ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

6.1-Amplificateurs différentiels & montage Darlington

Principes et analyses

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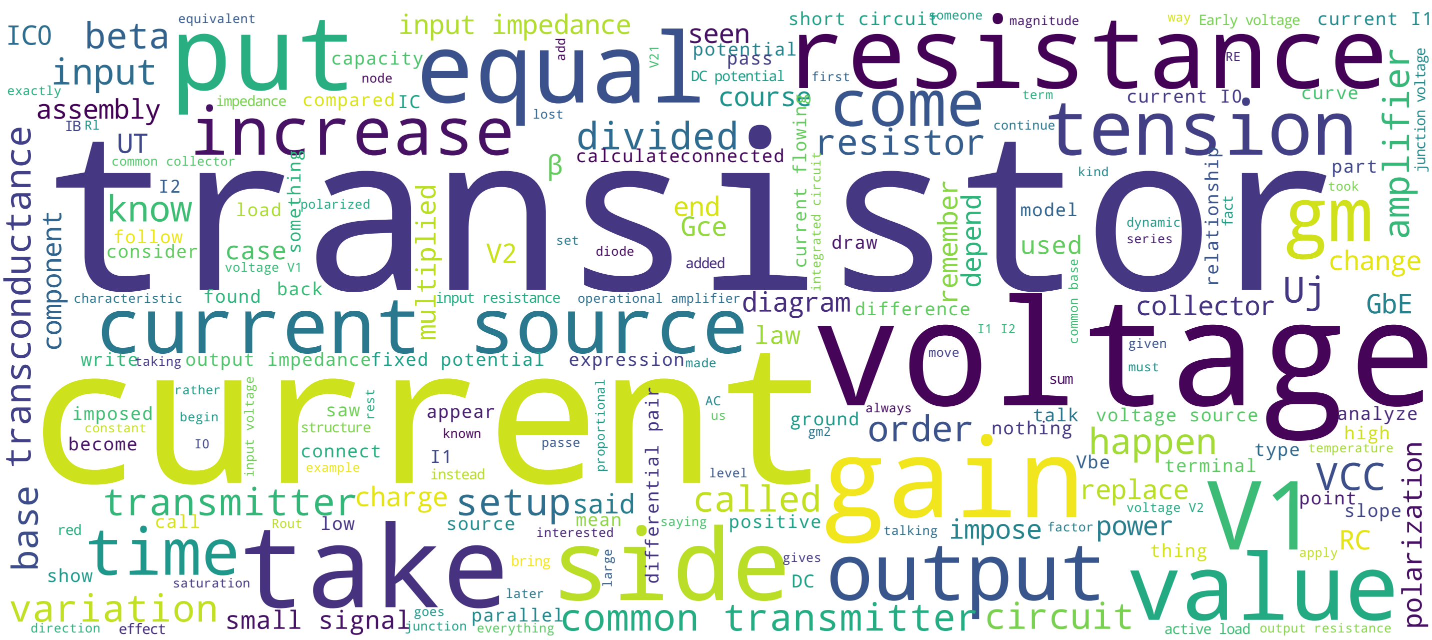
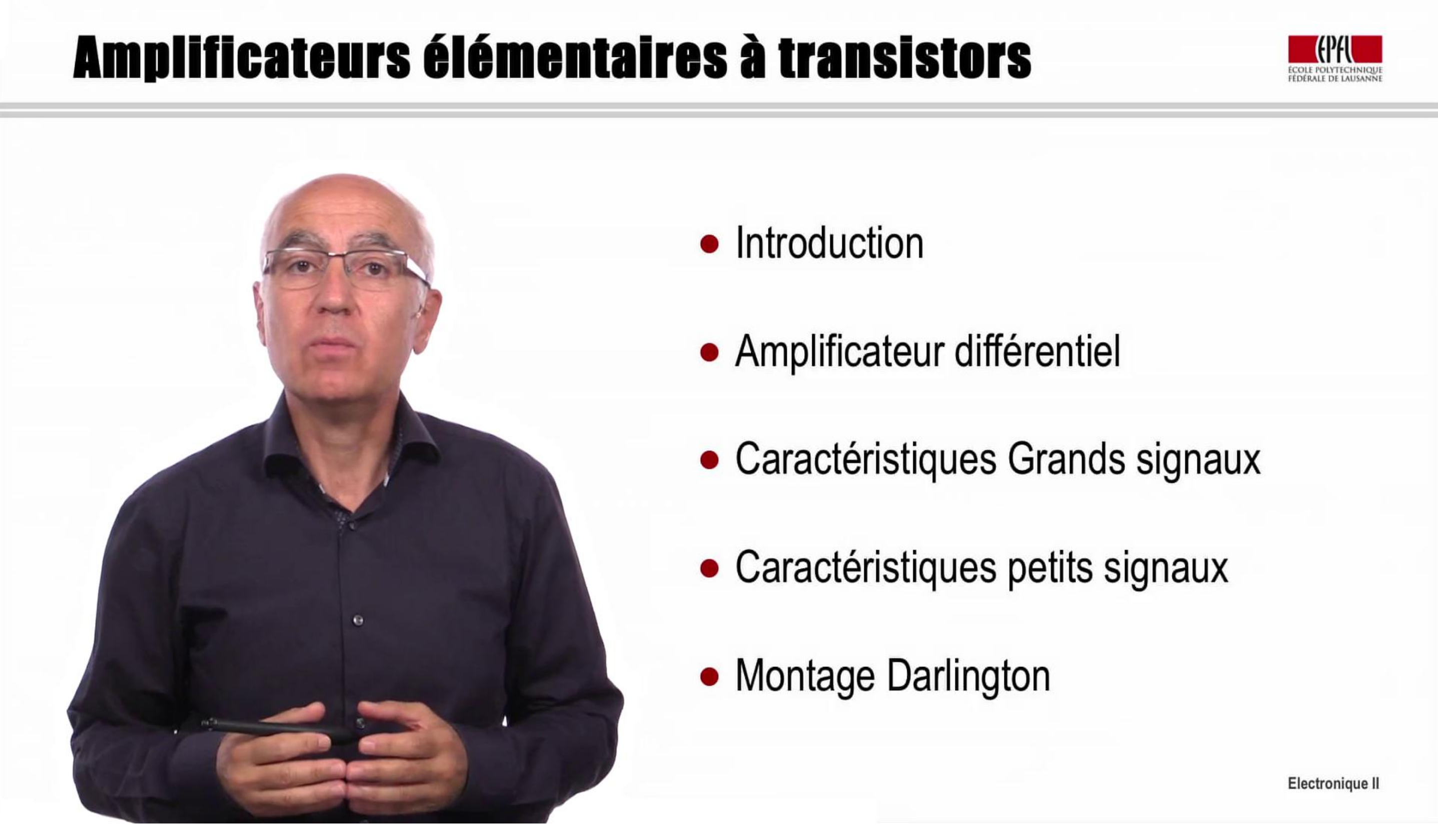


Video

EPFL

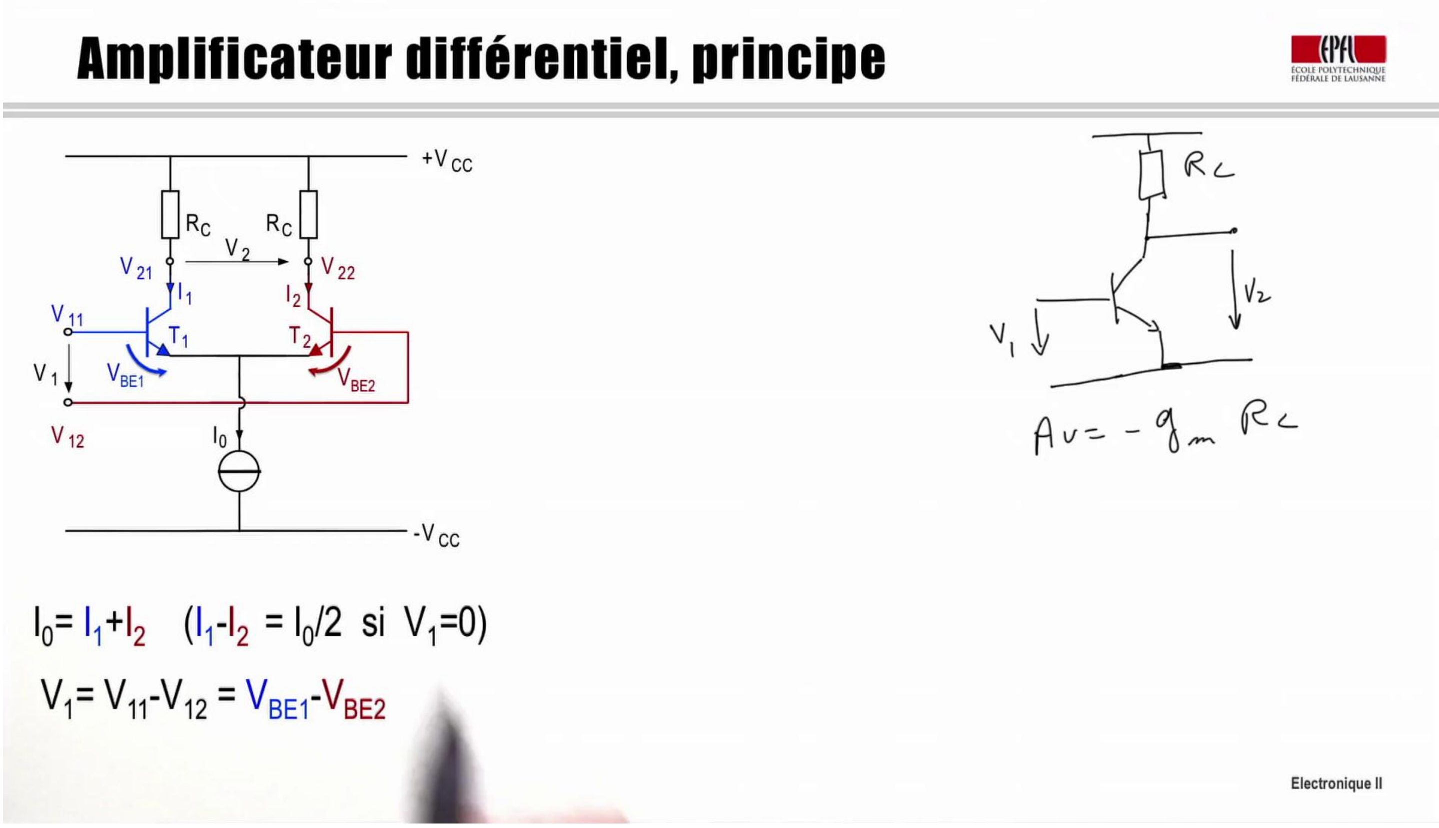


Good morning everyone. We practically arrive to the end of the analysis of all the basic structures. So in this video, we will learn what is called the differential amplifier. So with this last structure, we are going to make a type of amplifier that is a bit special, it's a bit similar to the common transmitter, but you will see right away that there is a fundamental difference compared to the common transmitter. And I will end in this series this week by the Darlington setup analysis and then I will resume everything we saw since the beginning of the study of transistors up to all the structures which we analyzed just to refresh the mind of those who follow this course. And I'll conclude with a treatment of a complete excercise which allowing you to see how is it used or how it is synthesized using different basic analog structures that we have traveled so far. So it is a crucial week because it will summarize all of what we saw from the beginning.

Notes

Summary

0m 05s

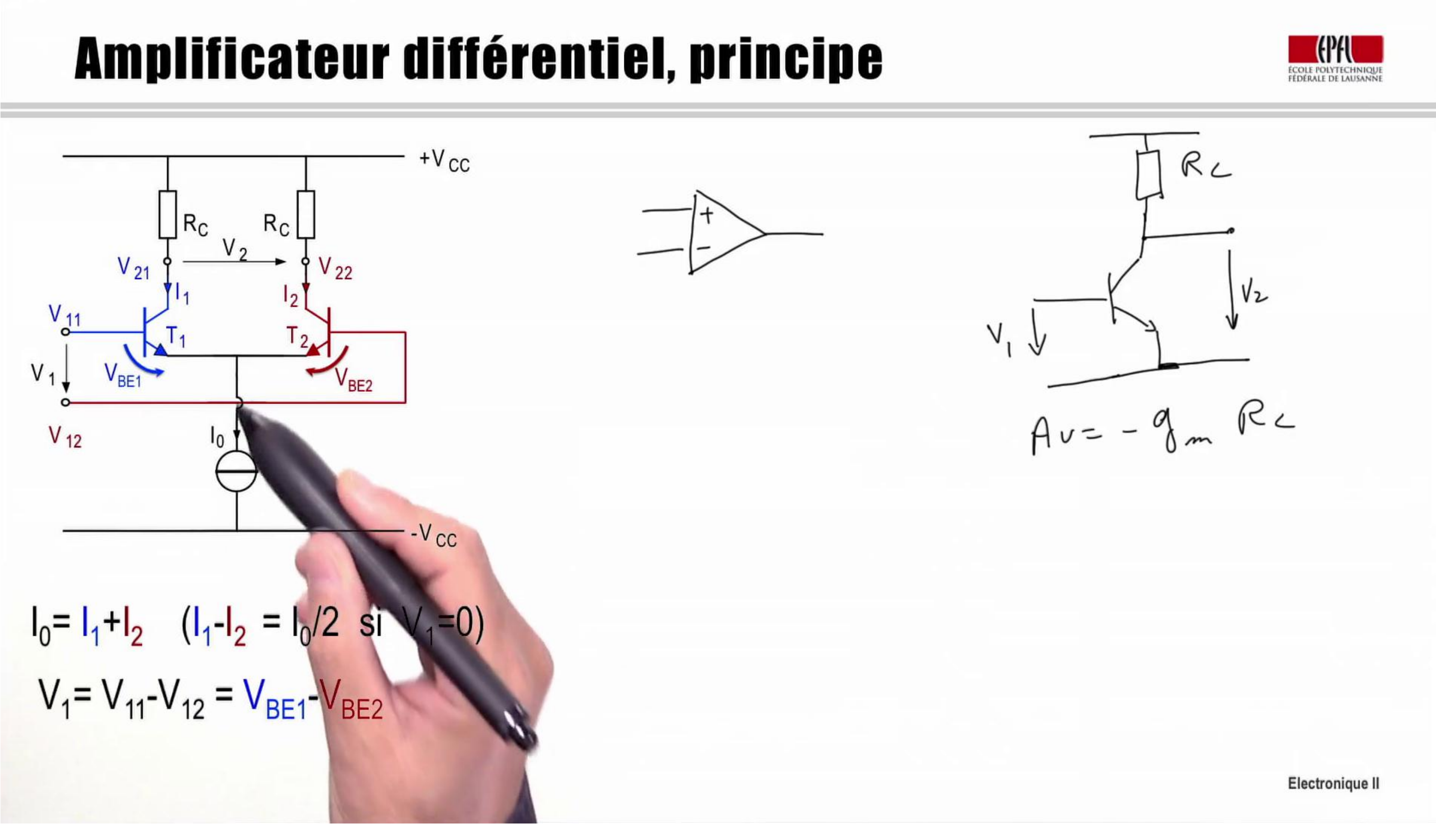


A differential amplifier, that is drawn here, compared to a common transmitter amplifier, wich I'll draw next so if you take our famous common transmitter, where we had a transistor then we arranged in a small pattern signals, to connect its transmitter to a fixed potential. So look, it's a fixed potential. They put a RC load and they brought a signal, in a manner to give an increase here and called this V1, and called this V2. If I compare this to that, I see there, the voltage V1 and the voltage V2 are both compared to a fixed potential. And it is a potential that we have a priori imposed. So it's a potential that can be grounded, someone has imposed, or a DC voltage. I will not go into details on how it is created because we saw it in long and wide. When you see the variation of the voltage V2 relative to this fixed potential, brought for example to V1 finally, this potential that is the same, well, this generates a current passing in RC etc. etc. I will like to compare this to this, just remember that the gain that was found, this is a gain which is -gm x RC and gm corresponds to a polarized current divided by UT. I come to this setup. Look there. Instead of one transistor, I put two.

