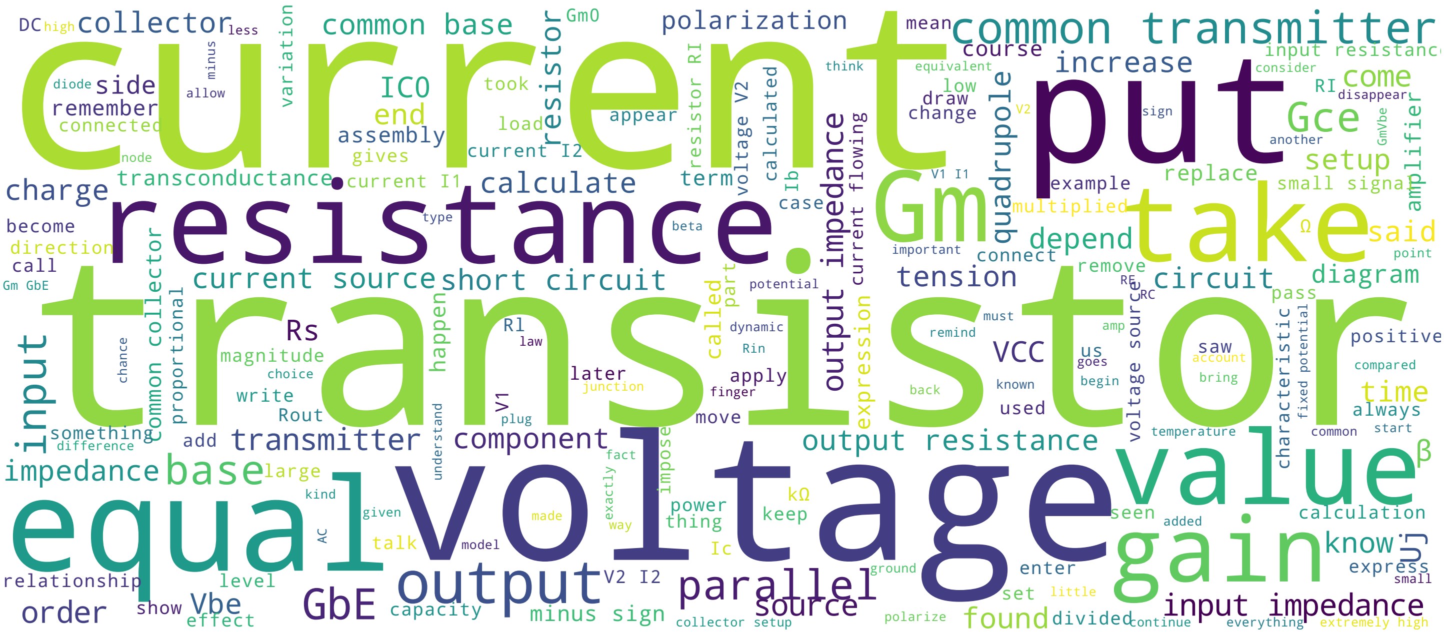
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

3.2-Configurations petits signaux

Configurations EC, BC, CC

Prof. Maher Kayal

Electronics Laboratory-ELAB



Video

EPFL

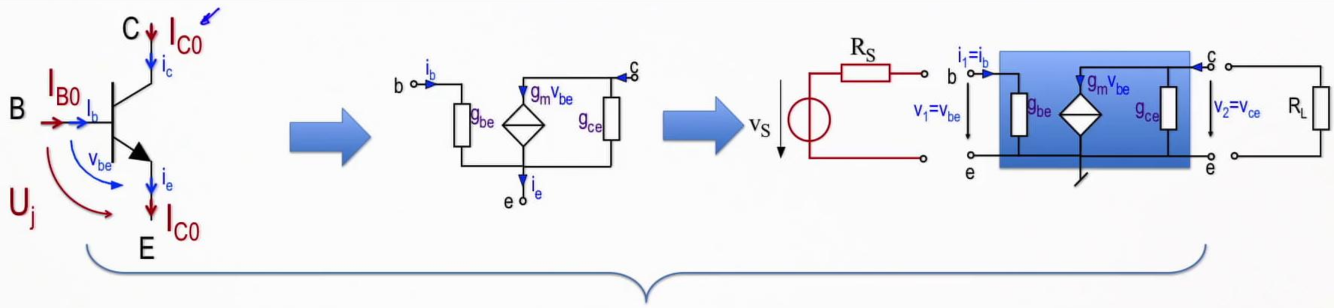
And here we come to the critical part of this lesson this week, it is the analysis of the three basic setups. This part of the course is going to seem a bit tedious because there are a lot of calculations. But believe me that at the end of this week you will see, we will draw highly relevant conclusions, that are very easy to understand. So, there will be a lot of calculations, but I will not go into details of calculations, it is almost boring. I'll try to do the minimum possible. And I will let you continue these calculations on your own. I also let you check, there will be all that you need to calculate on your own, but I will try to look into the necessary conclusions for you to get the message that there are three basic set ups: common transmitter, common collector, common base. And with these three basic set ups, there will be features. These characteristics describe the input resistance, the output resistance, the gain and especially the use of the set up. You will see when we begin to synthesize what will come out of this part, that I inform is a bit hard. You see it will become extremely simple and that will allows us to synthesize relatively complex electronic circuits.

Notes

Summary

0m 04s

Montage Emetteur Commun (EC)



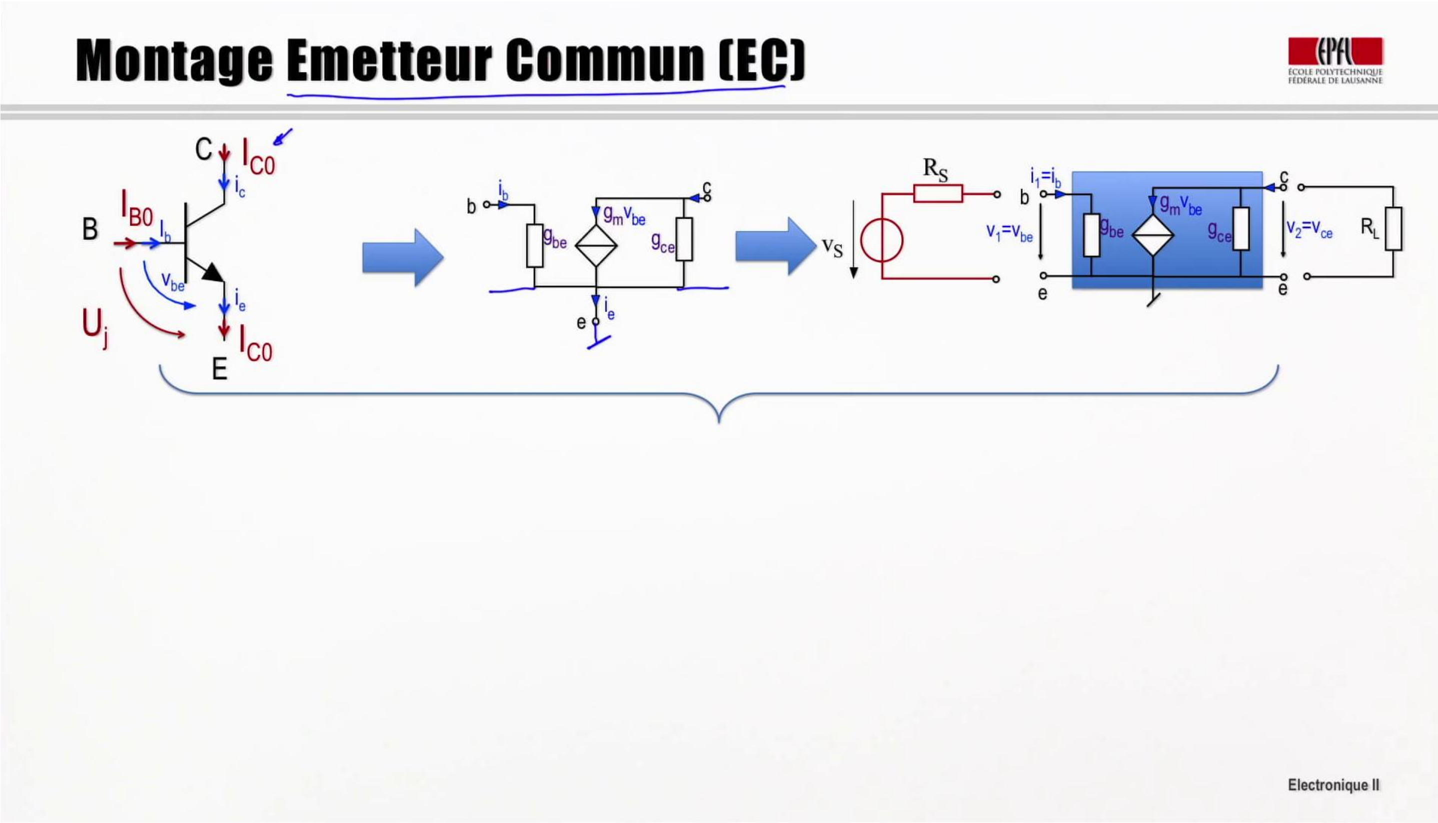
Electronique II

I go back in this vision of things. I will repeat it again. Here is the transistor symbol. I put in red the polarization. I put in blue what helped us to get this diagram here. When we took this path, it is once we did the abstraction that there is direct current and direct voltage. And we polarized our transistor and then said, we will forget the polarization. We will focus on a transistor where finally we know IC0 because it was imposed and it is a choice, so it's its designer who will decide. We take it and we will turn it to create three configurations. We will start with the configuration called common transmitter. So common transmitter, it means I'm going to put the transmitter in common between the input and the output. Look that's what I'll get. I'll make a quadrupole. This quadrupole, it will allow me to have, in common between the input and the output, the transmitter. I'll extract as decided earlier in the first video of this week that I finally am interested in the input resistance and output resistance and the transconductance value. So, I'll calculate it and I'll extract the Gm.

