ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Amplificateur opérationnel

2.1 Montage inverseur indépendant de la fréquence

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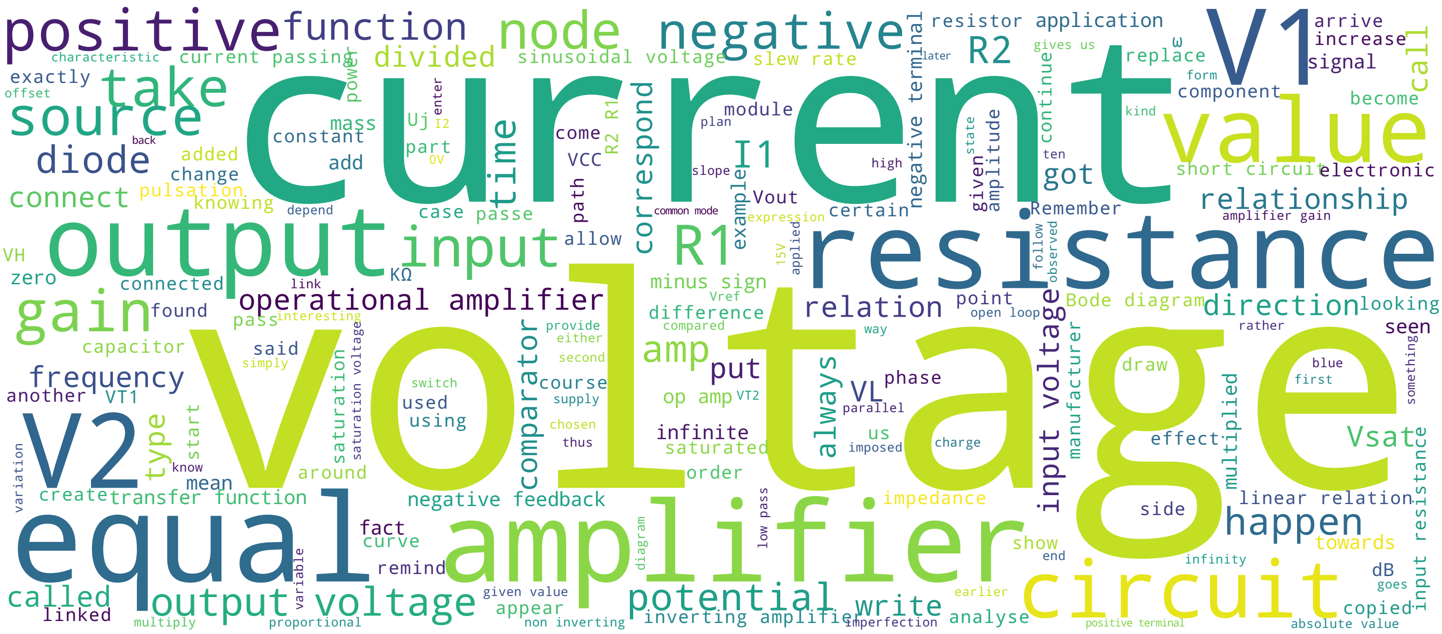


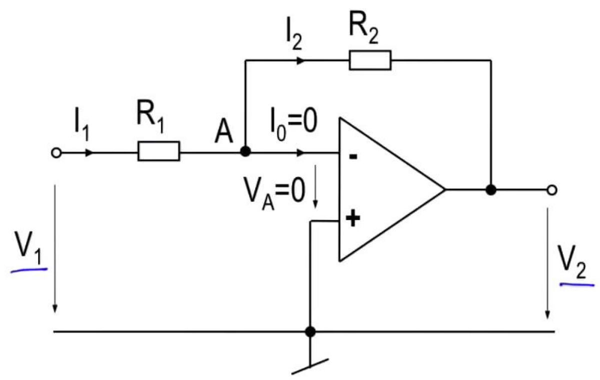
Video

EPFL

Amplificateur inverseur

- Etape 1: potentiel au nœud A

  $V_A = -\Delta v = 0$ (gain $A=\infty$)



Electronique I

Let's resume the study of an inverting amplifier, by looking at the outcome we got last time by making an operational amplifier in and using it as an inverting amplifier. I will look at a circuit using what is called an inverting amplifier. The term "inverting" derives from the fact that the voltage output, which we can see here has an opposite sign to the voltage input, which we can see there. So the *V2* voltage will be in *sin* in opposition to the*V1*. one. So let's look at what this means and how it works. I will remind you that, from now on, we've understood that when there is negative feedback, that's when we can bring back voltage or power from the output towards a node and towards an amplifier's negative terminal, which creates negative feedback.

