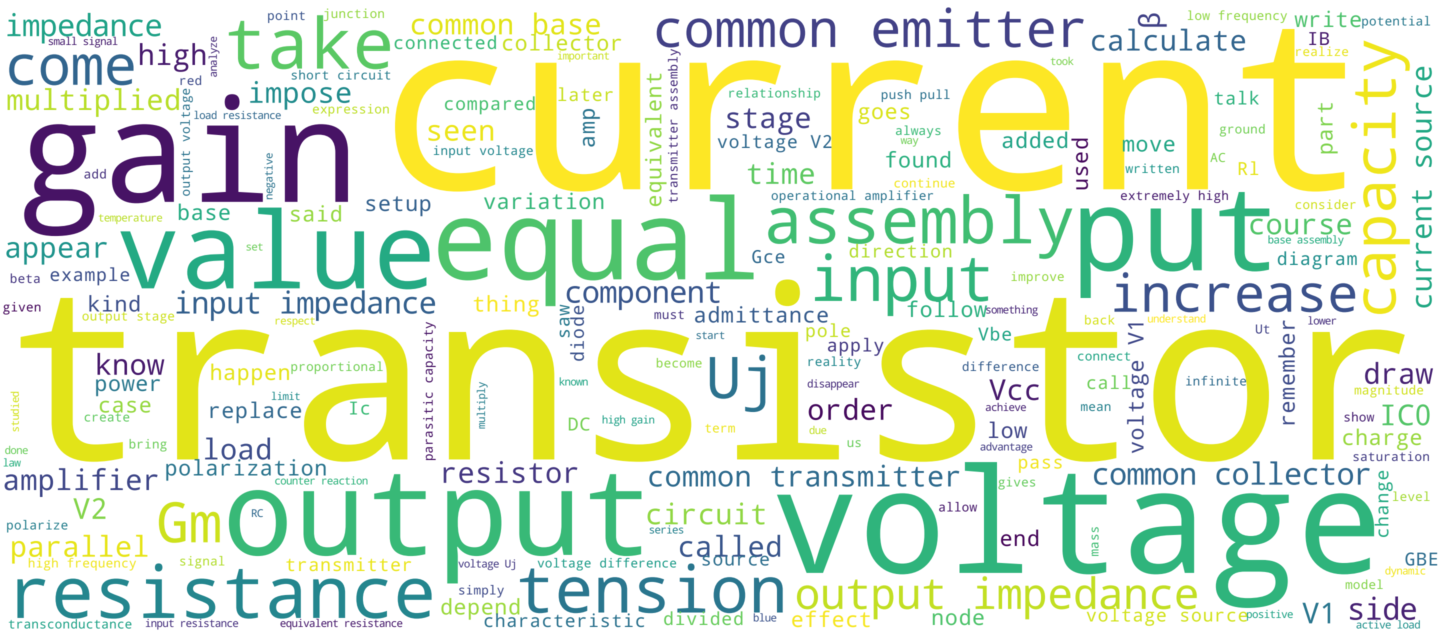
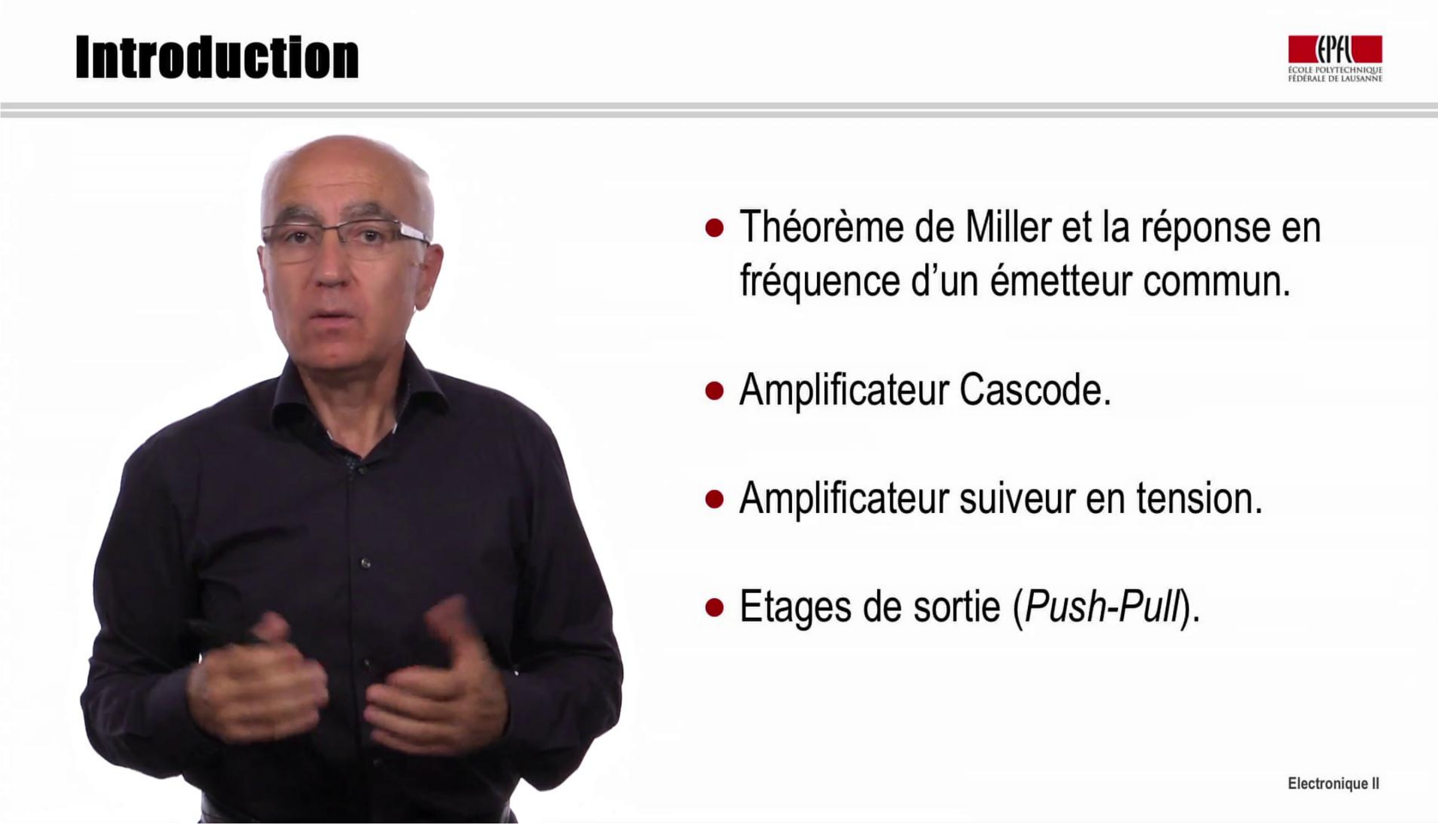
5.3-Amplificateurs élémentaires à transistors

Amplificateurs cascode et suiveur

Prof. Maher Kayal
Electronics Laboratory-ELAB



Video

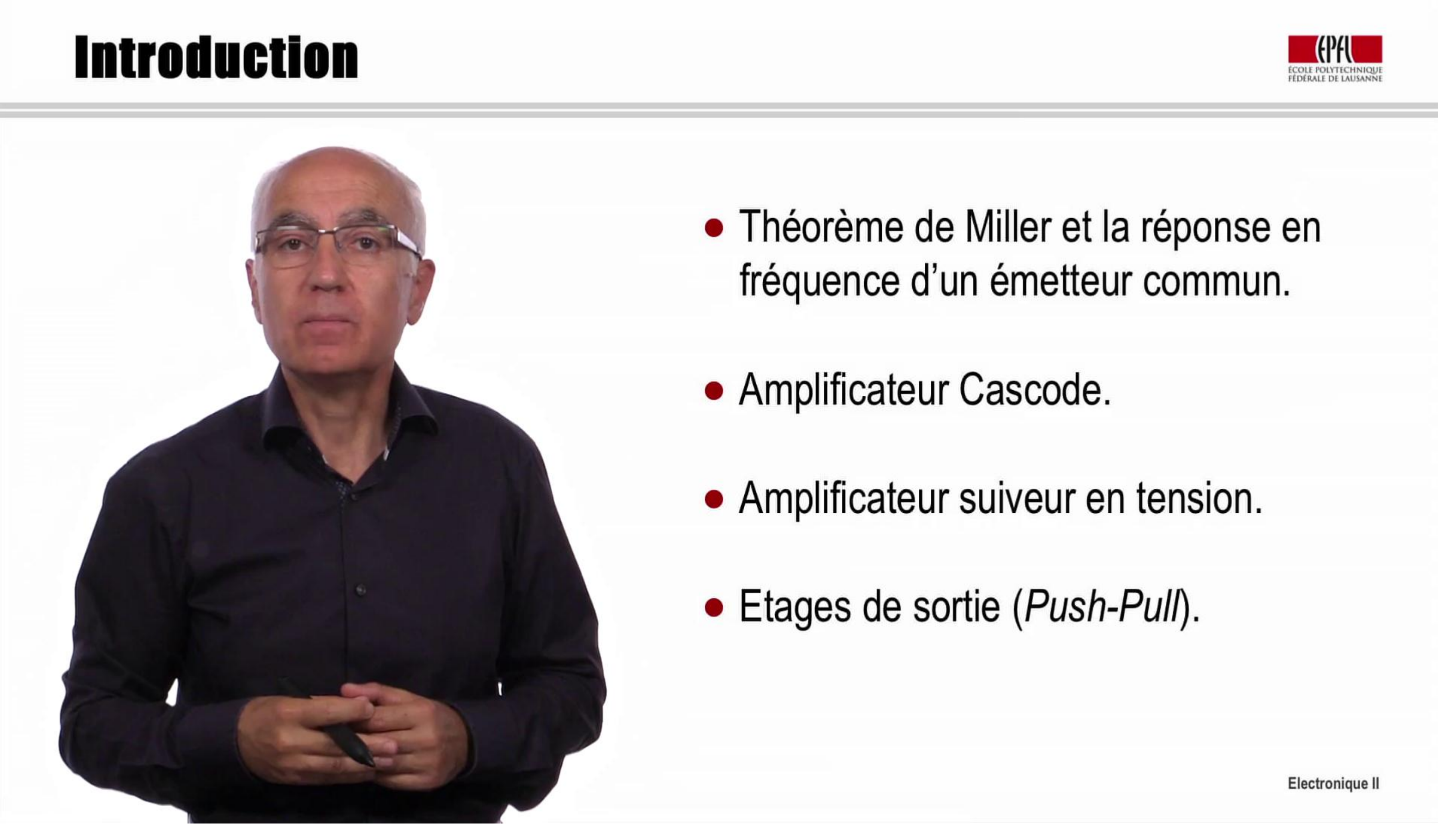


So we will continue the study of the voltage amplifiers therefore we analyzed the assemblies that will make gains in voltage then we realized it is mainly the common emitter assembly we had seen that the common base does the same thing but you will see today we will try to put the two together to do the following thing. That is in this part of the course we will realize that there is a limitation and these limitations are mainly frequency limitations. One, we do it ourselves, it's when we cut the DC component that limitation in low frequency when you put the coupling and decoupling capabilities and there we will realize that there is a high frequency limitation and frequencies are limited by a parasitic capacitance. We will first introduce the phenomenon or the Miller theorem which explains why a parasitic capacitance between the input and the output will have some high frequency effect for common emitter assemblies and we will improve the common emitter assembly by passing to an assembly that has already been studied and these are the Cascode assemblies. So we will pass through the Cascode assembly which in reality is the serialization of a common emitter and common base assembly and we will end the set by analysing the so-called output stages.

Notes

Summary

0m 05s

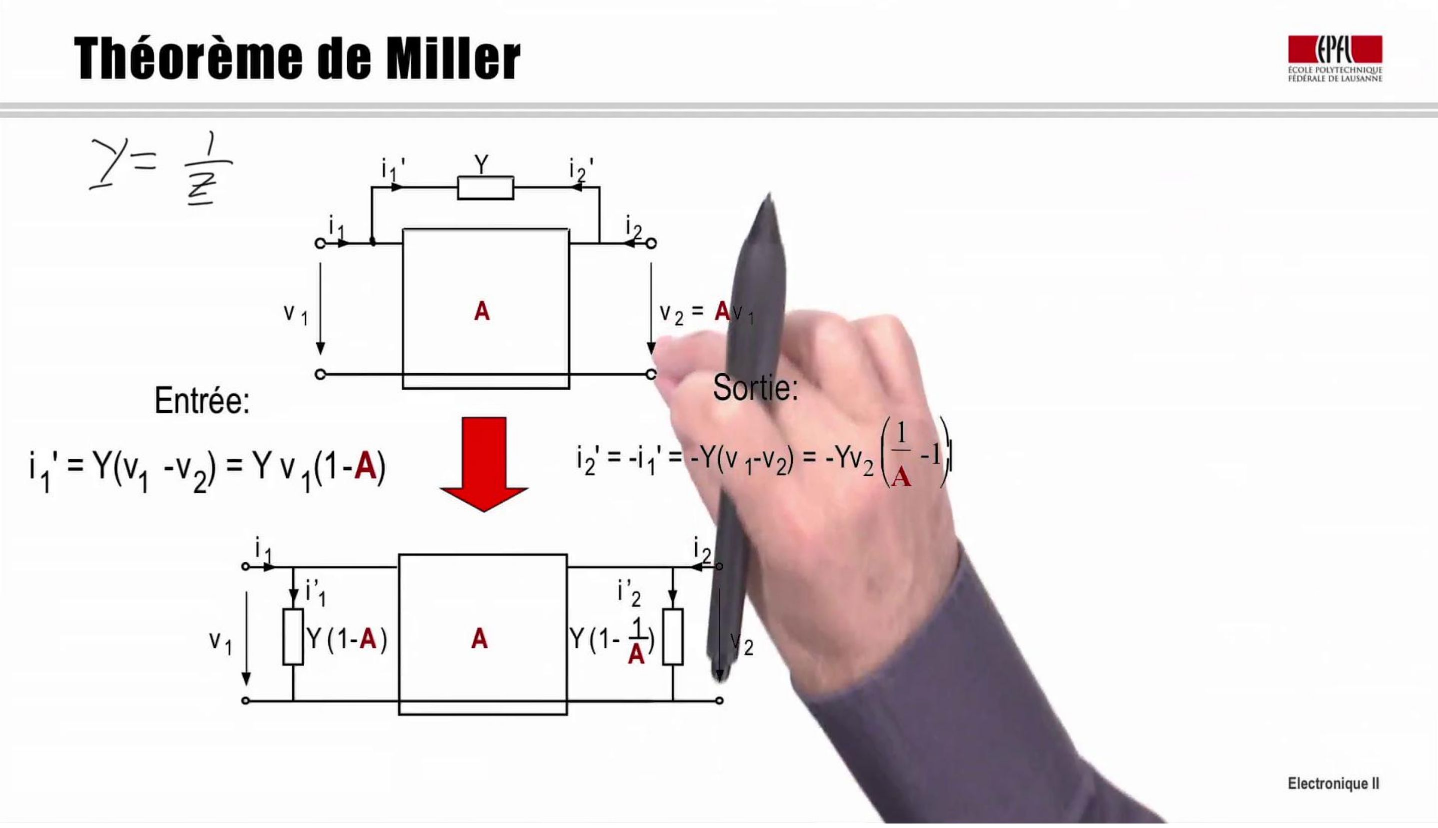


This is how to take an amplifier whose role is not to boost the voltage, but especially to make a buffer between a voltage stage and an external load and avoid having to degrade the gain of a common transmitter assembly or an assembly that achieves gain. You'll see it will be the common collector assembly that will play the role of a quintessential power amplifier it'll be a voltage follower, it follows the voltage but it will amplify the current and lower the output impedance. And we end with an improvement or some additional assemblies that follow the common collector assembly called the "push-pull", you will see what it is it's a little common collector improved slightly for a superior dynamics of this kind of installation.

Notes

Summary

1m 25s

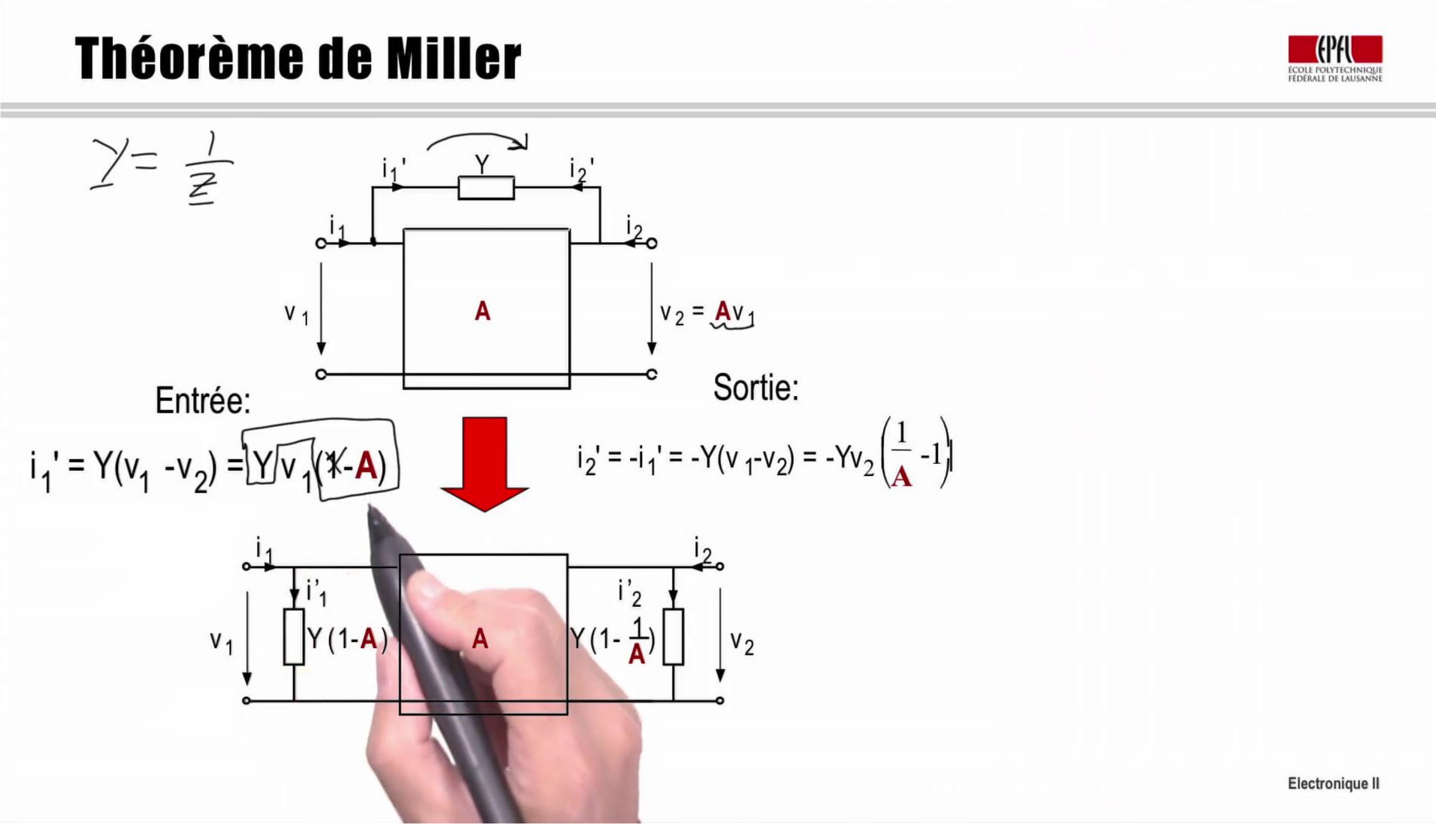


To start... I will address this Miller theorem. Miller theorem is a simple idea, if you take an amplifier and chance is there an impedance an admittance here I speak of an admittance So I remind you an admittance is simply Y=1/Z, it's the inverse of impedance. If you have an impedance which is between input and output where there is a component that comes between the input and the output, we will bring it back to the input and we'll see that this component appears here it could be presented as a load at the input. And an equivalent load at the input and the output which is proportional to this admittance and proportional to the gain. We can see it simply by analyzing what happens with the current in this node. If you take the node here and you will see that in the quadrupole which is your amp, there is an input voltage and an input current so a component of this current will pass through your admittance. And will continue its way to the output. But there is a gain between the two. That is to say, the output voltage V2, it is much larger than the input voltage V1 because there is the gain which multiplies the voltage V1. So the tension here and the tension there are related by this A which is between the two.