Notes

Summary

1m 23s

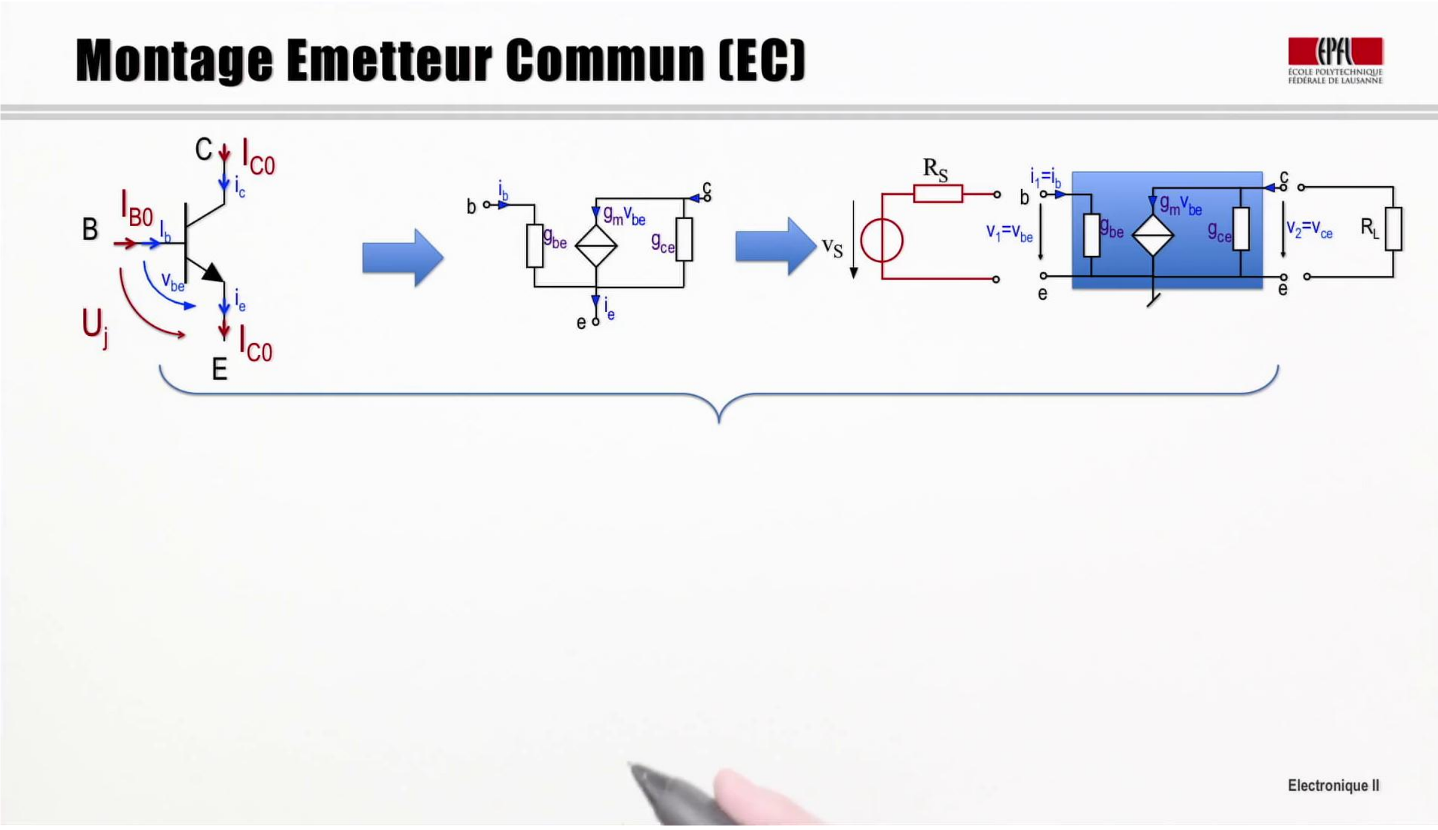


When I look at the small signals diagram of my transistor, it corresponds absolutely to take this diagram, put it in the quadrupole as it is and find a configuration in which I apply a charge here. If the AC point of view transmitter, it does not move. The ΔV rather the potential here is absolutely stable. And I share it between the input and the output, I get a quadrupole which is this and the transmitter is common. So we will see later how we will do with the transistor itself to impose a potential here which of the AC point of view, it does not move. It becomes a DC potential. So DC means it is a fixed potential and we get it and it is called common transmitter. So now, look. When we find the quadrupole, we said "we will come connect a source." We will come connect a charge. We said we are interested in what I see at the input of my quadrupole. It is here my quadrupole. I put my fingers here. I see V1. I see I1. I see that between the base and transmitter I have V1 that gives me Vbe. And I see that the current entering the base transistor is in fact the current I1. So from here to there, I see the V1 and I1 I have to do the ratio between V1 and I1. And find the 1/GbE.

Notes

Summary

2m 48s

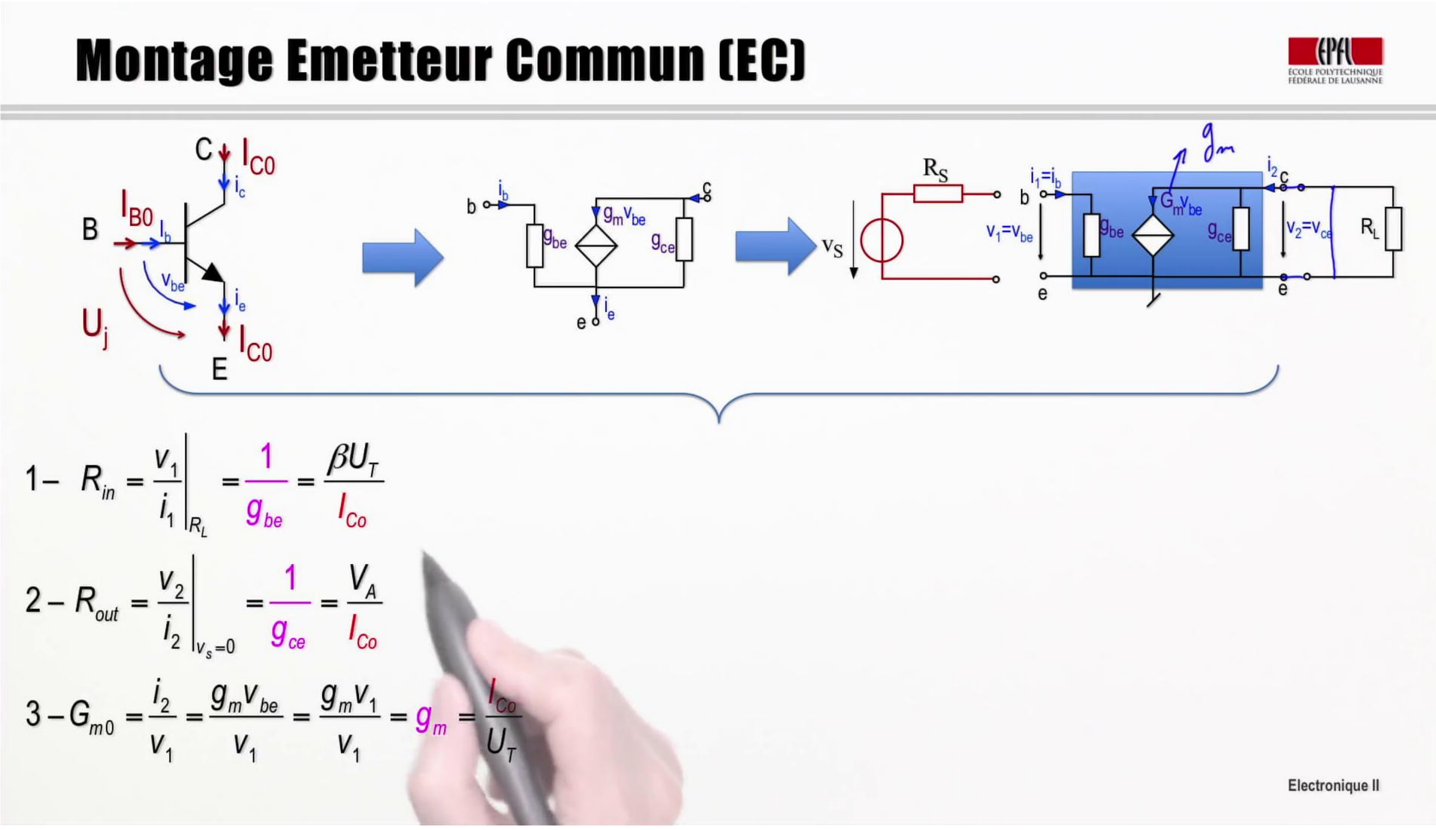


So I put my fingers here, and I say what is the resistance I see here, I see 1/GbE. So in that quadrupole, the input resistance will be 1/Gbe of a transistor as it is. So the 1/GbE of this ΔVbe/ΔIb. I will do the same at the output. I look here. I put my fingers here. I say "I have the voltage V2 and have the current I2 that enters here." What is the value of this impedance I see between the two or this resistor. It is V2/I2. And I see the Gce. I remind you that when we calculated output resistance, we said "it short circuits the input". So we put the voltage source ΔVbe = 0. So this Vbe here will be zero. So that, it will disappear. And I end up with 1/Gce and therefore the source will disappear. This will give a 1/Gce.