Notes

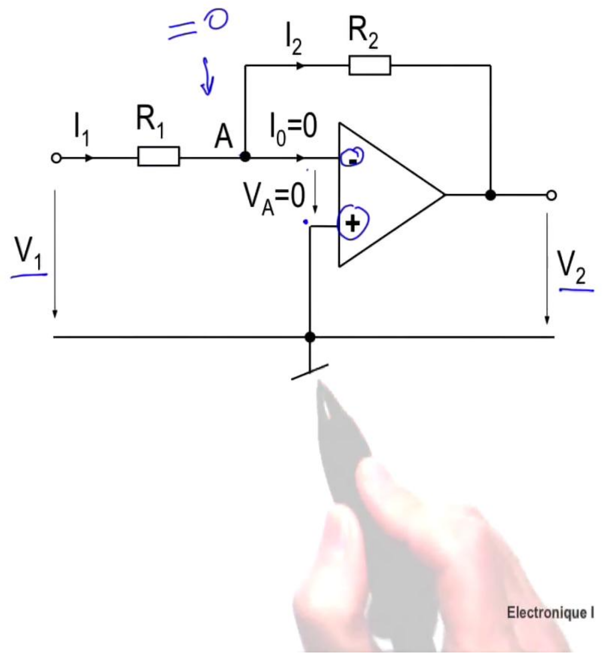
Summary

0m 04s

Amplificateur inverseur

- Etape 1: potentiel au nœud A

$$V_A = -\Delta v = 0 \text{ (gain A=}\infty)$$



This negative feedback enables us to find a linear relation because, if the output voltage is lower than the saturation voltage, be it positive or negative, that means that the power is stuck in the so-called linear section of the amplifier, Therefore, there is a linear relation between *V1* and *V2* and you will find out that this linear relation will pass through a resistance ratio which are resistance *R2* and *R1*. Just to remind you, once again, if the amplifier has an output voltage which isn't saturated, we can say that the tension between the negative and the positive terminals equals 0. So we have an amplifier which shows exactly the same voltage from there to there. Very interesting. Look at what happens in this kind of electrical circuit. I had linked the negative terminal to a fixed potential which controls the input and output, and the voltage is that of the mass. So it's as if, when I copied this potential there, I applied it here. A copy of this potential towards that potential means that I imposed a potential on the *A* node, Both the voltage I can see in that node, and the potential in this one equal 0. This is an identical copy of the mass.

Notes

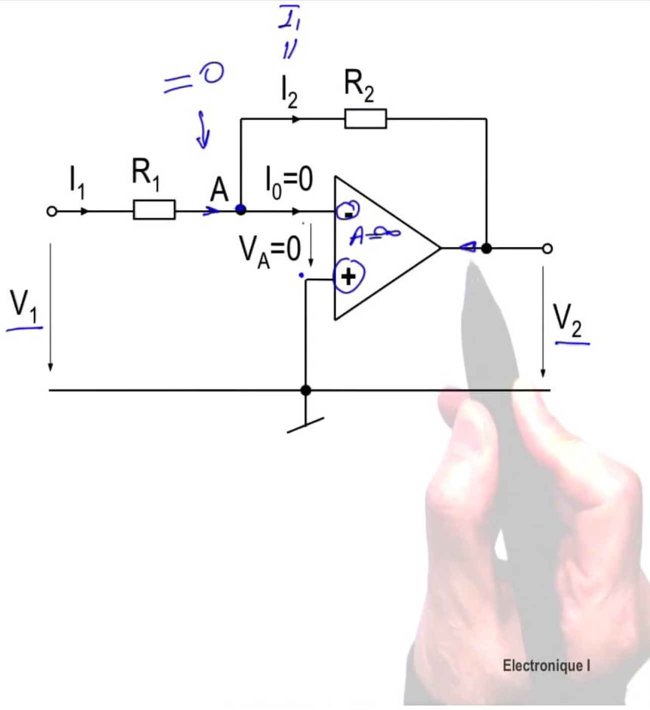
Summary

0m 53s

Amplificateur inverseur

- Etape 1: potentiel au nœud A

  $V_A = -\Delta v = 0$ (gain $A=\infty$)



But this doesn't create a short circuit at the mass. Very interesting, why? Let's imagine there's a current passing through here. This *I1* current will arrive here, in this node there. The amplifier will take no current, Remember impedance is infinite, therefore the *I0* current equals 0. So all of the *I1* current will go to trough the branch which is there and *I2* will be equal to *I1*. So we have the mass potential, but we have successfully avoided the current passing through the mass. The current will not pass through the mass, that voltage is equal to this voltage, but there is no short-circuit inside the amplifier, on the contrary, which is linked to the fact that the amplifier's gain is infinite and that this voltage there divided by infinity and brought back to the input, will equal 0. So what we imposed here is copied on that node there. So the current follows on its path there, and passes through the amplifier. So if it's a *I1* current which enters, *I* path is the same, it arrives towards the amplifier, continues here, it carries on its path it leaves towards - *VCC* if the current is positive or towards + *VCC* if the current is negative.