Notes

Summary

2m 20s

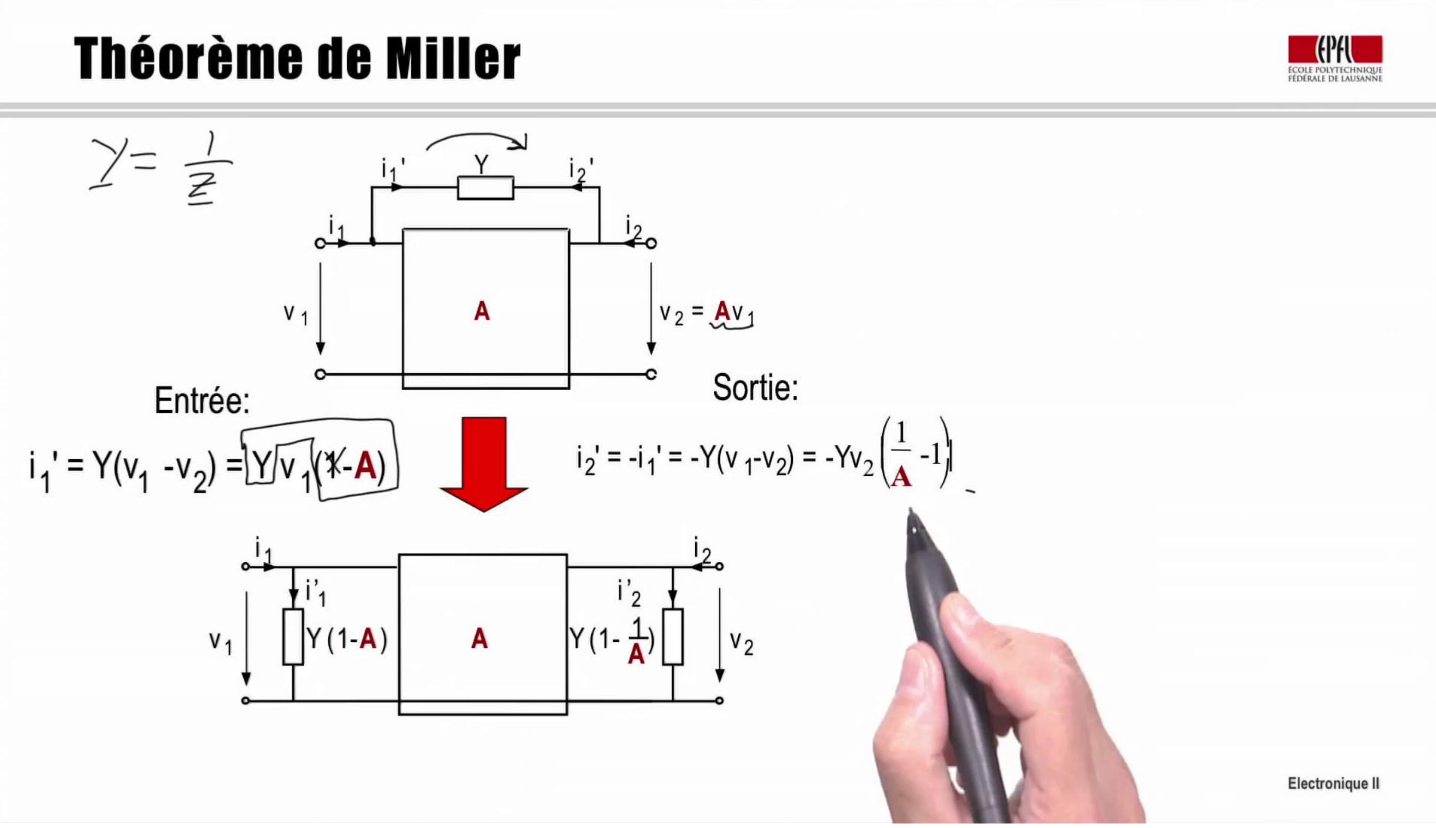


We will write this: that is to say the current which passes through this admittance it is called I' it is the value of the admittance which multiplies the difference voltage V1 - V2 So V1 - V2 is this vector that you see here. So if you change the value of V2 by the relationship we have here So I replace V2 by A x V1 and well we fall on this: we can take conspicuously V1 it will say that the admittance you see between the input and output will multiply the voltage and your impedance rather your voltage will be multiplied by 1 - A. So in reality, you have to see it like this, it is as if we took the admittance that is there and we replaced its value by this, so you have the equivalent of which is between the input and output but multiplied by 1 - A and A is a gain. A gain by definition is a high value so if this gain, we will take an example, you have a gain that is for the order of 1000, You have 1-1000, 1 with respect to 1000 can be neglected, you will find yourself with -A multiplying the value of Y. So we will continue our reflection if by chance A is a negative gain, it is like an example of a common emitter, So you'll find yourself with Y minus minus something it will give you the impedance or the admittance which will be multiplied by a gain and this minus sign will disappear.

Notes

Summary

3m 45s

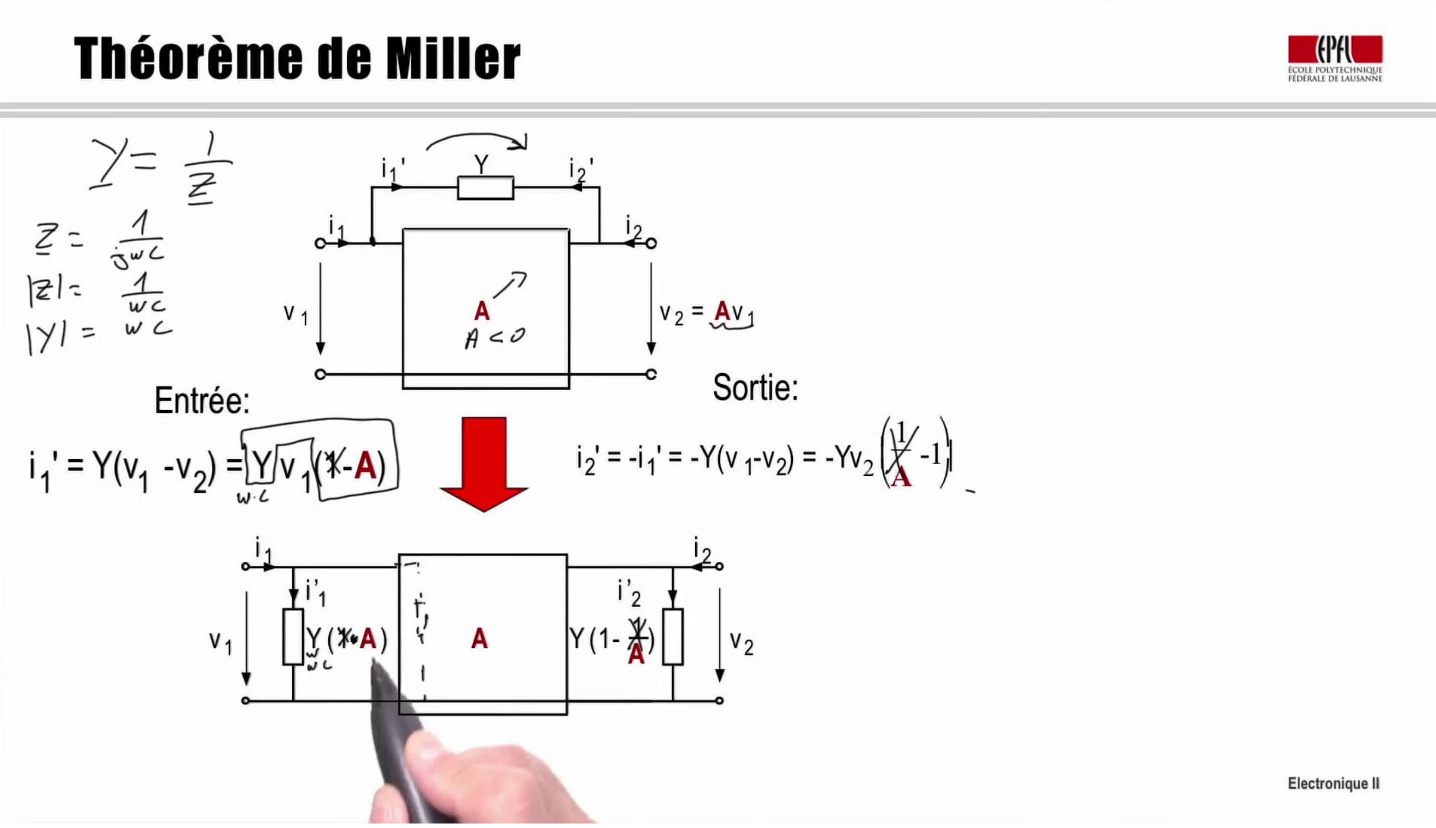


So we'll see it in practice. Before looking at it concretely I'd just like to show that you repeat the same thing at the output you will see that expression so at the output you express the current I'2 which is written here according to the voltage difference V1 - V2, you will find that it's -YV2 multiplying (1/A)-1. If A is high, this it tends towards 0, you'll find yourself with the minus and the minus here that will cancel each other out so it will give you a positive sign and when you find yourself with your admittance, which appears at the output multiplied by this factor it's like the equivalent of your admittance tipped it appears at the output with its own value in parallel with the output impedance, remember that within the quadrupole you will have an input impedance and an output impedance of course and that this input impedance is still here we don't see it we draw it here, but you will see that in reality at the input it's quite tricky at the output it is the value itself, more or less, yet at the input it is the value multiplied by -A So your admittance had a sign first positive, normal it's a passive component It will be found with a negative sign.

Notes

Summary

5m 22s

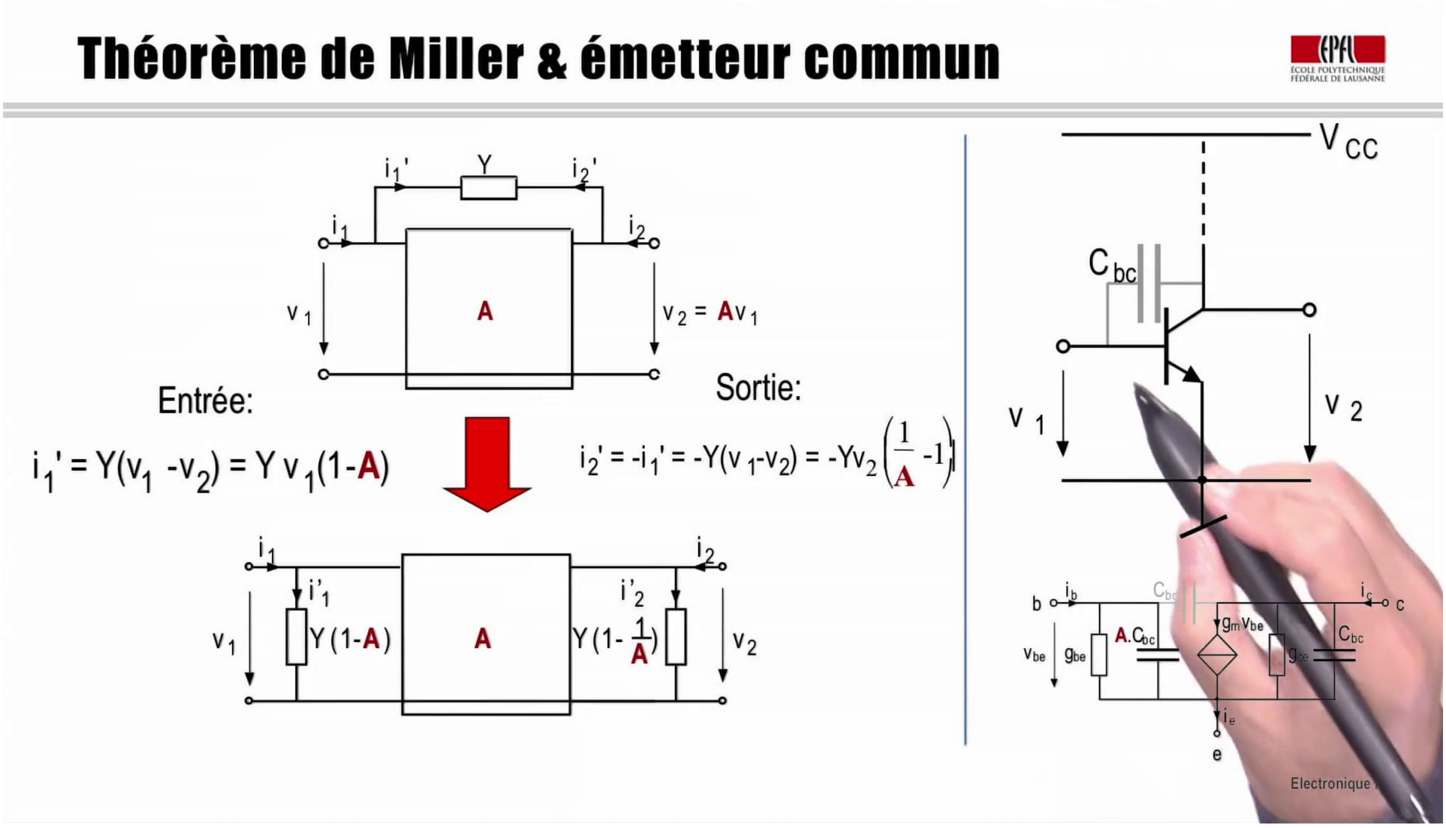


At the output it is the real admittance that is at the output, so that's what is most dangerous because here there is a gain. So we have boosted the value of a component wich has been added between the input and the output by the gain the more the gain is increased, the more this factor A increases, the more the value of the admittance is found increased by the value of the gain which is being increased with. So I'll take an example of a capacitive impedance. I remind you the impedance of a capacity: it's 1 / JΩC, if you are looking for the Z module you find it's 1 / ΩC, so the admittance Y and 1 is equal to ΩC. Imagine that you have a capacity which is between the input and the output and this capacity, its admittance is Ω x C and that Y one you write it here Ω x C and your A gain is negative if your gain is negative you will find yourself with minus minus the negative gain so you'll see here the equivalent of A times that ΩC. So it's like your capacity has been multiplied by a gain. It's A x C for the pulsation to which you apply a voltage at the input which has a variation that has a given pulse but then your passive component which ended up between the input to the output that you have added or it ended up as a parasite component, it was multiplied by a gain equal to A.

Notes

Summary

6m 46s

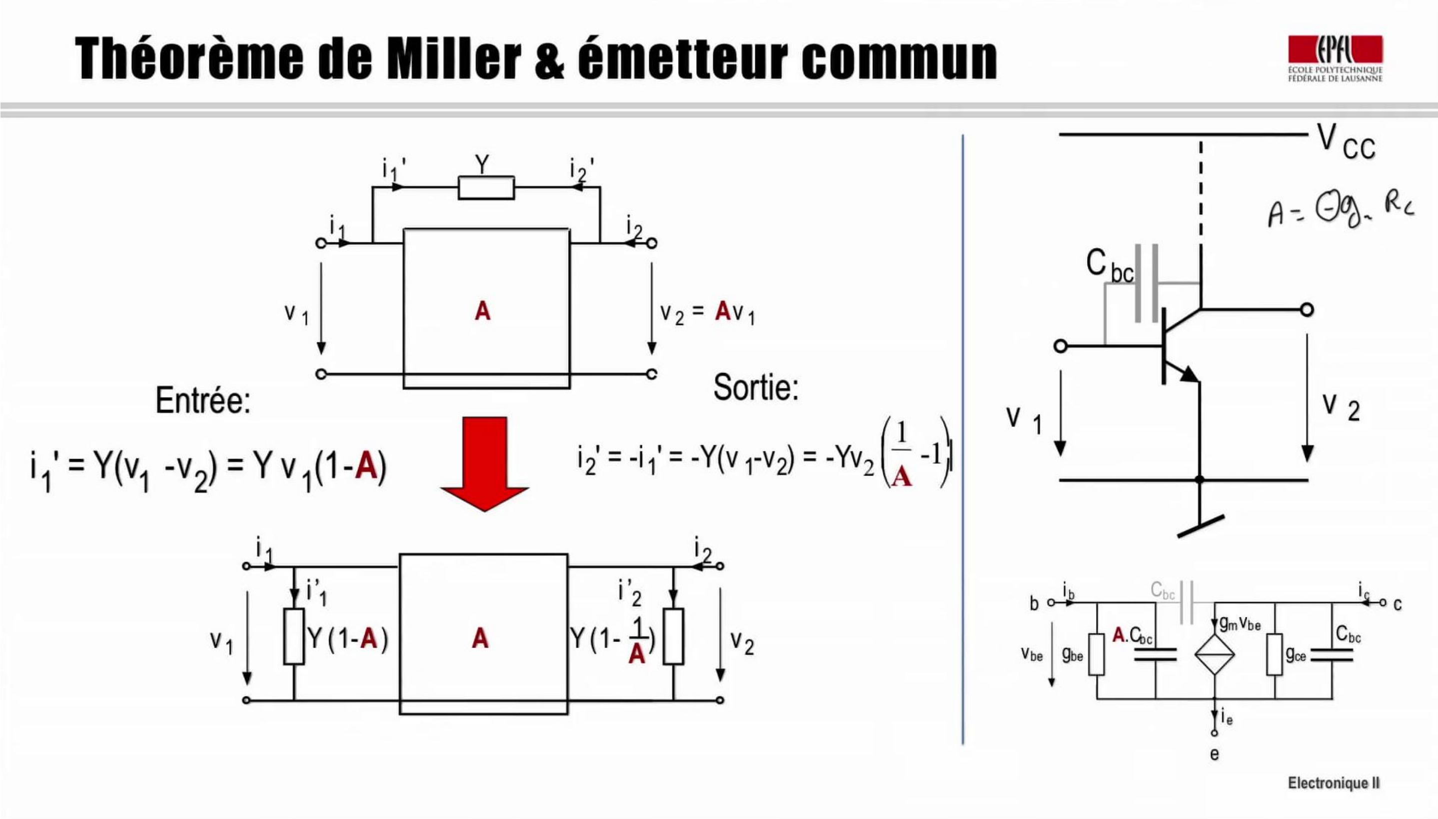


And the more you increase the gain, the more your capacity becomes greater. Imagine that there you have a value or an input resistor and your capacity comes in parallel with this resistance and you end up with a capacity in parallel with a resistance and that, is the equivalent scheme. The capacity is ΩC, it is found here at ΩC x A So your capacity becomes huge multiplied by the gain. So you end up with that famous problem that the Miller theorem seeks to express pay attention, there is a relationship between the components that are in counter-reaction between input and output and the gain you want to achieve. It's true that this is not very important to the output even though your component it appears at the output but at the entrance, your gain it will contribute to this. And it's the case of a common transmitter assembly. Let's see this. This is what I just explained, and here is your common emitter. The common emitter has a capacity between base and collector. actually your transistor has parasitic capacities. There is one between base and collector, one between base and emitter and one between collector and emitter.

Notes

Summary

8m 33s

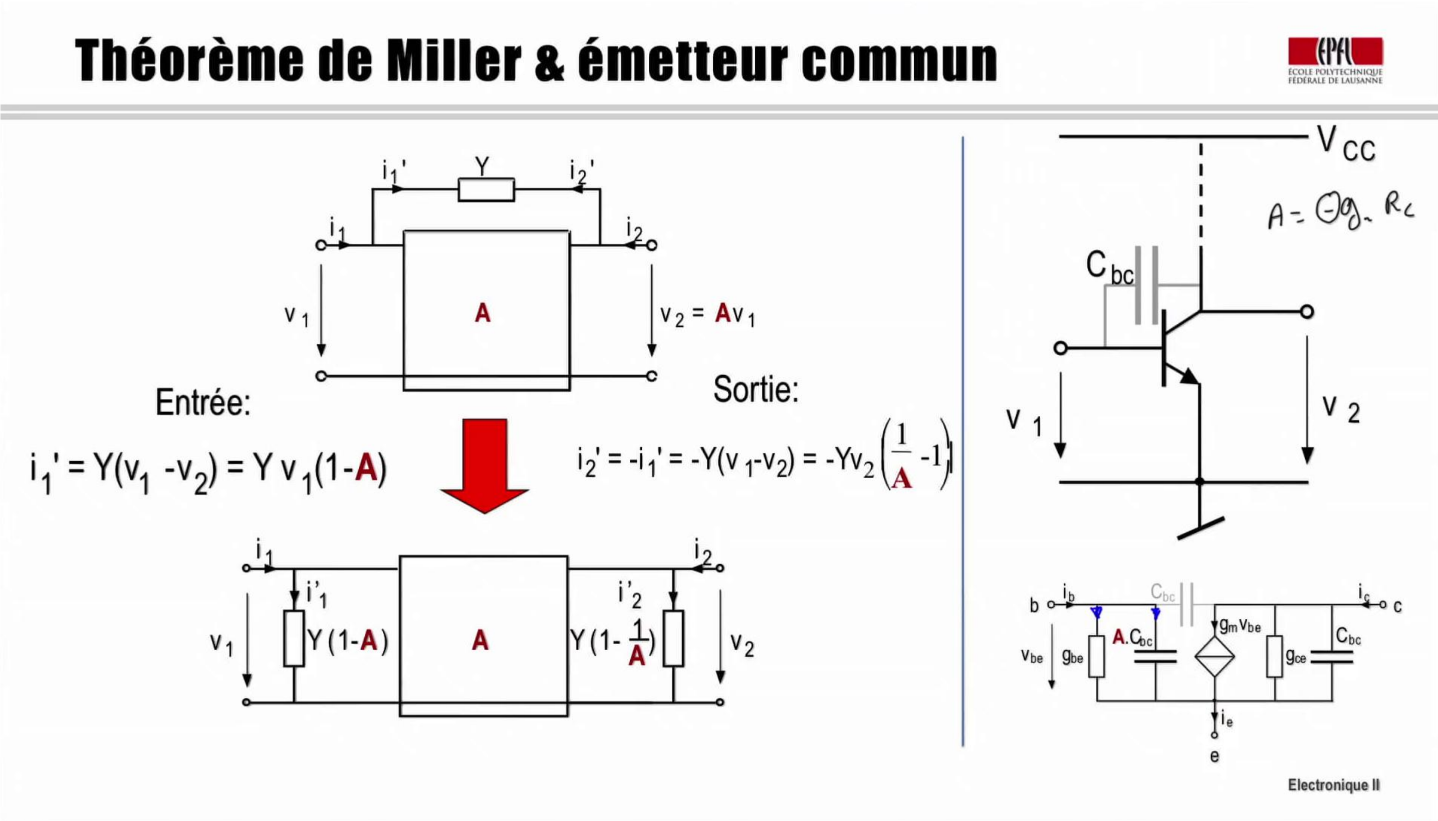


That is the reality of all electronic components there is capacities of a given value that are not intended but they are parasitic capacities, so it is not capacities we added ourselves, they are found in the component itself regardless of its value. When you take your common emitter and you'll put a load here, this load I don't present it here, it is simply to say it will be used to give me a gain A = - GN times the load resistance. If this load resistance is very high, typically a current source, so it can be infinite so you will have an extremely high gain, and well your parasitic capacity that is there it is indeed between the input and the output and between the input and the output: that is V1, that is V2, that is V1, that is V2. The equivalent of this capacity, according to Miller, will appear at the input multiplied by the amplifier gain and the gain of the amplifier is negative. So you will multiply a non-visible passive component, parasitic, by a gain and the gain it's your own wish when you make the amp but this component, it appears in parallel with the common emitter input impedance which is in reality a resistance of a value 1 / GBE.