Notes

Summary

4m 13s



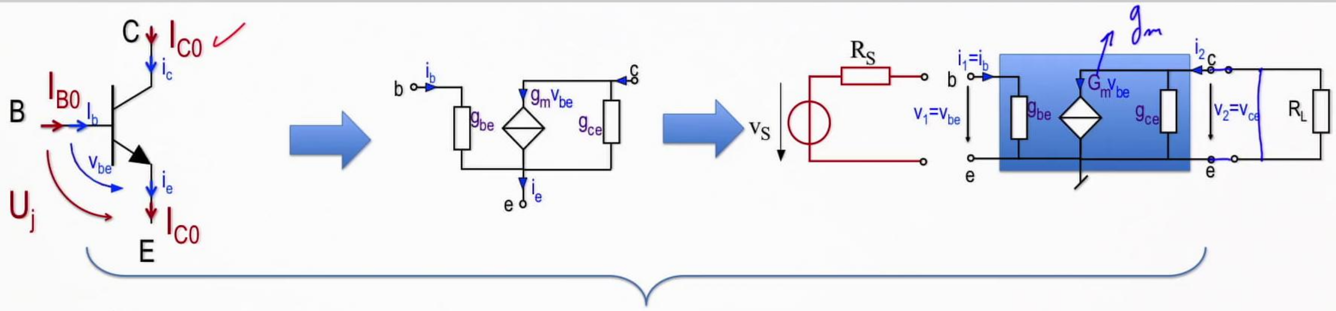
So start from this and do with this the next step I'm going now with exactly what I explained. That is, I took the 1/GbE. I said this is my input resistance. And there is V1/I1. And I know it's 1/GbE, we had calculated it, it is βUt on the polarization current. The output resistance Rout, it's V2/I2 with Vs = 0 so I short circuit this. So the ΔVbe = 0 therefore the power supply will disappear. It will remain V1/Gce. And the Gm of the transistor, that means I create a short circuit here. I plug this here and this here. And I'll end up with the resistor Rl which will be zero and Gce will be short circuited. So the current of short-circuit that goes through the current I2, it is absolutely equal to GmVbe. So this Gm I see here that I wrote in capital letters, it is nothing but the Gm of the transistor so I have the Gm of the transistor that I know is here. And now I have determined a quadrupole where I know its input impedance which is here, its output impedance which is here and the transconductance which is here and I just have to put this in the context of a circuit, I have all values. Observe this. IC0 is the polarization current which we determined before.

Notes

Summary

5m 10s

Montage Emetteur Commun (EC)



$$1- \ R_{in} = \left.\frac{v_1}{i_1}\right|_{R_L} = \frac{1}{g_{be}} = \frac{\beta U_T}{I_{Co}}$$

1mA

$$2- R_{out} = \left.\frac{v_2}{i_2}\right|_{v_s=0} = \frac{1}{g_{ce}} = \frac{V_A}{I_{Co}}$$

$$3- G_{m0} = \frac{i_2}{v_1} = \frac{g_m v_{be}}{v_1} = \frac{g_m v_1}{v_1} = g_m = \frac{I_{Co}}{U_T}$$

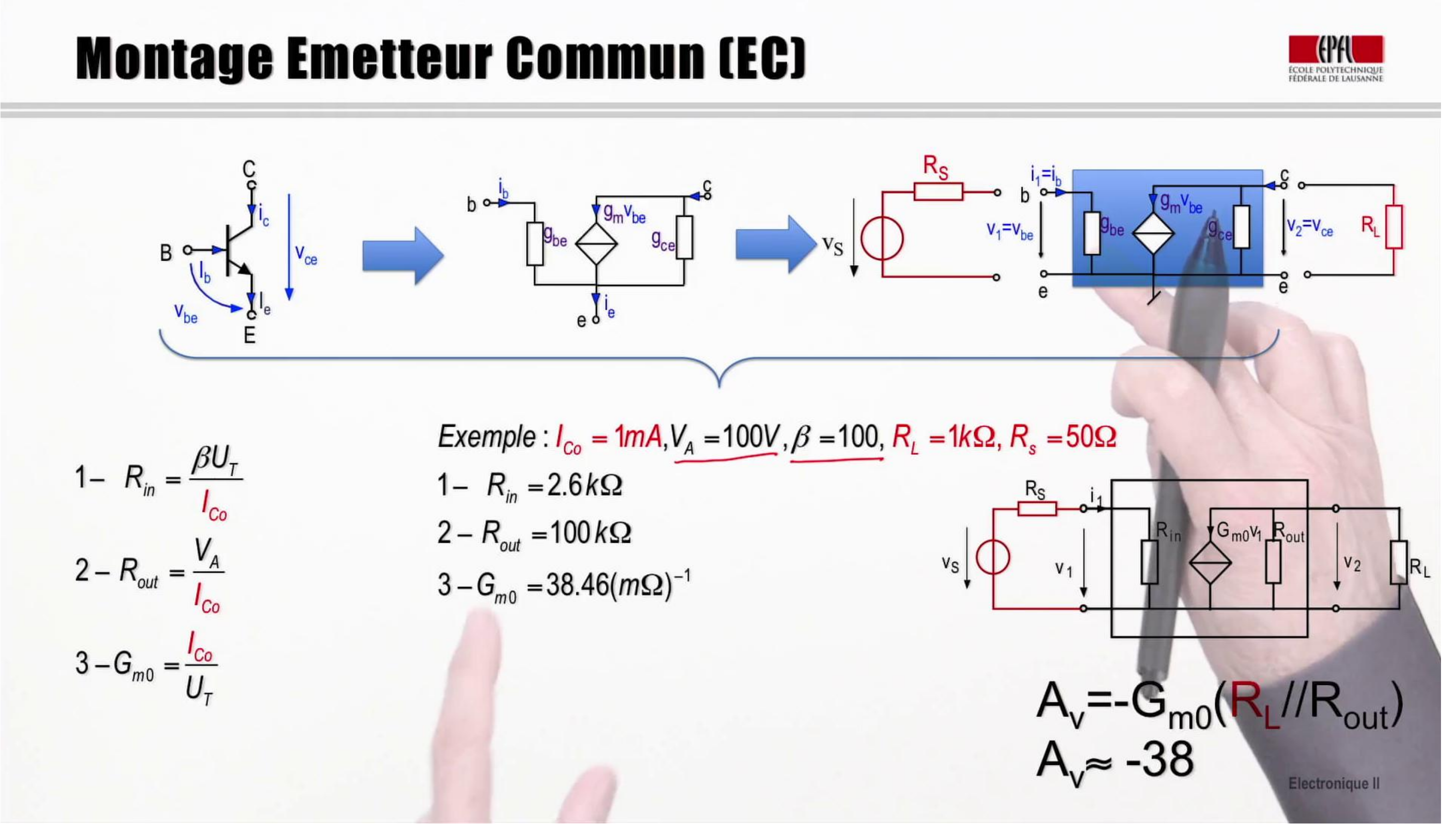
Electronique II

This is the trickiest part of the circuit design, it's determining the polarization. So there you have this current DC. You remove your transistor, you replace it with this that gives you the quadrupole (inaudible). You know the input impedance because β depends on the β of transistor. The 26mV for the thermodynamic potential, IC0, it's your choice. You also have Rout which is 1/GbE. And you have Gm. Look, there is only IC0 which is your choice and everything else depends on your component. So we see how important the choice of determining IC0. Now once we saw the three Rin, Rout and Gm0, I'll do a little exercise with you by calculating the real numerical values in an example just a case study to put a polarization value. They will say: you applied IC0 = 1 mA. And we will provide values for RI and we will provide values for Rs. So we know everything about it and we will calculate with this what we get as set up type.