Notes

Summary

1m 09s

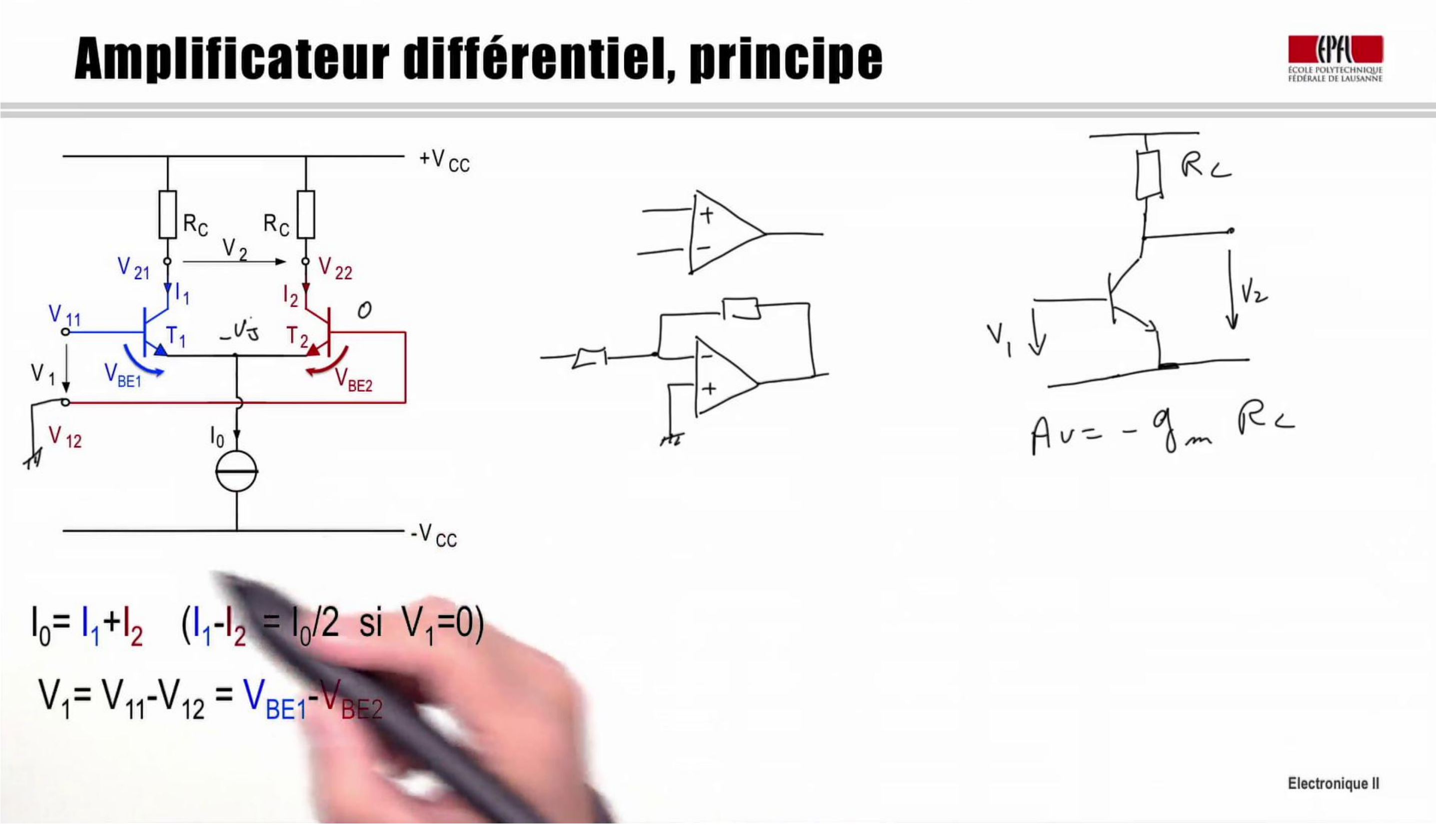


Both transistors are connected by their transmitters and the two bases constitute the input to this setup and the two terminals that you see, V11, V12 are generally, these two terminals that, quite often, when you take an operational amplifier you were told that there is an input (+) and an input (-) and in it is an integrated circuit, and this circuit represents a positive-negative input that are in reality these two potentials V11 and V12 and they say to you here, there is a differential voltage and often there is such a gain there, that this gain is terribly great to make these two tensions close to each other. They say in an ideal amp, the gain is infinite and V (+) = V (-). So in reality, there is a setup like this placed at the input of an setup of the type of integrated circuit which is the operational amplifier. The comparison to the common transmitter, I return to this point, it's that an issuer that is in between, it floats. Look, we put a power source, this current source, in terms of DC, It could endure any DC potential. So you can apply here any voltage that would float between the supply rails, between (+ VCC) and (-VCC).

Notes

Summary

2m 41s



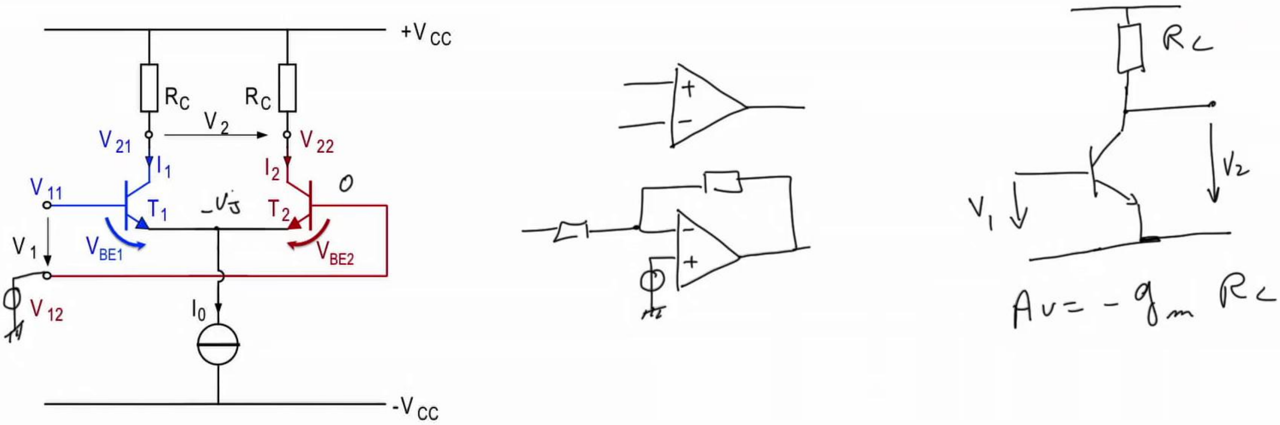
So it is a potential which is quite arbitrary, which is imposed by the person who is doing the setup. So if you take an operational amplifier, and I will take, ie, amplifier with a potential, the (+) to ground against a feedback through resistors, and you will see that one has the impression that imposes a potential 0 here And they say, "Here is the entrance to the other side." So it's like someone is taking the (+) and impose it on one of these two inputs, So if you plug it here, and you say: this setup is inside, we will reason on this reflection, they will say: there, one has a given potential data, good, we will go to 0 V, there, I have a voltage drop, If the transistor conducts on the order of Uj to DC. So the analysis brings me back quickly that this potential will be stabilize to -Uj. So again, I meet the fact that the transmitter of this transistor is found at a fixed potential imposed by someone who as connected from outside a ground. So if the person would come and put a voltage source here well, this voltage source would require a different voltage on the droping basis of Uj, bring back the transmitter to another value DC.

Notes

Summary

4m 04s

Amplificateur différentiel, principe



$I_0 = I_1 + I_2 \quad (I_1 - I_2 = I_0/2 \text{ si } V_1 = 0)$

$V_1 = V_{11} - V_{12} = V_{BE1} - V_{BE2}$

Electronique II

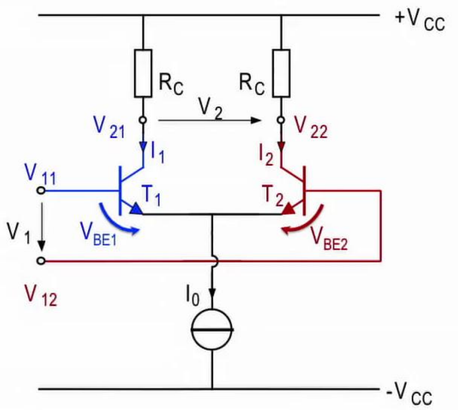
so basically, we are saying that transmitters are virtually at a stable potential, So we have a DC potential imposed by what would have imposed on the base. when I say all this, to show that we dont have to define it, the potential that had been set and they brought back in a potential imposed by someone, here, it is imposed by anyone that would use this setup, and the setup, alone will adapt and will bring back a polarization to that node.

Notes

Summary

5m 32s

Amplificateur différentiel, principe



$I_0 = I_1 + I_2 \quad (I_1 - I_2 = I_0/2 \text{ si } V_1 = 0)$

$V_1 = V_{11} - V_{12} = V_{BE1} - V_{BE2}$

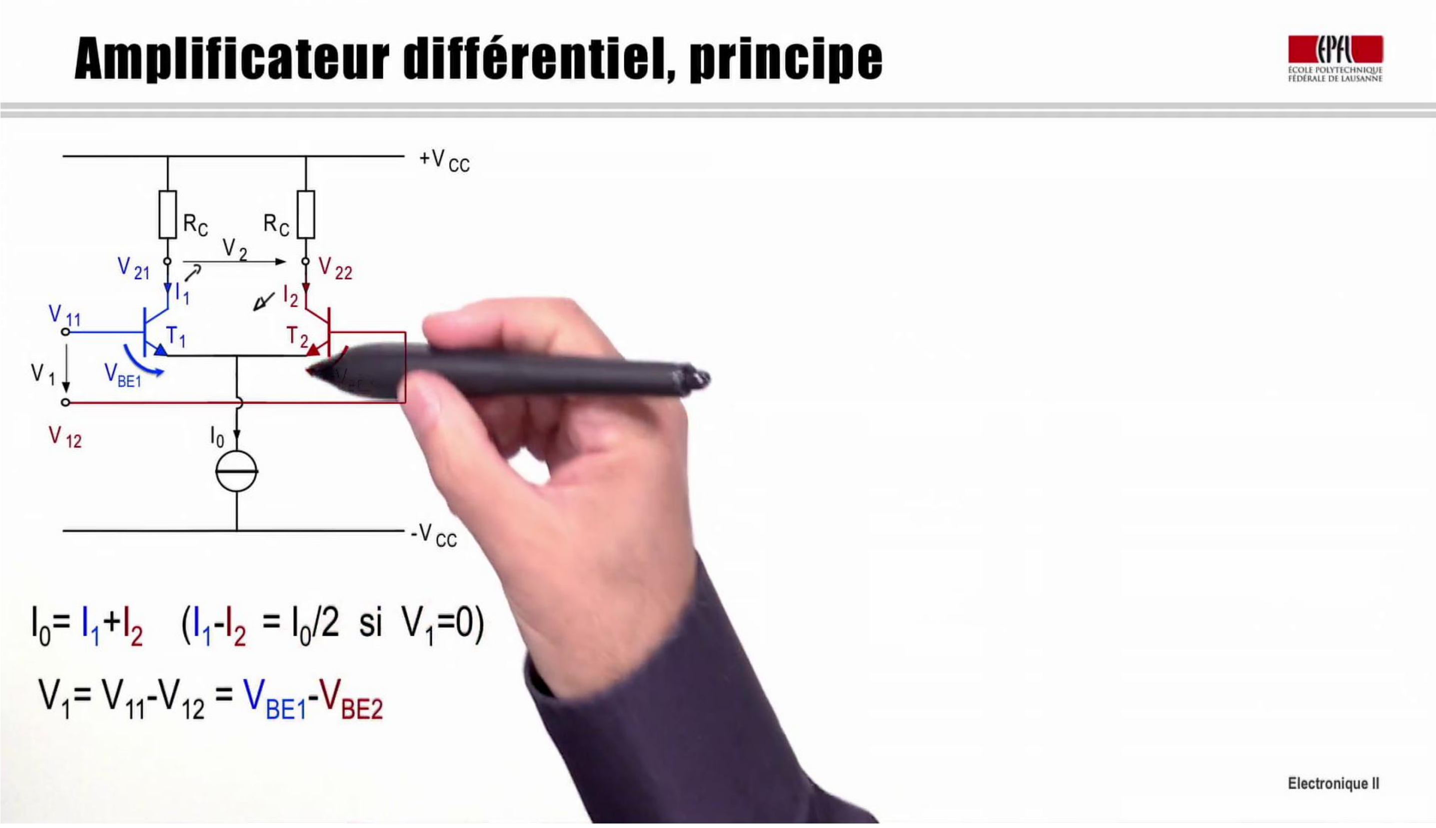
Electronique II

Then I'll erase all that is written above, and we will begin to analyze with the data which are absolutely linked to a very basic analysis from what I see in this diagram. First, I see that I have a voltage which is located between the base of two transistors and this voltage one, takes into consideration, if I say that, it's V1, that too is V1, it goes like this, and then, it gives me V1. So I can easily write V1 is V11 - V12 which is nothing else than VBE1 - VBE2. Therefore, the input voltage, it takes two junction voltages, but one in opposition to each other. Now I look at what will happen with the currents, I take the two currents I1 and I2, I pass them into 2 transistors I sum both of them in this node there, and I said: I0 is alwas equal to the sum of these two. So I impose the fact that there is a current source which is always the sum of the two currents. So let's do an analysis of what we just saw. I re-clear again my arrow and we will analyze it. We will finally say if I impose a common mode here, as just now, we put it to ground, it can be any voltage, if you take a common mode, that is to say that this potential is fixed, and you begin to increase V1, that means it's VBE1 which will increase, and VBE2 that will decrease of the same amount.

Notes

Summary

6m 07s

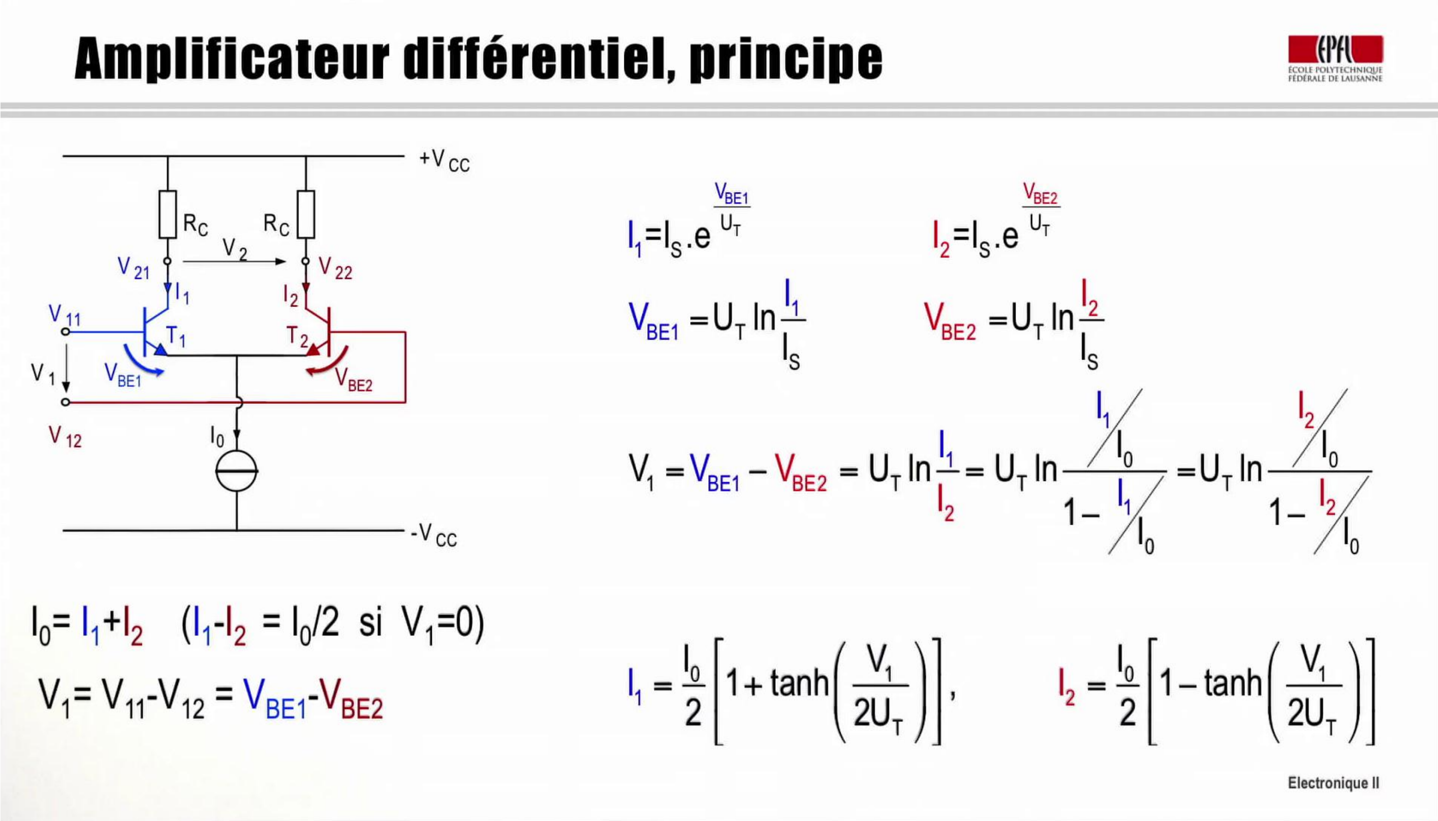


So any change that I see on VBE1, it is brought back on VBE2 and one is in phase opposition compared to other, therefore it increases on one side and it lower on the other side. What will happen with the currents, It's exactly the same thing. When you increase VBE1, you will increase the l1 current and what happens on the other side, you lower VBE2, therefore, you will reduce the current I2. So the two currents will also move in the opposite direction one against another of the same quantiy which is shared between 2 transistors. So the one who has understood this, he understood that we have practically a swing with a pivot and this pivot is located around this point and we will rotate it, we will go up or down, what I gain on one side I'll lose it on the other side either from excitement at the input that compared to this current which passing in both branches. Who says current that passes in the two branches, would also say voltage V2. Why? Because this current one, it's converted to a voltage through the resistance RC, it is also converted into a voltage through the resistance RC and if RC and RC are the same, so when the tension rises on one side, it go down on that side there, and vice versa.