Notes

Summary

9m 59s



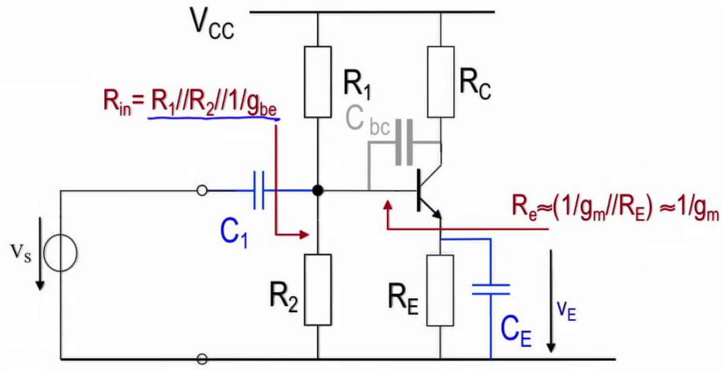
So if you inject a current here it finds itself on a path it can go in the 1 / GBE, a resistance and it will also want to go through that capacity whose value of the parasitic capacity may be of one pico, but multiplied by a gain may be a gain equal to 1000 it will end multiplied by 1,000 times the 1 pico so you will have a capacity equivalent to the input in nanofarads in parallel with a resistor. So the current that will pass through the capacity will increase due to the value that has been boosted by the gain and you limit the bandwidth of your signal, because this impedance will pull down the voltage level, so you find yourself with an amplifier that has a pole that appears towards the high frequencies and the more one increases the gain the more this capacity will crack down, it will drop our amplifier bandwidth and we can not do anything with the assembly as it is because we are not the ones that added that. This is related to the component itself. I talked about high frequency limitation so the Miller effect will act on a high frequency pole which is equal to 1 / GBE parallel to A x CBC And CBC c is the parasitic capacity between the input and the output that you find which is given by the manufacturer.

Notes

Summary

11m 19s

Réponse basse fréquence d'un émetteur commun



Il y a deux pôles basses fréquences :

$$f_{p1} = \frac{1}{2\pi C_1 R_{in}} = \frac{1}{2\pi C_1 \left(\frac{1}{g_{be}} // R_2 // R_1\right)}$$

$$f_{p2} \approx \frac{1}{2\pi C_E \left(\frac{1}{g_m} // R_E\right)} \approx \frac{g_m}{2\pi C_E}$$

Electronique II

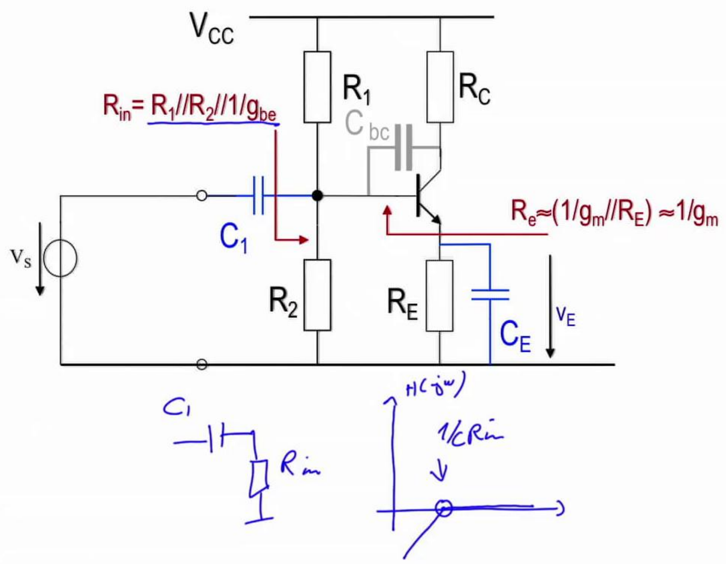
So I'll go see the low frequency capacities, we will now look at the low-frequency effect, there are two capacities that we have added ourselves possibly even a third one if we will look at what happens on that side and we will imagine that we put our load here and we added a capacity. The role of this capacity is indeed to create a limitation for low frequencies because we would like to contact an AC signal and decouple the DC component, so the component that has a zero frequency we would like to cut it, so we added this capacity. If you look at this complete common transmitter assembly now, with this capacity taking the role of bringing the transmitter to ground and this capacity to couple the AC component, I considered that the source resistance is 0 then this capacity what will it have? If I put my hand on all the assembly on this side there and I consider that this capacity is already acting, so it has short-circuited the resistance, this assembly we have already calculated its input impedance and we saw that the input impedance is this expression there, It is the parallelization of R1 parallel with R2 parallel with 1 / GBE I see from here. So all my assembly, it becomes an equivalent resistance.

Notes

Summary

12m 45s

Réponse basse fréquence d'un émetteur commun



Il y a deux pôles basses fréquences :

$$f_{p1} = \frac{1}{2\pi C_1 R_{in}} = \frac{1}{2\pi C_1 (\frac{1}{g_{be}} // R_2 // R_1)}$$

$$f_{p2} \approx \frac{1}{2\pi C_E (\frac{1}{g_m} // R_E)} \approx \frac{g_m}{2\pi C_E}$$

Electronique II

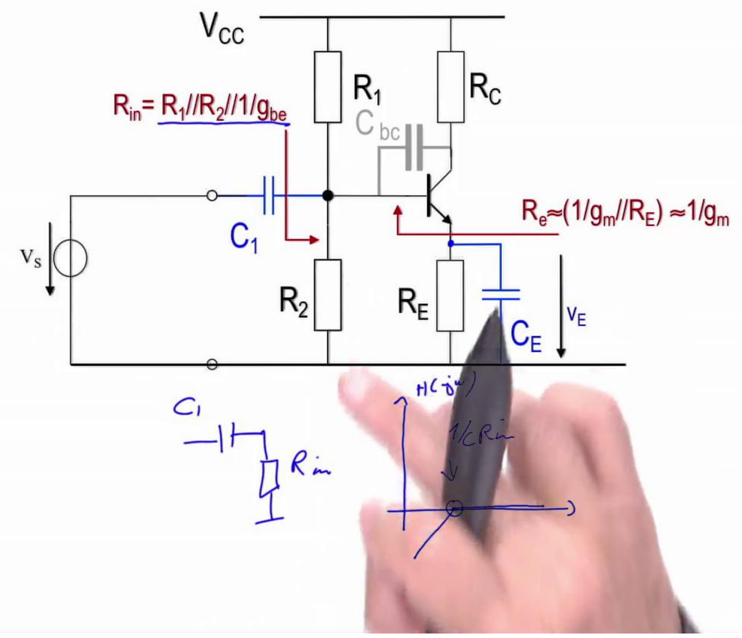
So if I draw under my equivalent circuit, I'll find myself with a capacity C1 and an input resistance and this input resistance is Rin. And this is a RC circuit of high pass nature, so in a Bode diagram it will create an H(jΩ) that has a pole that will appear at 1 / CRin. So I find myself with this pulsation which creates me precisely the limitation in low frequency. Is it the unique capacity? no, there is a second one. This capacity, its expression is there, So we see that the input impedance is what I noticed here, therefore the Rin is what we calculated. Of course I considered at that time that the EC capacity is acting, so I put the transmitter to the ground otherwise I should have written in addition than that... that the expression 1 / GBE R1 parallel with R2 parallel to β1 / GBE + βRE but I considered that there is no component in the resistance RE that it is already short-circuited by the capacity. We are used to doing that, that is to say, we decouple when we solve this kind of problem, the effect of two capabilities that is of course an approximation because if the two cutoff frequencies are close there is the contribution of one of the capacities in relation to the other.

Notes

Summary

14m 07s

Réponse basse fréquence d'un émetteur commun



Il y a deux pôles basses fréquences :

$$f_{p1} = \frac{1}{2\pi C_1 R_{in}} = \frac{1}{2\pi C_1 (\frac{1}{g_{be}} // R_2 // R_1)}$$

$$f_{p2} \approx \frac{1}{2\pi C_E (\frac{1}{g_m} // R_E)} \approx \frac{g_m}{2\pi C_E}$$

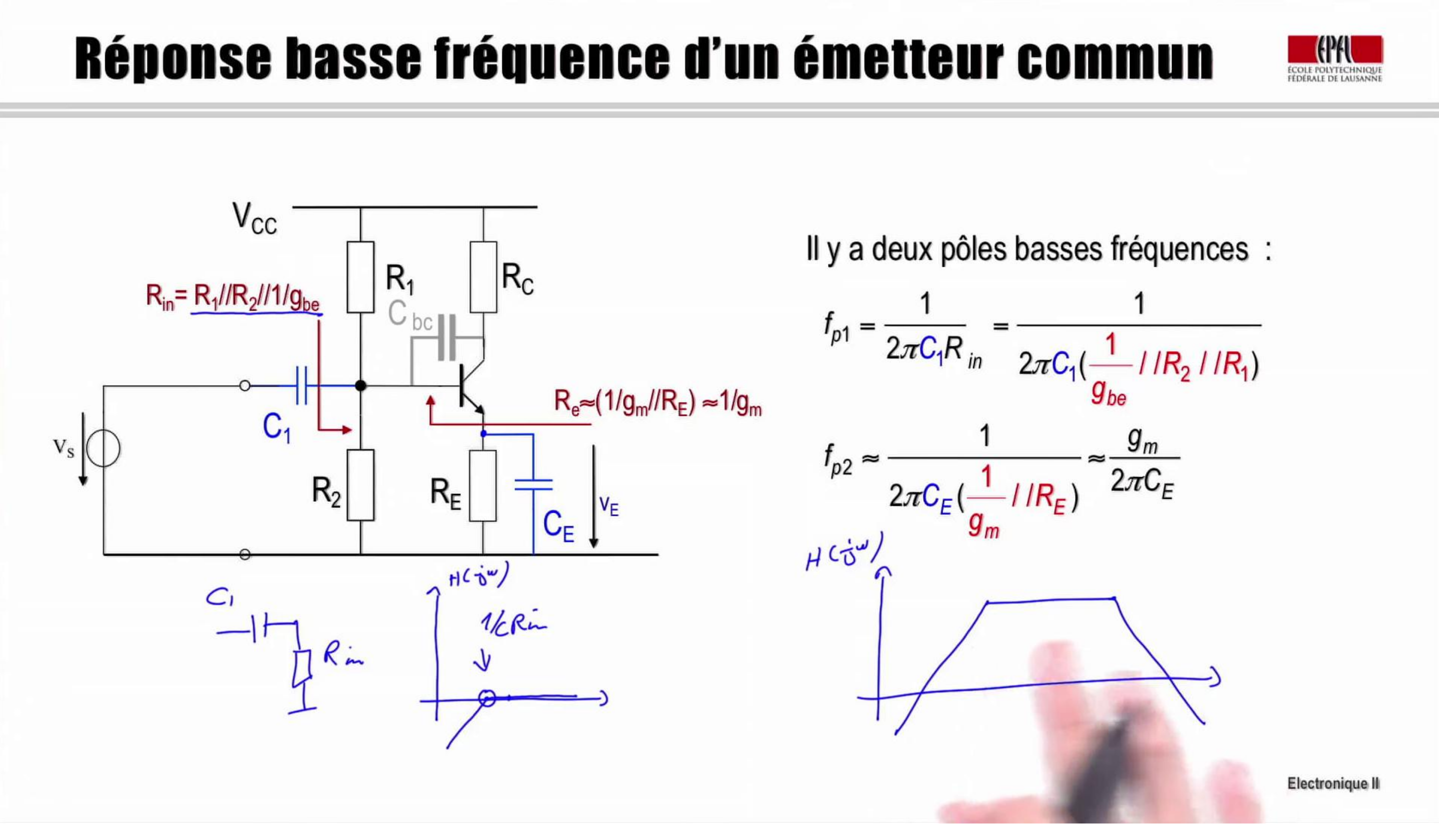
Electronique II

Given that we are interested when we make this kind of amplifier to the flat portion of these characteristics, it's when we have the gain so we consider that both the effect of this resistance and this capacity or all that resistance and capacity we assimilate it as if one has already acted and calculating for the other and the two effects are superimposed in a diagram of Bode. Now if I have to apply the same and look at the effect of that capacity. The same ! I put my finger where I have my capacity node and all the rest of my circuit I transform it into an equivalent resistance. So I have to watch the equivalent resistance that I see from here. Having obviously the assembly or diagram equivalent to AC, I know that without the resistance RE I see from here it's approximately of the order of 1 / GM, otherwise there is R1 parallel with R2 divided by... sorry, R1 parallel with R2 multiplied by β that will also give me a resistor that comes in parallel but we consider that the 1 / GM is the smallest resistance then and when you put a resistor in parallel RE must be taken into account so if there is RE parallel with 1 / GM parallel with the effect of these two resistances well you'll find an equivalent resistance here And that I think a student who took the course so far knows how to calculate the equivalent resistance AC in a node.

Notes

Summary

15m 41s

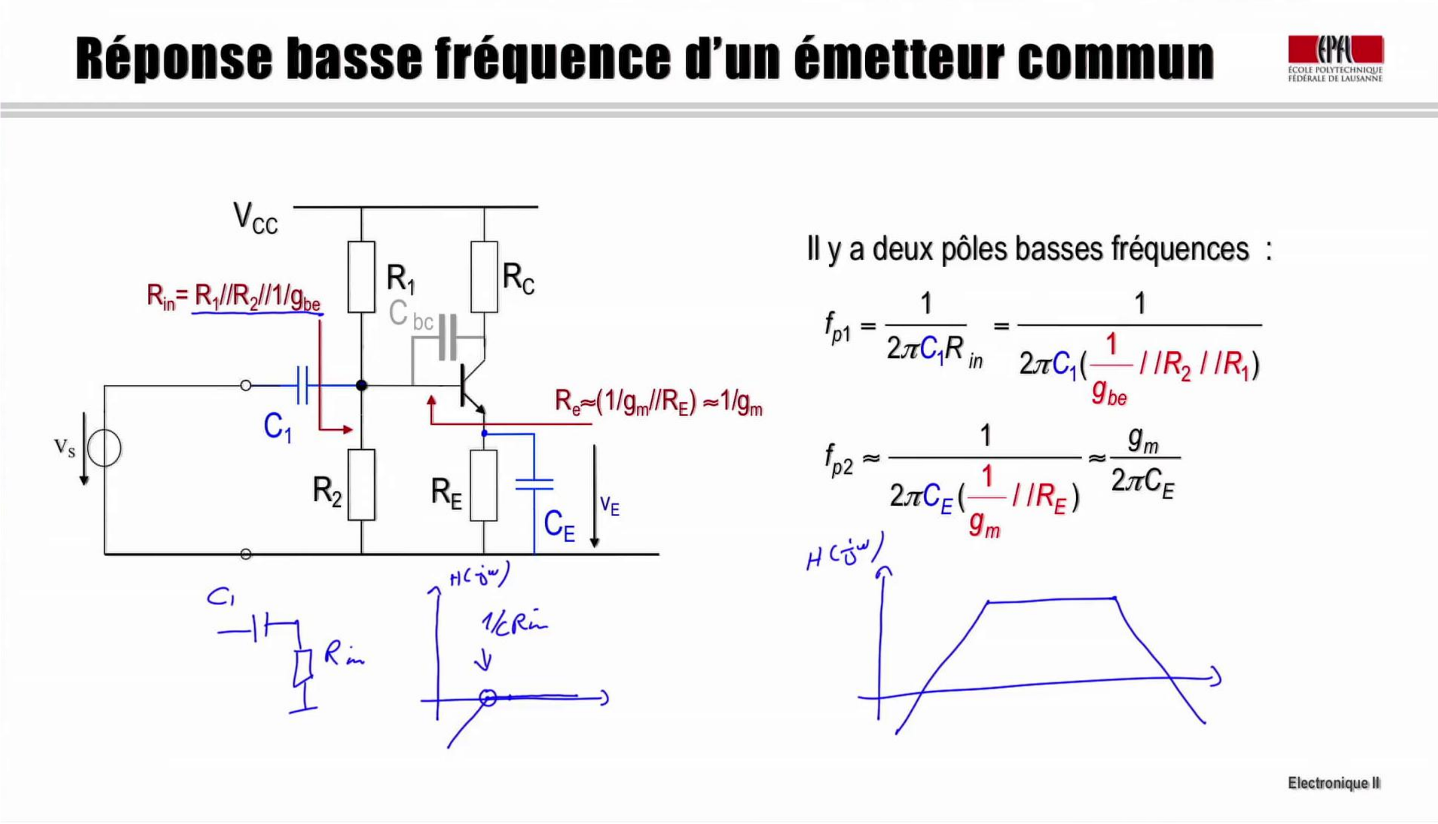


In this example there, it's the approximation that brings us back to 1 / GM parallel with RE and I neglected RE because quite often, it is a much higher resistance than the 1 / GM So what dominates is the smallest resistance it is 1 / GM. So again, I have here the contribution of 1 / GM and the EC capacity and I'll come up with a second pole the GM / 2 x π / E x EC and I find here an effect for low frequency, here another effect for the low frequency, I bring back this in my Bode and it will show me from what pole I'm getting in the asymptotic diagram the part that is flat, so from where my amplifier acts as a common emitter amplifier with low frequency limitation due to this this node and that node and a high frequency limitation which is due to the parasitic capacity we just saw before. So there, the bandwidth of an amplifier like that H (jω) will have a gain here which is proportional to GM times the load resistance and which will have a contribution here of these two poles for low frequencies and here the contribution of this capacity for high frequency. Thus the bandwidth is delimited by these two poles and by the pole which is due to this capacity for the high frequencies.

Notes

Summary

17m 10s

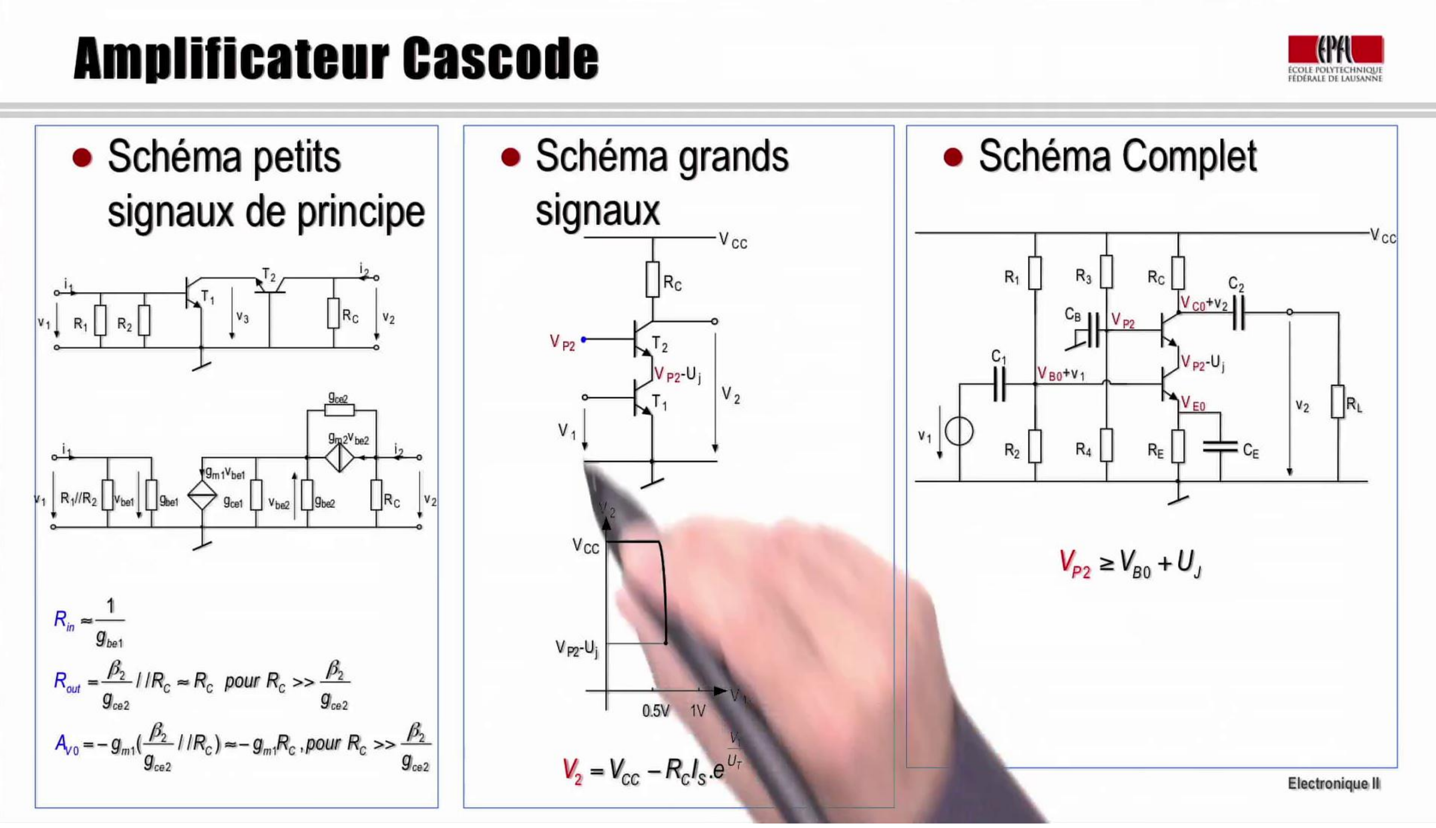


And there it is, when asked to look at the frequency response, we calculate these two poles and calculate the other. So I draw your attention that very often to calculate C1 and calculate EC well it is necessary to also make these calculations. If we want to create ourselves these low frequency poles well it is necessary to look at the value C1 when setting a value to FP1 Rin is known by the polarization and so I think you know very well calculate it well it will give you the value of C1 and if you impose a value for... the pole that appears here, well it is for you to calculate Ce knowing the 1 / Gm that you own from your assembly. And here it is, this is how one calculates the response during low and high frequency. It is exactly the same thing that would have been done with the common base assembly or common collector, there is no difference, it is always we put our pen at each place or a capacity, and we calculate the pole where there is this effect and we do the same here to find so we have a second capacity we look at this node there, everything else is down to resistance. In this case, all the rest consists of a resistance and we calculate the C times this resistance or the C times the equivalent resistance that appears in this node.