Notes

Summary

6m 38s

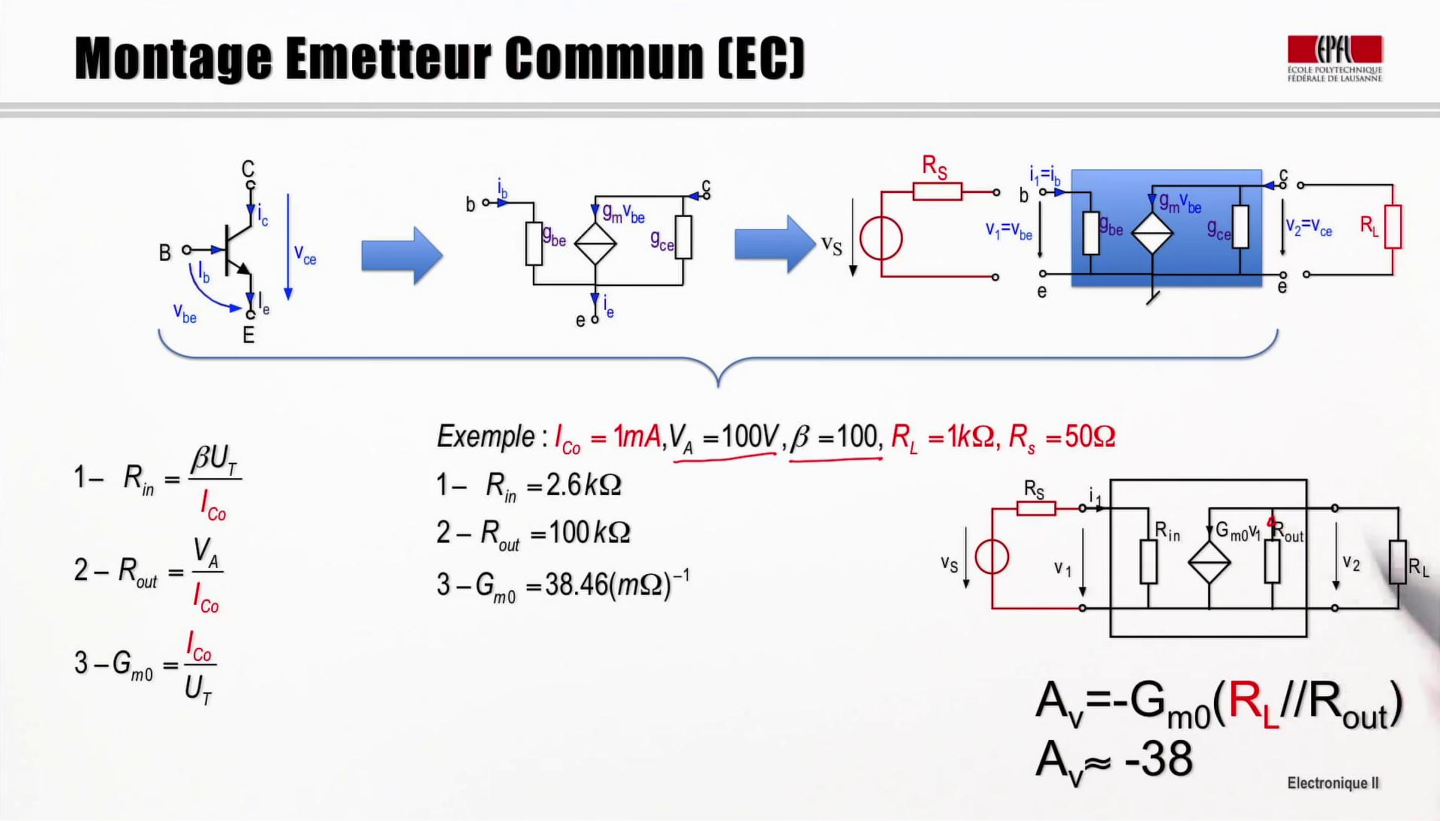


Here are the same diagrams. I copied the input impedance, output impedance and the the Gm0 and I took a numerical example. I applied a current IC0= 1mA. So you have your polarized transistor by putting 1 mA. I took a transistor in the early voltage, Va = 100 V. It has a β equal to 100. This is not your choice, it is the component. And you plugged an Rl charge resistor. I chose 1kΩ. And you have connected a source here Rs equal to 50Ω. And I will replace these values here. I find Rin, with these values, equals 2,6kΩ. I find Rout equal to 100kΩ. And I find that the Gm of the transistor in this Gm0 is 38.46 mS or mΩ or 1 / mΩ as a unit. What can I qualify this? I can say that a common transmitter is a set up where I managed to put the transmitter in fixed voltage AC. It is in common between the input and the output, its input impedance, for polarization current relatively small not that big, is of the order of 2,6kΩ so it is not very large, it is a few kΩ. However I found that the output resistance of this set up here is a resistance which is one hundred kΩ, it is quite large.

Notes

Summary

7m 49s

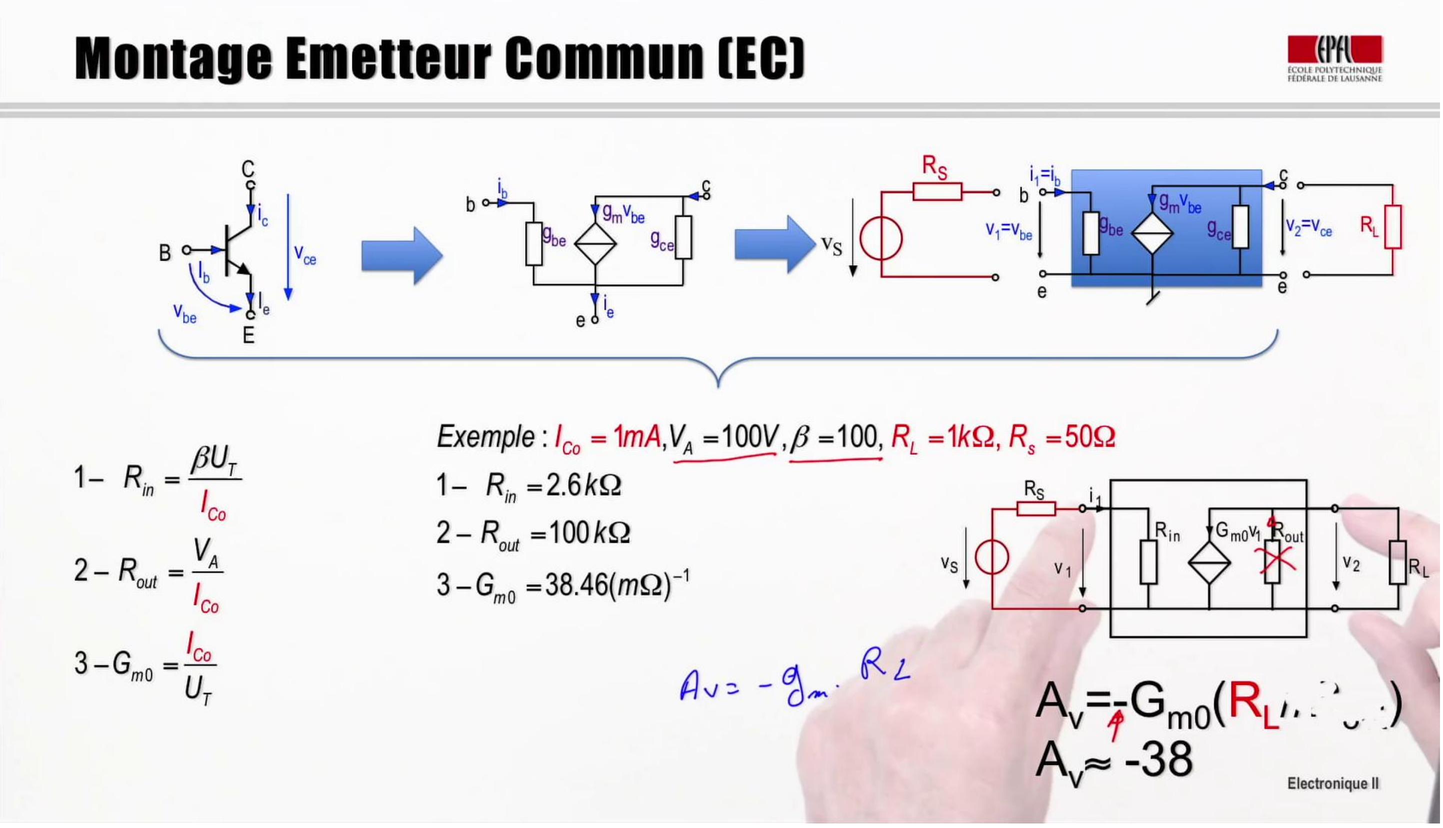


Therefore the output resistance is quite large, which clearly shows that I have a current source controlled in parallel with a resistor 1/Gce and 1/Gce is 100kΩ so this is a power source that has a large output resistance. And the transconductance it is this value we calculated. Let's see my quadrupole. The analysis that had been done before, it was our quadrupole we have the values of each component, I plug my Rl resistance, I take my source with a resistance of 50Ω and I will do a gain calculation. I want to see how it will behave. We saw that when you take this quadrupole, we call transconductance quadrupole, you calculate the vaccum gain. So if you want to look the gain without putting Rl you find that the voltage V2 depends on what current will be converted into a voltage in the Rout resistance. This current has a negative sign. Why ? Because the current it goes up in this direction. And you have V2 in this sense so we have current and voltage in the opposite direction. In the configuration or rather in Switzerland standards, we consider these two vectors in the opposite direction, which gives us a minus sign.

Notes

Summary

9m 25s

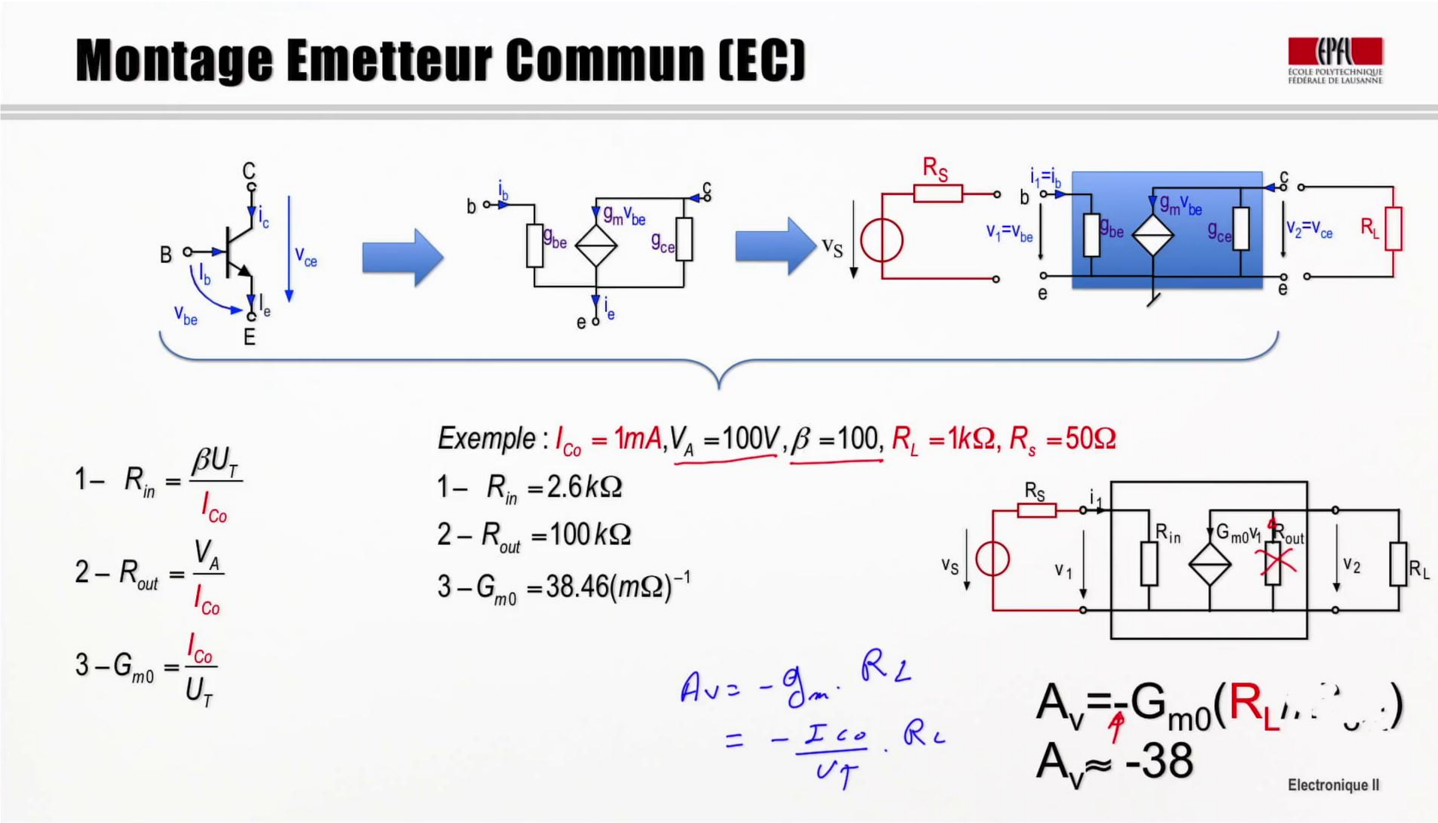


This sign you see here is a negative sign and when connecting the resistor RI in parallel with Rout, namely in this example you have Rl equal to 1kΩ and Rout equal to 100kΩ, so 1kΩ in parallel with 100kΩ, I remind you that when you put a small resistance with a resistance 100 times greater it is the smal that will dominate in parallel so it's like you neglect the Rout resistor. So you will end up with Gm0V1 that will pass through the resistor Rl. So if you apply the simplification that I have shown you is that you've found this R out as neglected. The internal resistance of the transistor (inaudible) compared to RI so you find Gm.Rl. This is really the expression of the gain of a common transistor emitter it's equal to Gm.Rl, the gain is equal to -Gm times resistance Rl you put if the resistor RI is small compared to the output resistance of your quadrupole. And you do the math, you find that Gm is of the order of magnitude of 38. It was 1kΩ*38.46 mS, it gives you the order of magnitude of 38 with a minus sign, that is to say, the tension that you find here is reversed compared to the voltage you put there. If there is a sinusoidal voltage, there is a 180 ° phase shift and this is a voltage amplifier.