Notes

Summary

7m 38s

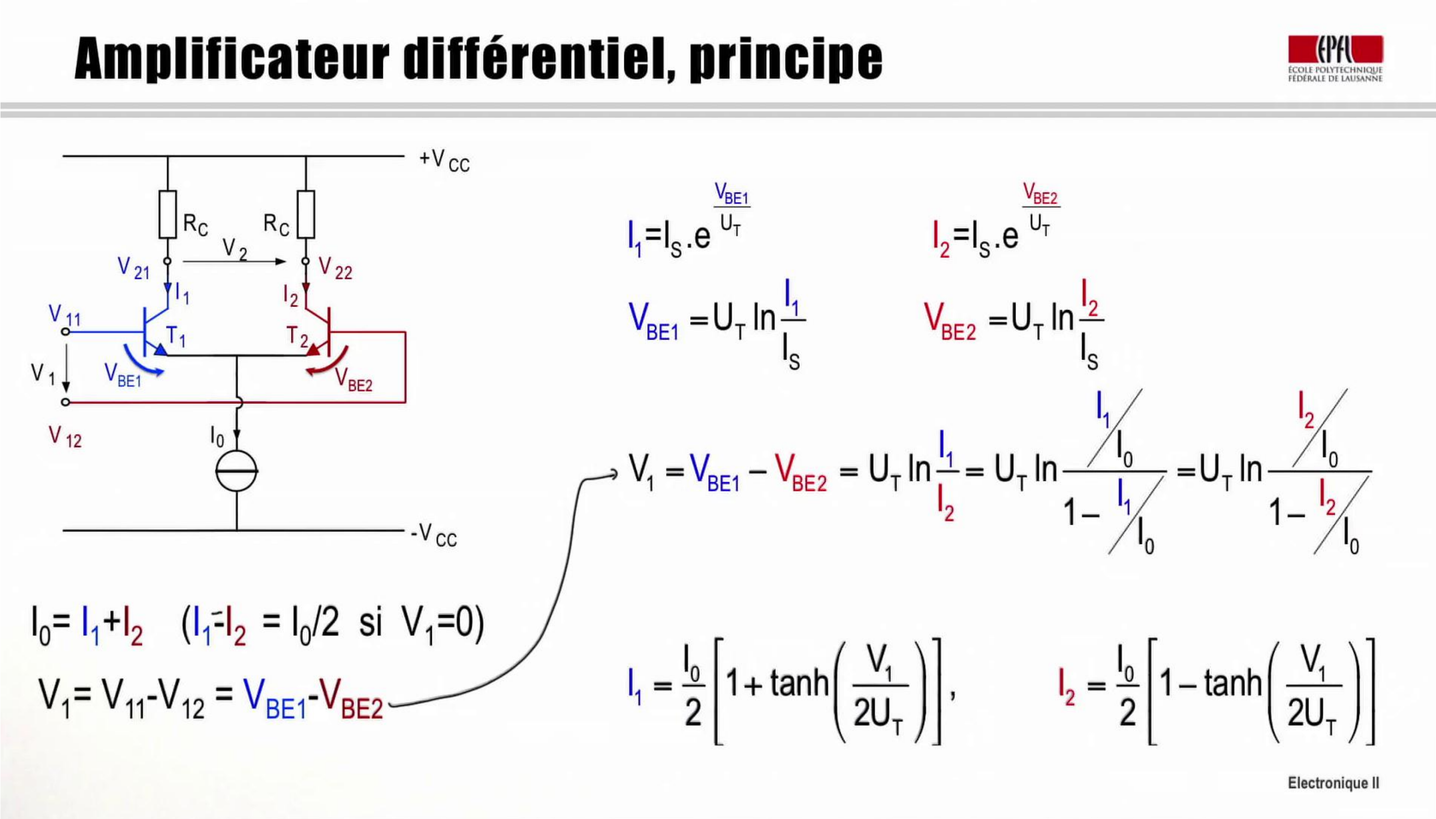


So we will see on the output a differential voltage, if we look between V21 and V22, as we can watch between V22 and V21, - Is it a story of terminal, so we'll see this potential swinging like a swing. You can imagine that when it increases to one side, it go down on the other, and the same of either side, well we control it by the input voltage. It's called the differential pair. I'll take this structure and I will analyze to extract from it an amplifier. I take the diagram of my differential pair. The findings that we have just made here, that is to say it has been said that the sum of voltages V1, it's VBE1 - VBE2, which as noted there and the current flowing I0, it is all the time the sum of blue current and red current, I1+I2 and at rest, when V11 = V12 equal to any voltage wich floating between (-VCC) and (+ VCC) well, you'll fall, on a voltage which is the same on both, so VBE1 = VBE2 and at that time, your current I0 is divided into two and you will have I1 = I0/2 I2 = I0/2 And that's what I've noted here. that's if you have I1 = I2, then there is a mistake is I1 = I2 = I0/2 when the voltage V1 = 0.

Notes

Summary

8m 54s

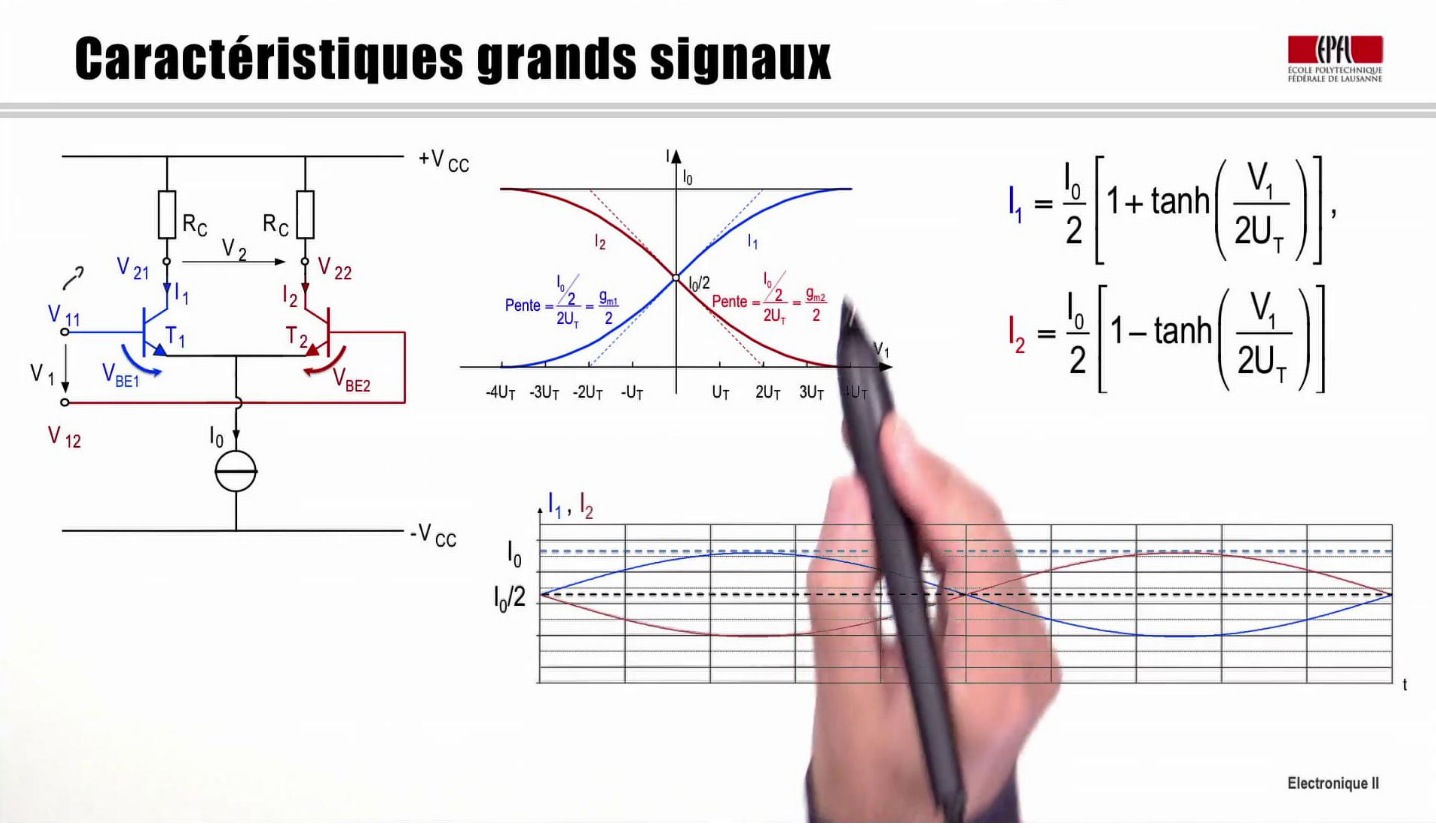


I take the transistors laws, each of these transistors is governed by the famous exponential law which would say that the current I1 is proportional to the control voltage V BE1 through this exponential. Same for I2. So I will write both laws. I express VBE1 therefore, it is logarithm I1/IS multiplied by UT. Same for VBE2. All this, I apply what I see there. I say at the entrance, caution VB1, or rather V1, it is the difference of VBE1 - VBE2 which brings me to simplify this because that is a ratio of I1/I2 because IS is simplified, I replace I1 by its value because I know that the relation between I1 and I2, it's the complement to this I0, and it will give me a relationship between V1 and I1 or V1 and I2 and I say I1 = f (V1). So I take you back to the mathematics courses to see that when I have that kind of relationship, it is called "hyperbolic tangent" and the hyperbolic tangent of V1 / 2UT, plus 1, multiplied by I0 / 2, is nothing other than the current you order. It is a non-linear law. And there again, it is the expression I2 which is of the same nature, there is a (-) here and a (+) here and there are I1 and I2 expressed. then I'll take these two relations and I'll go and draw that expression and see the plotted relationship between I1, I2 and V1, V1. So, I recall that V1, it's the differential input voltage.

Notes

Summary

10m 30s

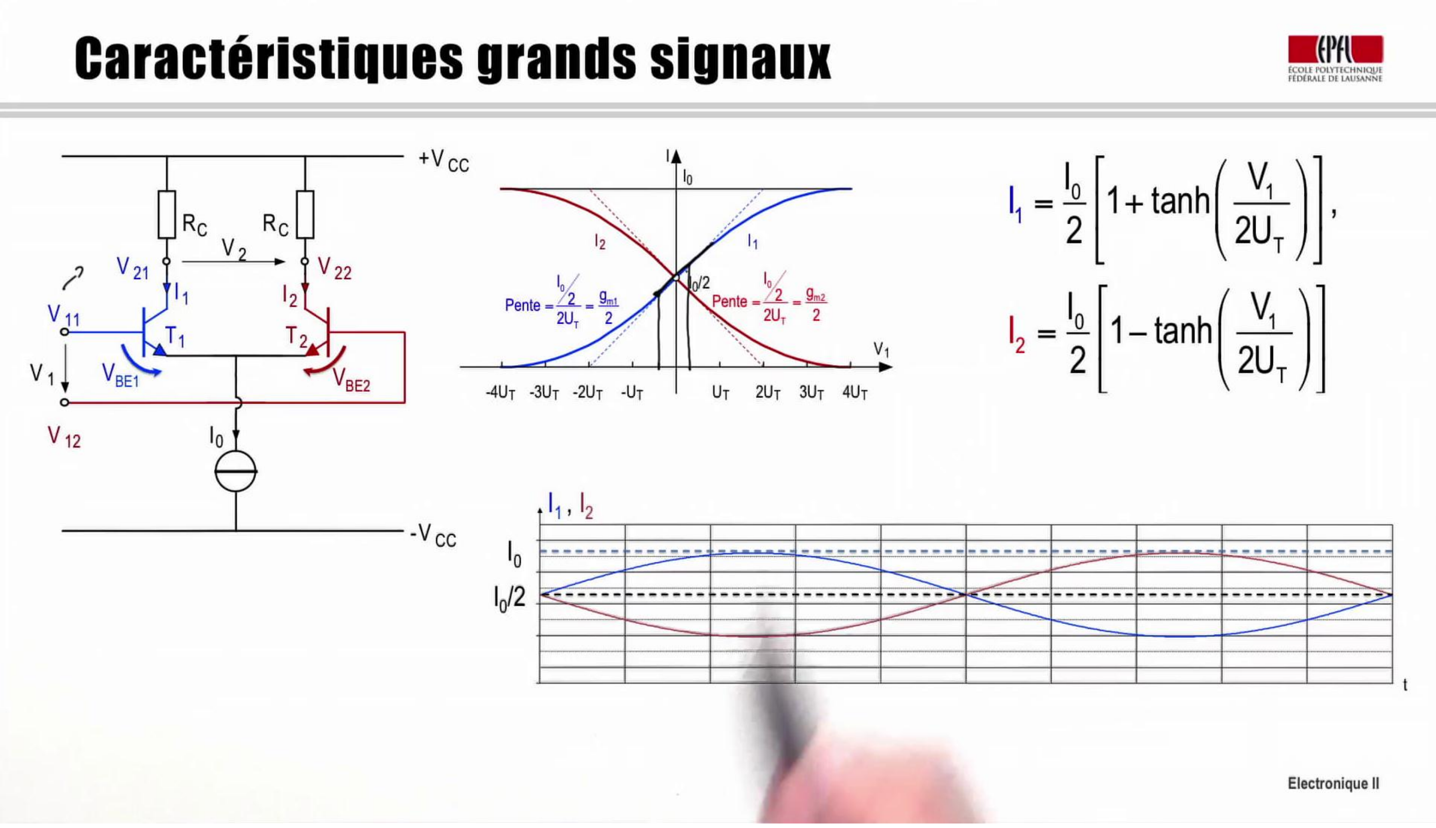


I take I1 and I2 and I draw them here. I see indeed if V11 = V12, equal to a given potential, Well, there I0 / 2Well, therefore when V1 = 0, so when this was bypassed like that, well, you will end up in that point. When V1 = 0, you find I0/2 the current I1 = I2. And it's the only one point where the two currents are the same. Because if you start increase V1, what's going to happen, if V1 increases, the VBE1 voltage increases, I1 will increase, And you end up with this current that will increase according to that law. So I1 will be managed by V1 and given what is increasing on one side is decreasing from the other side, the other current would follow the same law but in the opposite direction when the current in the blue transistor increases, the other decreases to the same quantity. So the one we add to one side, is subtracted from the other side because the sum of the two is always equal to a constant. so we see that there is a law which describes V1, or rather I = f (V1) sorry I1 = f (V1) and I2 = f (V1) that is, thereof, the other is red color.

Notes

Summary

12m 13s



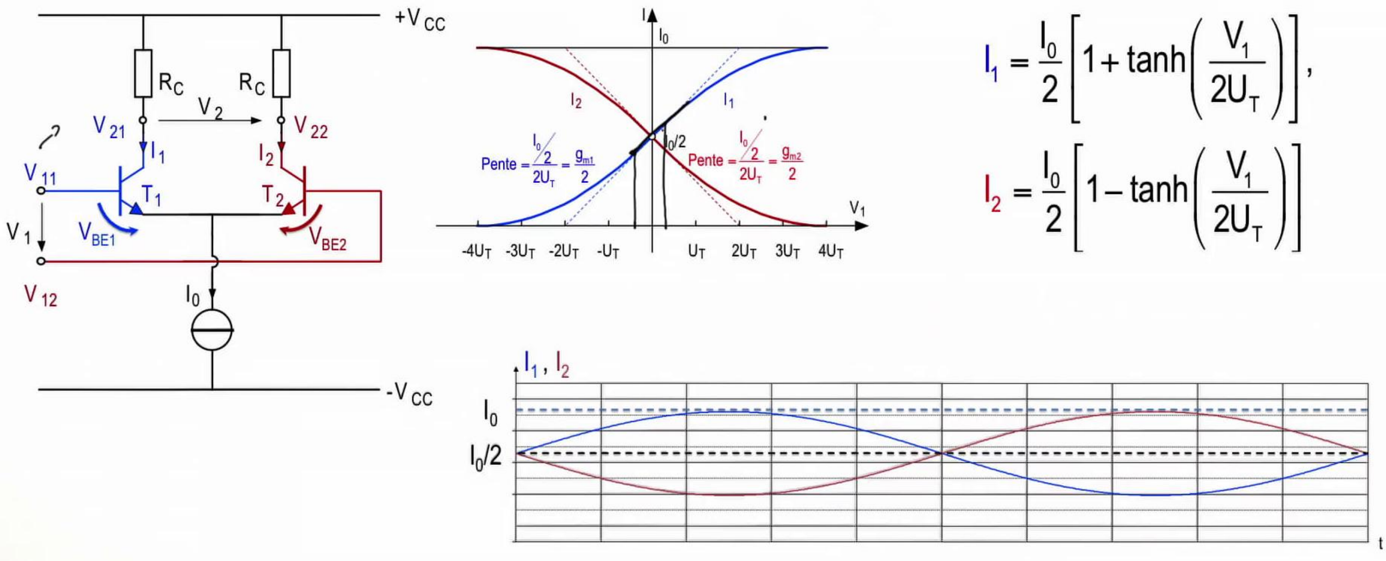
There, what is very interesting is that I find what I'm looking all the time, it is a transconductance me, I wanted to create a structure as the normal transistor where I take a proportion of variation on my curve therefore in this case here, it is the blue line or the red line or both at the same time and I say: finally, the transconductance, is that I'm taking a tensionV1, I'll vary and I expect that I see a current that follows, What I see here? when I increase V1, the current increases and I drops, it is a transconductance but I have it on both sides. So I have two transconductances, I have two currents that follow each other and it is a voltage-current conversion and that current-voltage conversion there is a zone which is fairly linear this is the one I presented as a slope of the tangent around the origin you see with the features blue or red, which are nothing else that the derivative of that law one that will give me the slope of the tangent when I have the current I1 = I2 = I0/2 and if I replace this relationship, therefore, I seek the value of the slope analytically the dI / dV1 when V1 = 0, I come across this relationship (I0/2) / 2UT. So this is I0 / 4UT.

Notes

Summary

13m 46s

Caractéristiques grands signaux



$$I_1 = \frac{I_0}{2}\left[1 + \tanh\left(\frac{V_1}{2U_T}\right)\right],$$

$$I_2 = \frac{I_0}{2}\left[1 - \tanh\left(\frac{V_1}{2U_T}\right)\right]$$

Electronique II

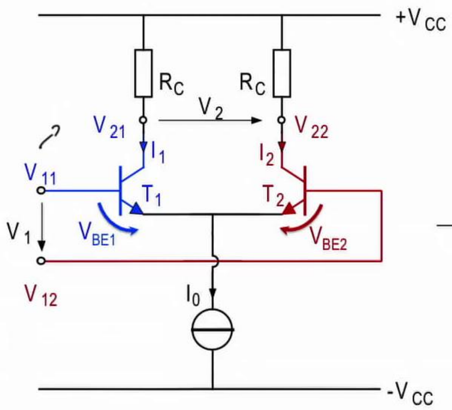
When I tell you to rest, when the voltage V11 = V12, each of the transistors is driven by the half of this current. So, at rest, I have a current I0/2 and I0/2. So you may well say: the gm2 of this transistor that, the gm2 of the transistor this is nothing else than the bias current therethrough, divided by UT. So then this slope is the transconductance of the transistor, gm2/2 and that one it's gm1 / 2. So I see here a slope and a slope there, which are nothing other than the transconductance of each of these two transistors. There, in additional, I have traced the variation of the current fonction on the time when we applying a sinusoidal voltage at the input and when a current increases, the other decreases and when all the current source is deviated in a transistor, it will reach I0 and when all the current is deviated in the other, it will reach I0 in the red transistor. So we have a swing where when one hits the ground, we have these swings where there is all the current that switched from one side or the other, well, we've saturated the system. So, we saturate in currrent because we lost all the current source. since lost all power source. Caution!