Notes

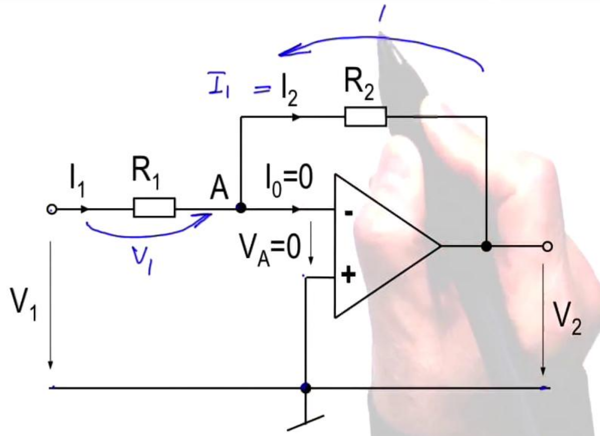
Summary

2m 23s

Amplificateur inverseur

- Etape 1: potentiel au nœud A

  $V_A = -\Delta v = 0$ (gain $A=\infty$)



Electronique I

Now, let's resume the analysis of this circuit. So we said that the *VA* voltage equals 0 volts. The *V1* voltage that I can see in this node here and that node there is exactly the same, The same voltage appears here. Here, it is against the real mass and there, against the virtual mass, because there is no physical short circuit between those two nodes there. The current which I observed will continue its path and will come through here. Let's analyse *V2*. From here to there*V2* the current flows from the positive to the negative terminal, so knowing that this potential here is the same as what I can see there, and knowing that this potential is copied there, I conclude that the *V2* voltage is exactly the same as what I can see in that direction there. This is the *V2* voltage.

Notes

Summary

3m 50s

Amplificateur inverseur

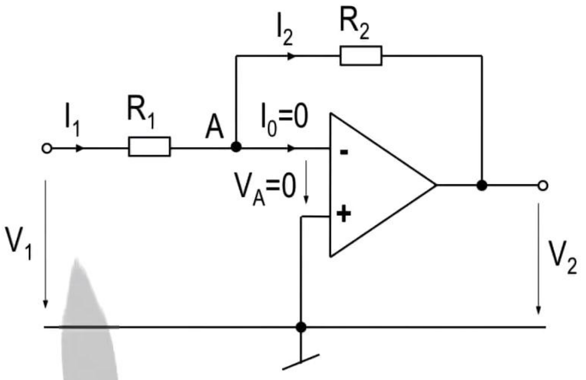
- Etape 1: potentiel au nœud A

$$V_A = -\Delta v = 0 \quad (\text{gain } A=\infty)$$

- Etape 2: Somme des courants nulle au nœud A

$$I_1 = I_2 + I_0 = \frac{V_1 - V_A}{R_1} = \frac{V_1}{R_1}$$

$$I_2 = \frac{V_A - V_2}{R_2} = -\frac{V_2}{R_2} = I_1$$



$$\frac{V_2}{V_1} = -\frac{R_2}{R_1} \qquad R_{in} = \frac{V_1}{I_1} = R_1$$

Electronique I

What you can see around this circuit shows you the relationship between *V1 I1*, *V2 I2* namely that *I1* is equal to *V2*. Now, let's write up write what happens when I write *I1 = V1/R1 =...* Note that the *V2* voltage is positive in this direction so (...) in accordance with Kirchhof's laws I have to put a minus sign on the current relation (that's - *V2* divided by the resistance *R2*.) By matching these two currents, we see a relation between *V1* and *V2* which are respectively proportionate to *R1* and *R2*, so we can write *V2 = V1 times R2 divided by R1* with a minus sign which derives from the fact that the two voltages flow in opposite directions. Here is a summary of what we have just observed. We've seen a step by step application of what has just been discussed, which has brought us to the link between the *V2* and *R2* voltage. and this has enabled us to look at a type of circuit which is called the inverted operational amplifier circuit, It has two resistances, which gives us a relation with a phase inversion using a minus sign. The current that enters this *V1* amplifier corresponds to the value of resistance that we have chosen.