Notes

Summary

10m 40s

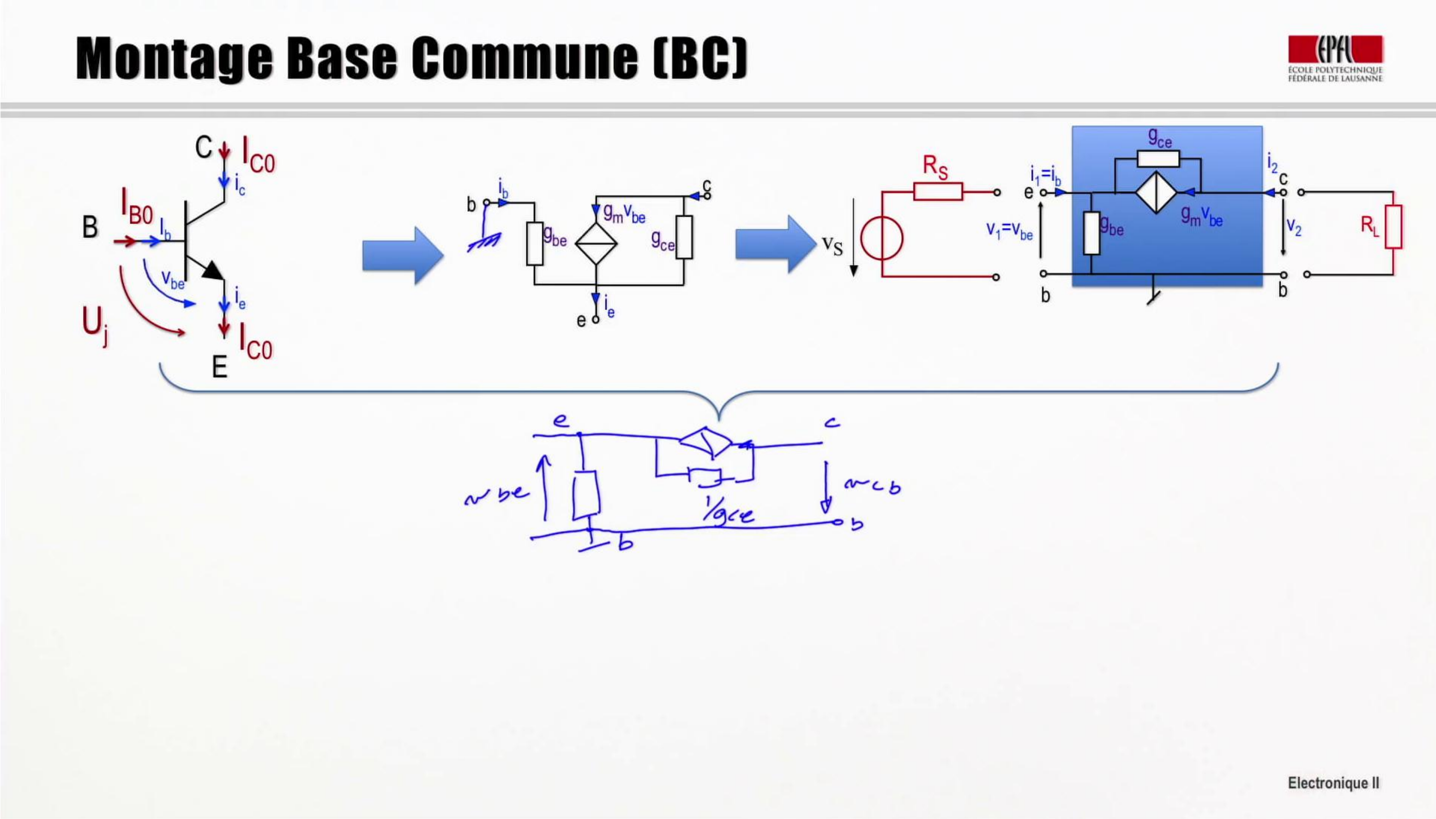


And we just realized with a common transmitter setup a gain that is equal to this times this. If you now write the set up like this: -(Ic0/Ut).Rl you know that the Ic0 it is your choice, it is you who selected it when you polarized. Rl is a part of the data and the thermodynamic voltage it's physics. So Ic0.Rl is a DC voltage, Ic0.Rl is a voltage drop of a resistor connected to a collector when talking about polarization, but we'll have the opportunity to see it later. But what I want to close with this set up, we saw our quadrupole exists, we could write these relationships, we calculated the impedances. The impedances depend mainly on a choice and physical settings so everything is known and we know all about the AC behavior of our set up.

Notes

Summary

12m 16s

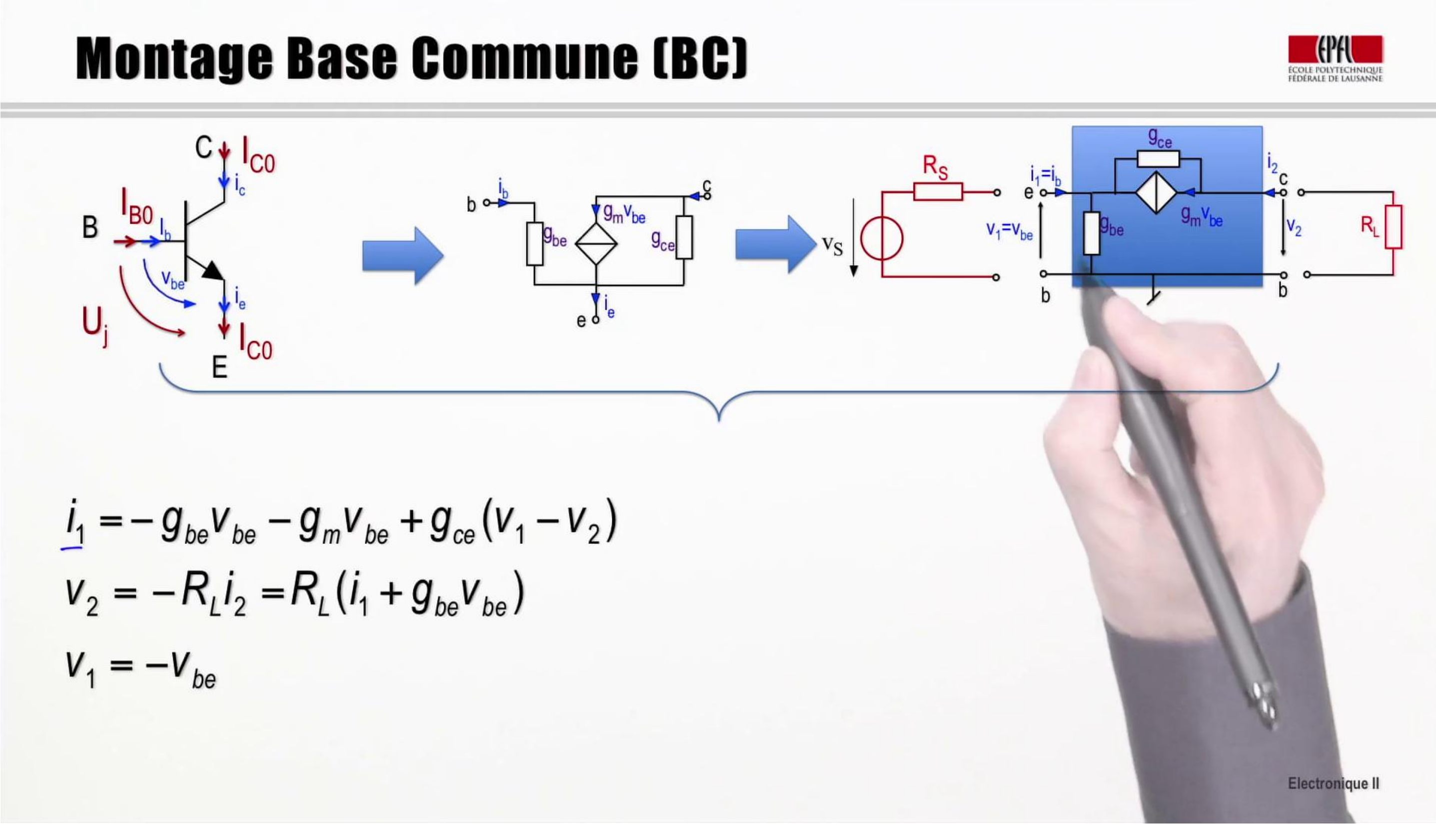


I will now take the same setup and I will use the base, but I'm going to put it in common between the input and the output. Remember, this is the small signals diagram of the transistor out of circuit. Now I would like to turn this transistor and put the base on a fixed potential and I will enter between the transmitter and base and exit between collector and base. So this is what I would like to put on the earth ground. So I would draw the diagram and it would become like this. So the 1/GbE would come here then I would put the base here and this would become the transmitter, after I have my controlled current source in parallel with my 1/Gce or Gce, it's as you want, if you talk in terms of resistance you need to stay in resistance or in conductance, and here you have the collector, you will have current passing through here and you will have the input here and we would like to have the common base between, this is the Vbe voltage and that's always the base and here I have the voltage Vbc, if I draw like this, where Vcb depends, that's Vcb. And I found this. Here it is quite interesting.