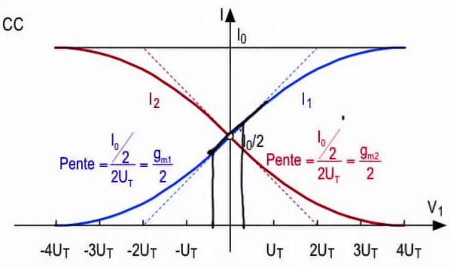
Notes

Summary

15m 09s

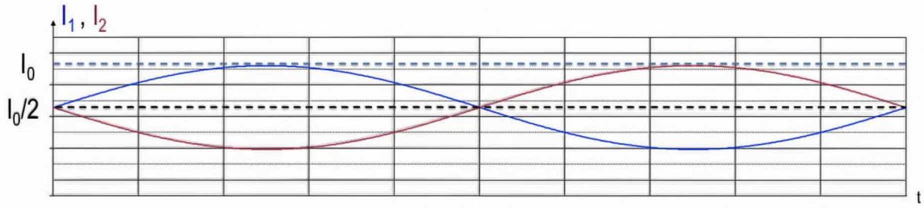
Caractéristiques grands signaux





$$I_1 = \frac{I_0}{2}\left[1 + \tanh\left(\frac{V_1}{2U_T}\right)\right],$$

$$I_2 = \frac{I_0}{2}\left[1 - \tanh\left(\frac{V_1}{2U_T}\right)\right]$$



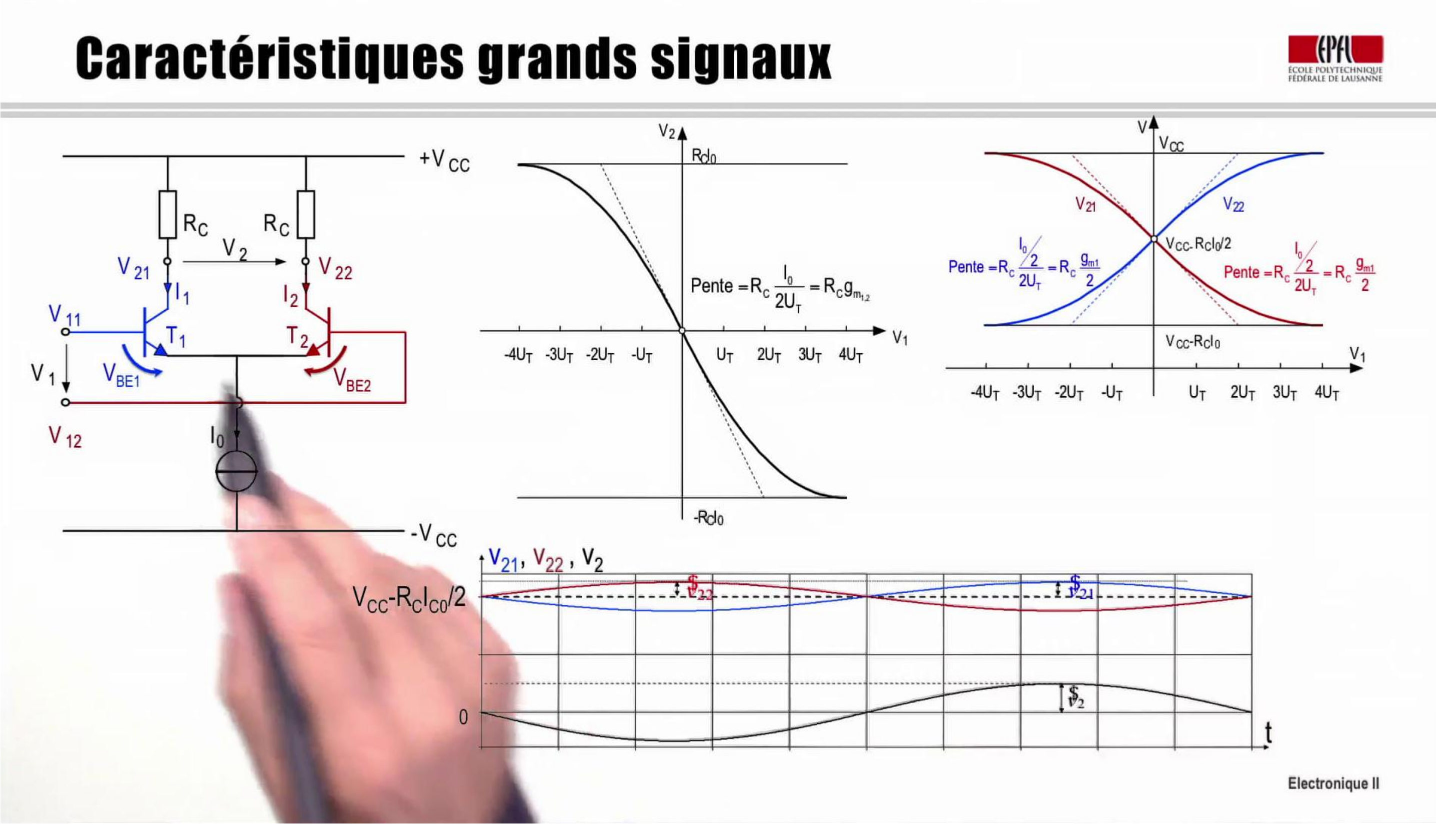
Electronique II

Here I'm not talking about transistor saturation because your transistor when it saturates, is when this voltage is then UC = 0, I'm talking about the saturation of the differential pair whole. It means that all power has already shifted to one side or the other. So we find the same thing you would find with a transistor with that story of transconductance.

Notes

Summary

16m 31s

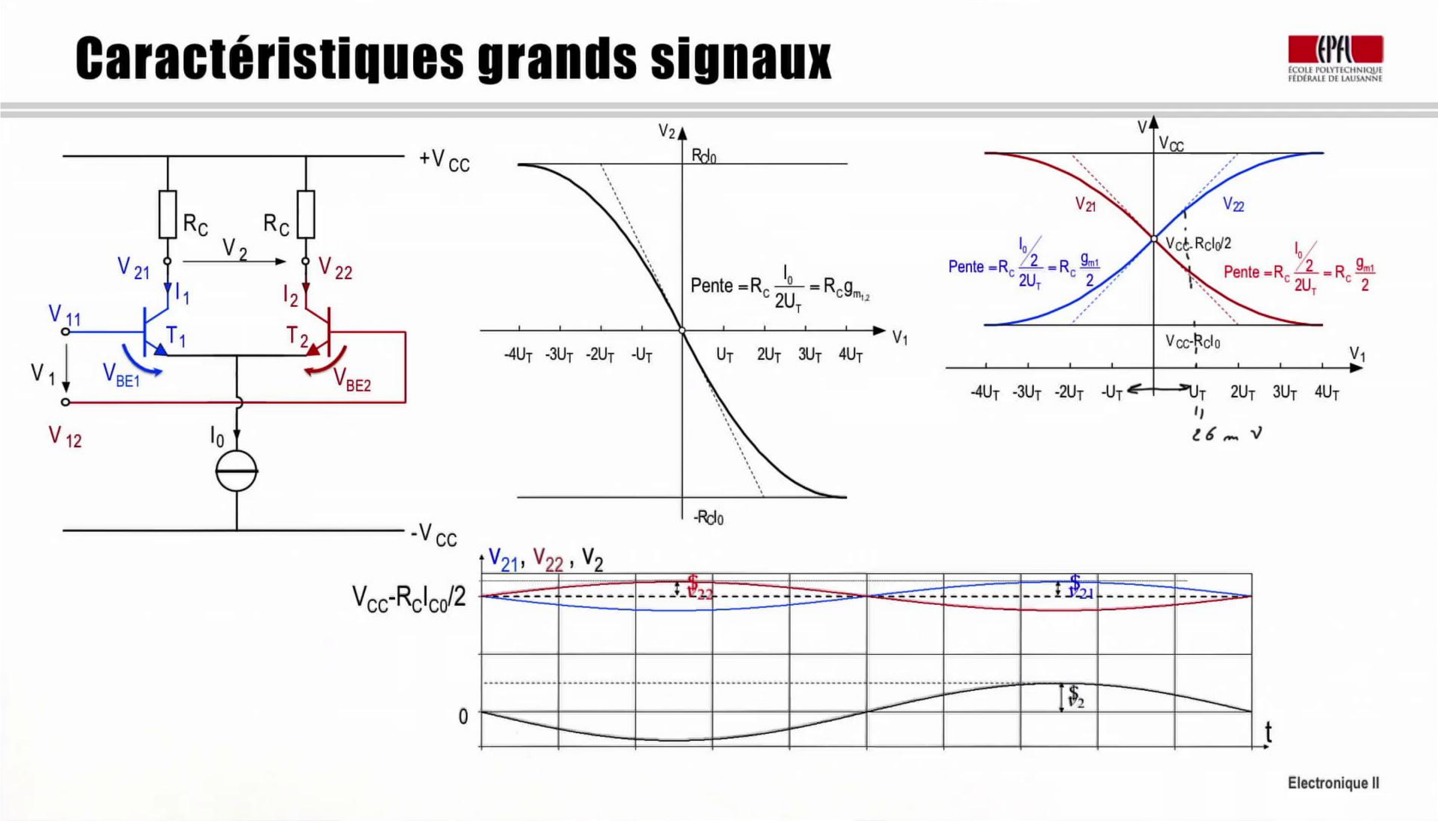


We will take now the same explanation but instead of talking about current, we will talk about tension. So instead of saying that the current I1 and the current I2, when one increases, the other will decrease, I will pass currents through a resistance. You remember that resistance, is the element that I use to convert a current into voltage, and I am interested in the change in voltage the terminals of the load because in a pattern small signals, even this tension one will become an short-circuit to the ground so, I'm interested to what is happening with the RC resistance and I am interested in the voltage V22, eiiher compared to the potential one, or relative to another DC potential, since it is a short-circuit in a AC pattern. So if I convert my current into a voltage, and I absolutely expect to see the same characteristic, the same aspect of my curve, I discovered in a short while for the current converted in voltage, because it is through a resistance it would become a voltage V22 and V21 and these two voltages will exactly follow the same pace that the currents.

Notes

Summary

16m 51s

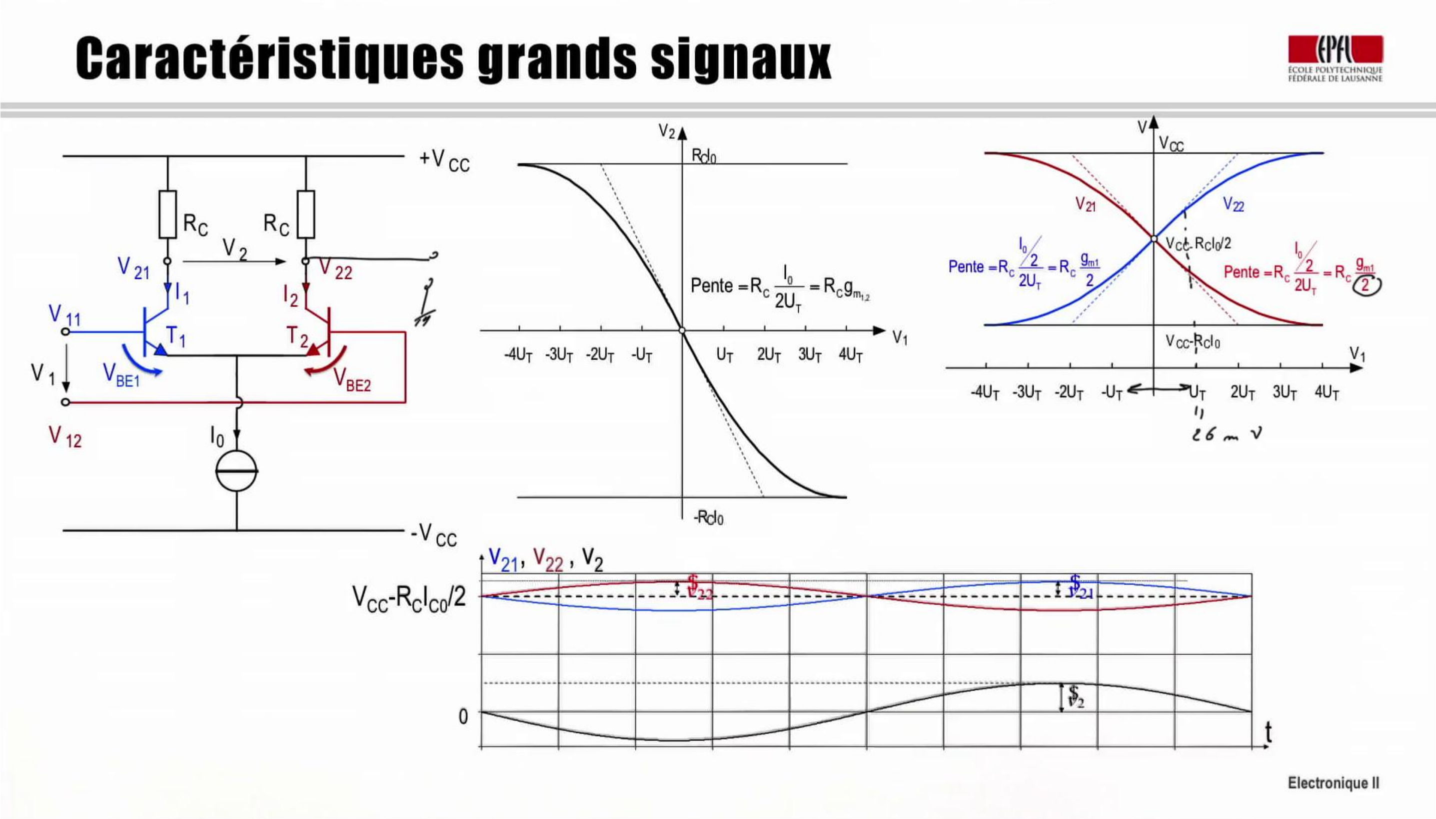


So if you are interested to V22 and V21, look at, V22 compared to any fixed potential, its variation is going to be linear, when the growth is weak So, look, when I talk about low I talk about of (-UT) and (+ UT) Therefore, there is an order of magnitude of 26 mV, there is very little variation before you get anyway in the non-linearity of this curve. So we're talking about all the very small variations at the input, an increase, and this increase translates into a voltage variation at the output. But which of these tensions? It may be that tension one when I increase V1, I will have V22 to follow, it depends if I look here and there, and V21 which will follow from the other side. with a different terminal, this phase is positive, that phase is negative. But then, I can well look at the difference V21 - V22 and then I look at taht potential compared to this potential. it's exactly the swing story that we talked about, if you are on these swings, one side, it goes up, and we look at the person in front we see that we have twice of our variation, same, we see the double of the variation when one is interested in us compared to the one who move in front or, if you look directly V22, with respect to a fixed potential, well, you look at the ground it is as if you are watching your swing compared to the earth so you see that you type on a fixed potential.

Notes

Summary

17m 57s

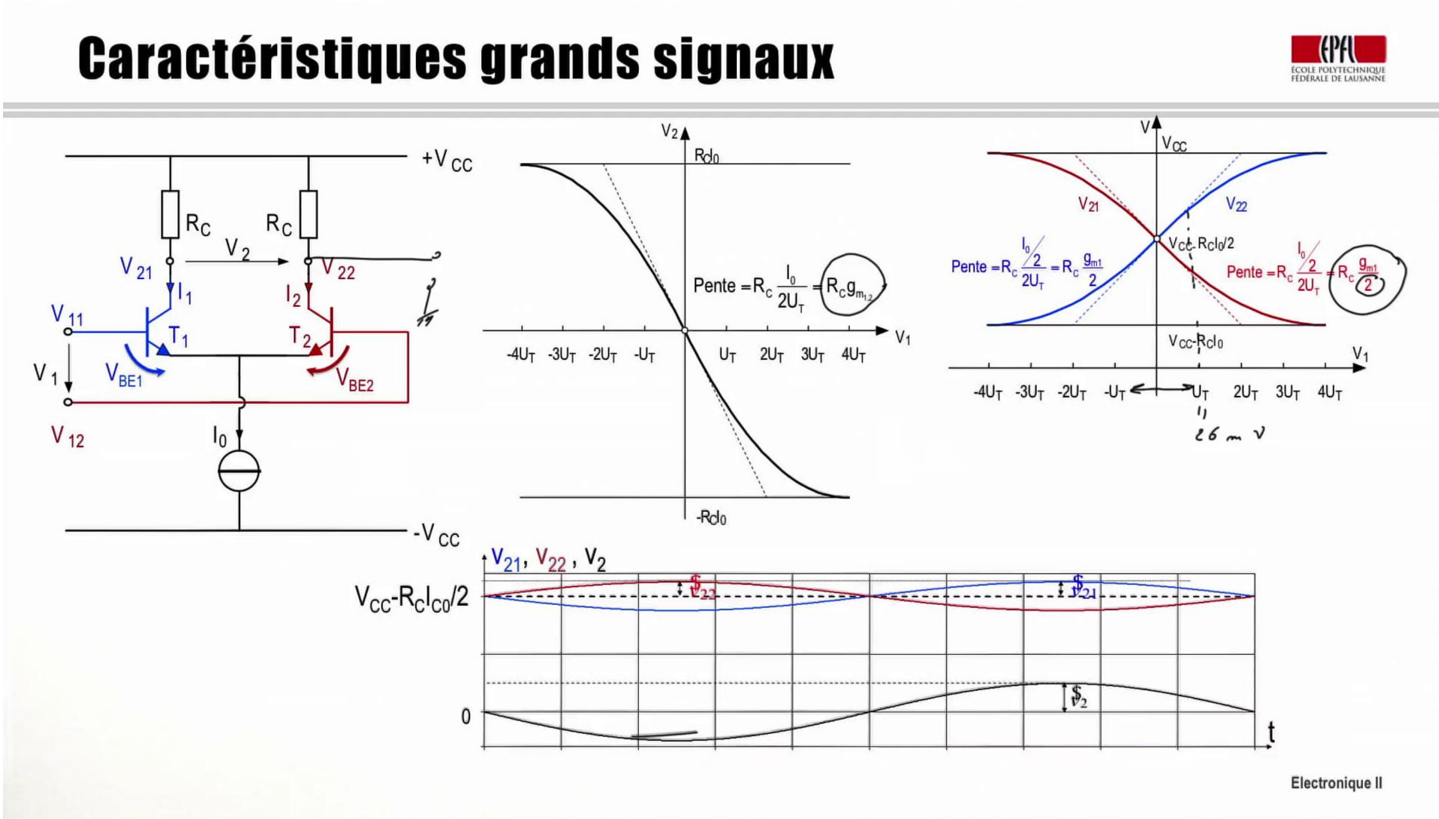


But if you look at the person in front, which goes up and down, you will find that it's twice the dynamics. So V2 it's taking these two curves and do the subtraction, which gives you this curve here. That is the voltage V2 = f (V1) this is a differential voltage compared to a differential voltage it is called "differential output" "differential input". When we look at either one side or the other side, we're talking about "unilateral" or "asymmetrical" because we look compared to the ground. On this curve there, we find that the gain, it's like a transistor since the transconductance we had seen it is (gm / 2) x RC and on this curve one, when I look at the one in front, it is multiplied by 2 so the factor 2 which was there, seen here disappear because it is gm1 or gm2 since it is the same gm given that tthe currents through the two at rest are the same. So the slope here in differential output is equal to RC x gm1 so I won a factor 2 on the gain. I repeat what I just said, when I go out to one side or from each other, I designed it here with V21 and V22 admitting that I have a voltage V1 sinusoidal at the entrance, then I see a phase is opposite to the other when the red voltage increases the other come down, and vice versa, and the peak values V22 and V21 are known on both sides are the same.

