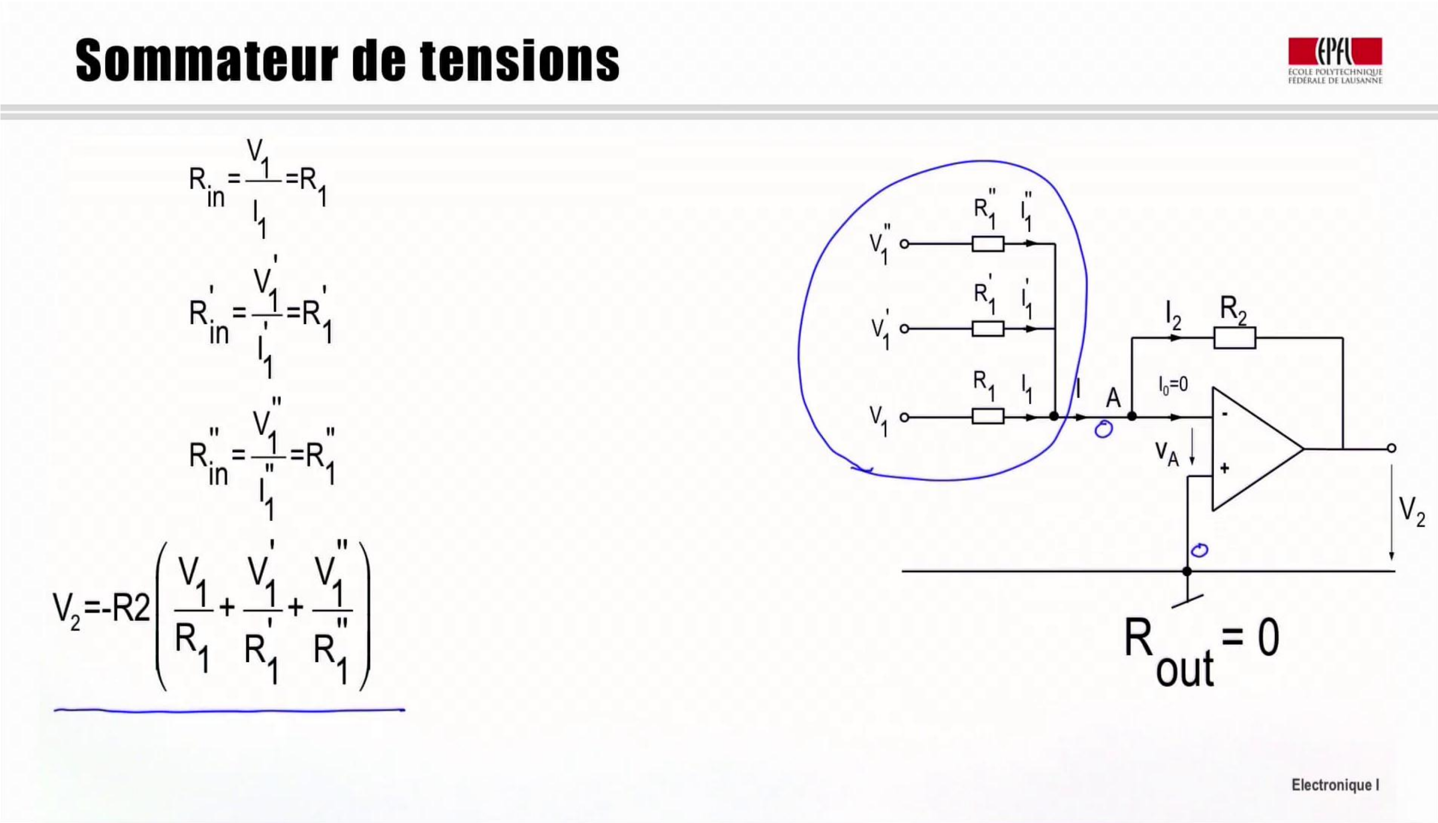
Electronique I

It's absolutely not the voltages because the voltages that appear here, you will see *V1* here, you've got the voltage *V'1* there and the voltage *V''1* here. And this will stay at 0V the entire time. So now let's look at Kirchhoff's Law. Kirchhoff's Law tells us that current *I* is the sum of this, plus this, plus that. Very good. This same currrent doesn't even enter the amp. It goes through it, it will become *I2*. So *I2* is always equal to the sum of the currents *I1* + *I'1* + *I''1*. So it's a law that adds up all the currents that pass through while the potential retains the same value. And when we start looking at what will happen with the voltage *V2*, let's remind ourselves that *V2* is this one, this is *V2*, so *V2* is equal to -*I2* x *R2* . So all these currents are multiplied by the *R2* resistor. They transform into a voltage equal to the output of *V2*, and that gives us something like this.