Notes

Summary

13m 13s

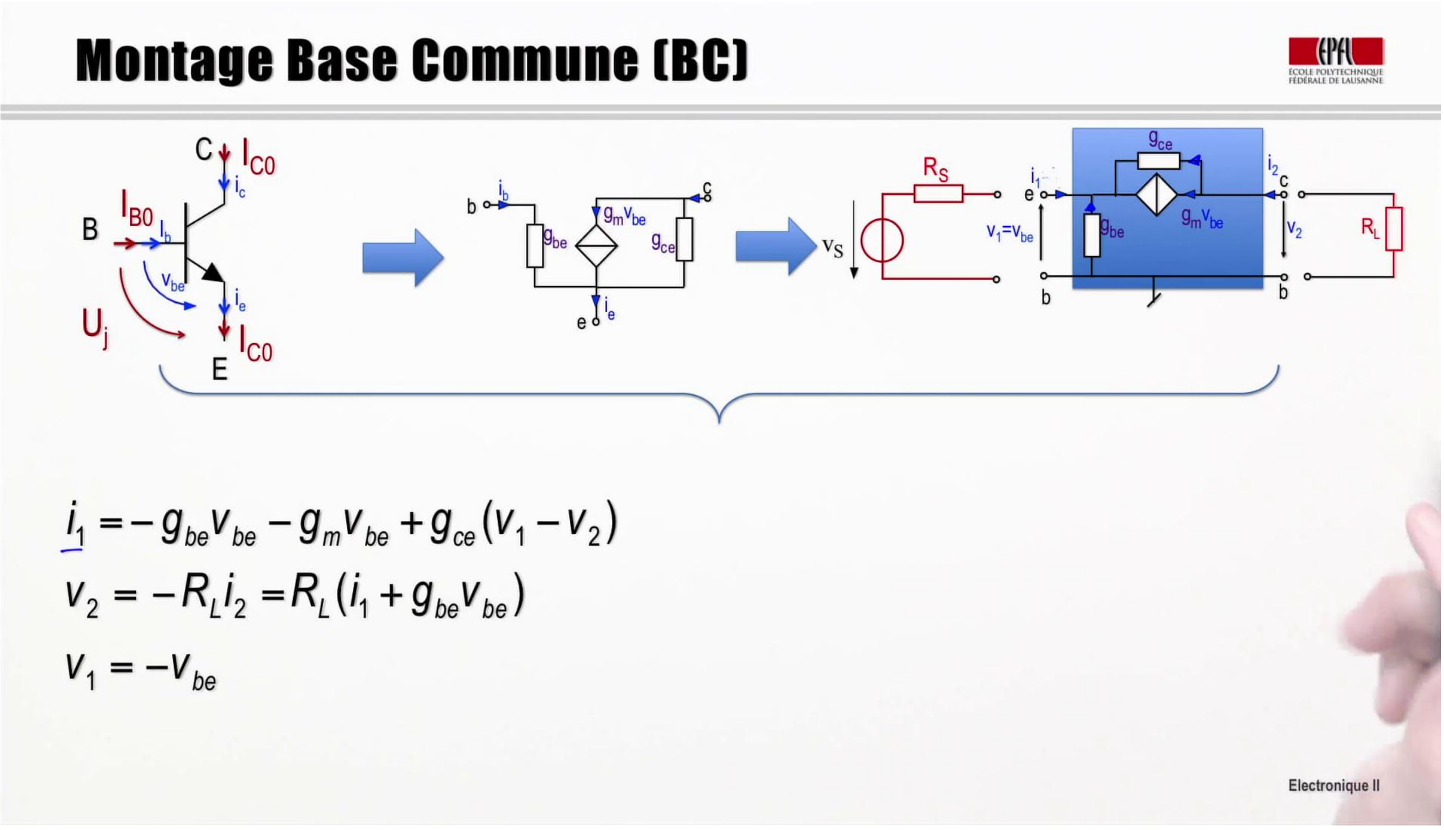


What is happening, we see that when I take the resistor RI and I look from here the impedance, I see Rl will interact with the input voltage because look, the current going through here, will continue its path and go through here. So the RI value has an effect. That is why we said "input impedance is defined with pluged Rl ". Same when I cancel the source, this source does not exist, Rs would be parallel with 1/GbE so I have Rs parallel with GbE and you see it depends on the value of Rs: if Rs is very, very big, it can be removed with respect to 1/GbE. But otherwise it is Rs that can dominate, otherwise if they have the same order of magnitude it is necessary to calculate two resistors in parallel. I will now think about what will happen with my setup in the quadrupole. What would I like to do? I would like to calculate what is the resistance that I see here, that is to say I would calculate V1 / I1 and I would like to calculate V2 / I2 to take into account Rout and Rin. I would like to express I1. So I1 is the current that enters here. Look at this current here, the GmVbe. This is Vbe and the current will enter the base of the transistor, it will have this direction.

Notes

Summary

14m 42s

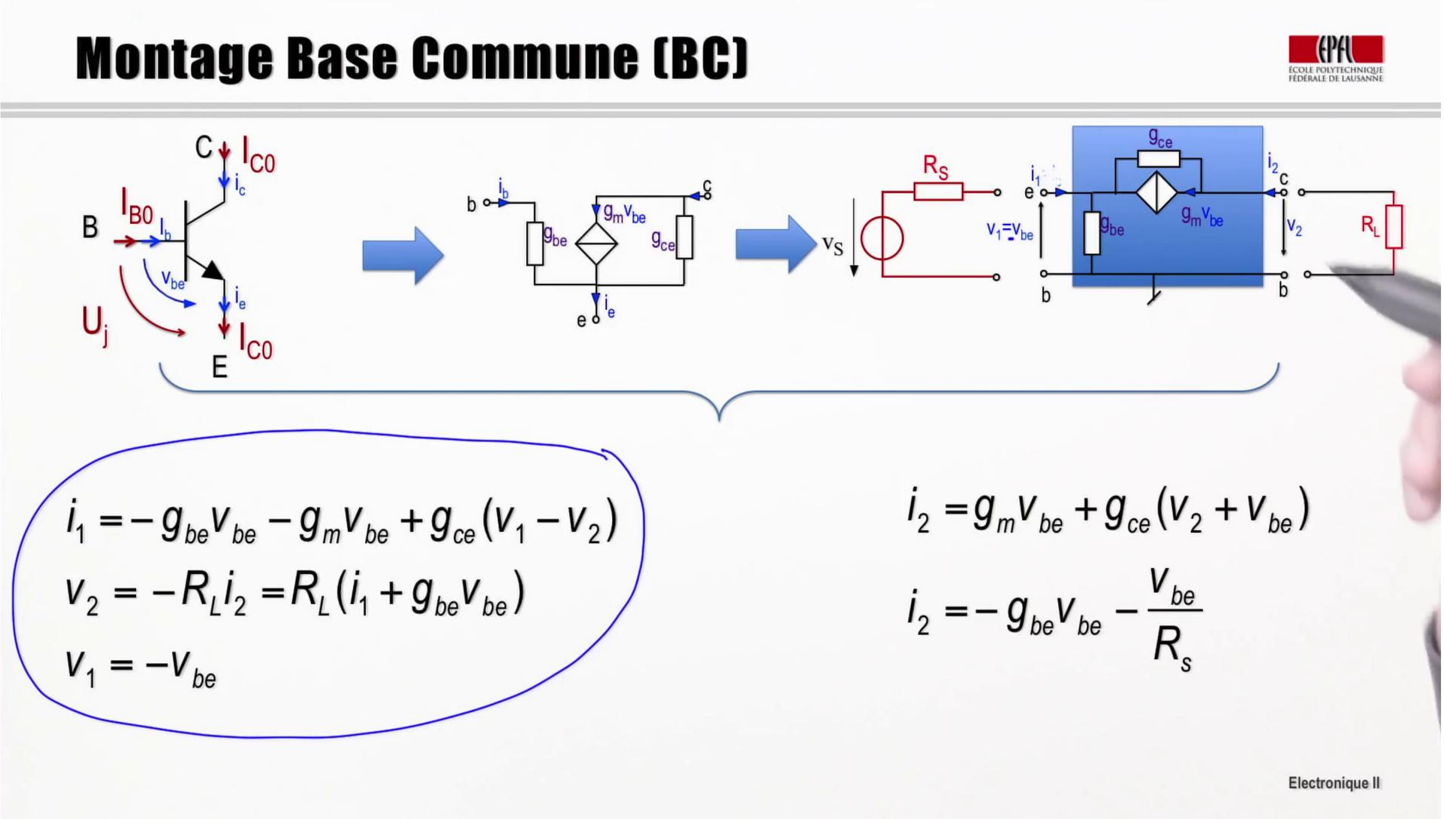


The current enters the base, it comes out in the transmitter so it's a current flowing in this direction. Vbe as the voltage, Ib is the current that is in this direction and this current I1, where there is a mistake I will immediately correct, it is not equal to Ib. So that, does not exist. This current I1 is proportional to what? It is proportional to this -GbeVbe. That's -GbeVbe, that's Vbe, that's Gbe. GbeVbe is a current, it is this current here. This current here gives this expression, it has a negative sign because this current plus this current, plus this current is equal to 0. This current that comes from here, it is GmVbe so we see it here, there is always a minus, of course, because it is a current that enters the node. Now I would like to see the current flowing here. This current flowing here depends on what? It depends on the voltage V2-V1/Gce if I want to take account of this plus sign I put in place of what I just said, I must say (V1-V2).Gce. So there I have expressed the current I1. I would like to express the voltage V2. The voltage V2, there is resistance that will have to pass in a current I2, so it's -RlI2.