Notes

Summary

18m 48s

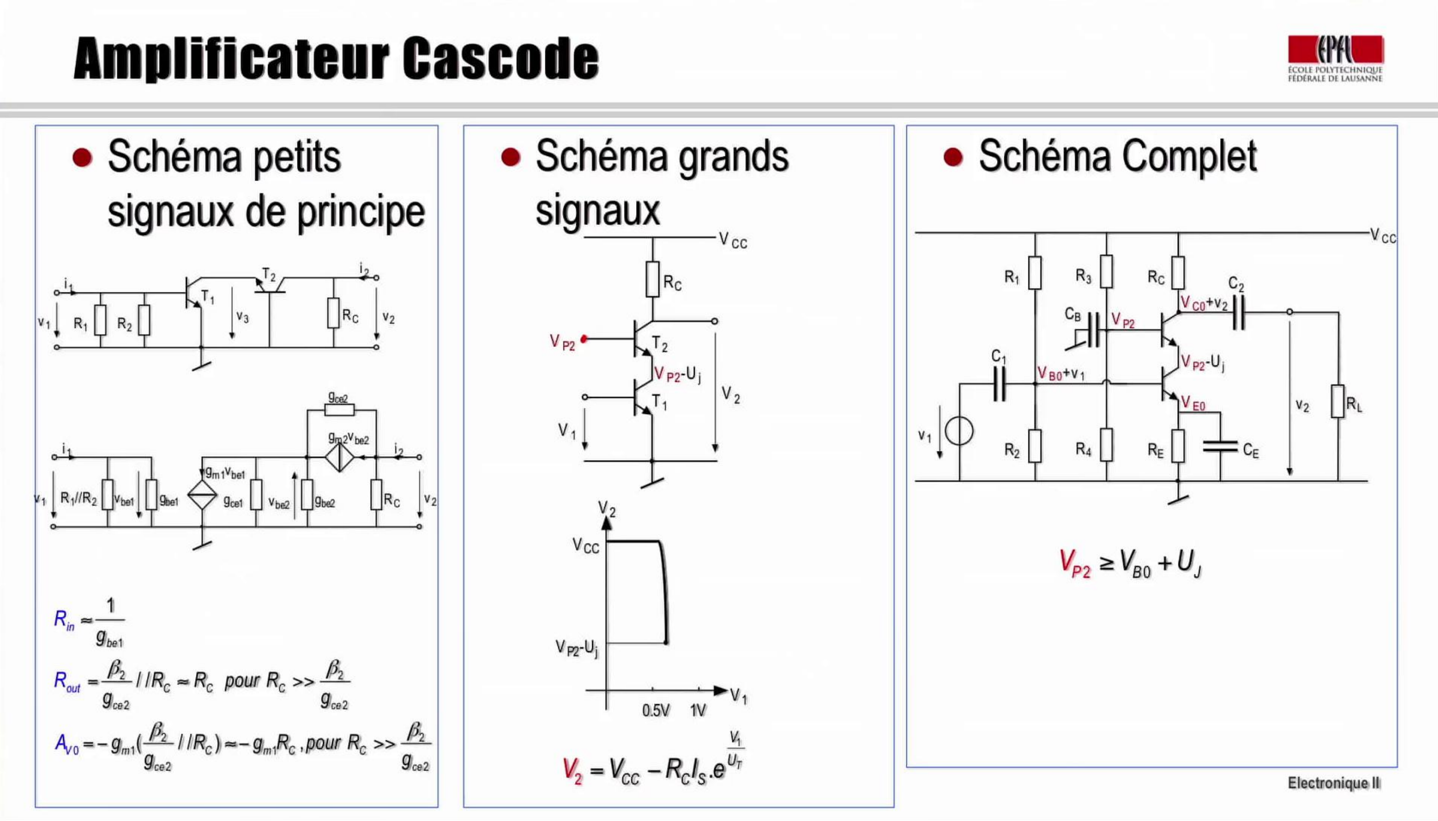


To improve the common transmitter assembly at least for this history of Miller capacity, we resorted to an amplifier which has already been studied it is called the Cascode amplifier. the Cascode assembly as presented just a few weeks back, it is shown that I have a common transmitter assembly but I put it right after... I put immediately after the common emitter common base. This is among the most usual use of the common base, it is in the Cascode assemblies that it will come after the common emitter assembly you can see it here or there, Here you see your common emitter it is in series with a common base assembly why common base? Because the base is a fixed potential. There I applied Vp2 so that potential there, and it is at mass that I created myself and this is where I realize it.

Notes

Summary

20m 11s

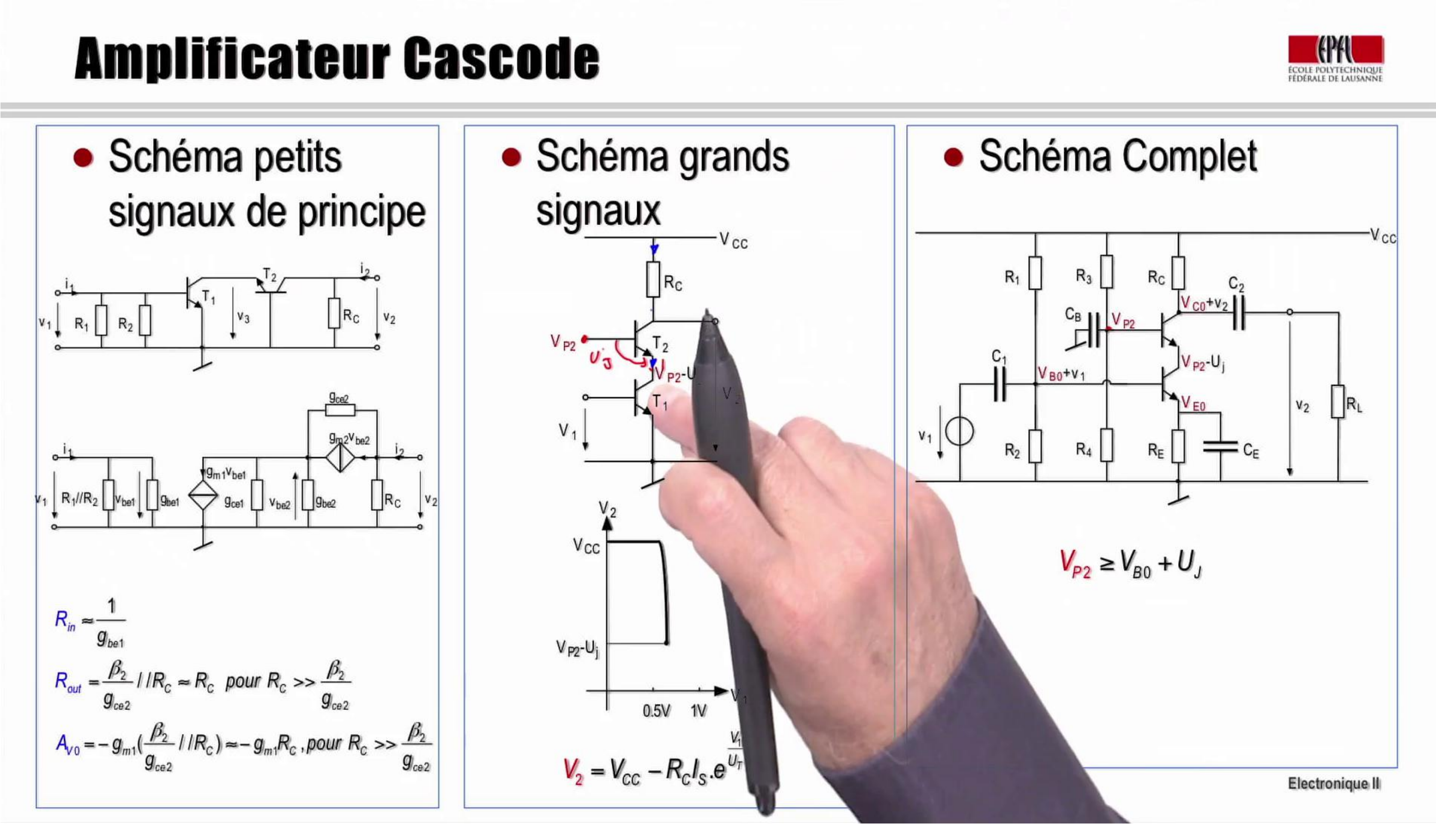


I take the common base assembly, I impose a fixed potential through a resistive divider, the same as I did for the common emitter to polarize it I calculate a DC potential that I call Vp2 I apply here, I usually also put a decoupling capacity, It is the same effect as this capacity, it is a quite large capacity that is used there so that capacity when it is loaded imposes a quasi stable potential that does not move here therefore it is practically a source of DC voltage we did the same for this potential and we come to take our common transmitter and we put through this the common base assembly before coming to charge. So in reality you see your load instead of the load being right on the collector, it is found after the common base, so in the collector of the common base. The output of the common transmitter enters in the input of the common base, you see the base it is in common between the input and the output as here the transmitter is in common between the input and the output, we already calculated all this so you know it, you know how to calculate the input impedance, the output impedance and the gain of this assembly. I'll comment just now on what it is and why.

Notes

Summary

21m 13s

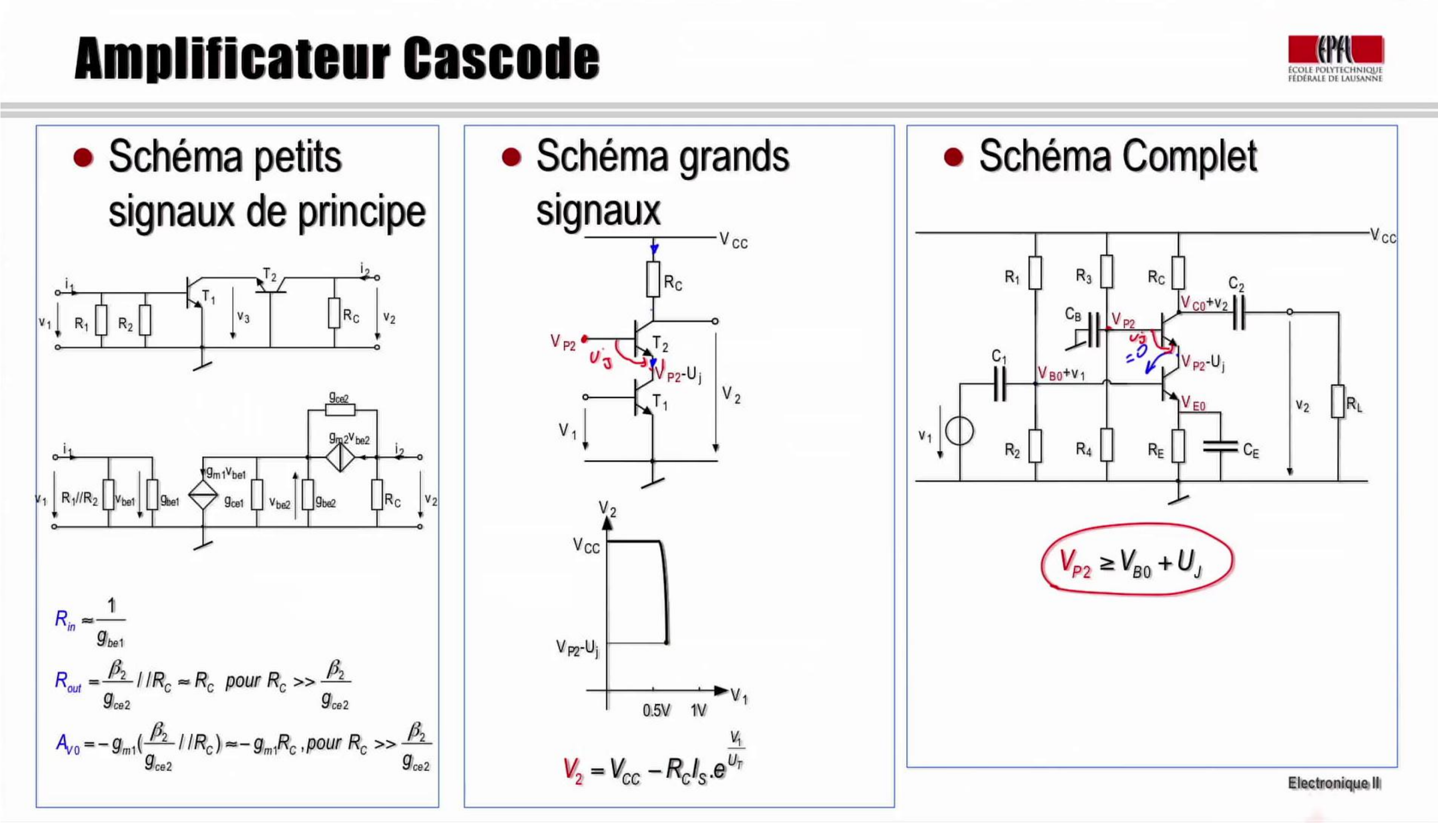


Simply, I would like to draw attention to those who have to do the polarization. What will happen with your collector of the common transmitter that is here, it will be found with a fairly stable potential. When you impose a potential VP2 based on your common base, that's this VP2 You drop this voltage by a UJ value, you end up with VP2-UJ, so this VP2-UJ is not supposed to move it's supposed to be stable, so the collector of your transistor is not seeing a DCPS signal which moves, it is practically stable DC. What moves in this story? You put a voltage V1 there, you convert it by transistor effect in a current. So your current that I will draw in blue, that's this current Δi which is there it is the same as there pretty much. So when you vary V1, you vary i and the current through the common base assembly which is a follower in current, the current that goes into the collector is the same as in the emitter, it will be directly returned from conversion all this current current current in the load, so it looks like the load is connected to the collector. But is the collector moving? No ! The collector, it is almost stable, not moving thanks to this polarization.

Notes

Summary

22m 31s

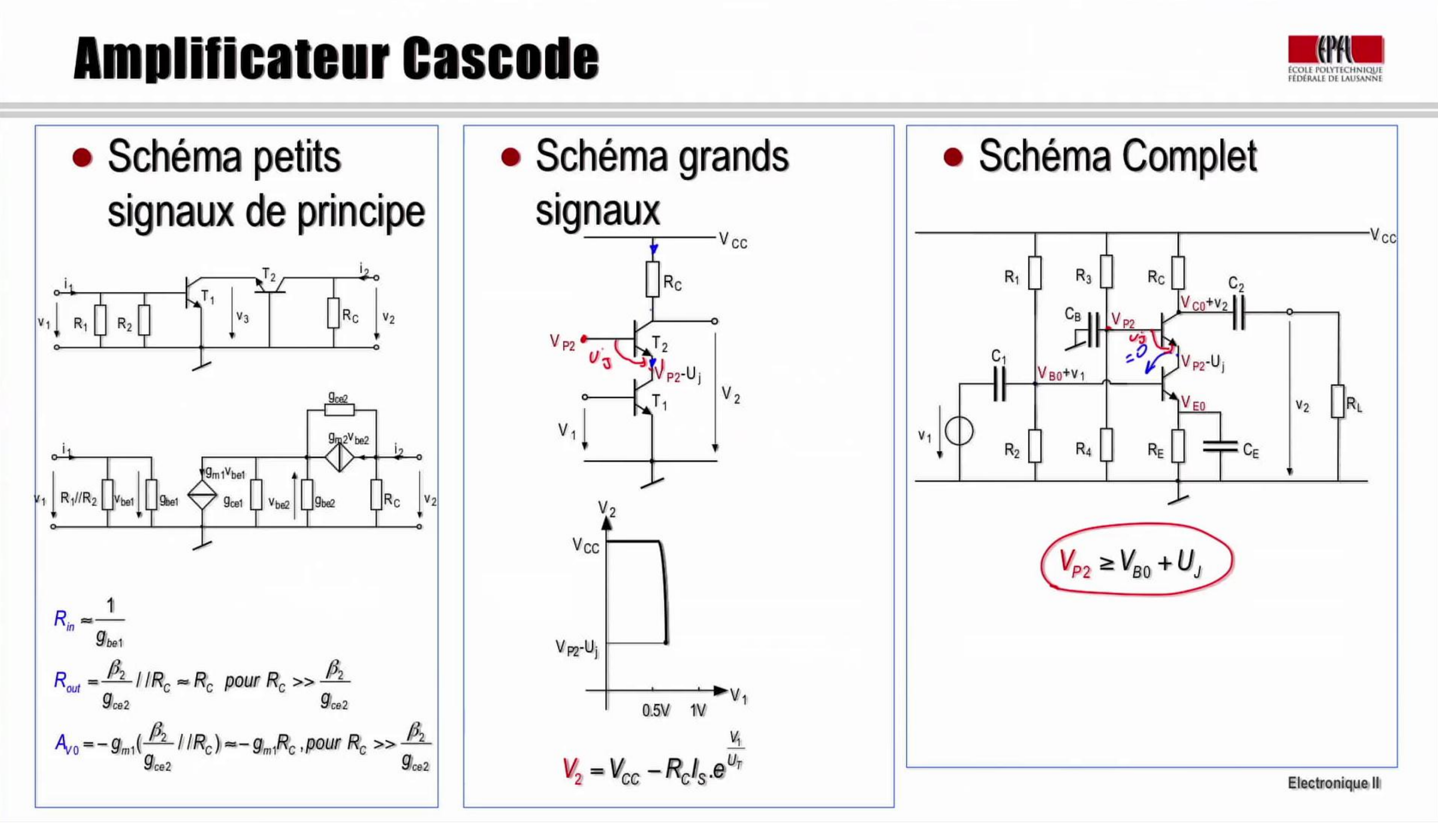


What is the minimum value that I can impose here? This minimum value of this voltage, is equal to the voltage that therefore generally this voltage that you see there when it is equal to this tension which is here your transistor is in the saturation threshold so the minimum that I can impose on this VP2 is when VP2 is equal to VB0 + Uj, that's what I noted here, that is really the minimum. If you look at VP2 when you impose a DC voltage here if you have a voltage difference there from here to here equals zero it is possible for a transistor, it means your transistor is at the saturation threshold, you are going to have a voltage Uj here and you find the voltage VP2 So I noted there VP2 = AVB0 plus voltage Ui we have from here to there. and that is the minimum. So this is why I write in DC the value of this VP2 according to VB0 if someone asks you to polarize it when you impose VB0 you need at all costs to comply with this rule otherwise your transistor will be saturated it is therefore the minimum value that can be tolerated in this type of assembly. Here is this assembly, we will analyze it now with the advantages it has with respect to a common transmitter.