Notes

Summary

1m 33s



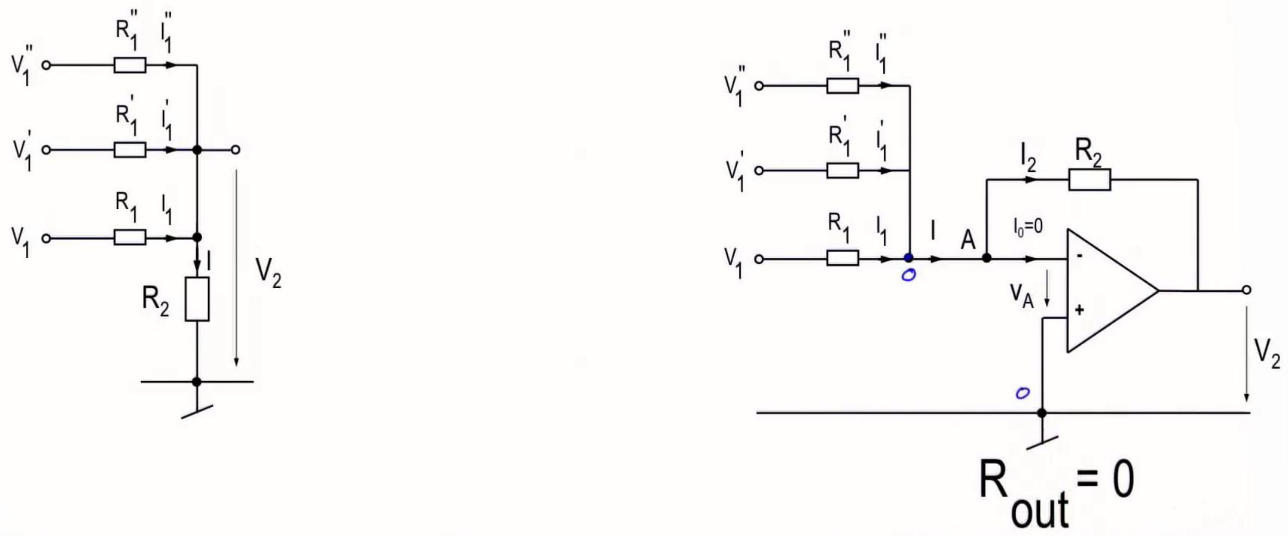
Here is the diagram once we examine it with the links that have just been explained. You'll see that the voltage *V2* is equal to: *V1/R1 + V'1/R'1 + V''1/R''1*, with + sign adding it all up, and which is multiplied by the *R2* resistor. In other terms, you have *V1* which is multiplied by a gain equal to *-R2/R1* , the same for *V'1*, and for *V''1*. This type of circuit allows us to carry out what is called a mixing of voltages. We can add voltage sources that won't influence each other because we have a potential here that is absolutely constant, independent from this part of the circuit because your amplifier gives out negative feedback, while this voltage here allows the potential of 0V to be copied to this node here thanks to the virtual area. So this potential is managed by the negative feedback and these different voltage sources are absolutely independent from each other. In other words, you can connect three voltage sources. We could say that we have one voltage source *V1*, and a voltage source *V'1*, which are by nature completely independent.