Notes

Summary

19m 27s

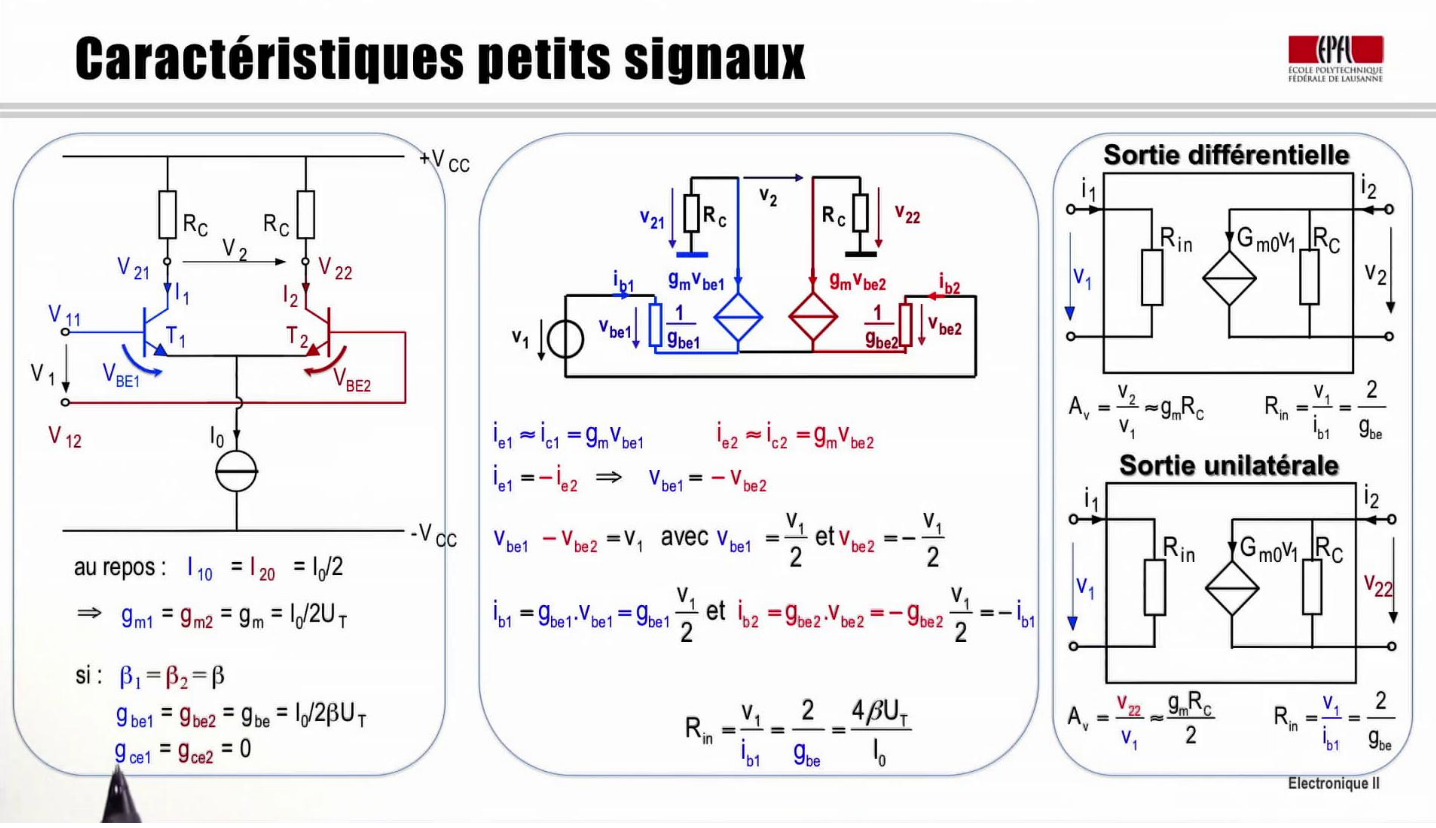


Now, if you take from that side, the difference between the two, and there you have to impose a common mode because there is not a DC potential that we look to know the common mode, this, you study it in other courses Where it is shown that by imposing common modes, in the case of resistans, there is no problem, because we switch compared to a DC potential known but we will see just now with the active loads, it will be something else. And we see a variation in tension that is double what we would have seen on one side or the other. And I will take you to remember this: the gain, when in differential output, it's like a common transmitter, the gain when we are with a unilateral release, is half of a normal common transmitter gain.

Notes

Summary

21m 01s

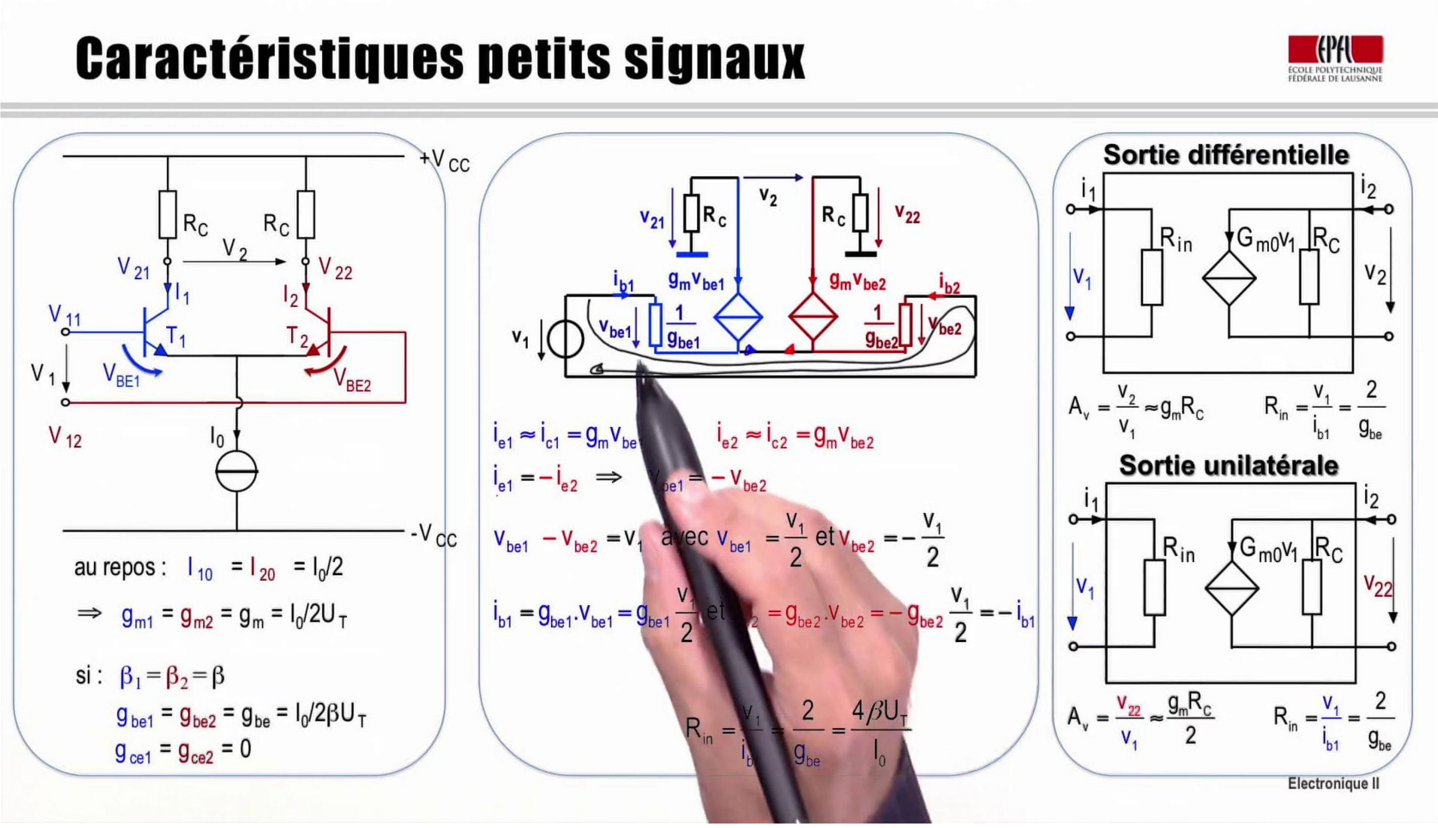


We always used to go through the scheme small signals. So we will make the scheme small signals of the differential pair. I've always presented that like that, one part with the actual pattern, that we would have achieved we draw the diagram small signal next considering that we polarized it and we extracted small signal parameters, and once we have finished it, we standardized this to replace the scheme small signals by a quadripole having an input impedance an output impedance, and a controlled current source. So we will do the same. the polarization is by this current source. As soon as the current I0 imposed here, each of the transistors, when the two voltages are the same, sees half of the current pass through. So I can write transconductances gm1 and gm2 that I call gm because it's the same thing, which in this case is equal to the polarization divided by UT therefore I0 / 2UT. Now the beta of transistors, I consider that it is the same beta. the Gbe of the transistors are the same, and it is easy to write because I know gm/beta so I divided it by beta and I find the transistor gbe and for me to be easy to do the calculation, I consider that there is no Early effect, that it is an ideal current source, the transistor T1 and T2, therefore the output conductance is equal to 0 or the output resistance of the transistors is infinite.

Notes

Summary

21m 47s

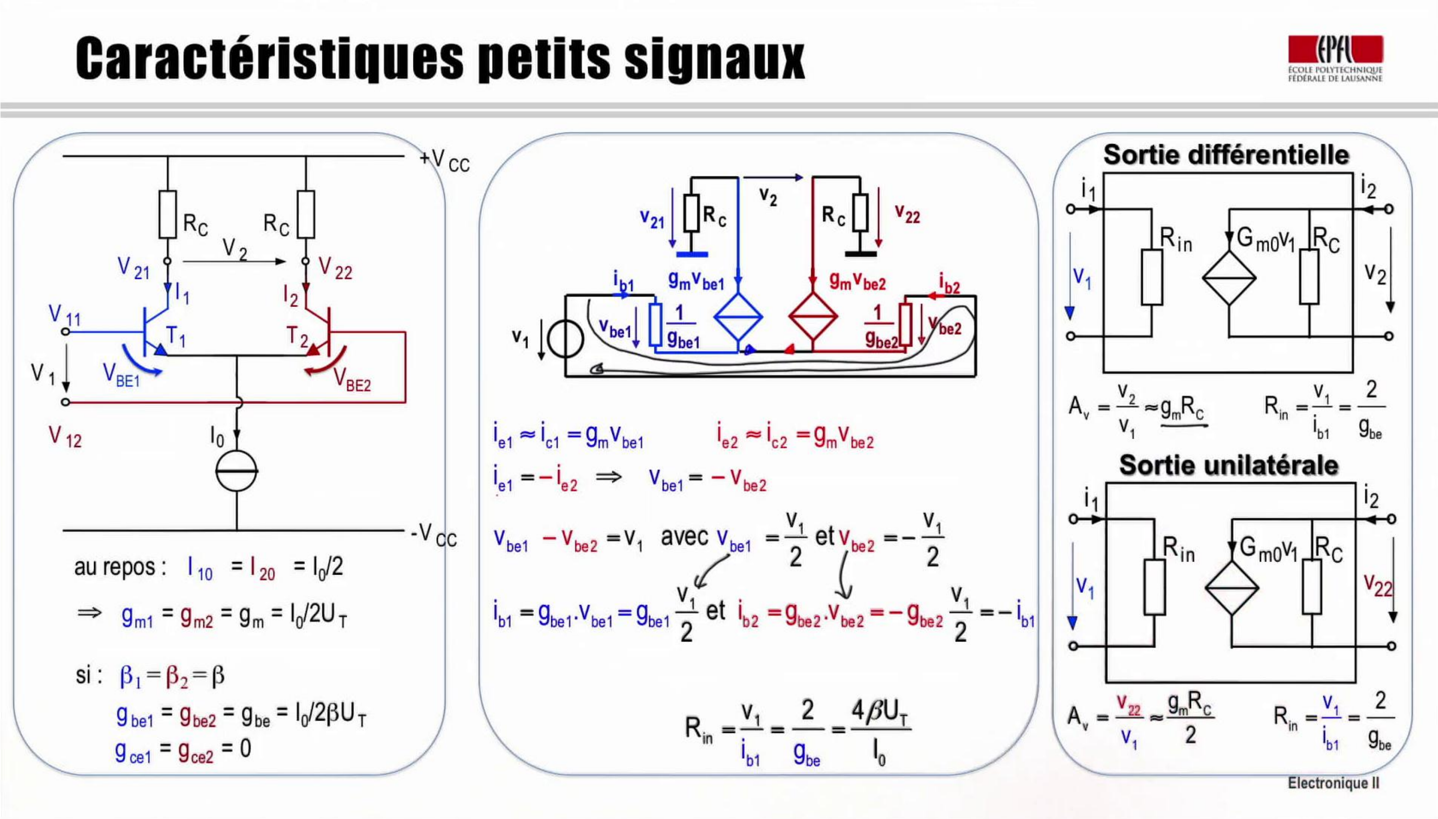


And there I draw the scheme small signals. You see your transistor in blue, and your transistor in red it is a controlled current source with its RC load and look at here, as the transmitter is floating, so I put a current source it is a potential which can take any value. If it is not imposed by these two terminals, it can take any value between (+ VCC) and (-VCC). So I make this link there is a current source so it is infinite resistance I don't show it I replace, and I finally show the two input impedances. And I leave in an extremely simple reasoning. The current ie1, it's the current flowing, here it is the current flowing through the transmitter there. The ie2 current is the current that passes trought there, So it's the current that will come in this transmitter, there. The both will join but since this current and this current are in the same wire in an AC signal, thus the current ie1 = -ie2. Similar to what was said to v1, the voltage v1, it appears here, like this, really like this in this mesh. So it's nothing but VBE1 - Vbe2. And VBE1 tension - Vbe2 is v1 of course that's what I just wrote. When I see a voltage increase and the other decrease in the same way, it means that the voltage VBE1 is v1 / 2 and Vbe2 is -v1/2.