Notes

Summary

23m 57s

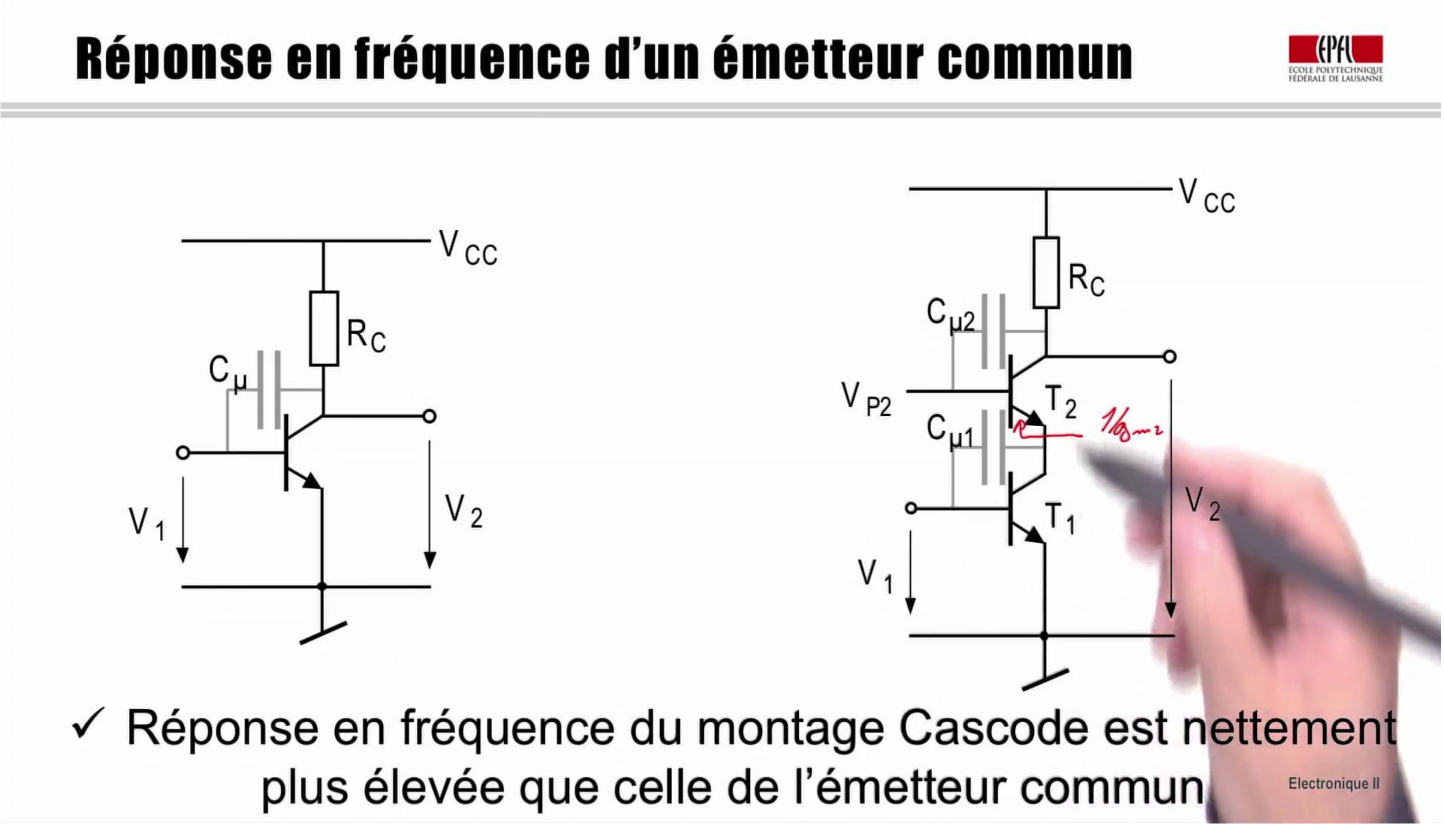


Knowing that its input impedance is the same as the common transmitter assembly. When you put a resistor RC, you will see a gain that is quite similar to a common emitter assembly then if the resistance is naturally passive. We will see later with the (inaudible) active, But then what is the benefit? The output impedance, well the output impedance is the one I see here this is equivalent to Rc as output impedance. So finally what is it? It looks like the same as the common emitter? No, it's the Miller effect which gives the advantage to this assembly.

Notes

Summary

25m 21s

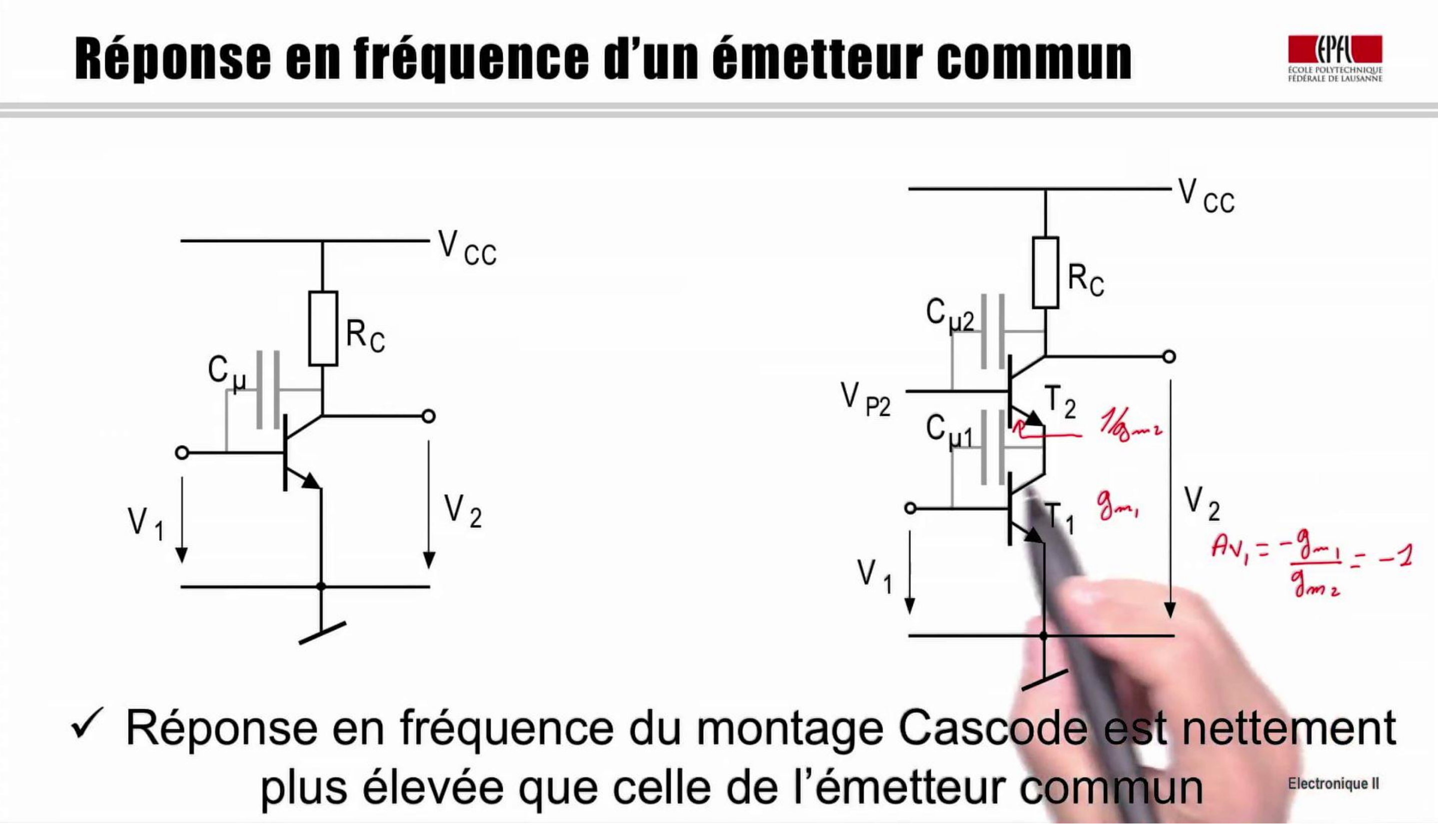


The frequency response of a common emitter suffered by this parasitic capacity. Listen to what I'll say, it found itself between input and output because the input was, the output was there and I found myself with a parasitic element that whenever I want to make a gain, this component appears to the unput multiplied by the gain and limit my amplifier bandwidth. Come here. If the gain remains the same, the input impedance is the same, the output impedance is the same, but this capacity is no longer between the input and the output, I enter here, I exit there and here I do not see a parasitic capacity between this node and that node. Even if the transistor has a parasitic capacity from here to there, But it is not going to be here. Now will come the second benefit: the common emitter here as an assembly that you see How is the assembly loaded? The impedance that I see there, this impedance is 1 / Gm2, by the way T2 and T1 are the same, the test current which traverses them is the same, so the Gm of the two transistors is the same. the Gm is IC0 on Ut. If it is the same IC0 passing in both, it is the same Gm of the two transistors.

Notes

Summary

25m 58s



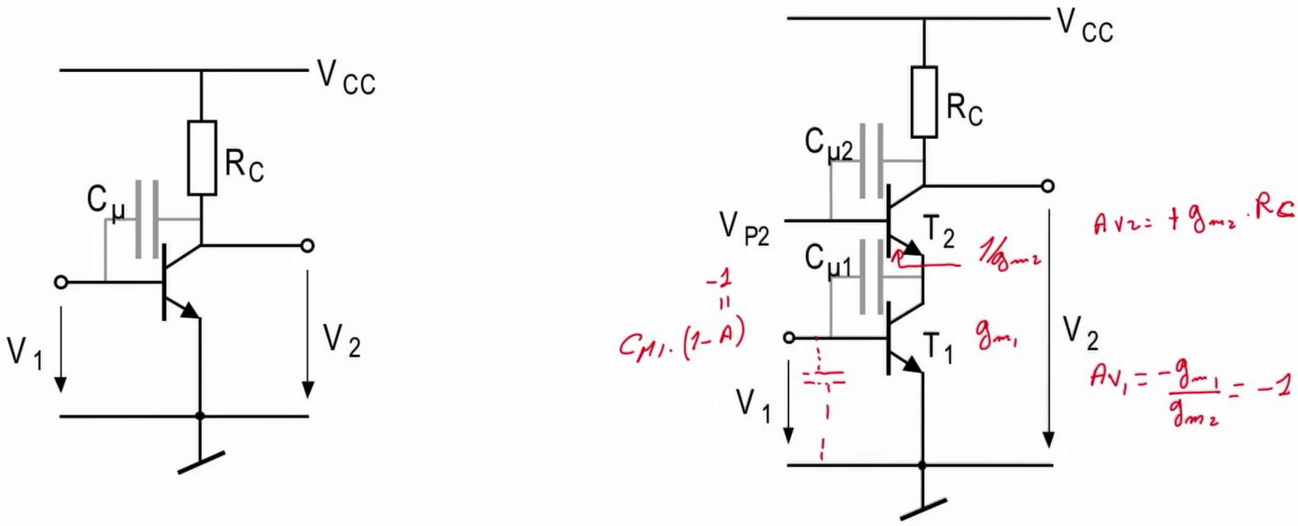
So this transistor has a transconductance that is Gm1 and this transistor has 1 / Gm2 and the gain of this assembly, the lower one, the assembly gain Av1 = -Gm1 times the resistance that sees in the load which is 1 / Gm2. if both of them are the same so this equals -1. The gain is equal to -1 and we have just seen it. You remember we said that tension is equal to this voltage there in DC, so if it is in Ac it's a DC potential which appears here, so finally this voltage modulate the current that the transistor follows and throws it into the resistance Rc, it is converted into a voltage at the output and which will act on V2. Now what is the gain...

Notes

Summary

27m 19s

Réponse en fréquence d'un émetteur commun



✓ Réponse en fréquence du montage Cascode est nettement plus élevée que celle de l'émetteur commun

Electronique II

so if the Av1 gain of this assembly equals -1, the gain of the upper stage I call AV2, it is -Gm2 multiplied by the resistance Rc or Rl, so this gain is the same thing as a common transmitter multiplied by -1, sorry there is a sign + thus the global gain of the two t is Av1 times Av2, it is exactly the same thing as a common emitter but the Miller effect is much less important because this same capacity multiplied by a gain is equal to -1 we recall that the equivalent capacity Miller which appears at the input will be equal to this capacity it's Cμ1 multiplied by 1 - A and A equals -1, therefore -1 with the minus it becomes plus, and it's not the total gain so that capability is two times plus two times Cμ1 and it's not the total gain you would have done with the assembly. So we won largely in the high frequency pole or that capacity limits but it really limits at much lower values than we would have obtained with a gain carried out with the common emitter here and the gain of the whole would have multiplied the capacity Cμ. So the frequency response of the assembly Cascode is significantly higher than the common emitter one and to our advantage when we want to achieve extremely high earnings.

Notes

Summary

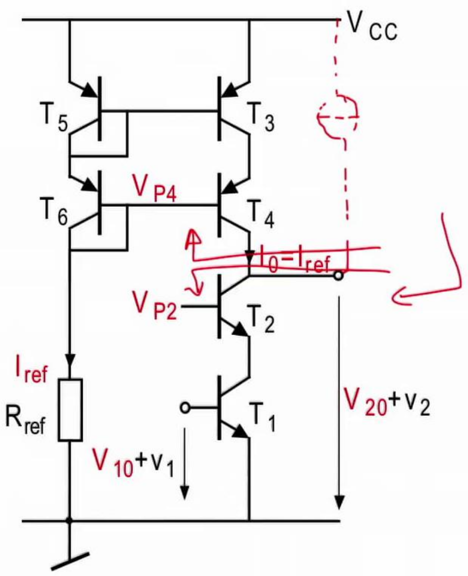
28m 12s

Amplificateur cascode à charge active

$$R_{in} = \frac{1}{g_{be1}}$$

$$R_{out} \approx \frac{\beta_2}{g_{ce1}} // \frac{\beta_4}{g_{ce3}}$$

$$A_{V0} = -g_{m1} R_{out} = -g_{m1}\left(\frac{\beta_2}{g_{ce1}} // \frac{\beta_4}{g_{ce3}}\right)$$



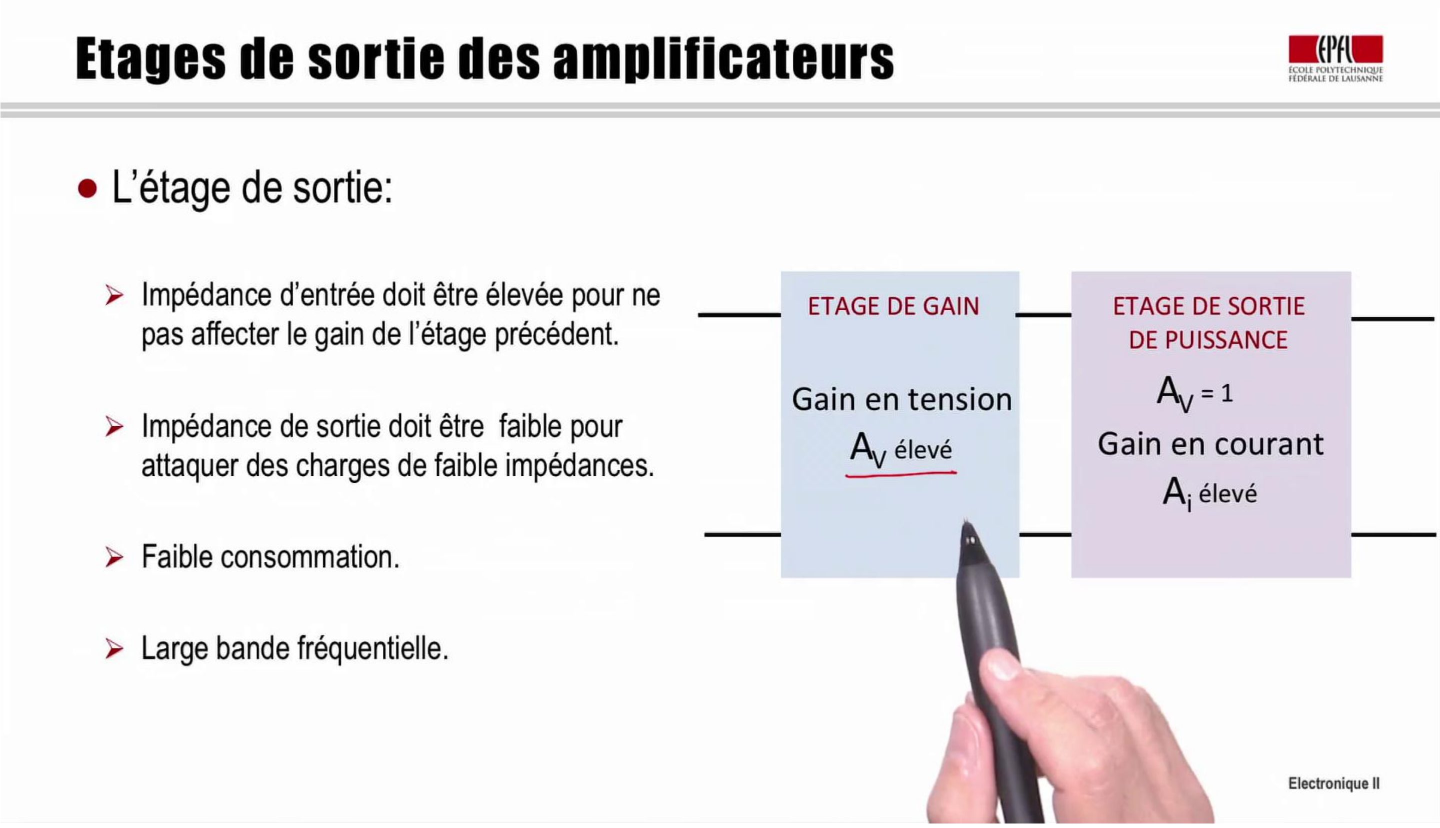
Electronique II

This benefit is seen when we replace the active load. You remember that when using an active load, we are active loads for impedance here which is almost infinite. If your common transmitting assembly is a Cascode assembly the one we have just analyzed. And there the equivalent of that, it is a current source that is connected here. So if you come to do that, the gain it is really boosted and that becomes very large because the passive load is Gm x R, but then the resistance, it is the output impedance I see since there Rout is the impedance I see here in parallel with the impedance that I see there. And this impedance I see here, I let you go check, is β4 on Gce3 it's of this order of magnitude, the one I see down is β2 on Gce1. So the parallelization of these two gives you an extremely high output impedance compared to a common transmitter assembly where we would have not seen the β which multiply the gain, we would have found 1 / Gce1. So in this kind of assembly you see that we get to really achieve extremely high gains with an output which is in current because we have a very high impedance and a gain which may tend to very high values. The input impedance is the same as the common emitter so the output impedance is the one that will influence the gain and what explains with this one would make very high gains this is called OTA transconductance amplifier.

Notes

Summary

29m 50s



That's all that was related to these kinds of stages, we analyzed the common emitter assemblies and its improvement by the Cascode mount, so you've seen that often under voltage gain we talk about the common transmitter or Cascode, you will see later we can also talk about differential mounting, it will come next week Nevertheless, when making a voltage gain, in tension I'll get back on the slide before and just report what we just see and understand, when one wants to make a very high gain, one is led to see the following thing, look at this well: here in this assembly we find ourselves with a gain whose output impedance is very very high so if you want to put in parallel with this assembly a low impedance, you will degrade its gain.

Notes

Summary

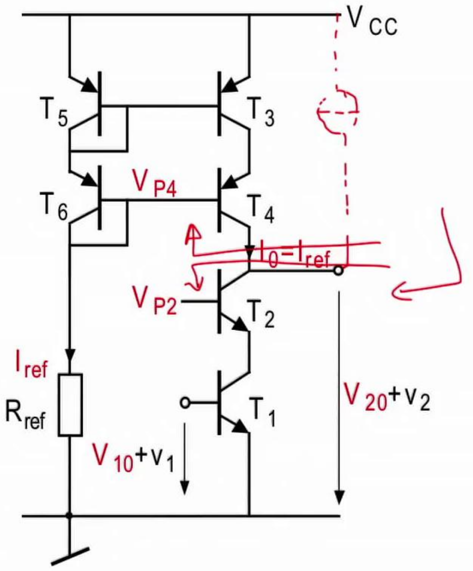
31m 28s

Amplificateur cascode à charge active

$$R_{in} = \frac{1}{g_{be1}}$$

$$R_{out} \approx \frac{\beta_2}{g_{ce1}} // \frac{\beta_4}{g_{ce3}}$$

$$A_{V0} = -g_{m1} R_{out} = -g_{m1}\left(\frac{\beta_2}{g_{ce1}} // \frac{\beta_4}{g_{ce3}}\right)$$



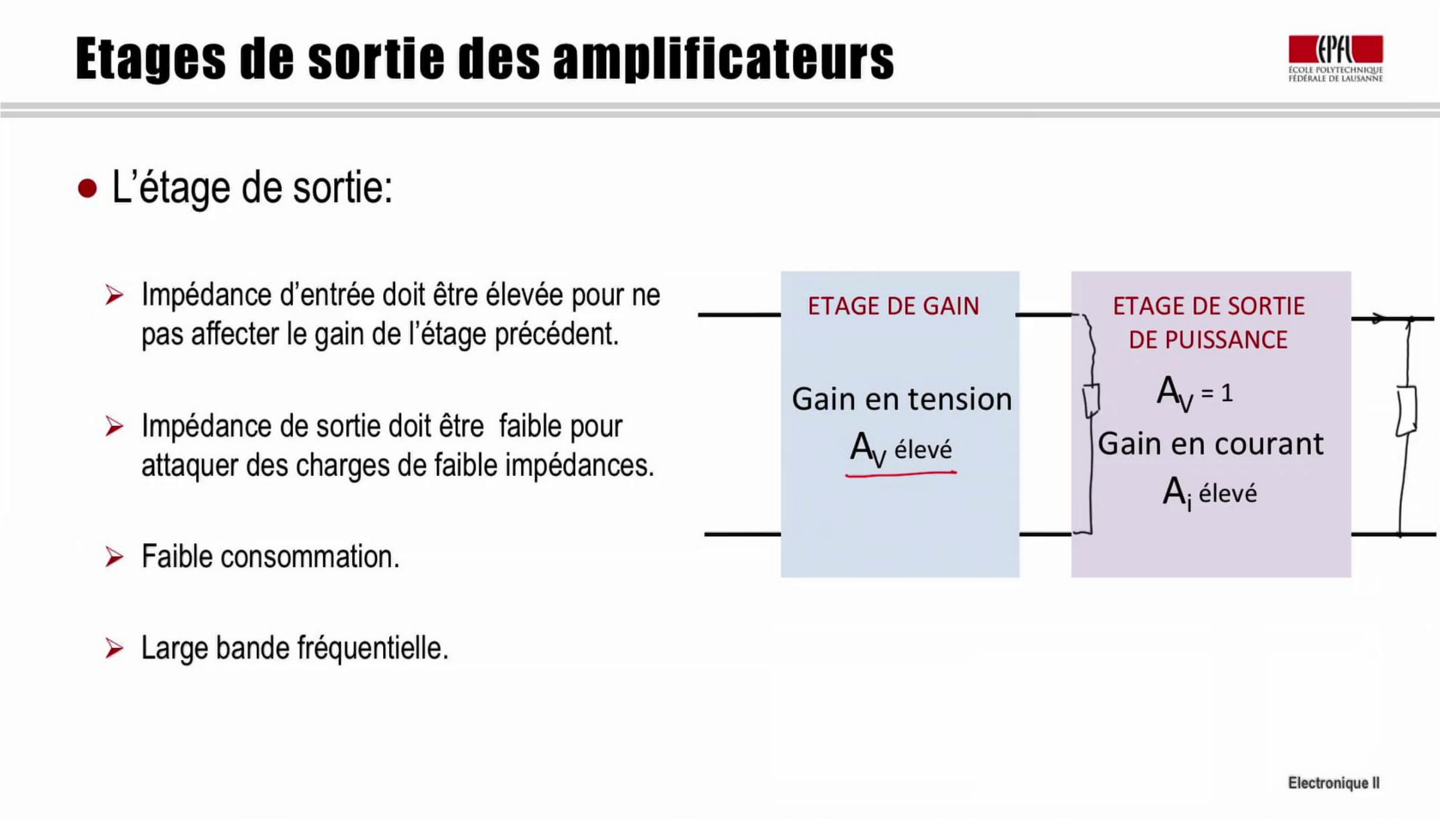
Electronique II

So imagine that someone will come and connect to this node there a low resistance which belongs to a stage that would come after. well this impedance it would come in parallel and immediately your gain collapses. This gain rather it is very high, we just plug it a low resistance so it will immediately collapse and you lose the advantage of this gain.