Notes

Summary

4m 50s

Amplificateur inverseur

- Etape 1: potentiel au nœud A

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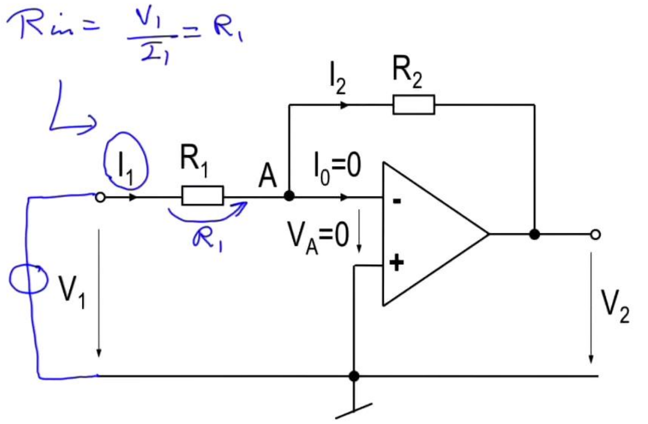
- Etape 2: Somme des courants nulle au nœud A

$$I_1 = I_2 + I_0 = \frac{V_1 - V_A}{R_1} = \frac{V_1}{R_1}$$

$$I_2 = \frac{V_A - V_2}{R_2} = -\frac{V_2}{R_2} = I_1$$



$$\frac{100K}{10K} = \frac{10K}{1K} = \frac{V_2}{V_1} = -\frac{R_2}{R_1}$$

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

Electronique I

If we reflect on what this means, If you connect a source here, this source there will have to provide the *I1* current, and this *I1* current is totally proportionate to the value of *V1*, which is the value of your source, and which will have the *R1* resistance as its charge resistance. And we call this an internal resistance. It's the resistance that we see when we look at the amplifier from this node and it is called *R in* which is equal to *V1/I1*, so in this instance to the *R1* resistance. So the source you are going to connect there will have to be debited in a resistance which has the resistance value that you have chosen. This brings us back to the next point: you can see there is a *R2* on *R1*, so the amplifier's gain, the relation between output and input voltage is *R2* sur *R1*. It's a given value. And this given value is completely independent of the absolute value of *R2* and of *R1*. If you want an outcome equal to ten, you only have to choose a resistance of 10 KΩ on a resistance of 1 KΩ, but you can also use 100 KΩ divided by 10 KΩ. You can continue like that, as all this equals to ten.

Notes

Summary

6m 43s

Amplificateur inverseur

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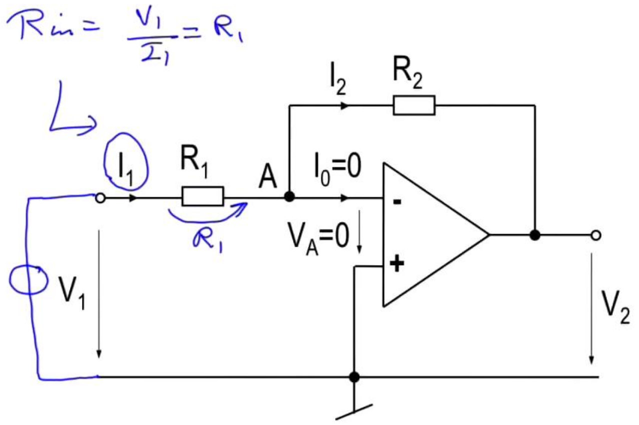
$$I_1 = I_2 + I_0 = \frac{V_1 - V_A}{R_1} = \frac{V_1}{R_1}$$

$$I_2 = \frac{V_A - V_2}{R_2} = -\frac{V_2}{R_2} = I_1$$



$$\frac{100K}{10K} = \frac{10K}{1K} = \frac{V_2}{V_1} = -\frac{R_2}{R_1} \qquad R_{in} = \frac{V_1}{I_1} = R_1$$

Electronique I

And yet, if you look at the *I1* current that you will consume and which will be provided by the source, this current there isn't observing the gain, it's observing your input resistance. What happens if you connect a source here which can't provide the necessary current for the *R1* resistance, you run the risk of not being able to provide enough power to the *R1* to allow for the signal to be converted into output voltage. Don't forget that the whole of the current which leaves from this side is the current that your amplifier is capable of giving, so the resistance relation seems to incur a gain, therefore a multiplication between the output voltage and the input voltage and that the input resistance which is linked to the absolute value of the *R1* resistance risks being a restrictive factor and leads us to reflect prior to choosing the resistance relation in order to determine what current we will produce in the input resistance.

Notes

Summary

8m 12s