Notes

Summary

2m 48s

En comparaison



Electronique I

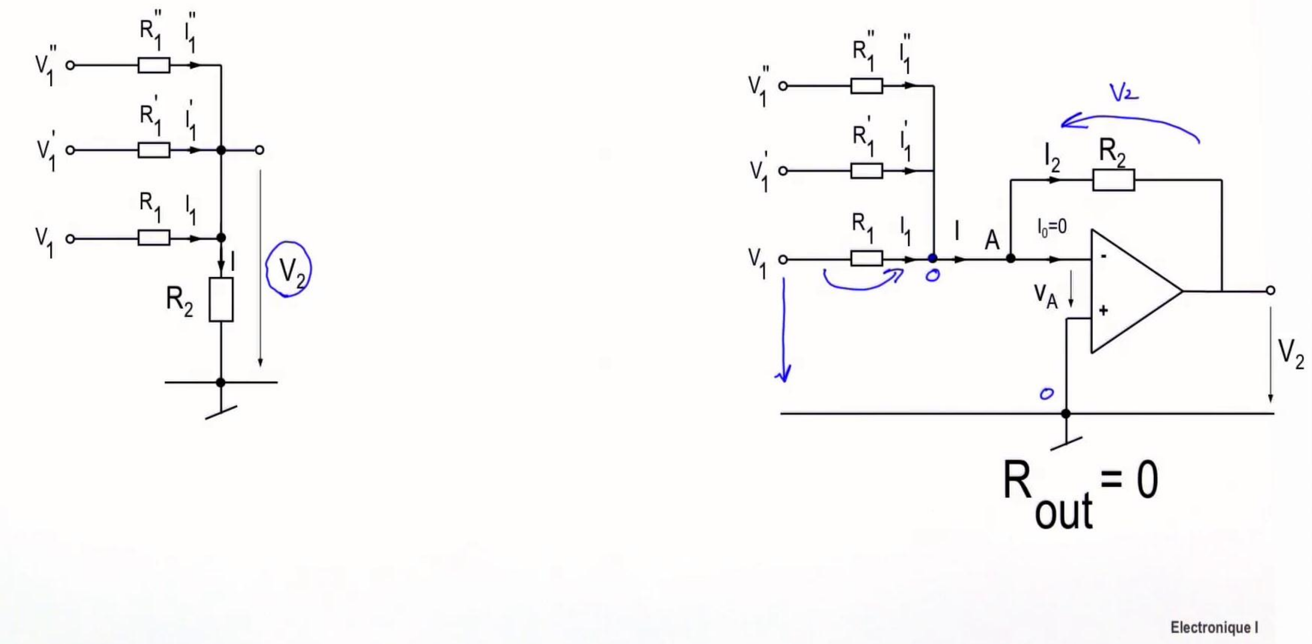
You can connect an audio source at this side here, another audio source from the other side, so we could have some classical music here, here we could have some pop music, and you could add a singer here, and you would only have to put variable resistors here and you will have just made what we call a mixing table, because you would be mixing three voltage sources, where the voltage output is the weighted sum of these three sources. You can then write down the gains, raise the volume of the classical music by putting $R2$ higher up than <$R1$, lower the sound of the pop music and wipe out the sound or the voice of anyone talking who comes near the source. So this, this is the origin of what we call an adder, and this adder takes over sources which are entirely independent and sends them to the output. I would like to draw your attention to the fact that this diagram here does not correspond with that diagram there. In this diagram, the voltage that you see in the node to which we add the current is always the same, 0V copied from here. The voltage that you see here, is a voltage that's the same as $V2$, and the voltage $V2$ depends, of course, on I.