Notes

Summary

32m 18s

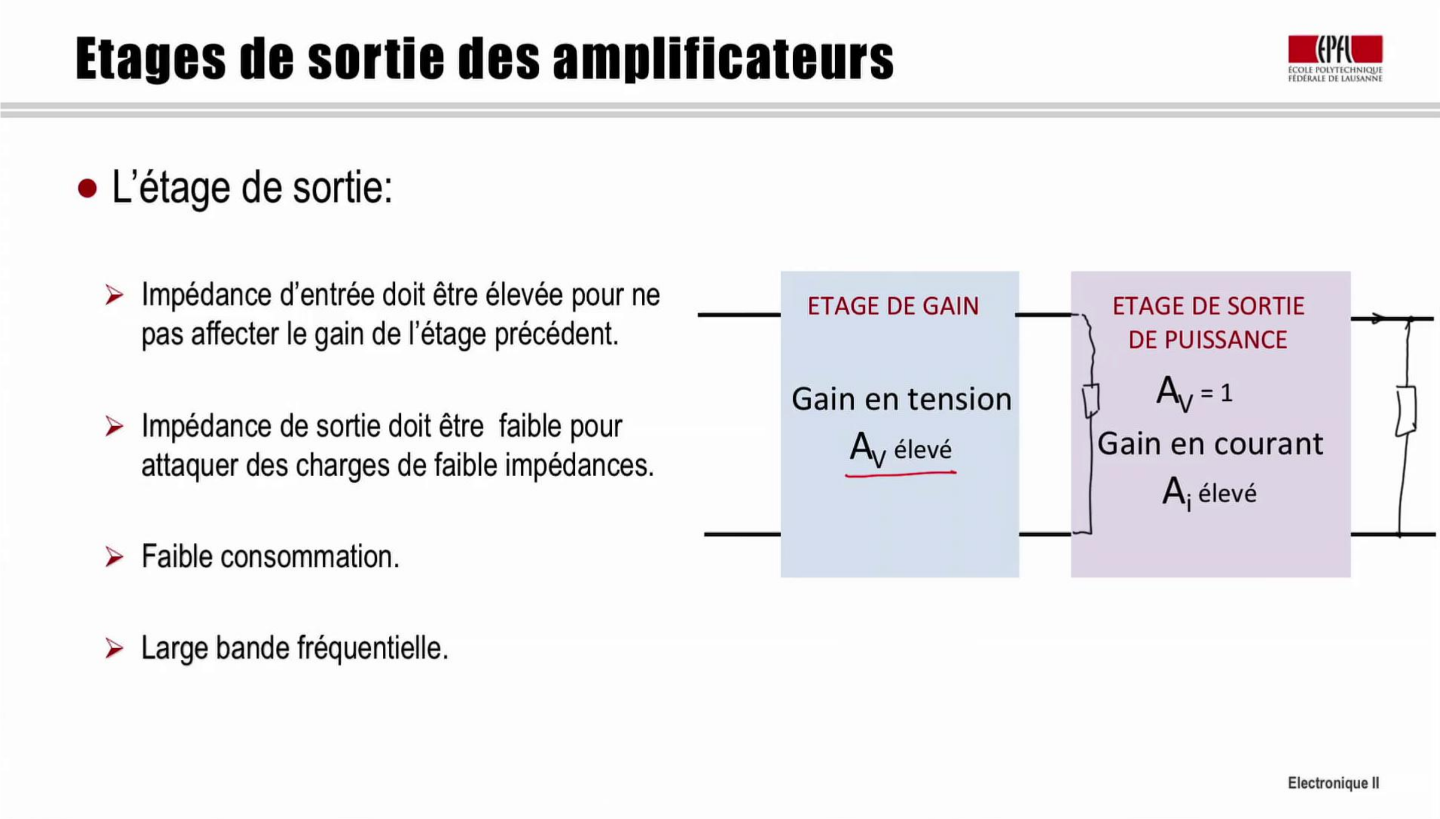


So what we are going to do now is take our stages of gains and often when we do integrated circuits, we realize gains, we call them infinite gains very very large and we have an amplifier that made the gain In tension. So any stage we attach it here, if this gain there or this stage there has an input impedance which is going to be here of a finite value which comes to connect at the output of this assembly, We have just seen that the advantage is the load resistance which allows it to get the gain, you will totally degrade the gain stage and it is not good. So we need what is called an output stage which is characterized by an input impedance which is supposed to be very high and especially if you want to connect a low load here, if you connect a low load here, you will get back with the gain realising by this stage, but when it turns into a voltage you must have an assembly capable of supplying the current needed to that load which allows the voltage which appears at the output not to be affected by this. So we would like, to have an output called a voltage output that is to say, the output impedance of this assembly is very low.

Notes

Summary

32m 38s

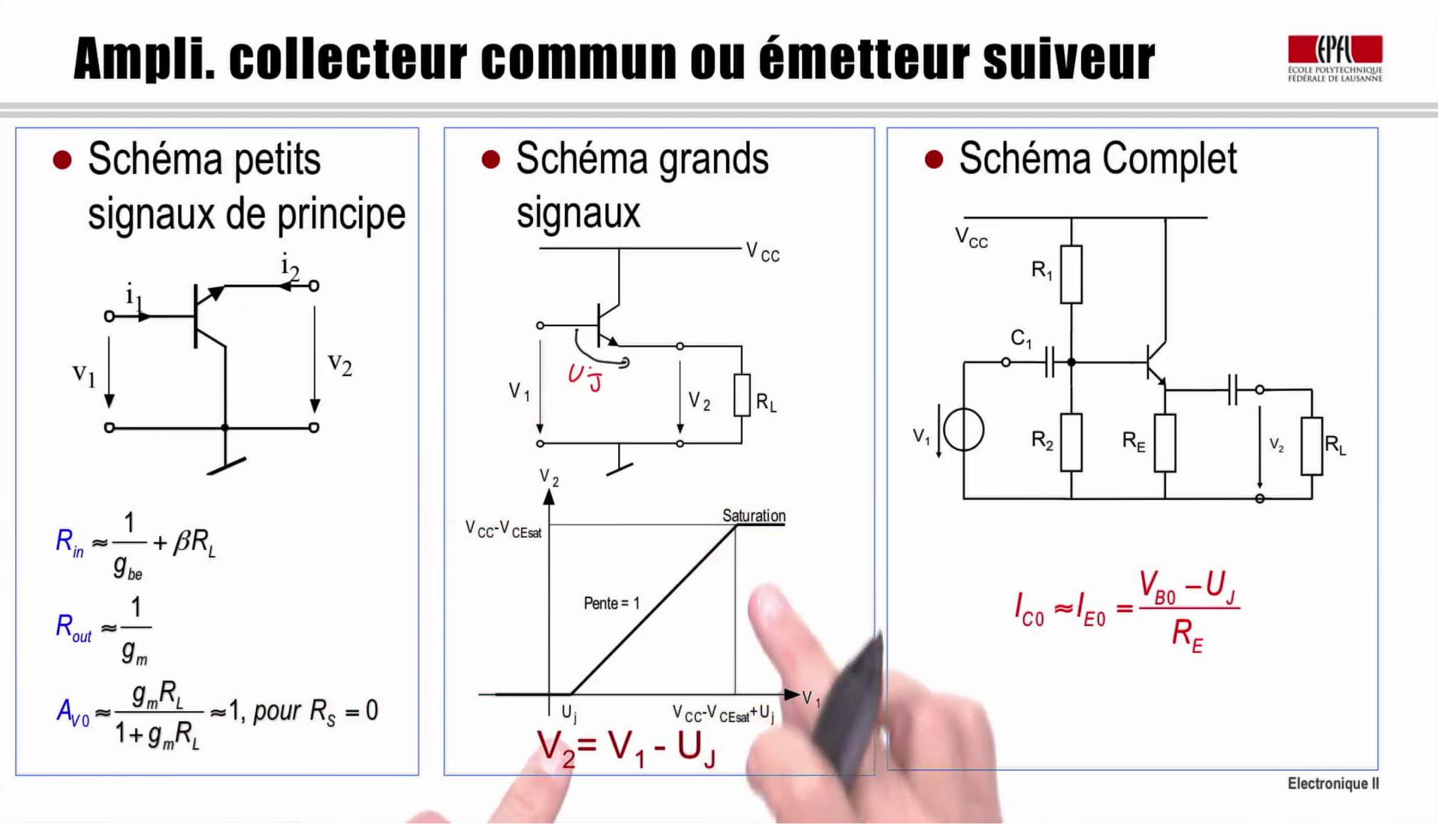


and even if it does not do a gain, so even if the tension there and there are the same, we would like that the output impedance is low for not affect this. And we would like that its input impedance wil be very high and the assembly that does it is indeed the common collector. It is characterized by high input impedance a low output of impedance, so it's the assembly par excellence to achieve what is called the output stage or the output power. So I repeat, the input impedance should be high to not affect the gain, what is seen must be very high, the output impedance must be low in order to be able to supply a current without the resistance that comes here limits this current. And usually as everywhere we would like a low consumption and a very very wide bandwidth.

Notes

Summary

34m 06s

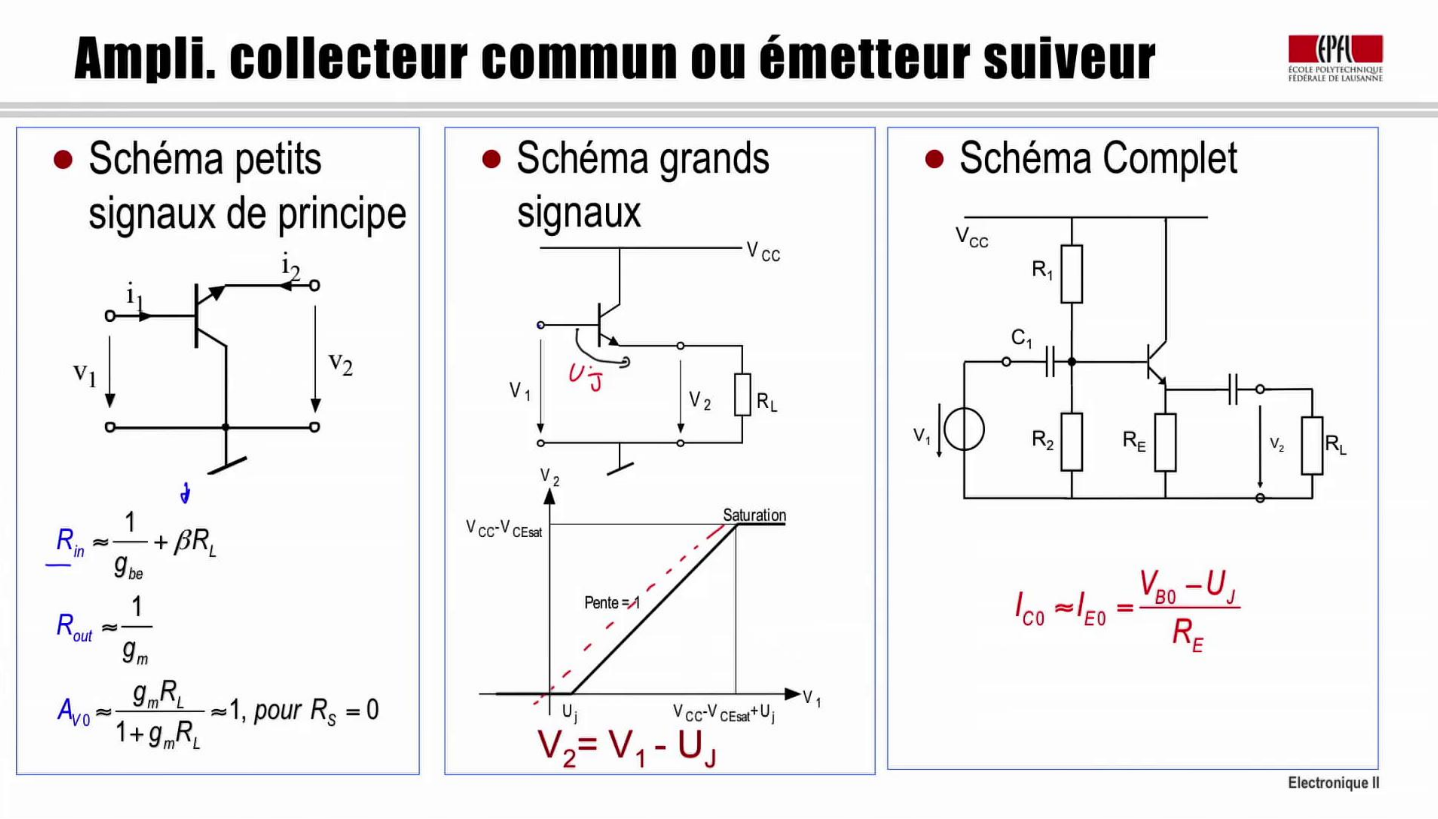


To remind you what we studied before concerning the common collector amplifier, It is the complete realization, that is to say it is polarized as all assemblies. this resistor is used to have a current flowing through it, we impose a DC potential on its base, the increase is coupled on the basis, we can couple the output on the collector and generally here we impose a fixed potential DC on the collector and we find ourselves with this famous calculation which allows us to impose a constant current. thus, presented as large signals, the difference between the voltage V1 and V2, it is the tension that you see here and which is the voltage Uj. So this tension and this one are following each other with a voltage difference Ube which is of the order of magnitude of UJ. So that's what you see on this curve this is the characteristic large signals, it is that the voltage V2 as a function of V1 it is simply a straight line with a shift compared to a straight that would have passed in the center so that would have been like that so that it is a perfect follower but it is shifted to Uj because it is necessary to drive the transistor and here are the characteristics AC the input impedance is high because it is 1 / Gbe + β x Rl, you will see, next week we wil analyze how one increases this β by a assembly that we will call Darlington.

Notes

Summary

34m 57s



The output impedance is low is what we want this is the lowest impedance that we can have at the output of a transistor it is that which appears from its transmitter and the gain is of the order of 1. So this tension there and here will follow in increase with a given offset of J so this is a gain which is 45 degrees slope. And that's reminder of what is the common collector.

Notes

Summary

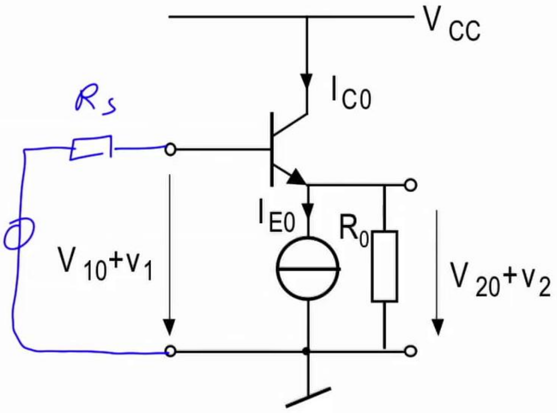
36m 29s

Ampli. collecteur commun ou émetteur suiveur

$$R_{in} \approx \frac{1}{g_{be}} + \beta R_0 \simeq \infty$$

$$R_{out} \approx \left(\frac{1}{g_m} + \frac{R_S}{\beta}\right) // R_0$$

$$A_{V0} \approx \frac{g_m R_0}{1 + g_m R_0} \approx 1, \; pour \; R_S = 0$$



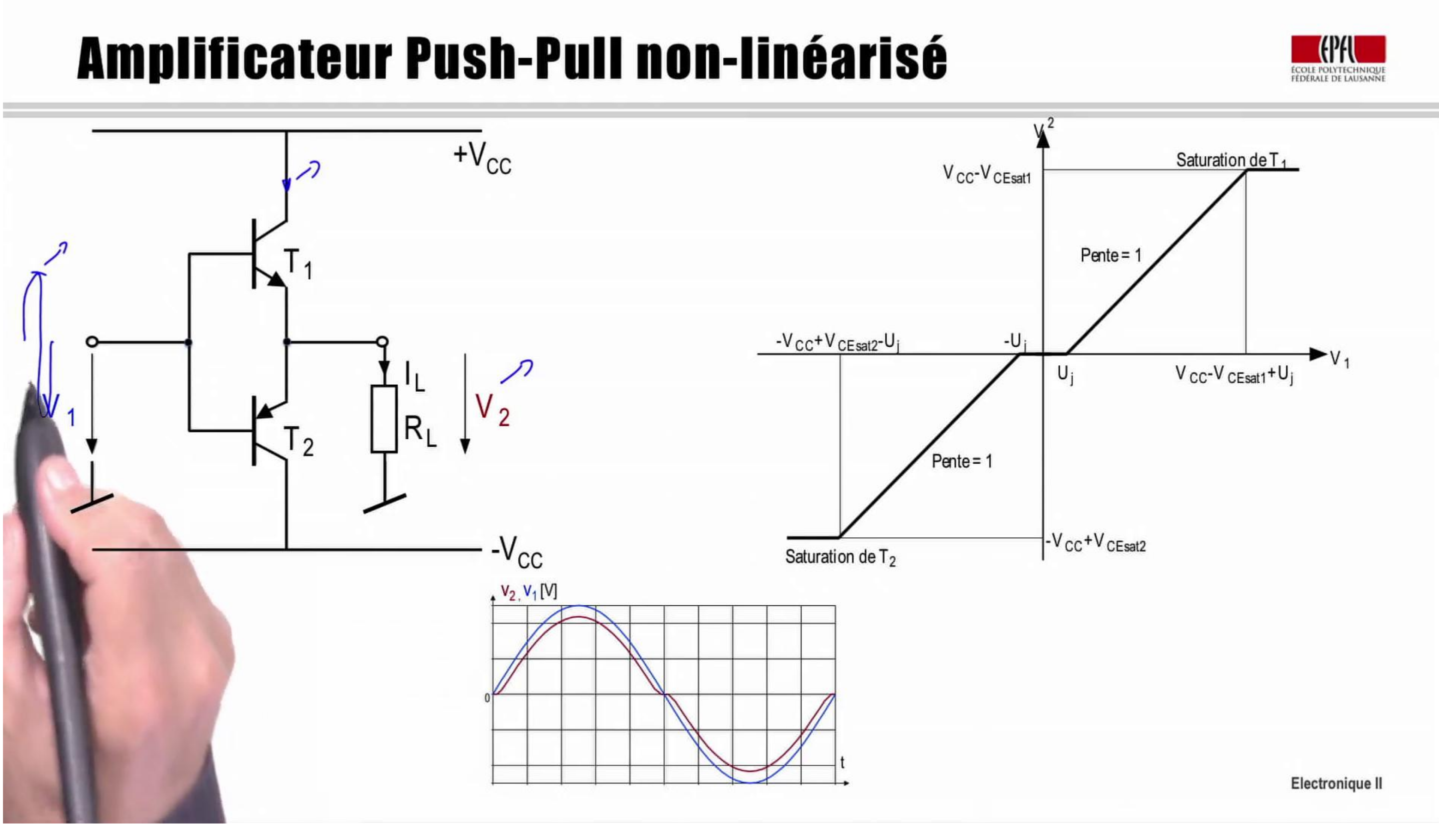
Electronique II

Very quickly also, you take the common collector assembly and we saw that everywhere we can remove the passive load, to an active load So you put a current mirror here which have an impedance R0, you find that the input impedance is really boosted to extreme values because if R0 is very high, you end up with 1 / GbE + βR0 and then if R0 is equal to infinity it is as if you are saying that this is actually infinite so the input impedance becomes extremely high. The output impedance will depend on the load resistance and parallel with 1/Gm and generally it's dominated by 1/Gm. We agree that the resistance Rs it's if you ever have a voltage source here having a resistance Rs which provides the increases. So that is the resistance Rs, it is divided by the β and all that parallel with R0, R0 is very high, So here when you put it is low, it's Rs/β if the β is very high compared with low Rs So this term will disappear so the Rout will tend often to 1/Gm and finally the gain is GmR0 / 1 + GmR0, the GmR0 given that R0 is a very high resistance there if you put infinite so you neglect the 1 Gm Gm fall, This gives R0 on R0 which is of the order of 1.