Notes

Summary

16m 08s



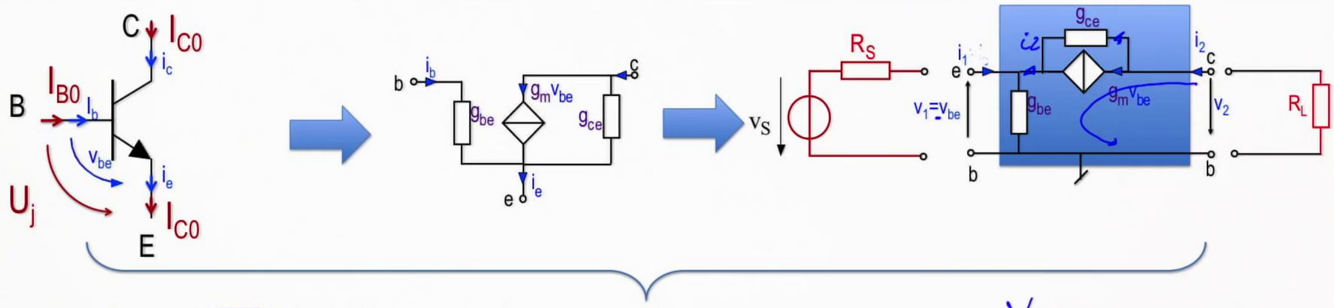
The direction of the voltage is positive in this direction, the current is positive in that direction so there is a minus sign to add. And this same current I2 is the current leaving here. That's the current I2. And there I can express it as they had done before so it's the current I1-GbE so I have to consider this current. This current then will be equal to, I replace I2 with the two currents that arrive so this node here, with the correct sign it gives I2 + GbeVbe. And I remember that V1 is simply equal to -Vbe... Here too there is an error because there is a minus. V1 is positive in this direction, Vbe is positive in this direction here so I have to take into account what appears here. So now I have everything you need to express the input resistance, the output resistance and the value of the transconductance to normalize this diagram here in relation to this quadrupole diagram we studied. We talked about the input impedance so we found all the relationships that allow us to do so. Now I am correcting the same mistake just now with this and I'll add the minus I had forgotten in my diagram. Let's move to this side. I would watch the output resistance so it's V2 / I2, I will calculate V2.

Notes

Summary

17m 42s

Montage Base Commune (BC)



$$V_S = 0$$

$$i_1 = -g_{be} v_{be} - g_m v_{be} + g_{ce}(v_1 - v_2)$$

$$v_2 = -R_L i_2 = R_L(i_1 + g_{be} v_{be})$$

$$v_1 = -v_{be}$$

$$i_2 = g_m v_{be} + g_{ce}(v_2 + v_{be})$$

$$i_2 = -g_{be} v_{be} - \frac{v_{be}}{R_s}$$

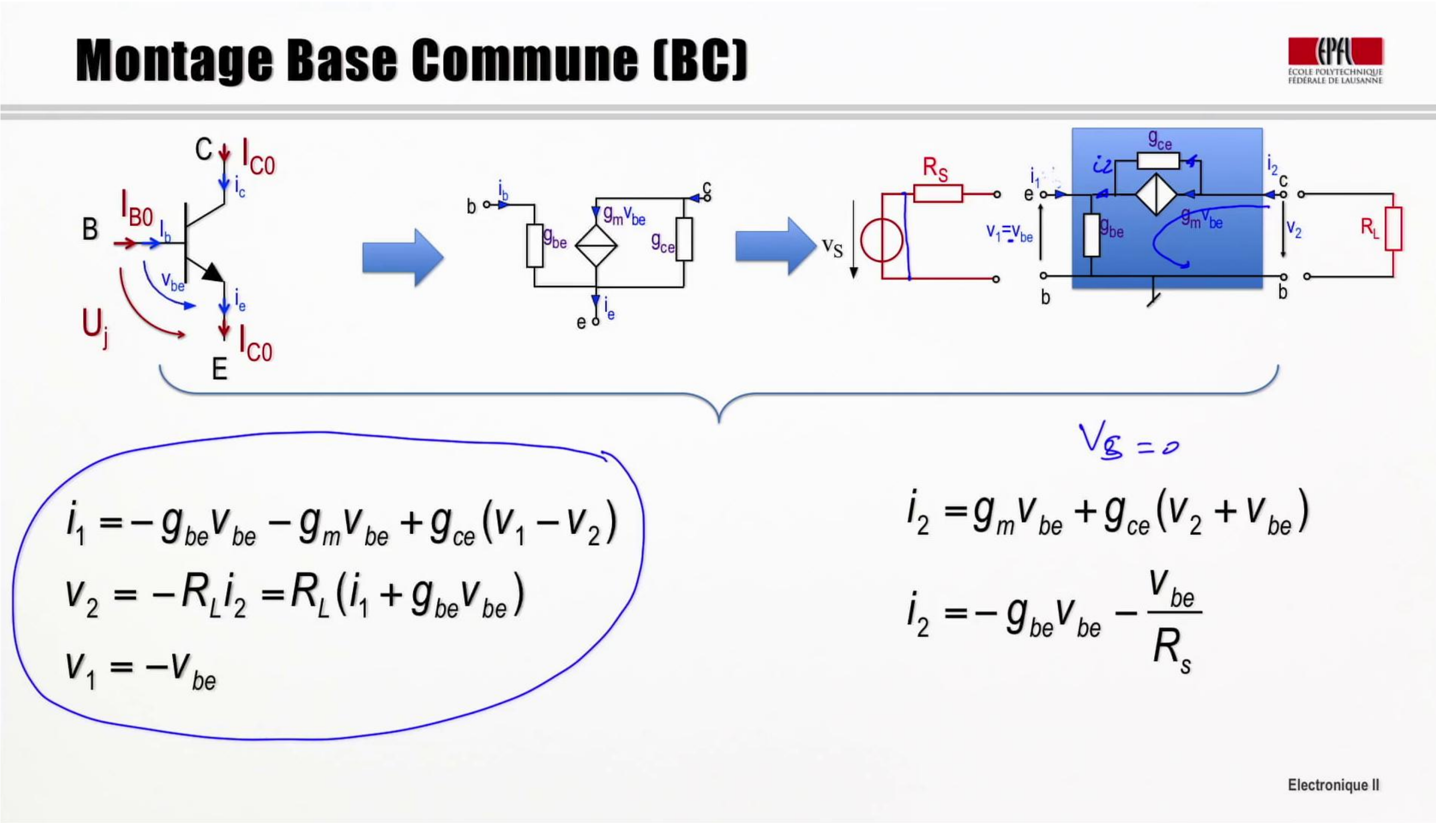
Electronique II

V2 is the voltage that I see from here to here so if I take this mesh it is like this. This is V2 which is equal to the sum of this voltage across Gce and V1 voltage, but the current I2 flowing in that direction will be proportional to this current GmVbe plus what was calculated as current in the Gce. The Gce is seen carrying a current that is equal to the difference of the voltage, V2-V1, taking into account the signs multiplied by Gce, that's what allows me to calculate the current in Gce. And here I express the current I2 because we were told that it is the current that passes through here and it comes out on the other side, it's always the same. This is also I2. Once it has passed here it comes out on the other side I2 so it depends on the current flowing in the GbeVbe with a minus sign and the VeRs, why? Because here I said Vs = 0. So if you cancel this voltage source, so you replace it by a short circuit and we said that the output resistance is calculated at the source equal to 0, but we keep the source we cancel the increase, but we keep the source so that the resistance Rs of the source if it has an effect on the output resistance this effect appears.

Notes

Summary

19m 15s



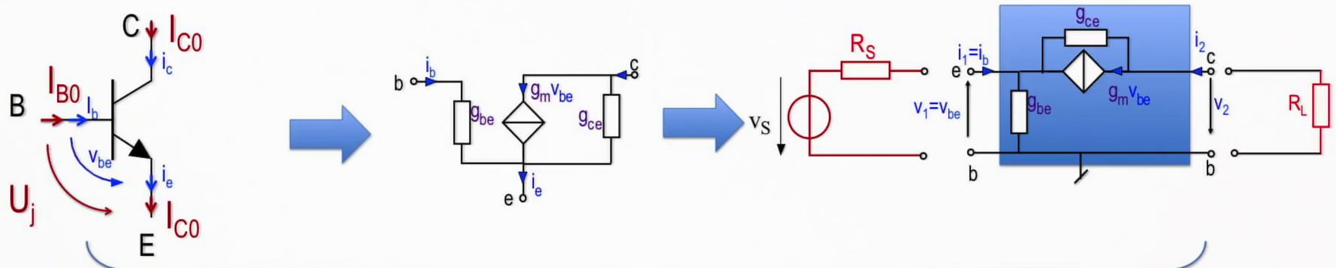
So the resistance Rs would occur in parallel with this resistance and we see it directly, the paralleling of the effect of Vbe and Rs is as if we had brought the resistance and put it in parallel with Vbe. So we have all we need to calculate input resistance and the output resistance therefore I will make a simplification. As I told you I will not do it here because I have to do V1 / I1 and V2 / I2, this is what will give me the following relationships.