Notes

Summary

4m 14s

En comparaison

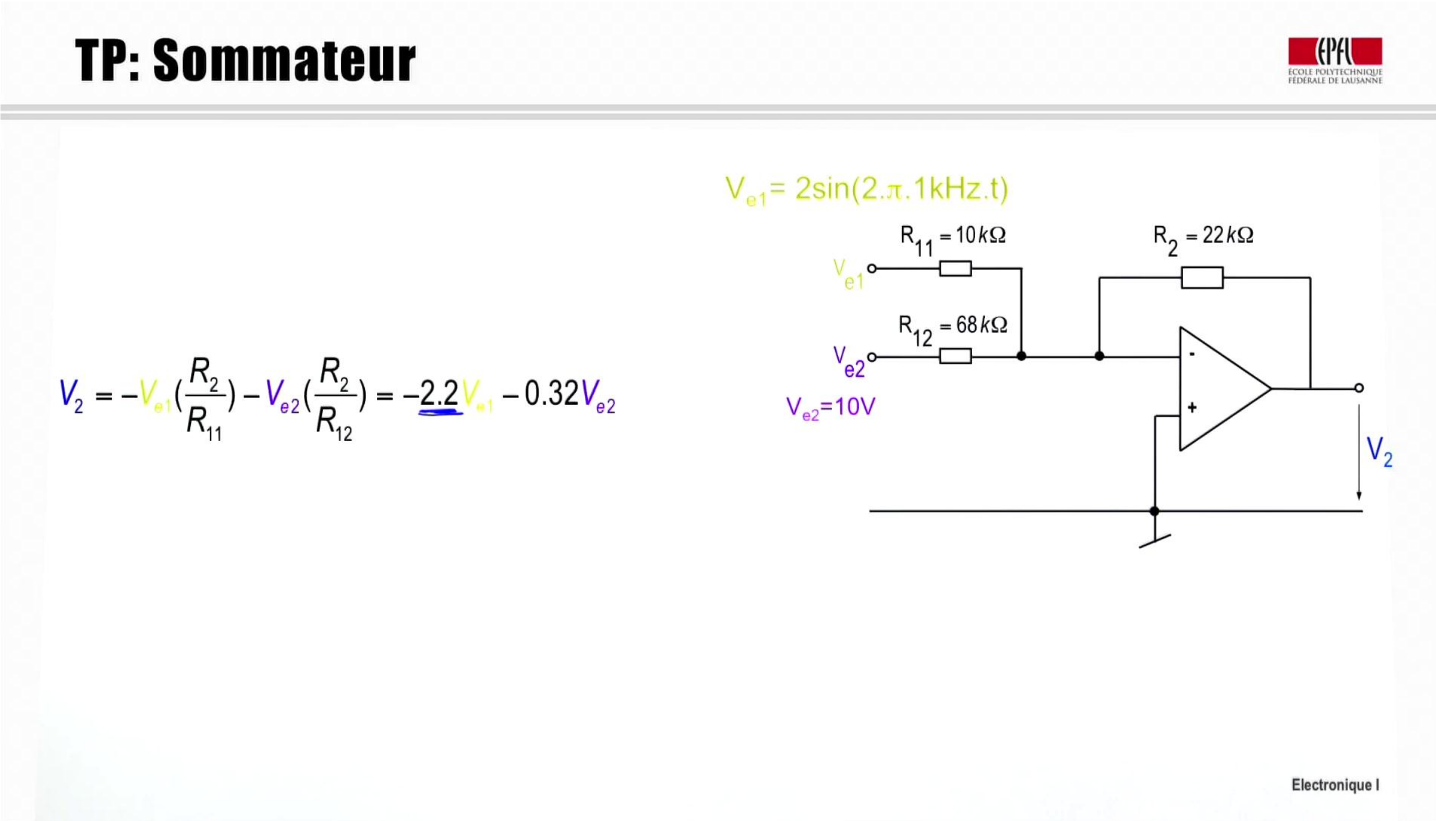


The voltage *V2* is this voltage here, as you can see, but it's always between the output of *V2* and the virtual area. And the current that comes from here passes through *I2* and subsumes the voltage *V2* with its own value. However here, this voltage is in constant flux, including the effect on this resistor and the current *I1*. So when this voltage increases, you will see that the voltage *V1* - *V2* will influence the current *I1*, which is not the case here. The voltage *V1* is completely independent on the variation of the voltage *V2* because it is between *V1* and the mass, so between this node here and this node here. And this has nothing to do with what is happening with the current *I2* which is the sum of these two other sources. Here, the voltage *V2* depends on this current exactly, this current, this current and the level of voltage here influences the value of *I1*. It will also influence the value *I'1* and the value of *I"1*.