Notes

Summary

36m 53s

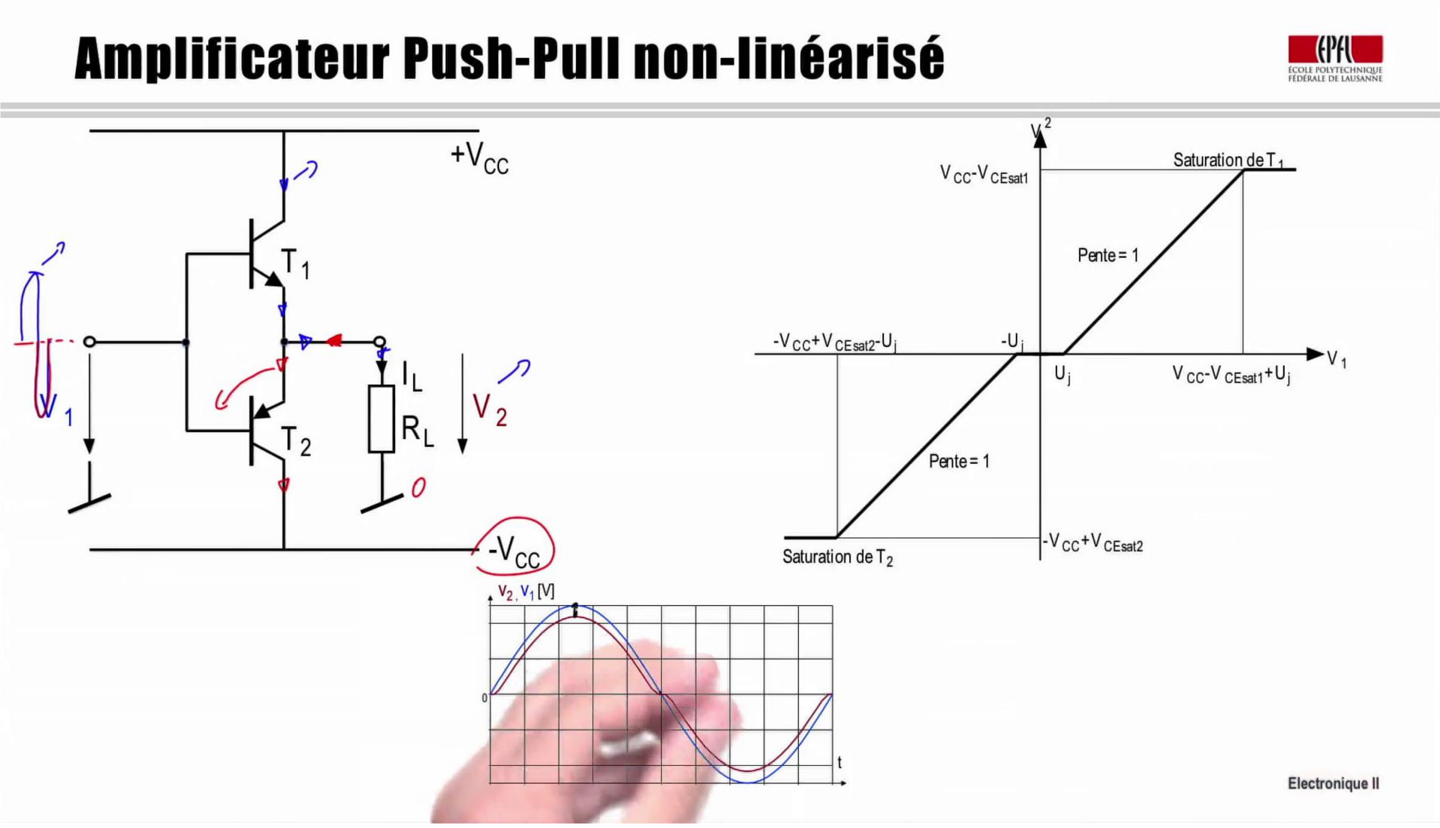


Improved Push-Pull mounting in specific applications. If you take the common collector assembly, while ago I showed you the common collector assembly you will imagine that this part does not exist. This is a common collector. I will enter on V1, I'm having a transistor whose collector is connected to +Vcc and I put a resistance against the mass. But what happens if I am applying voltage which compared to the mass can have a positive component, a negative component and I am really having a mass and a positive value and a negative value and well at that point we appeal to two common collector assemblies. Look, this is a common collector type NPN, that's a common-collector PNP. So here when I move up the tension, the current is here when the voltage is going up, the current here it will go up, This voltage V2 will go up with. If now I am on the other side of my component So I'm compared to the mass here, I lower the tension, if I drop down this tension here I go down with this value that I draw in red, you'll see that this tension is going down so this transistor will block And there I will have this junction there which will increase in that direction for a PNP transistor.

Notes

Summary

38m 30s



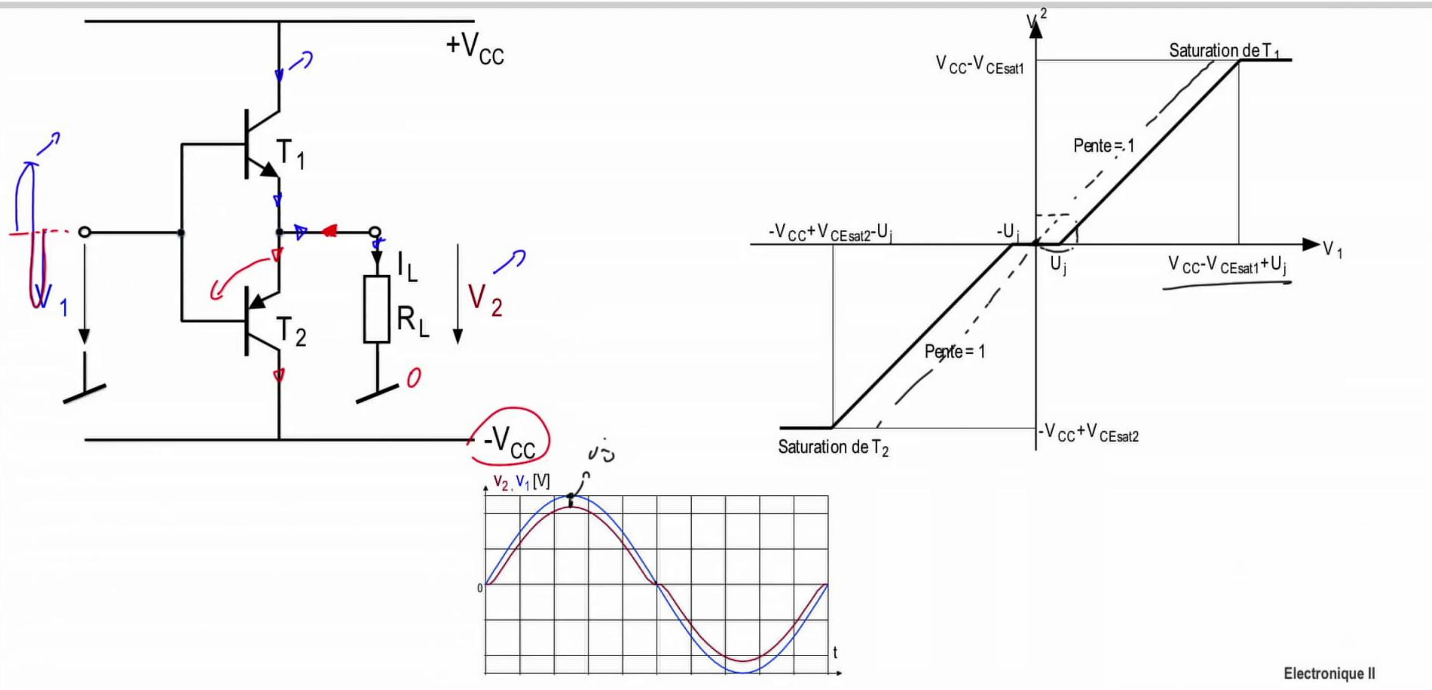
So it will draw a current that I design in red, I'll have the blue power that enters through this transistor, it goes in that direction in my load and I'll have the red current that will pass from the mass, it turns red here, it comes here, it continues its path and it goes to a voltage -Vcc So he goes from 0 to -Vcc or it goes from +Vcc to 0. So if you put a voltage of 5V and -5 V, we understand very very well, it's from 5V to 0 as the current goes down in the blue direction and from 0 to -5 which will pass to the -Vcc. And then your positive and negative alternating I draw the input voltage V1 that I appliy here in blue and I watch what happens to the output voltage, look there is always a lag between the two worth Uj because when this transistor will lead look at, if I apply a voltage equal to 0, I am here. It's none of those transistors that will drive. So here I really have 0V. There is no current nor blue nor red, we see it here. It was said that there is a common collector up, a common collector down. Which explains that I have a great signal characteristic, common NPN collector up and the common collector down so the PNP. And I put them both together and it will make me all these features.

Notes

Summary

39m 56s

Amplificateur Push-Pull non-linéarisé



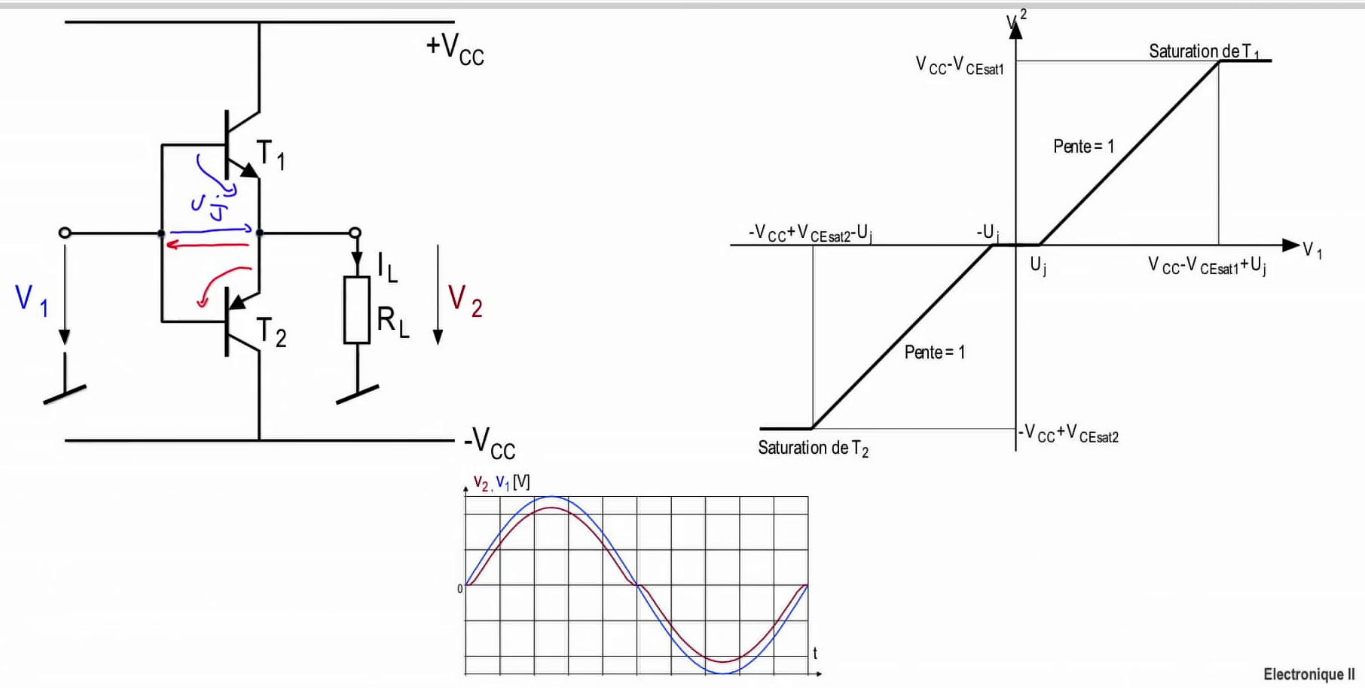
If I have a voltage V1 equal to 0, I have nothing that leads both are blocked. When I increases in one direction there, I'll have a transistor that will lead and it'll be the NPN and I will have a gain equal to 1 like any common collector and I have the current that will pass so in this case the voltage V2 will follow the voltage V1. Same on the other side, that is the blue part but I all the time have the offset, remember that 45 degrees is this straight here. And what you see here, there is always a lag and it is seen that it is voltage Uj which is between the input and the output. What is very interesting in this kind of assembly, I was thinking a little, you can if you get to increase this tension beyond the voltage Vcc. So this tension, it becomes almost Uj greater than a collector voltage. Well you will have this tension here wich will almost comes to your transistor saturation limit and this explains what is written there. There I noted that the input voltage V1 is Vcc if you put UCEsat = 0, you consider that the saturation voltage is nul, you see that you can increase the voltage V1 to Vcc + Uj and there we usually reach to the supply voltage but think about it by your side what happens if you move up this tension slightly greater than Vcc so you put Vcc + Uj and you bring the voltage V1 to Vcc + Uj.

Notes

Summary

41m 27s

Amplificateur Push-Pull non-linéarisé



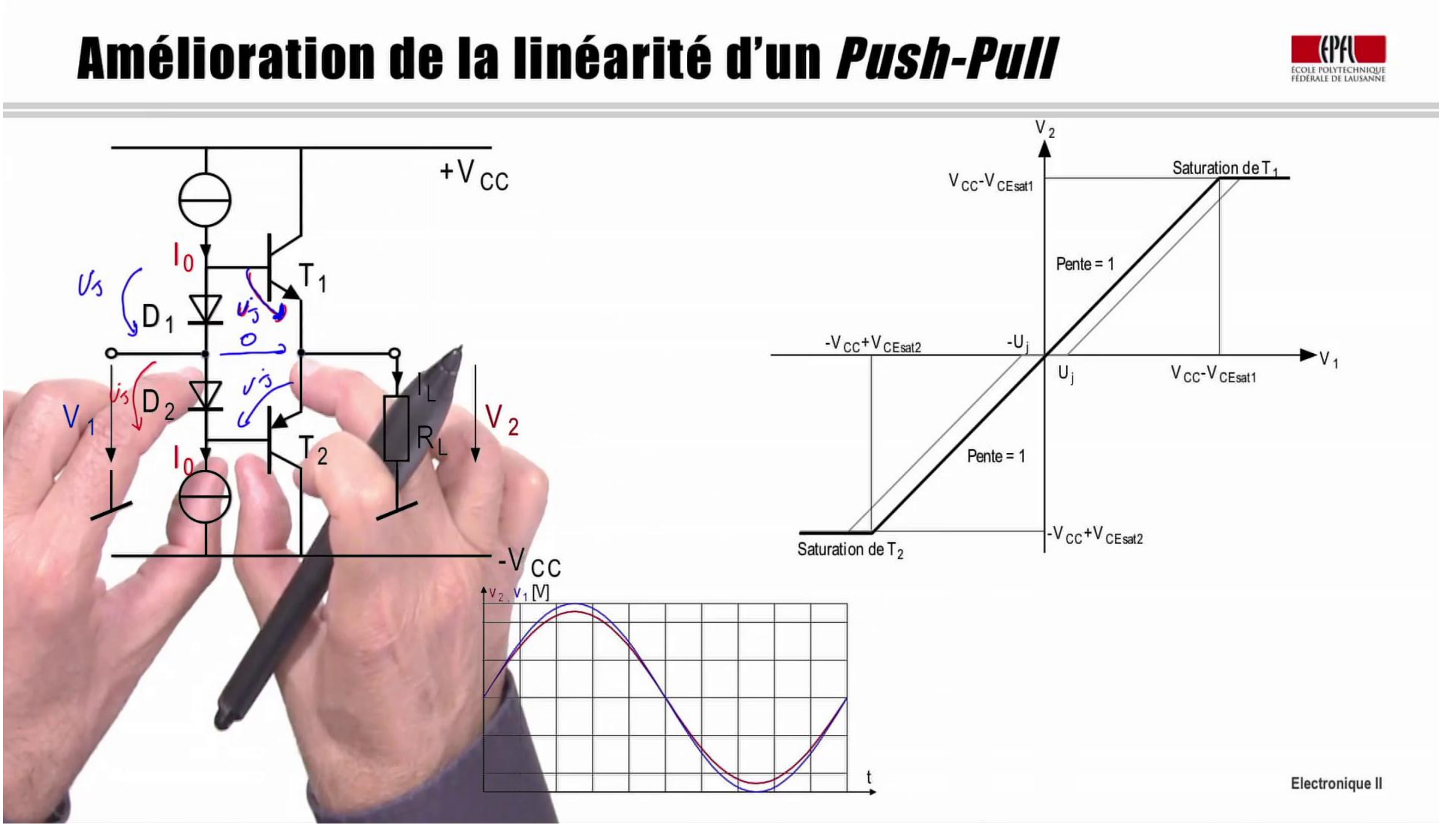
Electronique II

You will see that if it is equal to 0, you will see the voltage V2 will reach Vcc and that is the upper limit which is the saturation of your transistor. Otherwise, if you can not go beyond well the maximum voltage you can reach here you will have this voltage Uj. And if you go up you bring this tension to Vcc the output voltage is always Vcc-Uj So you will lose Uij against these power rails. So I introduced the assembly Push-Pull as presented, the Push-Pull word comes from the fact that we "push" we push the current and draws the "push-pull" current of this current because there are both current directions. Now we will analyze the same assembly when you want to improve it so we understood I have a voltage difference to the positive component I'll erase what is written. When I have a positive component, I have a voltage difference of a value Uj, I see it here when I have the positive component, I always have a shift of Uj between node V1 and node V2. And when I have a negative component and well I have an Uj voltage difference in this sense, this is due to this and that's due to this. So I have all the time a shift of Uj. Could I absorb that Uj and shift these two straight and align them?

Notes

Summary

43m 05s



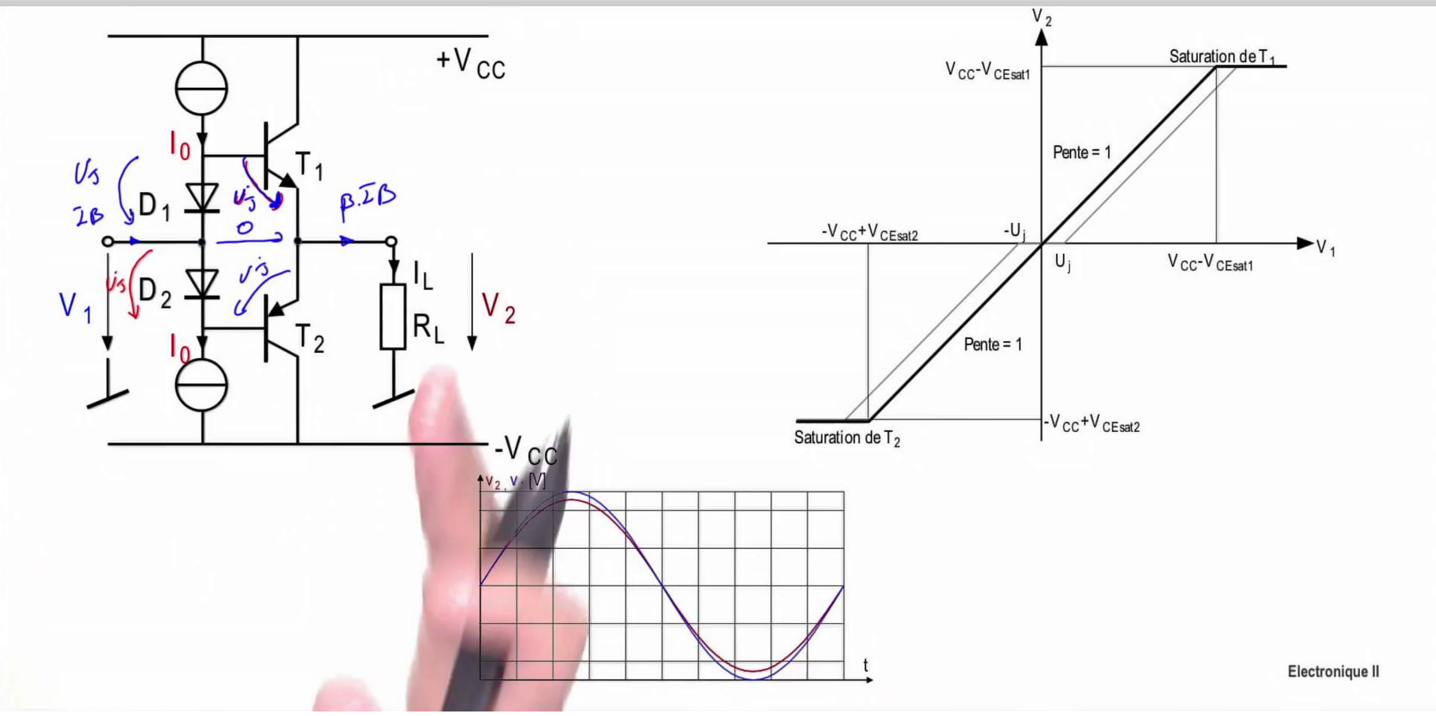
Of course. if I'm able to add a voltage source Uj here or add here a voltage source Uj. If I make from one side or the other, I have this difference becoming zero. So I have +Ui-Uj and +Uj-Uj and it'll vanish and I have these two voltages which are all the time trying to follow exactly without shift. There the two voltages V1 and V2 are shifted by this component which is because there is no polarization. Can we polarize? Yes it would give this. That is the polarization. What I just have to do, I told you I will create a shift of the order of magnitude of Uj for a positive component, here. I added a diode So here I have a Uj and there I also added another diode and there I have a voltage Uj. When this transistor will drive, it will also impose a tension here the order I should have done it in blue, what I'm going to do quickly. So this transistor will drive with Uj and this will impose Uj, Now if you look at the difference from here to there, this difference is 0. Check this is equal to this and that equals that. So when one or the other transistor will lead it's ok you have a voltage difference equals 0.