Notes

Summary

23m 17s

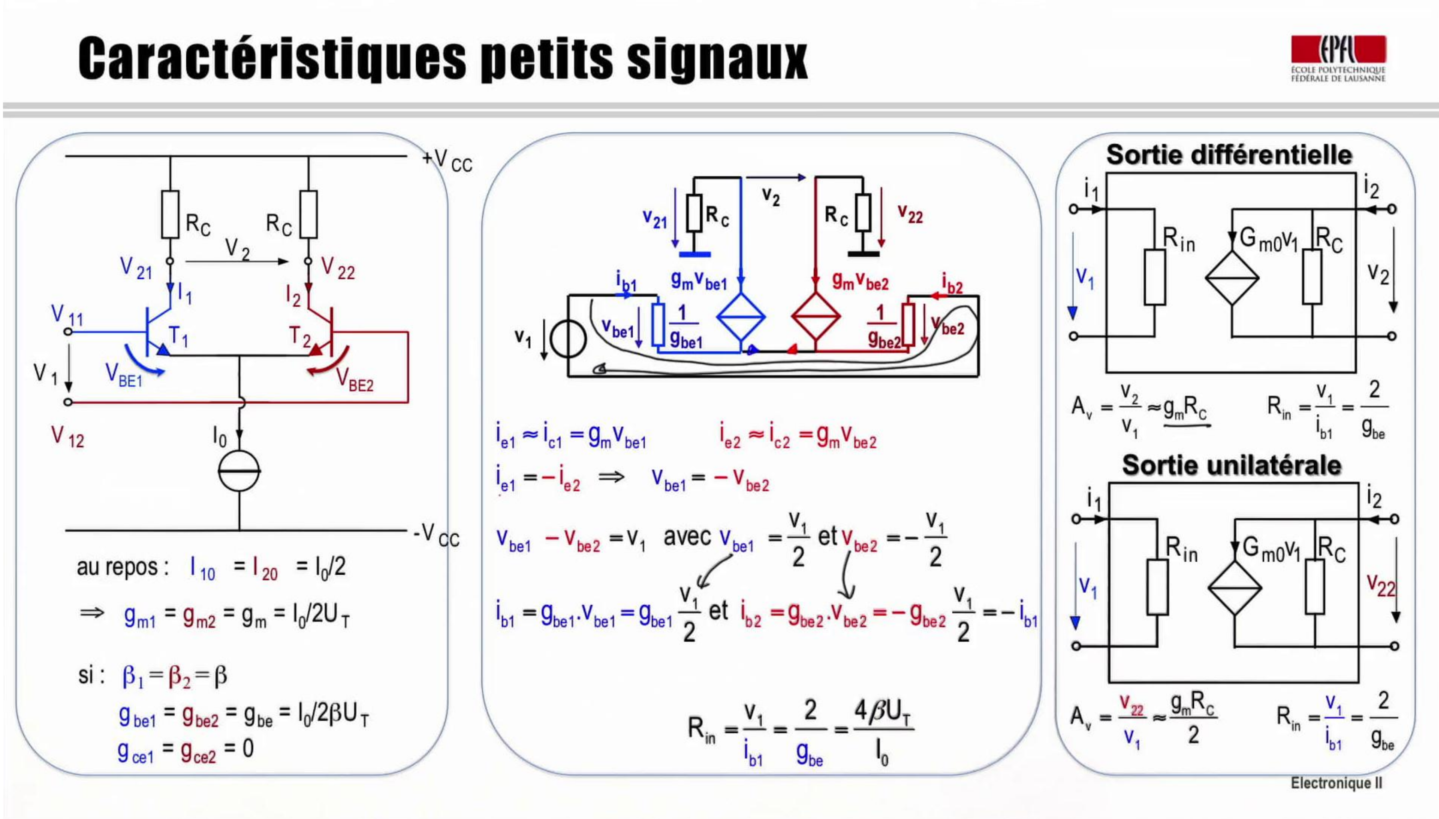


So that's pretty trivial to what has been written here, and then I'm leaving in the IB1 expression, the current flowing here this is multiplied by the GBE1 VBE1, the same as what we did all the time same here, ibe2, I can write that way in red, and I can replace VBE1 by its value there and Vbe2 by its value here and it will give me this relation which easily allows me to conclude that the input impedance I see at the entrance of a differential pair which must consider the dV1 voltage or v1 divided by the IB1 current, is just 2 x (1/gbe) I remind you that for a common transmitter, it was just 1/gbe, there, I have an input resistance which is twice superior than what I would have found with a common transmitter and we can understand very well because we must provide a current to the two transistors which are connected in that way. So now I have everything I need. We earlier calculated the Gm0. It has been discovered that there are two ways: either we go out in differential, it is the ratio of this voltage, divided by this tension one. And there, it's exactly like a common transmitter, the gain is gm x RC. Why there is no sign (-)? Because it's for you to decide.

Notes

Summary

24m 58s

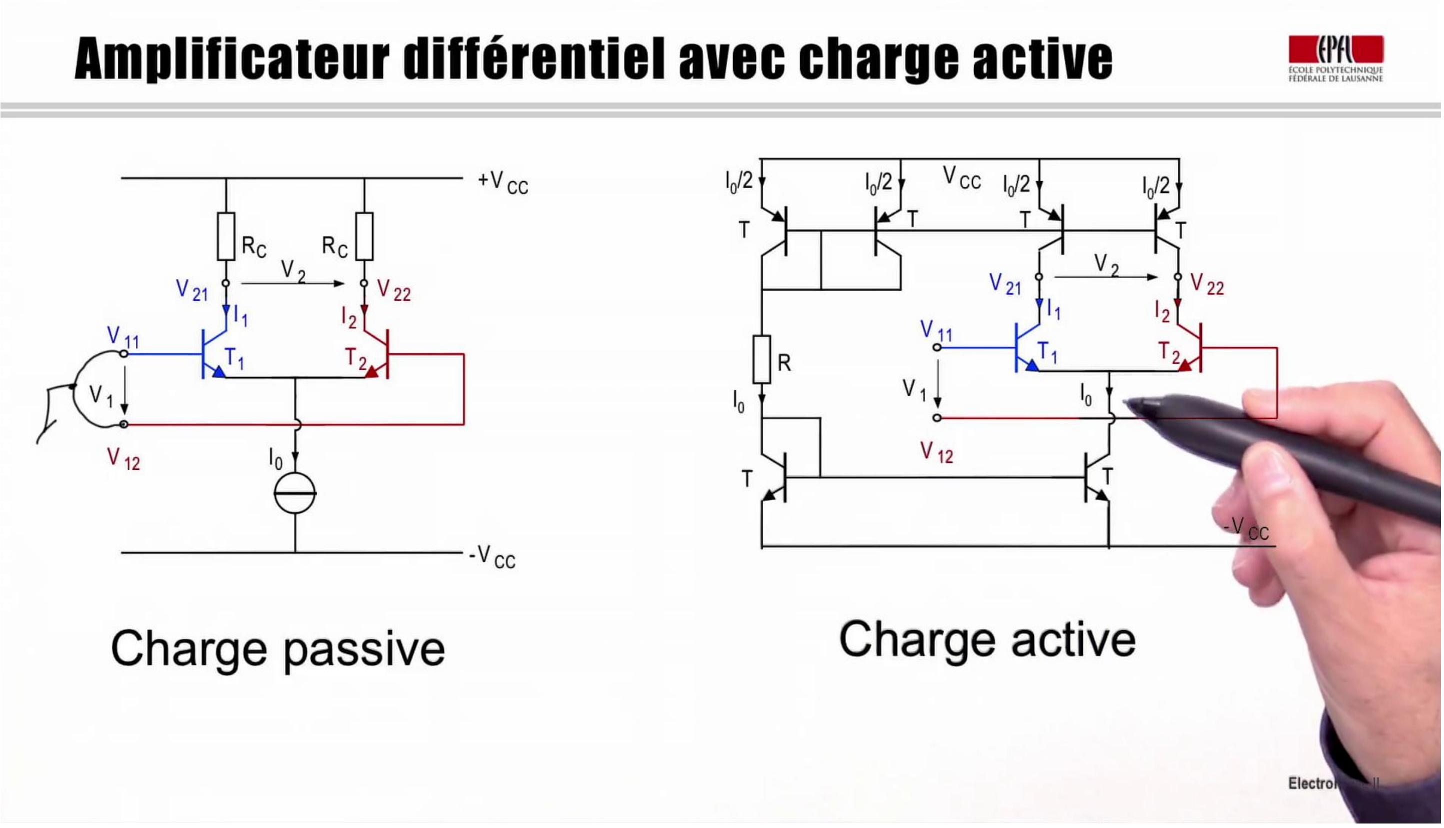


When this is differential, you can say that's positive that's negative or the contrary and then, you invert the V1 and V2 inputs. That's for you to decide where are located (+) and (-). Is it a story of terminal between V1 and V2. So the sign (-) it is added or not depending on if you decide V2, this is positive in that sense or V2 is positive in the other direction. The input impedance, is twice of a common transmitter when we have a differential input it's like a common transmitter with a difference here. Now, if I take a unilateral output, So I go out either that side either that side there, So, I forget half, it is as if I have a current I2 I operate, and the other, its variation, I let it slip in the supply I do not use it. So I lose half of effectiveness. I acted on the voltage but I have not consider the current when I go out unilaterally. So I lose half of the gain. Look at gm x RC, and there is gm x RC/2. And the input impedance remains the same, it does not change, it depends on the terminal one which is unaffected by the unilateral or differential output. So finally, adding these two quadrupoles which represent the differential pair in a circuit according to what comes out, either there, or on one side or the other.

Notes

Summary

26m 22s



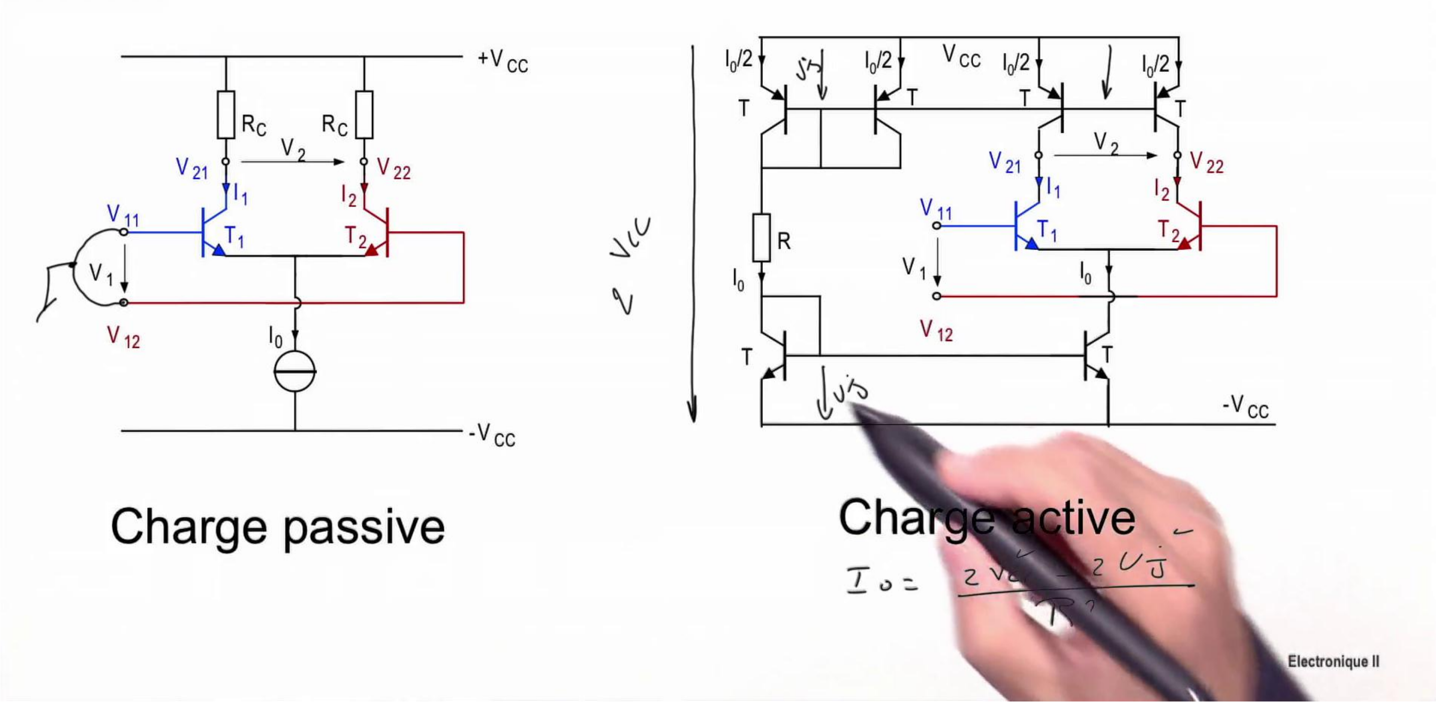
And to continue in the same reasoning, a differential amplifier with active load, you remember when we took the passive loads with resistors, and we said: we do with it that we have just analyzed, passives loads and what will happen if we replace the resistances by transistors which correspond to current sources and they are currents sources that are polarized to a fixed potential and we put an active load? So that's the plan. I simply draw your attention when you take this current I0 and connecting these two sets here, and you put a DC potential which is common between the two, well, what happen is that your current it splits, If everything is perfect, it is divided into 2 alone. Here, if you put an active load, you must be sure the current flowing there, there, added once passed by the transistor we give the current I0 here. Otherwise, this is the origin of a systematic offset which will appear in your amplifier when all the time we have a little more current, a little less current which gives a voltage which is also balanced. So I leave you look at this diagram there. I took the power source and I realized by a current mirror to create the current I0.

Notes

Summary

27m 51s

Amplificateur différentiel avec charge active



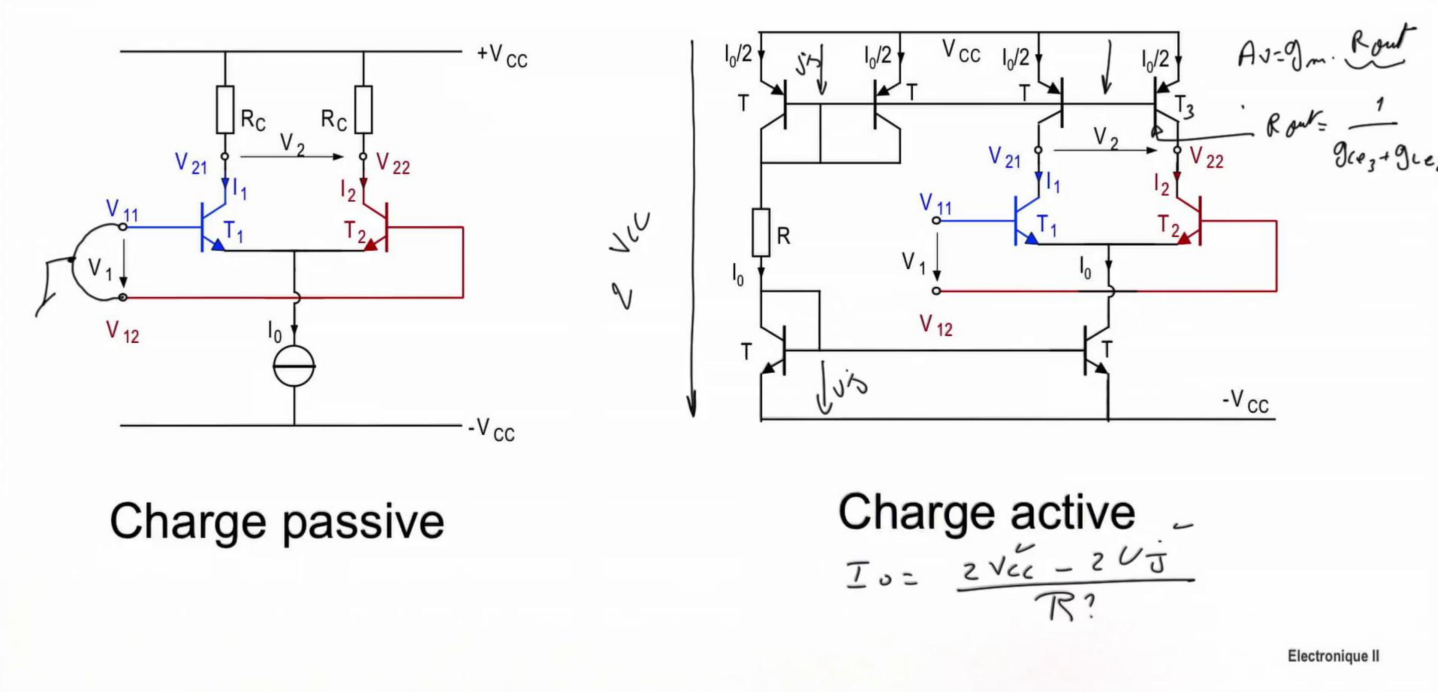
I use the power supply (+ VCC) (-VCC) So from here to there, I have 2 x VCC. I connect a diode connector transistor, but I put two in parallel, you'll see why, so here I have a voltage of the order of Uj and there I have a voltage of the order of Uj So I can very well calculate the current I0 as the current I0, it will be easily calculated, I0 = 2VDC - 2UJ, therefore, it is Ui + Uj and the 2VDC due to this tension, divided by a resistor I would have chosen myself. This tension one, I know it, that tension one, I know her, I only have to determine the resistance R to impose I0. I come now to the active load part, I'd like two current sources, look, it's a current source it's a current source. Why? Because the voltage here is the same. There I have the same voltage as you see here. This line is connected, therefore, I have a voltage that is imposed by these two transistors. When I take the I0 current and I make it go through two transistors absolutely the same So that structure is put into an integrated circuit, you can not do it with discrete components, you absolutely must take an integrated circuit, this tension then imposed at the base of these two transistors will absolutely copy the I0/2 current in each of these two transistors.