Notes

Summary

5m 36s



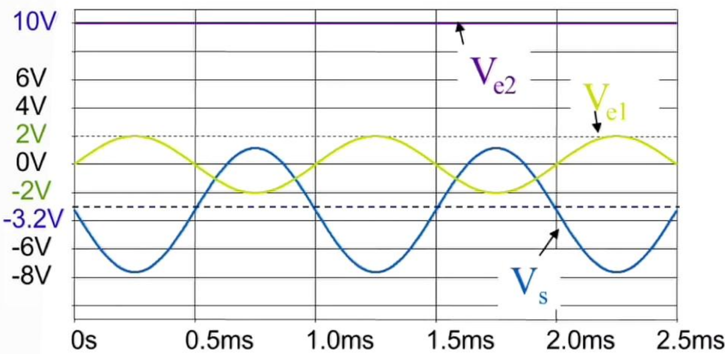
I now invite you to go to the laboratory and look at an example of a summing amplifier, and with this summing amplifier, we will try two inputs. Here is what you should connect. Take an operational amplifier. Create two voltage sources, one source of sinusoidal voltage, with a frequency of 1kΩ, and a peak value equal to 2V. In a second input, connect a DC voltage source with a value equal to 10V and use the diagram with the resistance ratio that I have suggested you put here. I advise you take the sinusoidal input, and establish a gain. You have the ratio that appears on this input here, this is the resistance ratio of *R2* over *R11* which is equal to 22kΩ over 10kΩ so this corresponds to 2.2. With this 2.2, a much weaker signal with respect to the sinusoidal voltage *Ve1* and the DC voltage, I suggest that you perform a damping effect, so put 22kΩ divided by 6.8 which leads us to 0.32 and, of course, with this being negative, let's observe what appears at the output. So we are in fact expecting a summation link with the minus signs. *Ve1* will be multiplied by the gain of 2.2. *Ve2* will be multiplied by the damping of 0.32. Let's see what happens when we analyse this before connecting it to an oscilloscope.

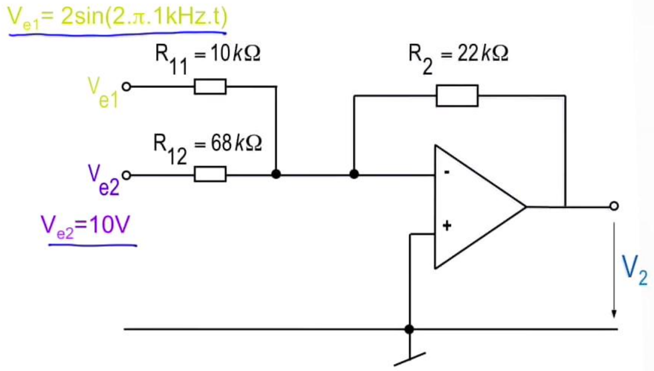
Notes

Summary

6m 44s

TP: Sommateur





$$V_2 = -V_{e1}\left(\frac{R_2}{R_{11}}\right) - V_{e2}\left(\frac{R_2}{R_{12}}\right) = -2.2V_{e1} - 0.32V_{e2}$$

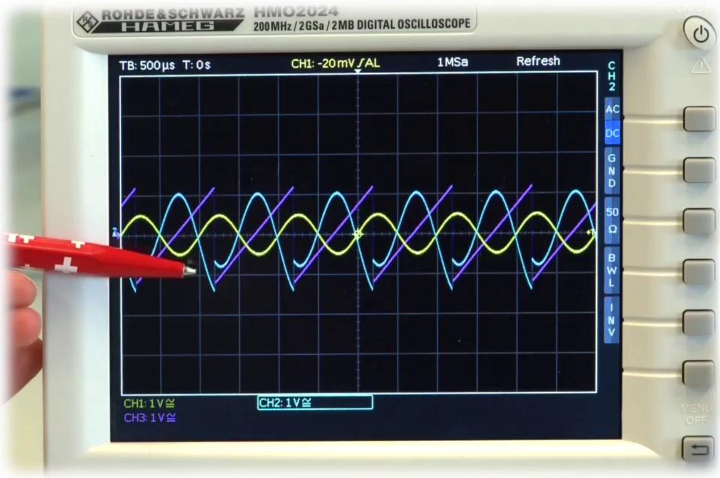
Electronique I

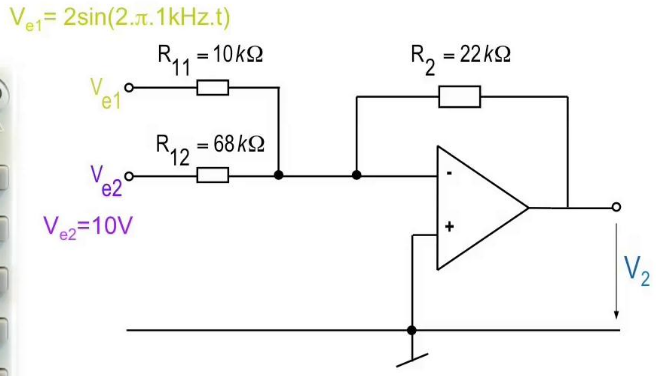
Here is our circuit. We have the voltage generated with a peak value of 2V. You can see plus 2V, minus 2V, with a mean value of 0V. And here is the DC voltage, which we have connected here, and the AC voltage which was connected here, as we look at the output the sum of the two balanced by the resistance ratio, and what we will see is that this sinusoidal voltage which has become, of course, 10V multiplied by 0.32 and altered with a minus sign, will give us a value of -3.2, that you see here will then become the average DC value at the output of *V2*. And so, our sinusoidal voltage multiplied by a gain equal to 2.2, which we can see here, will amplify with a 2.2 gain, and will invert the voltage, so we have a phase shift of 180° between the input voltage and the output voltage which is very visible at the output of this summer.