Notes

Summary

44m 40s

Amélioration de la linéarité d'un *Push-Pull*



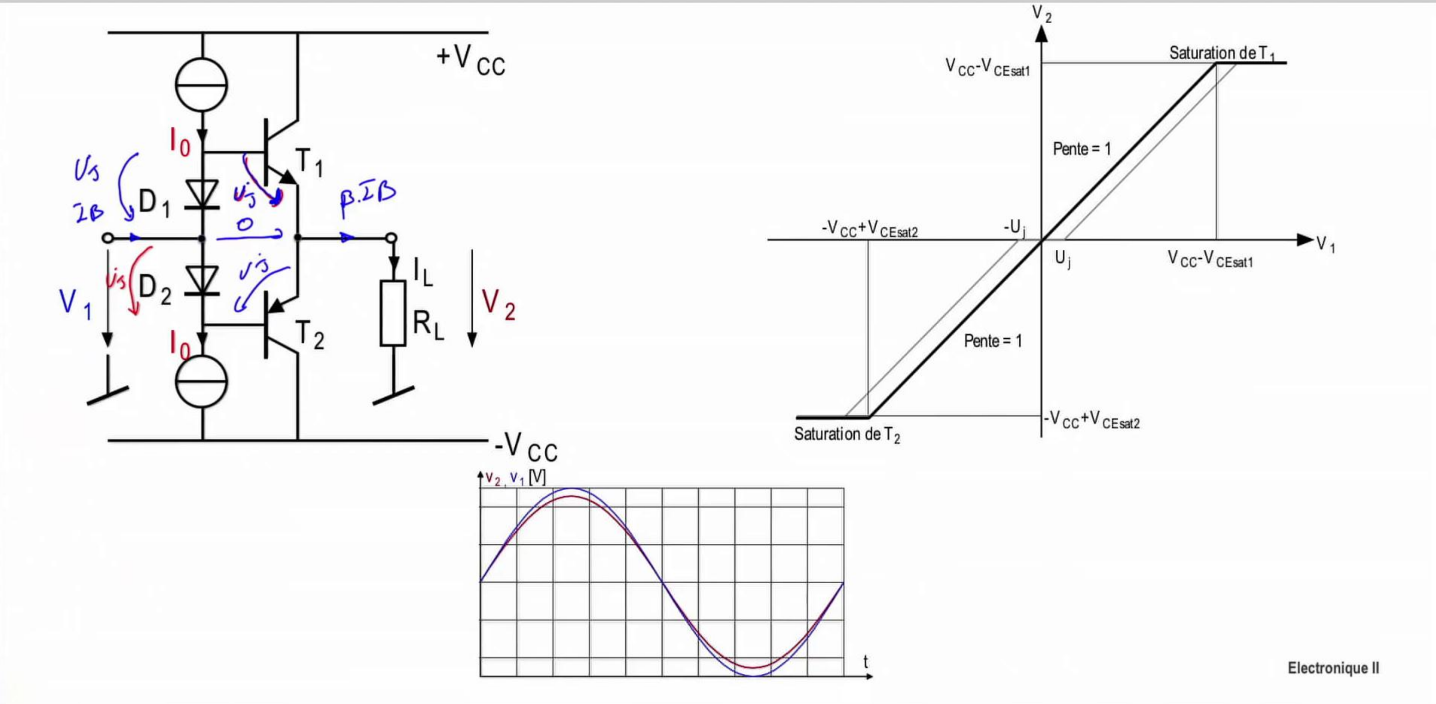
So it is a voltage follower, what we had as characteristic has complement aligned by this straight one admitting that this voltage is exactly equal to this one, it is exactly equal to that one. Is this the case in practice? No. Not quite. There is a lag Is there an opportunity to improve this? We will have a course on the output stages that I call power amplifiers, I'm going to review this kind of assembly a litle bit more And you will see that there are solutions that are used to improve this kind of pairing. Now when you look at this assembly, you say it's true that it's a follower in tension, I remember its role, the current that you take from here, this current is a current that passes in the base of one or other. The current that you draw from the other side is β times if it is a IB current, there it is a current β x IB. so we took very little current we sent much more current, 100 times, 200 times, 300 times of current from the other side. So I see the impedance from here is much larger than the impedance that I see there, this is a low impedance. And this is really what we do with this assembly, we will use it as power stage.

Notes

Summary

46m 12s

Amélioration de la linéarité d'un *Push-Pull*

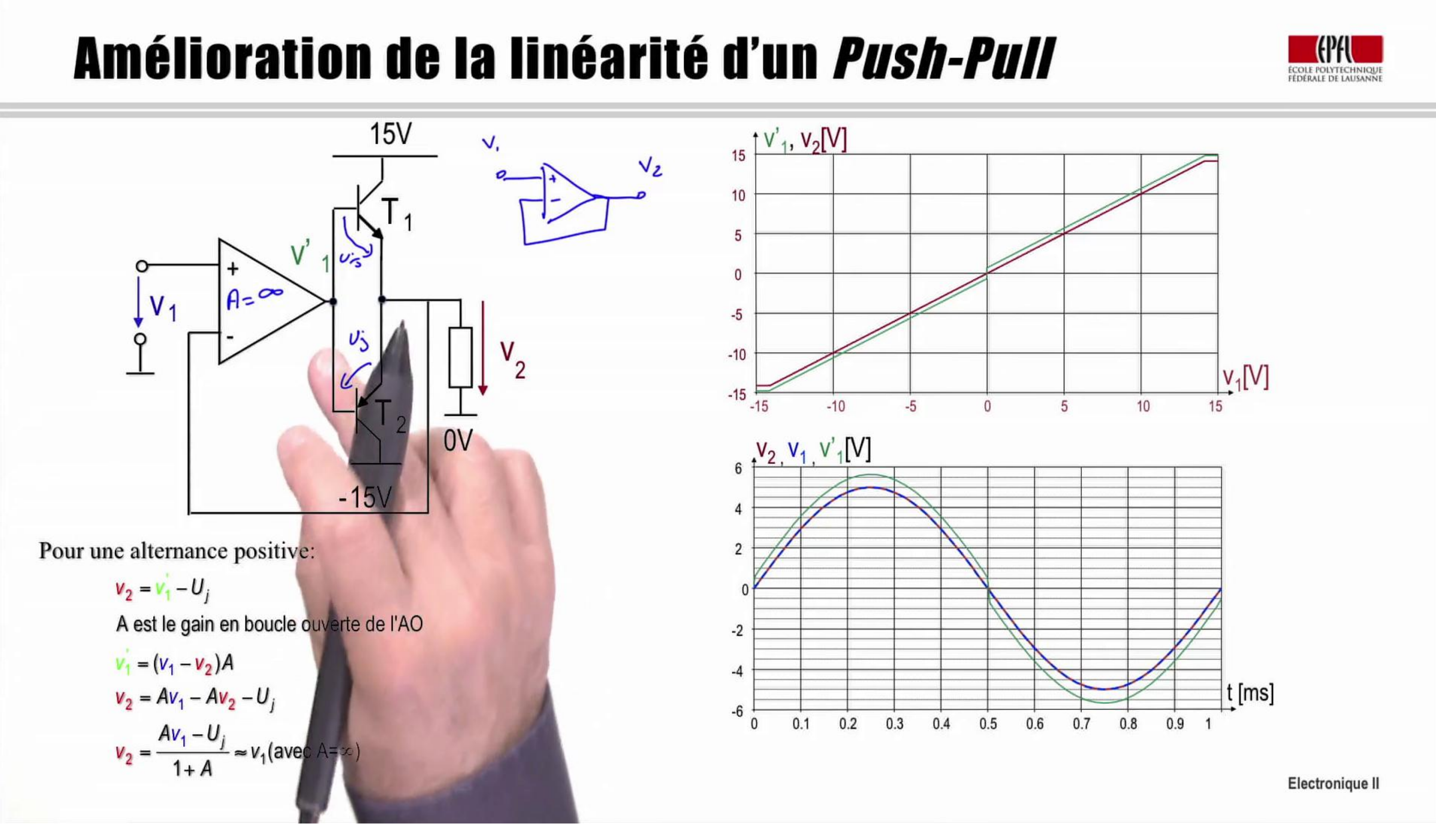


If I put behind that side, a voltage amplifier, the voltage amplifier will amplify the tension, it will come to follow this tension, it follows it. The input and output are the same, but then in terms of current, it takes little current to inject a lot of current. Why ? Because the current comes from there, from the power supply. the current is being drawn from the power supply or drawn from the negative supply finally sent back to the negative supply, it is not taken from the floor which is above. And you will see that we will replace these transistors later by an assembly called Darlington and the β will be much higher than the β of a single transistor. Can we improve this assembly? We can do the next thing.

Notes

Summary

47m 24s

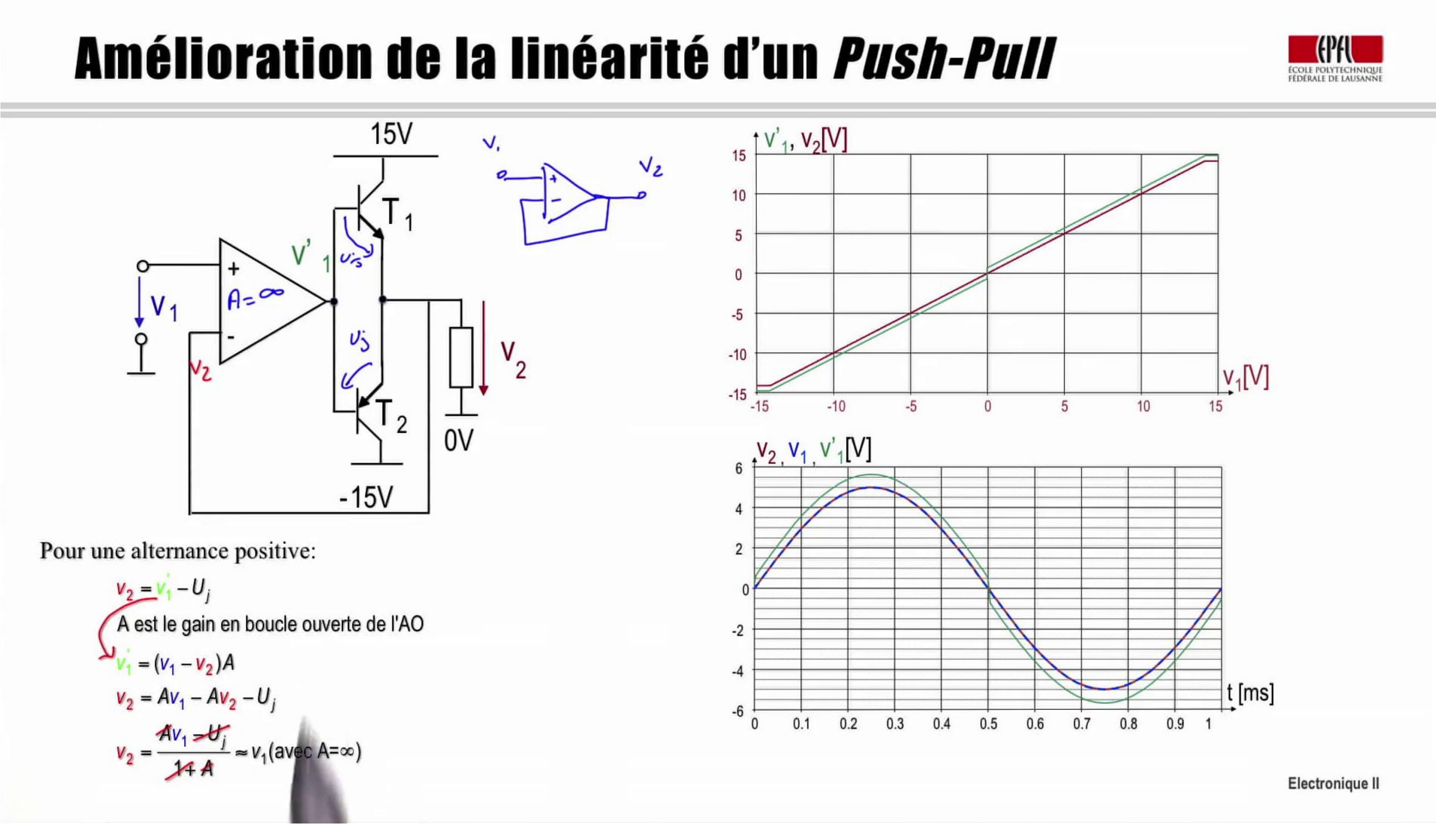


We can use a kind of counter-reaction. Before commenting this assembly, you know that an operational amplifier is a gain A which is infinite. This is a follower, So a follower assembly do not make a difference between this tension and this tension, both voltages are the same, this is the current which is amplified. So if the tensions are the same this stage there if you take it as it is, you put it inside your amp, your amp does not change. So if I draw it conceptually I would have seen something quite like that. I forgot the buffer between the two. And I look at my amp that is well and truly a follower. The tension I put here, appears at the output here, not this stage it added nothing, it just followed up in tension. What is its advantage? Well it still took little current from the amp, sent a lot of current in the load. And linear perspective when I said V1 is equal to V2, and well I linearized my assembly by the counter-reaction and we can watch it by analyzing what I have written about it. If you look at V2 voltage compared to V'1, there is a lag for an alternation on one side or the other, that's Uj and that's Uj. So when we drive up or down, there will have this lag.

Notes

Summary

48m 08s



So this voltage when it rises, it has an offset of +Uj relative to this voltage and when it goes down it has an offset of -Uj relative to this voltage. Then I noticed here: if V2 = V '1-Uj, I'm talking about the positive alternation. Now I look at this amp, the amp takes V2 it puts it here, So this is V2 too. the amp is (V1-V2) A = V'1. This is what makes an amp. So it takes the voltage difference (V1-V2)A and it will put it to the output. Now if I have V'1 which is equal to this and I've V2 that I have just expressed I can express V'1 and replace it by its value here so I take V'1 by its value, I put it there, I express what comes out of these two relations, it will give me V2 = AV1-AV2-Uj that I write according to V2 otherwise taking A highlight, it's AV1-Uj / 1 + A. So if I neglect this with respect to A x V1 and the 1 according to A, it will give me V2 is equal to V1. Why ? Because it's a A, which is very high therefore the infinite relative to 1 is A and infinite time V1-Uj is again AV1 and A will disappear so that gives me V2 = V1. And when you take this kind of assembly and you don't put the two diodes I reported with paths for current to polarize them well you find yourself with a characteristic that is almost the one in red and what you put, the part...

Notes

Summary

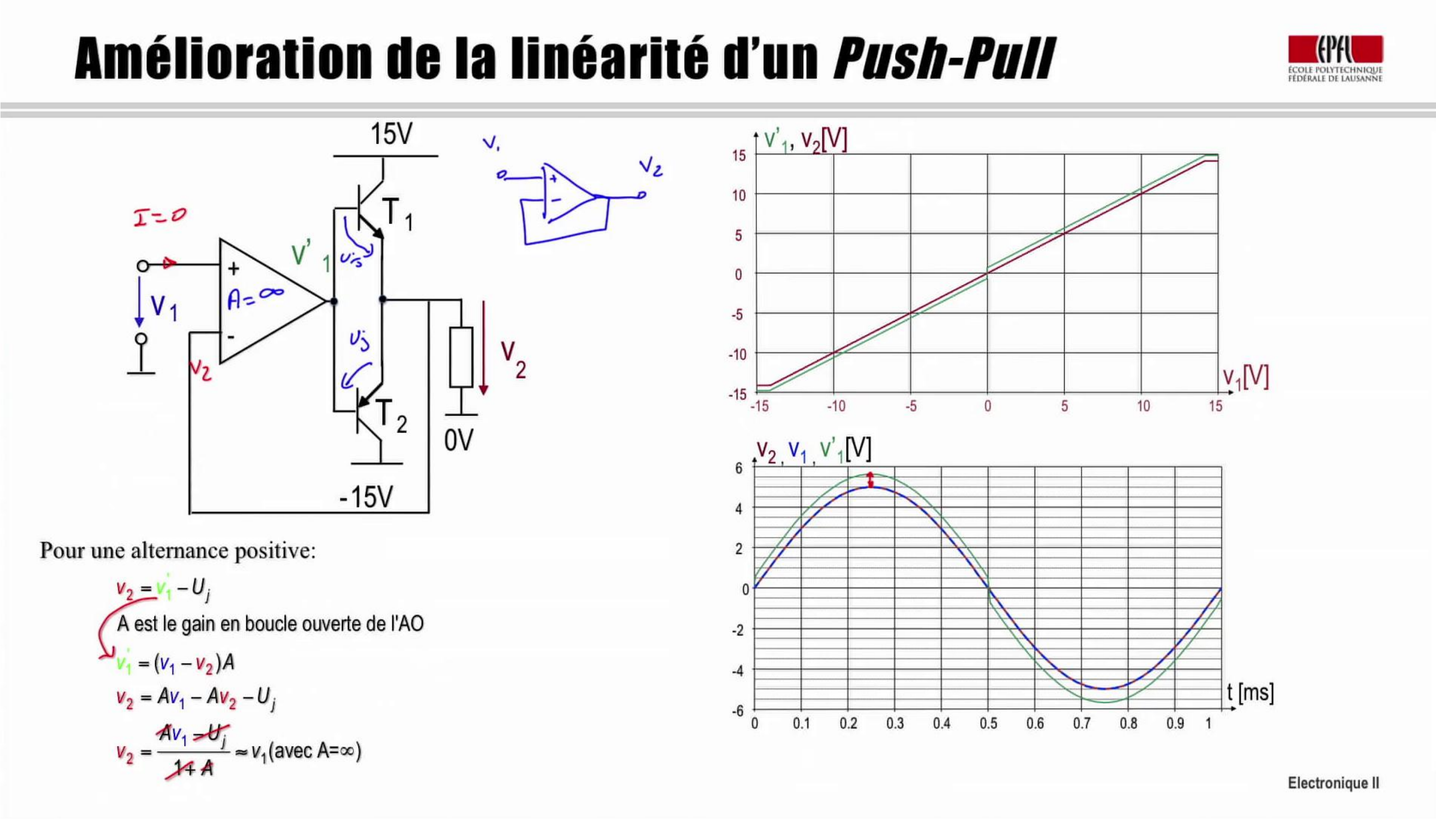
49m 38s

V1 which is in blue dashed line and the voltage V2 which is in red dashed line is absolutely confused it is simply V'1 that will be shifted of a Uj value relative to the output voltage to +Uj or -Uj. It depends how you look when there is a positive alternation or a negative alternation. Of course you can also add the two diodes So the two solutions may be accumulated, add here two diodes and do the counter-reaction, and get both for linearity which will be increased to such an assembly which acts as an output stage. Here there is a great advantage compared to the first, is that if your amp here has an infinite impedance, this current is equal to 0 and the stage which carries the voltage gain which is above really sees an infinite impedance, so it's great to achieve the output stages. I would like to summarize what we have just seen throughout this week. In my opinion this is one of the chapters, the most important to understand how to use the operational amplifiers because we saw all components that we will study in the next week and that will show us that an operational amplifier are stages that we're going to put one after the other.

Notes

Summary

51m 29s



So we realized that there is a stage for excellence that makes the voltage gain, it is called common emitter which improve by putting a common base in series because we make the Cascode Assembly and that we need the common collector to follow after the common emitter. On one side it does not degrade the gain and on the other side it allows for a buffer so that the output is reached to provide a high current in low loads. Next week I make a small introduction to the chapter ahead. Next week it will be a summary virtually of all what we saw, I'll just introduce at the beginning of my chapter what I call the differential amplifier, it is an important element for the operational amplifiers and you'll see the rest is doing stages that will follow and we are at the stage of synthesizing circuits to reason in terms of functional block and it will be a summary of what we have seen until now in this electronic course.

Notes

Summary

52m 45s