Notes

Summary

29m 19s

Amplificateur différentiel avec charge active

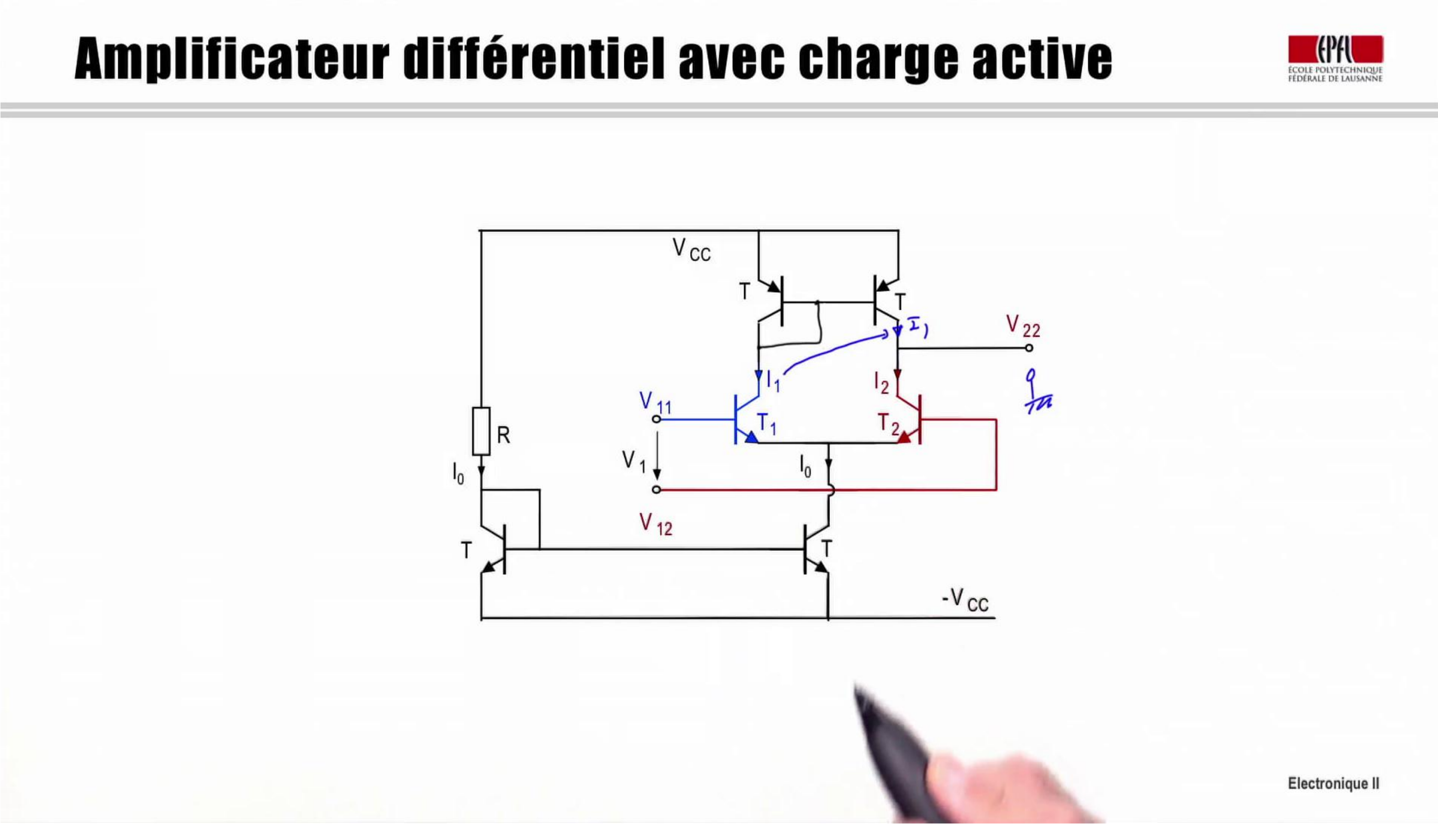


You will end up with I0 / 2 + I0 / 2 which summit here and give you I0, So this structure you see here this is your differential pair we have here but brought to a structure with active load and we are left with a differential voltage and an extremely high gain because it is gm, the gain, it is always gm x Rout and this Rout here is huge. The resistance that I see from here Rout, is the parallel of 1/gce of this transistor in parallel with the 1/gce of this transistorin that give you, I look at this, 1/(+ gce3 gce2), we will call it 3 same on the other side. So if you multiply gm on this gain, this output resistance, you will see that it give a gain which is phenomenal, it depends on your polarization of course, but we would have an exercice to do around it.

Notes

Summary

30m 47s

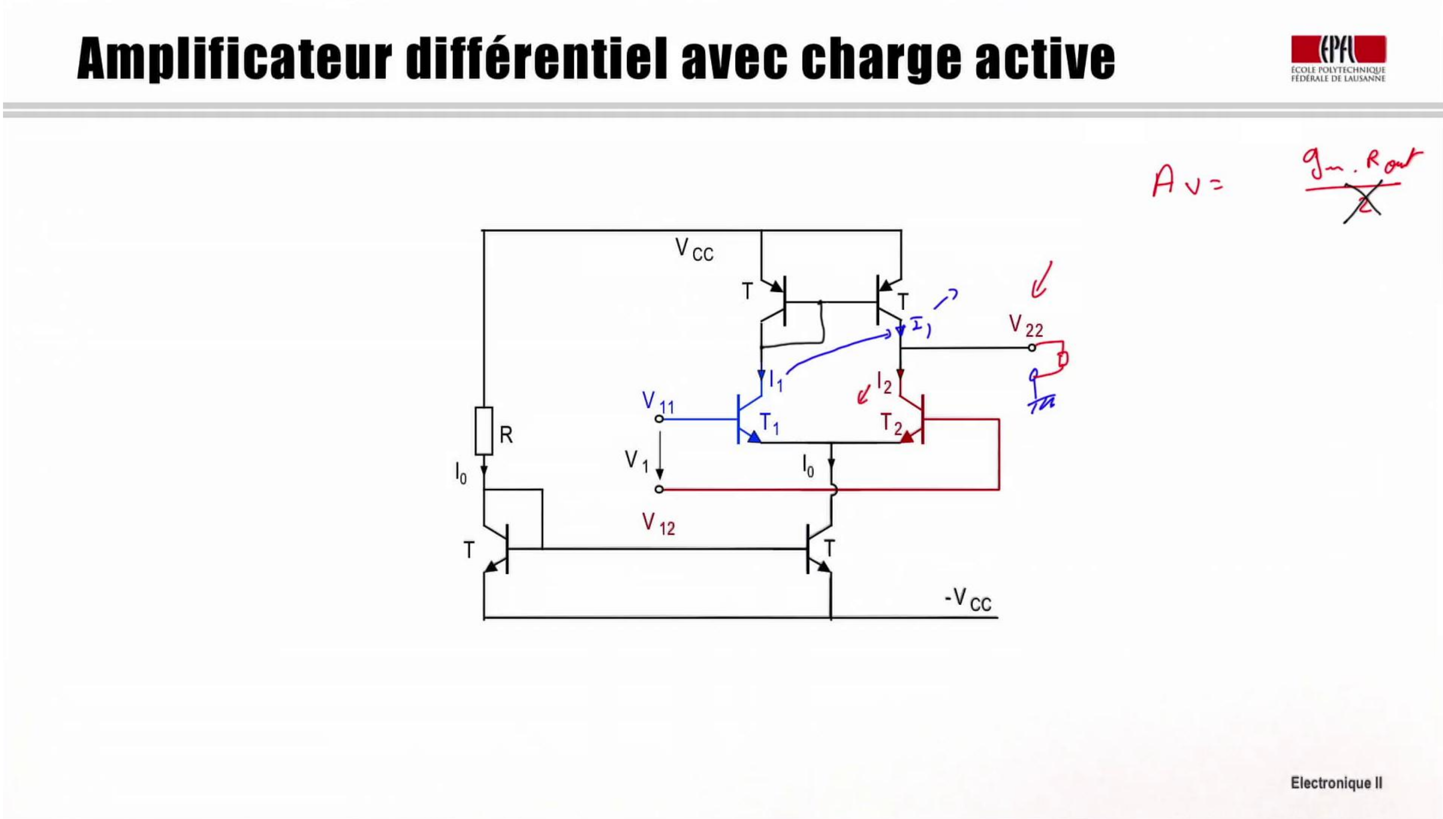


I would like to remind you what I lost just now when this link one did not exist. See this link, I'll delete it, I will delete this link then, It's like it does not exist. all the time, I just do something like that. If I polarizes the base of this transistor, of course, this arrangement would not work I would have to put a polarization what I had done in the scheme that was before. Now if I connect this, I connect there to there, there, there is another thing, it's like I tell the current I1 I'll copy it from here to there. This is a current mirror look it well, the current I1 will be here. Earlier, I had made a remark, I was said when a differential setup in which I only use half ie I have looked through what happens to that side according to that side, I just looked out, as it is now, according to a given DC potential, the variation of this current one, I left it spin in the supply and I did not use it There, in this kind of installation, It is'nt so. I take this current I1 and I sparkle it and I bring it back to the other side. I don't lose it, I do not let it go, I copied it on the other side.

Notes

Summary

31m 57s



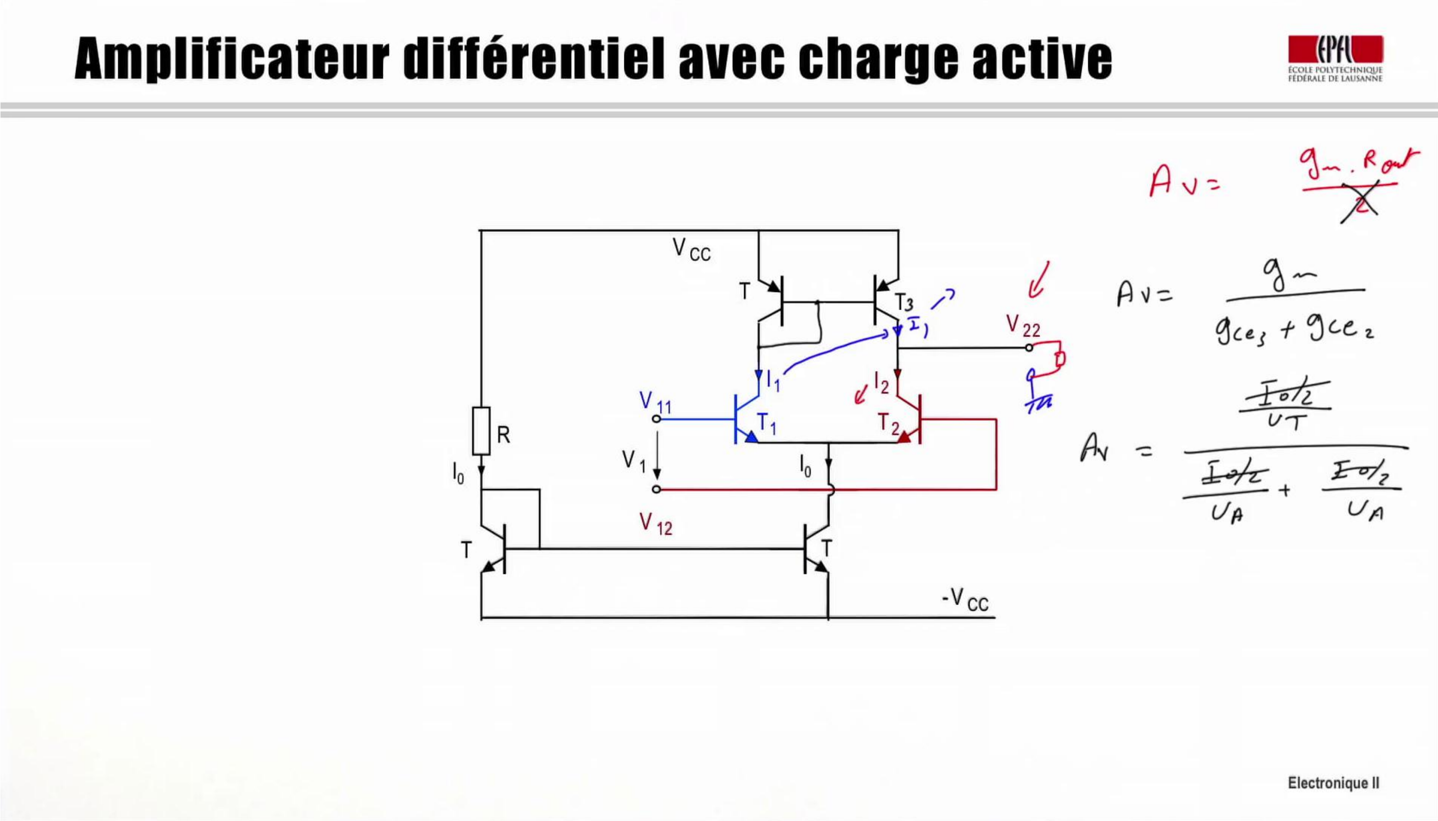
So when I1 increases here it is expected that I2 decreases Yes it's right, this is what will happen, but instead of leaving this variation outside the interest of the load, if you put a load here, there you see I1 that descends into your load and I2 which is withdrawing from your load it corresponds to a unilateral output because I go to one side in which I no longer have a gain that was divided by 2. We was saing, unfortunately, an unilateral exit makes us lose, gives us a gain equal gm multiplied by a load resistance, or an output resistance divided by 2. And here, in this case, since I recovered what I lost and I brought it back here, that factor 2 has been erased. So this is an setup in which I have a unilateral output and I have an absolutely full gain as a normal common transmitter which is equal to gm x Rout and as Rout remains what we have calculated earlier, which is very large, so I will find with that a gain gm, I'll call it again transistor T3, it will give me back a gain Av = gm / (+ gce3 gce2) which is very large, I let you do the math I'll still do it quickly for you the gm is the ploarized current which passes through both, so it was said that the gm it is a current I0/2 divided by UT.

Notes

Summary

33m 20s

Amplificateur différentiel avec charge active

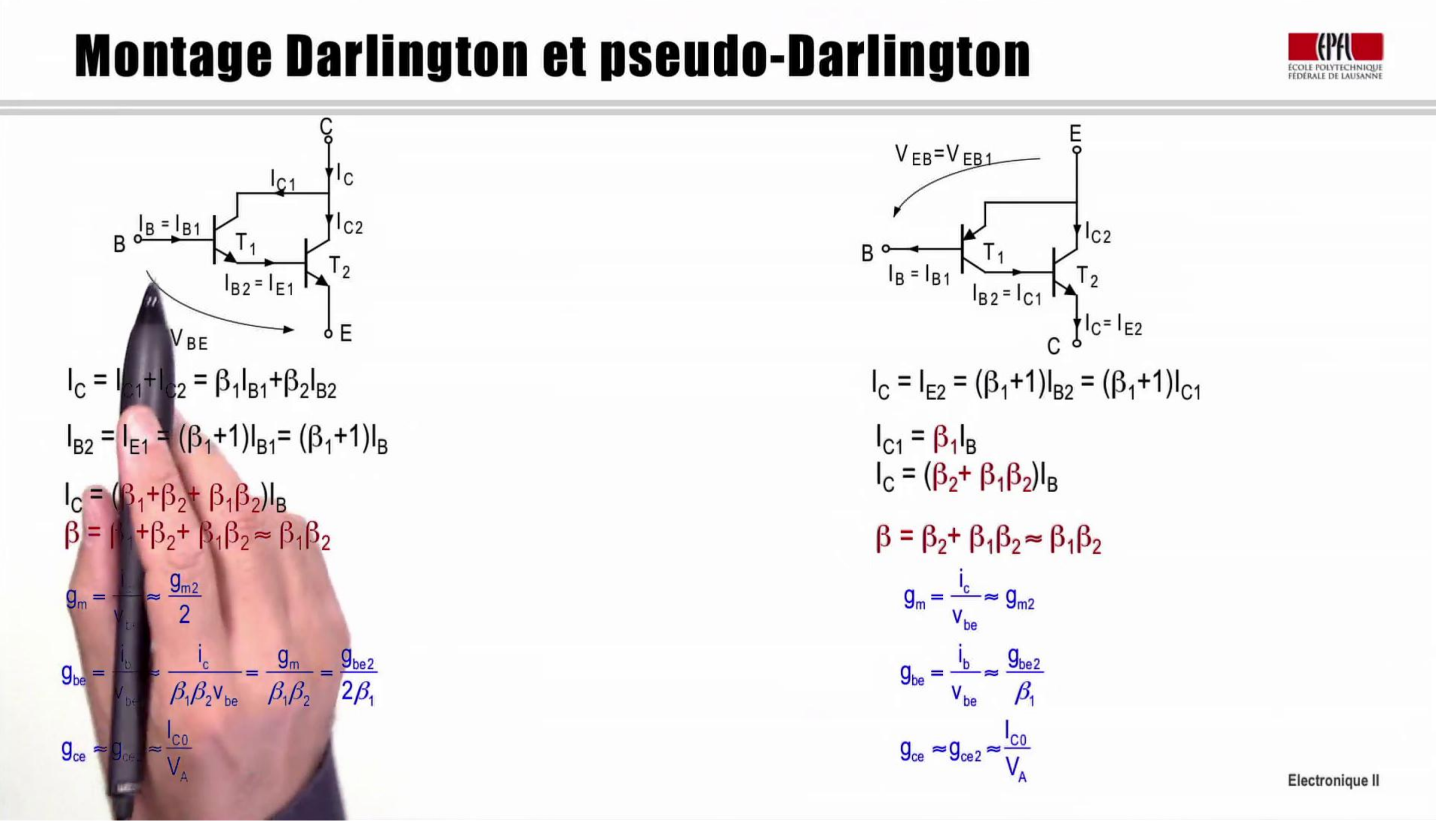


I divide, let's say both gce are the same, this transistor and this transistor have the same gce2 The two are traversed by half the current divided by the Early voltage, plus I0/2, divided by the Early voltage, and I can simplify. So we see that it is independent of the current and I find myself with 2UA / UT so it will depend on the value of AU. So that gain there, the gain of such a setup, depends on the value of the Early voltage. You can have an extremely high gain if you have low power transistors where the Early voltage is very large.