Notes

Summary

8m 30s





$$V_2 = -V_{e1}\left(\frac{R_2}{R_{11}}\right) - V_{e2}\left(\frac{R_2}{R_{12}}\right) = -2.2V_{e1} - 0.32V_{e2}$$

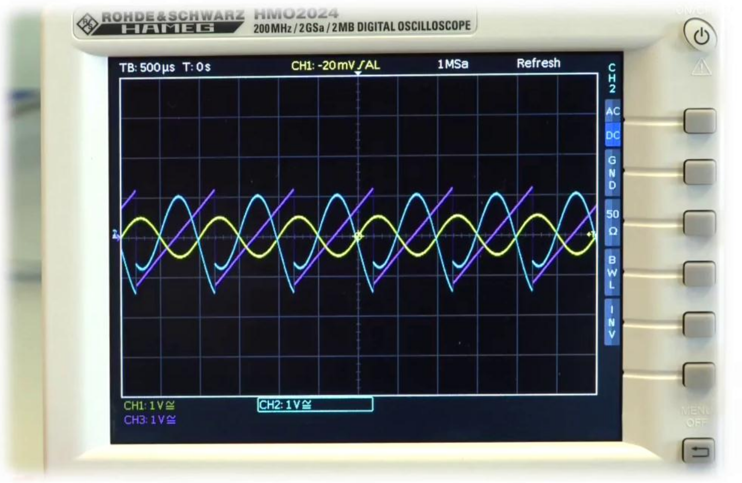
Electronique I

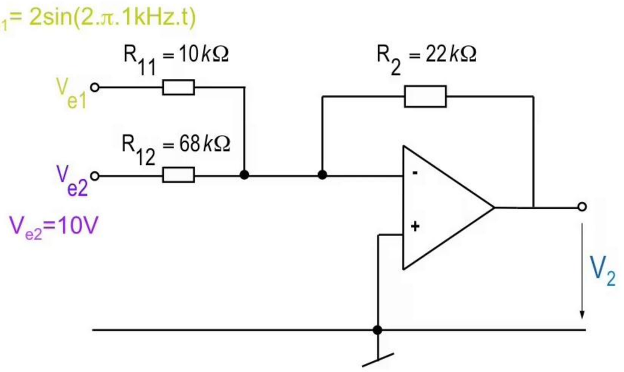
I now suggest to you that you take the same circuit and connect different types of voltage sources other than sinusoidal voltage. And as you can see, this type of summer is capable of measuring or taking any type of input voltage, incorporating them in and sending them to the output. For example, here we have a sinusoidal voltage which we would like to add to a square wave. It's enough to put it at the input of this summer and at the output, we have this blue line which in fact corresponds to the sum of a sinusoidal voltage and a square voltage. We suggest you do this and observe the results with an oscilloscope. Here is a similar thing, we can, of course, do this with a sawtooth wave with a sinusoidal voltage. You have the sawtooth wave that we add to the sinusoidal voltage. I'll leave that there so we can see the voltage in blue, which corresponds to the sum of both of them once they've been through the summer. It's enough to observe this on the oscilloscope and to do this exercise in your laboratory to look at what's going on.

Notes

Summary

9m 42s





$$V_2 = -V_{e1}\left(\frac{R_2}{R_{11}}\right) - V_{e2}\left(\frac{R_2}{R_{12}}\right) = -2.2V_{e1} - 0.32V_{e2}$$

Electronique I

And so, we've just finished looking at one use of an inverting amplifier, and we've just found out that this inverting amplifier is capable of taking an input signal, a voltage in this case, of multiplying it by a gain and performing an amplification or a damping of this signal, sent to the output and inverted due to a minus sign according to the gain that we have reached. And with that we finish today's chapter.

Notes

Summary

10m 52s