Notes

Summary

35m 06s

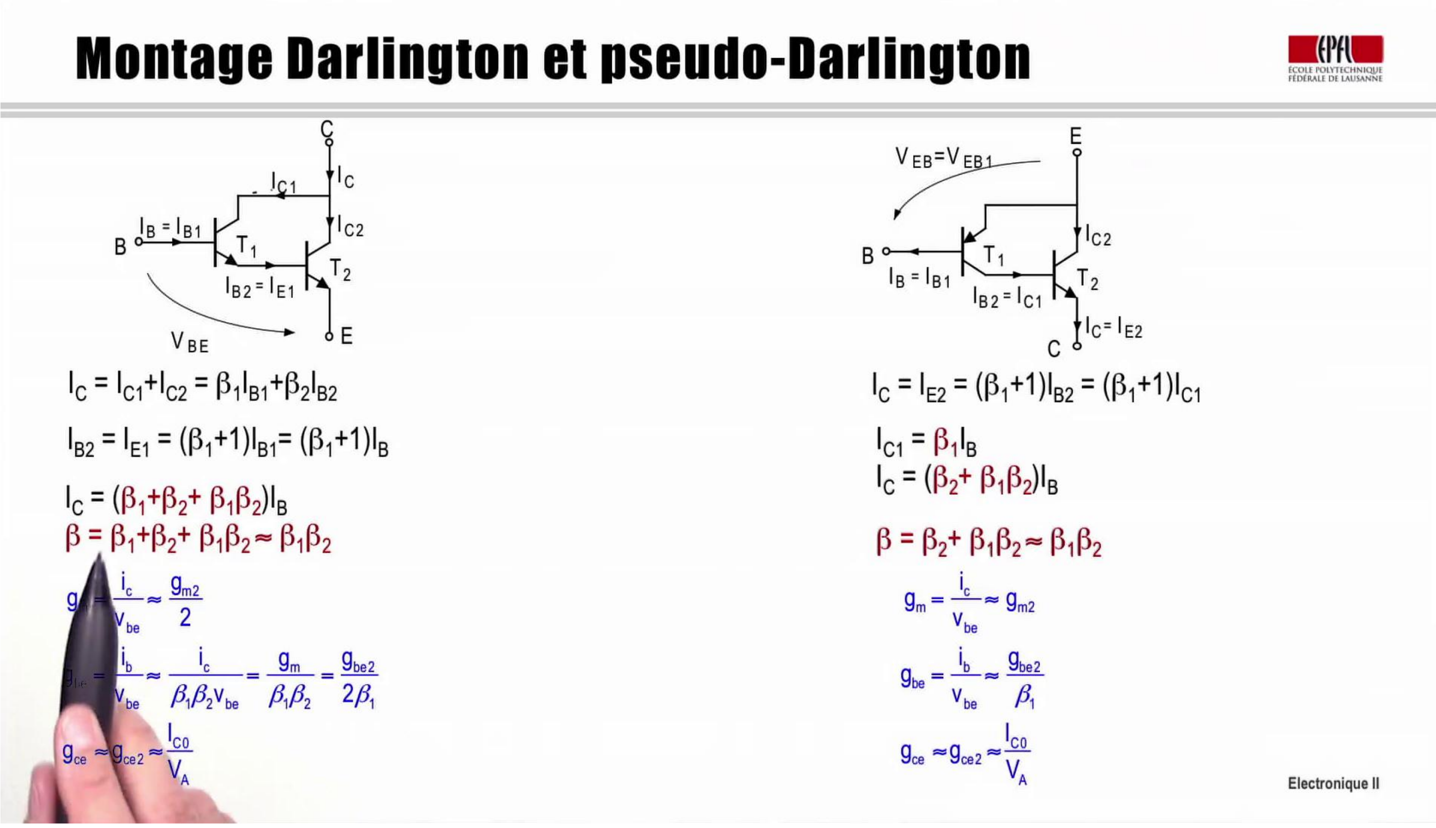


I end with a setup it looks like it's just a substitution of bipolar transistors. I would like to explain the futility of this transistor. When you take a simple transistor, it has a beta, beta, you can not change it, it is in your transistor, this is one of your transistor design parameters. Now, if you take a power transistor, you can not make high betas. Your transistor, when it has to undergo a change in voltage, UCE, very, very high, it suffers, physically speaking, of its inability to possess a high beta. What we do with it, we help it. If this transistor is the T2 transistor that has a low beta, we would put it with a second transistor that comes before and this is a transistor that often enough, are sold encapsulated both in a same box and it's called the Darlington circuit. So in other words, the imperfection of the transistor which has a low beta is corrected by the fact of using two transistors. And we do not forget that there I joined. There, to order it, I need 2 connections. Then I will analyze this setup and it will look like all this is calculated. I will analyze this setup taking the Darlington setup and watching what happens as if it had been a simple transistor So I say base-transmitter-collector knowing it, there are still two transistors that follow.

Notes

Summary

35m 48s

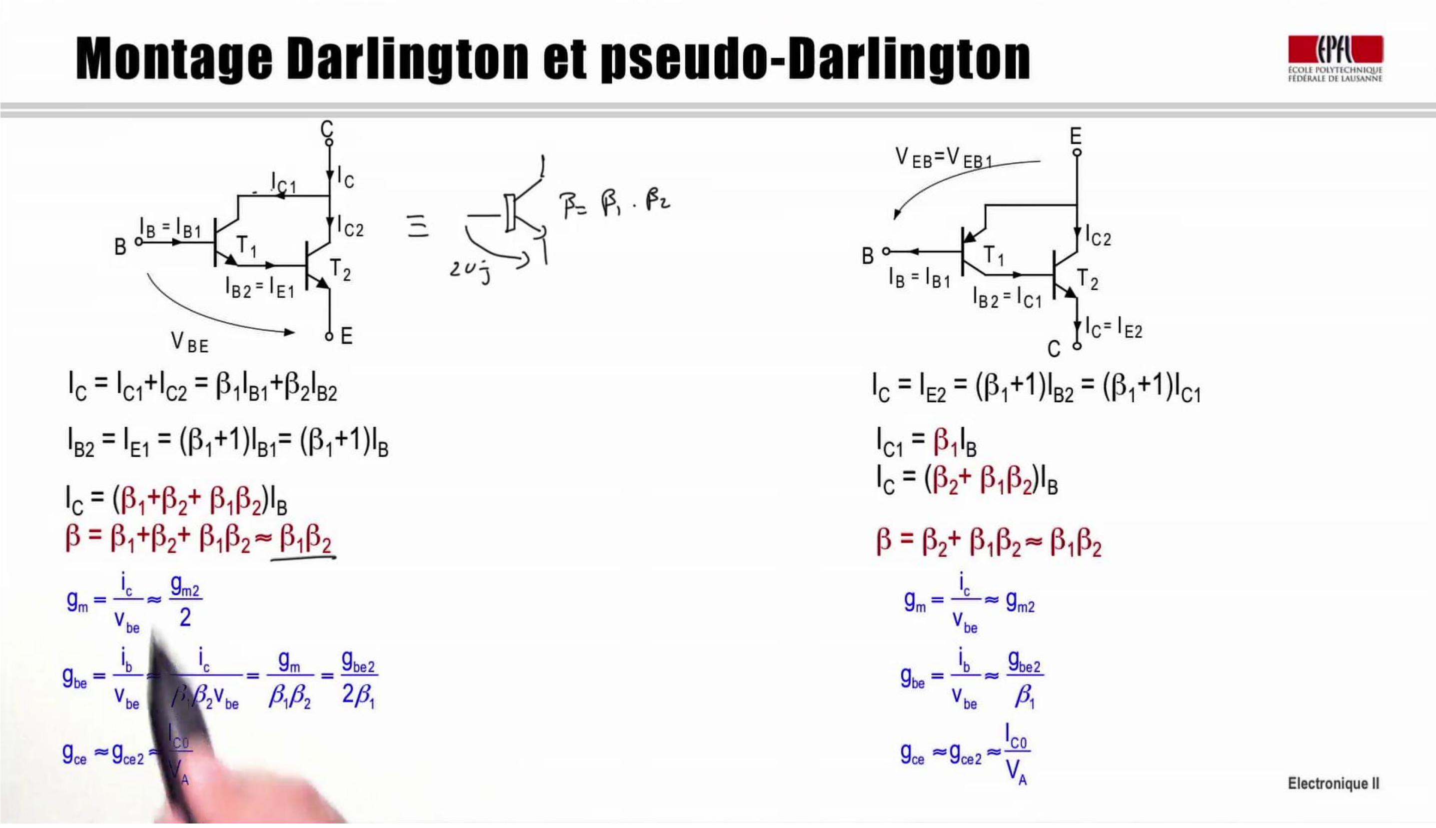


I consider that the current IC; that's what I wrote here, it will be divided in IC1 and IC2 here and current IC1, it passes into the first transistor and it comes out the other side it becomes IE1. So I can easily say that the stream that exits the IE1 is beta1 x IB1, and I called IB1, IB because I want at all costs to consider that there is a transistor which has 3 terminals: IC, IB and IE which come in and out of this transistor. So I write this relationship as simple as it is taking IC1 by expressing it as being equal to IE1 IE1 and saying it is beta IB1 and I calculate this and I look at what is the value of IC when I add IC1 and IC2 including this effect because the same current of the transmitter of this transistor become the base current of this transistor T2. So this transistor, it will release a current here that will be its own beta but given that it has already taken advantage of the beta of this transistor that is there, therefore, it makes beta1 x beta2 as an approximation of the two gains. So if you calculate that expression, You find that the current that comes out, or rather the current IC, that's IB multiplied by the product of the betas of the two transistors plus beta2, plus beta1.

Notes

Summary

37m 31s

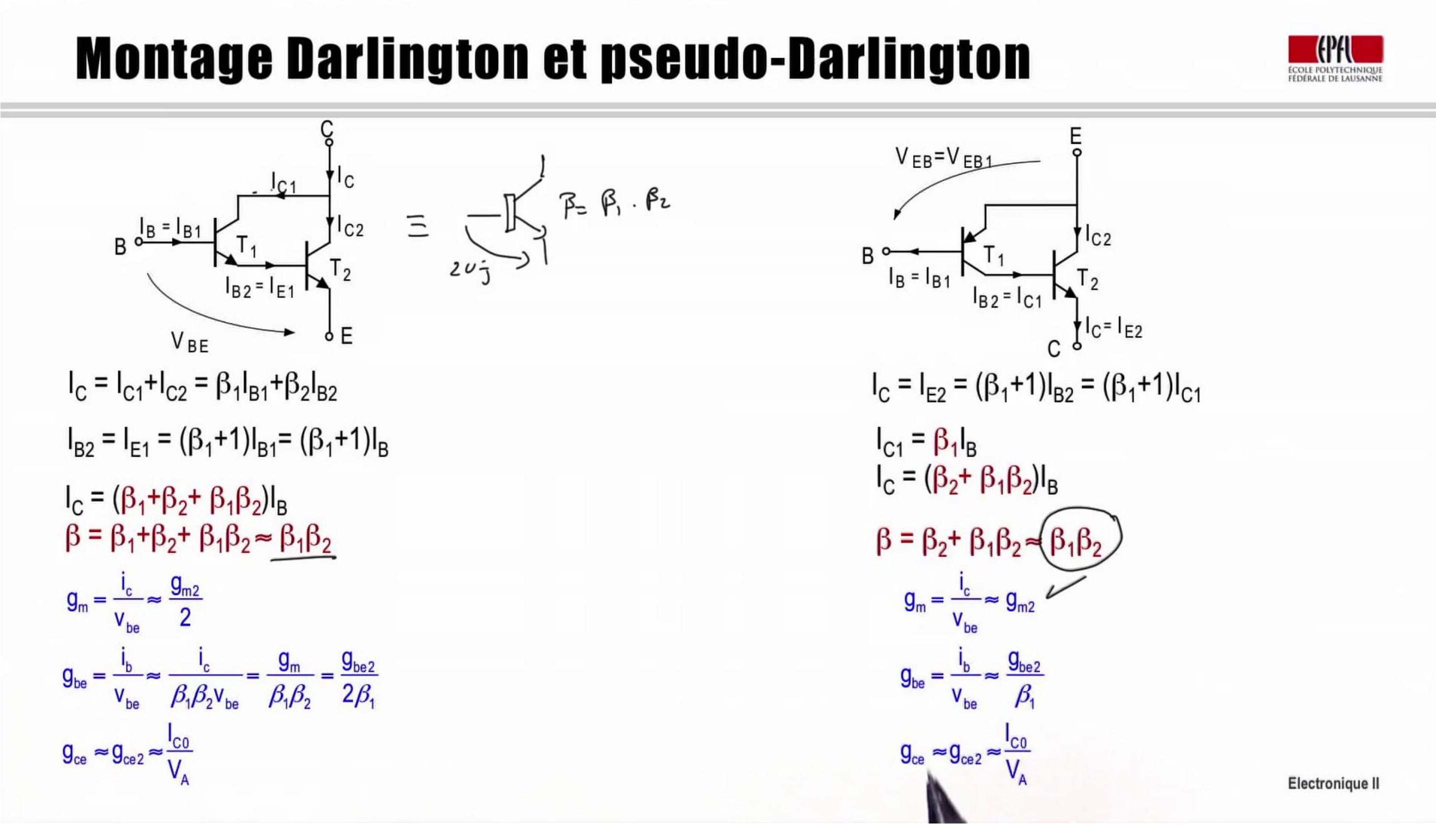


We can very well simplify (beta1 + beta2) compared to the product of (x beta1 beta2) and say this is of the order of magnitude of beta1 x beta2. So I just realized one equivalent of a transistor, if I draw bizarrely, we'll say that it is a super-transistor so the beta equals to beta1 X beta2 that a manufacturer gives you, but he tells you "Caution, there you are going to have two junction voltages when you order it." Because there is 2 jonctions following each other. Someone who says "I have two junction voltages, if I use it in an increase, the Voltage IBE delta will be divided on two transistors, which brings a gm on 2." You remember that the voltage variation generates a current variation, but then, this transistor instead of seeing a change, it will lose a variation on the first, which brings us roughly to say it has lost its transconductance because it needs twice variation to give us an equivalent change in current. Thus, the gm is divided by 2. Taking this expression and saying that the gbe, the input impedance, it's gm/beta but the beta, it became beta1 x beta2, I can very well say it's gm / (x beta1 beta2) I can bring to the output transistor gbE2 / 2bêta1 Early voltage is not affected because we will say to the approximation is the Early voltage of the transistor T2 will dominate because there is an Early voltage here but it does not bother us to see the output.

Notes

Summary

38m 52s

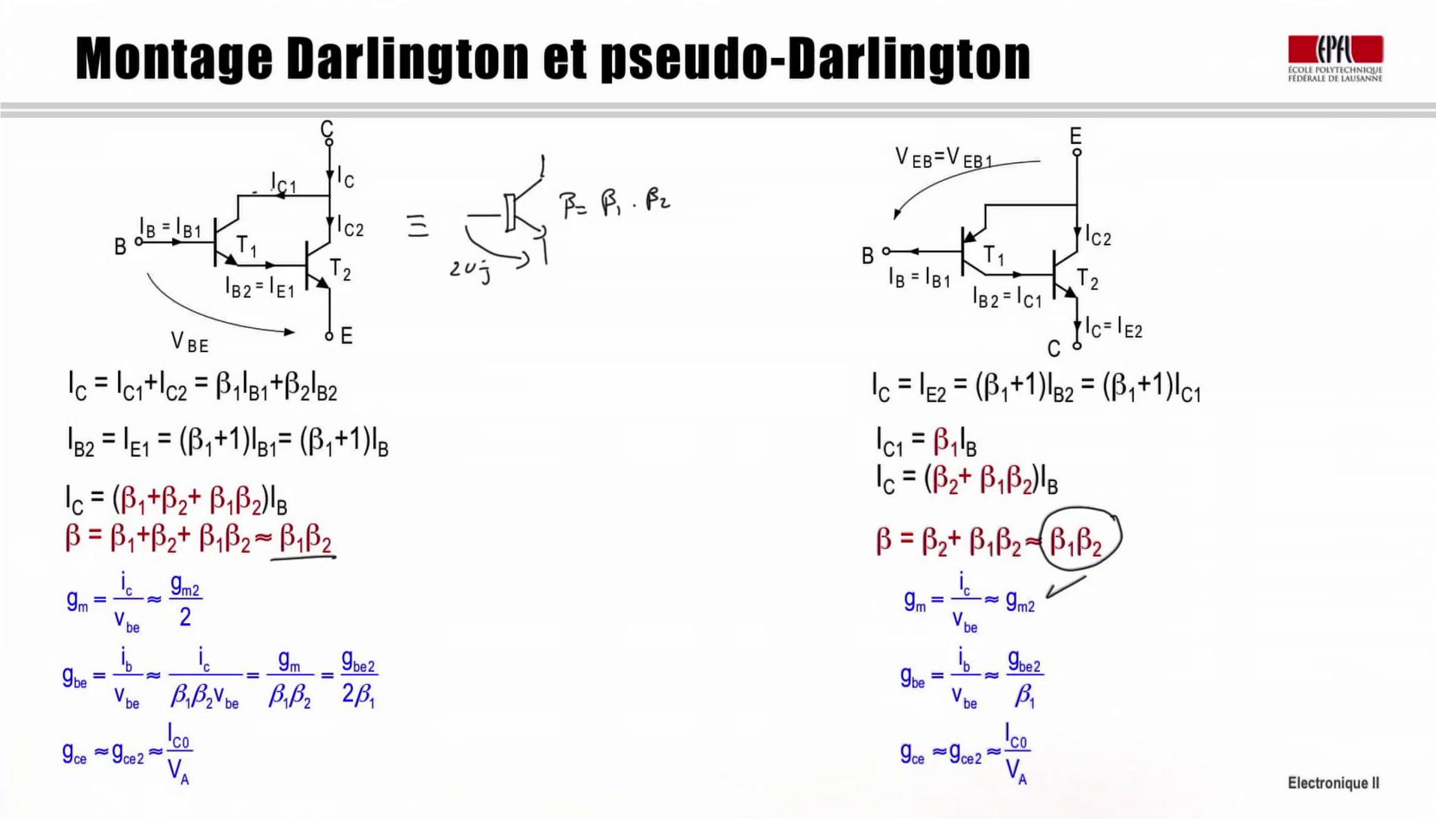


So I find these expressions and there is an setup so-called Darlington because we used two transistor of the same type and NPN and NPN I can do of course with PNP and PNP. But if I mix the transistors, one PNP, one NPN, in the PNP one, this is the control transistor, this is the one that will see the variation between the base and transmitter and the NPN transistor, this is the one that will play the output interface, I'll see there, what I have gained according to this, is that the gm wich was divided by 2 because of the fact that I lost twice the junction voltage when ordering, then I took it back to a junction voltage. So that will bring me to a transconductance as transconductance of a normal transistor. I won on transconductance and then, in terms of beta, I fall back on the same thing, more or less, beta1 beta2 x as a proxy. Now, what will happen with the input impedance?

Notes

Summary

40m 31s



The value of the input impedance here is not the same as there simply because the gm2 there was gm2/2 which made me gain a factor of 2 on the input resistance, the input resistance is 2bêta1 / GbE2, then it will become GbE2 / beta1 So, I have the factor 2 which missing here, therefore the input resistance of an setup made by a pseudo-Darlington, allows me to improve the gain setting which is the transconductance and it allows me to lose a factor of 2 on the input resistance, there, the input resistor is two times higher than what I have seen here while the output impedance is the same, the gce is the same. I have just finished a completely new structure, the differential setup which closed the series of analog structures that we will use to do with amplifiers and mostly transconductances. And it is one of the transconductances that is the most used, in this case, the input of an operational amplifier uses an input (+) and (-), so this is a differential pair and therefore this part of my course, ended, with just a variety of a bipolar transistor who was to booster the beta through the use of two transistors to multiply the beta and obtain a product of betas between two transistors.

Notes

Summary

41m 35s