Notes

Summary

20m 43s

Montage Base Commune (BC)



$g_{ce} << g_{be} << g_m$

$$1-\quad R_{in} = \left.\frac{v_1}{i_1}\right|_{R_L} = \frac{1+g_{ce}R_L}{g_m + g_{be}(1+g_{ce}R_L)+g_{ce}} \approx \frac{1}{g_m}$$

$$2-R_{out} = \left.\frac{v_2}{i_2}\right|_{v_s=0} = \frac{1}{g_{ce}}\left(1+\frac{g_m+g_{ce}}{g_{be}+1/R_S}\right) \approx \frac{1}{g_{ce}}\frac{1+g_m R_S}{1+g_{be}R_S} \approx \frac{\beta}{g_{ce}}\ si\ R_S >> \frac{1}{g_{be}}$$

$$3-G_{m0} = \frac{i_2}{v_1} = -(g_m+g_{be}) \approx -g_m$$

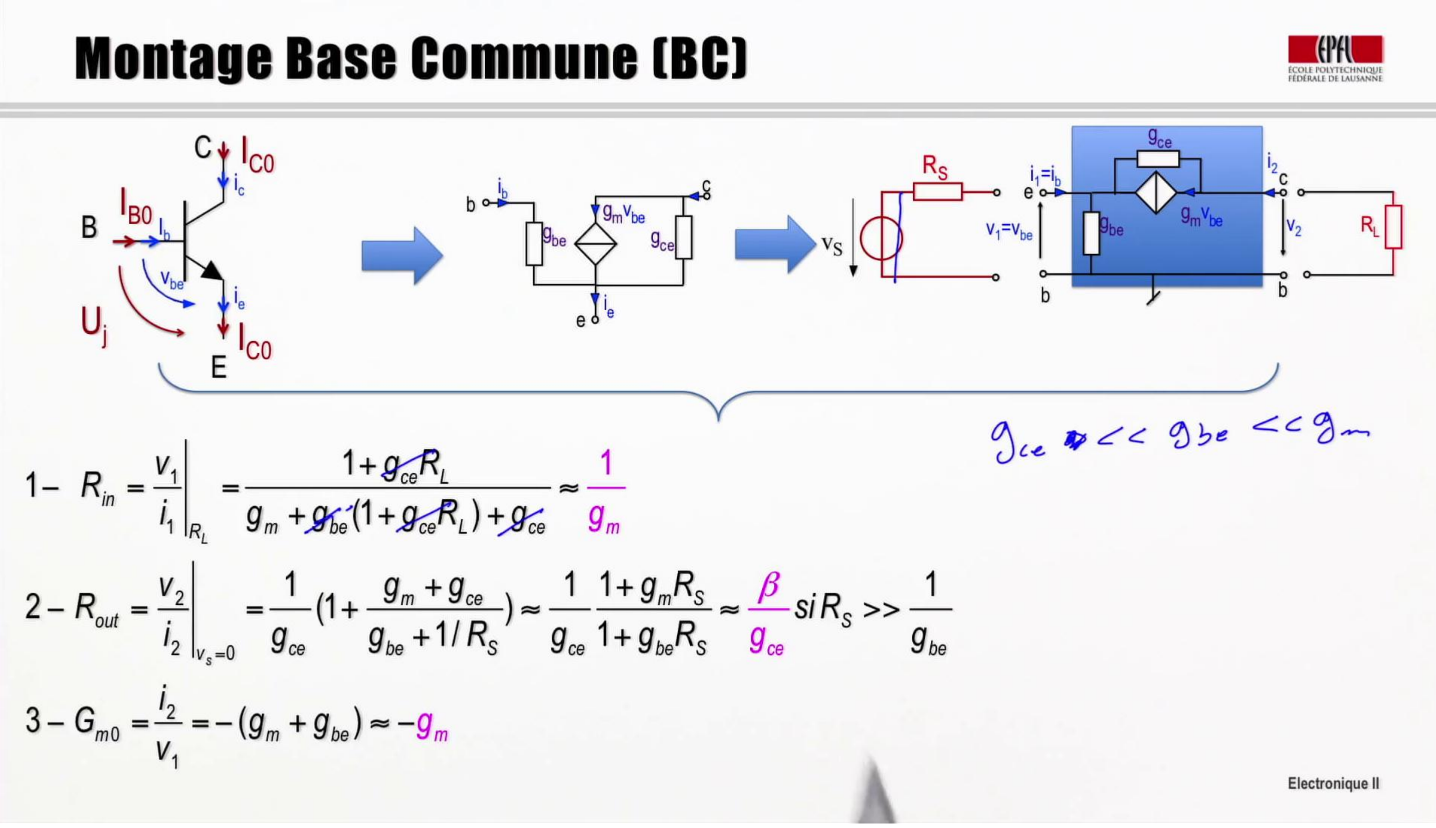
Electronique II

The relationships we'll get for Rin, in putting V1 / I1, while keeping RI, we will find this expression here: Rout is V2 / I2 canceling Vs. We will find this expression here and the Gm0, I short circuit here and I look at the current passing through. I'll find Gm + GbE with a minus sign. There, we'll get into this simplification game. I told you at the beginning, there is always the Gce which is much smaller than the Gbe which is much smaller than the Gm. When I see a Gce which sums up with a Gm I want to say, this is much bigger than this. So after when you look at a very small Gce which multiplies a resistance RI, I mean this, it will tend towards 0. The Gce, it is really small. So It will remain a 1. So I'll find myself with a Gm + GbE. So the Gbe in relation to Gm, I will remove it. And here the same, such as I simplified Gce by Rl, I will also remove it. All this will come down to 1 / Gm after these simplifications. So we will find that the input impedance of this set up, look at this set up here. When you look at it from here, it's like you plugged a resistance equivalent to all this. There is 1/Gm, that's what interests me. I will now look at the output impedance.

Notes

Summary

21m 18s

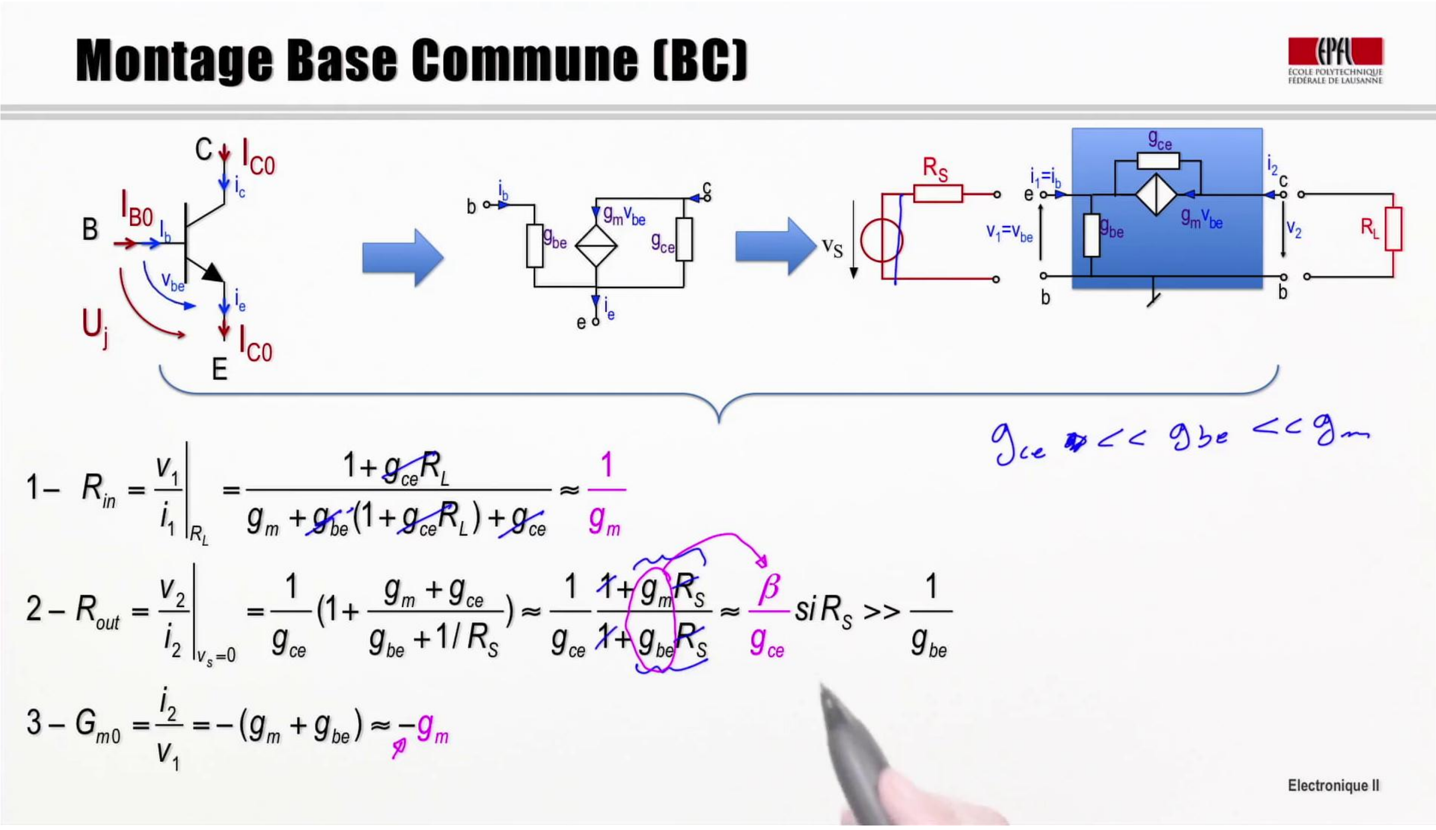


Same, we will make simplifications. We will find that 1/Gce, G1 + 1+ Gce over this expression here. If you expand it a little and you do some approximations, you come across this relationship. Here, I'll take the time to think with you. I think this is something that is of the order of magnitude. The impedance that I see here is of the order of 1 / Gce. Here I have 1 + GMRS. 1 + GbeRs. If by chance this term here, you have a term Gbe and you have a term Rs that multiplies. In reality what happens when one wants to see the output resistance, the source is canceled. So, I replace it by a short circuit. This source, it will disappear. What happens with it? Watch the Rs resistance. We'll put it in parallel with GbE. So I put Rs in parallel with GbE. If by chance, you have a resistor of a source of what you connected yourself which is much more greater than 1 / GbE, you have a very high resistance parallel with a much smaller resistance. You're going to neglect the resistance that is greater. Everything will move towards 1/GbE. And that's what I would like to express here. If by chance your Rs resistance is much greater than 1 / GbE, what will happen with that relationship?

Notes

Summary

23m 03s

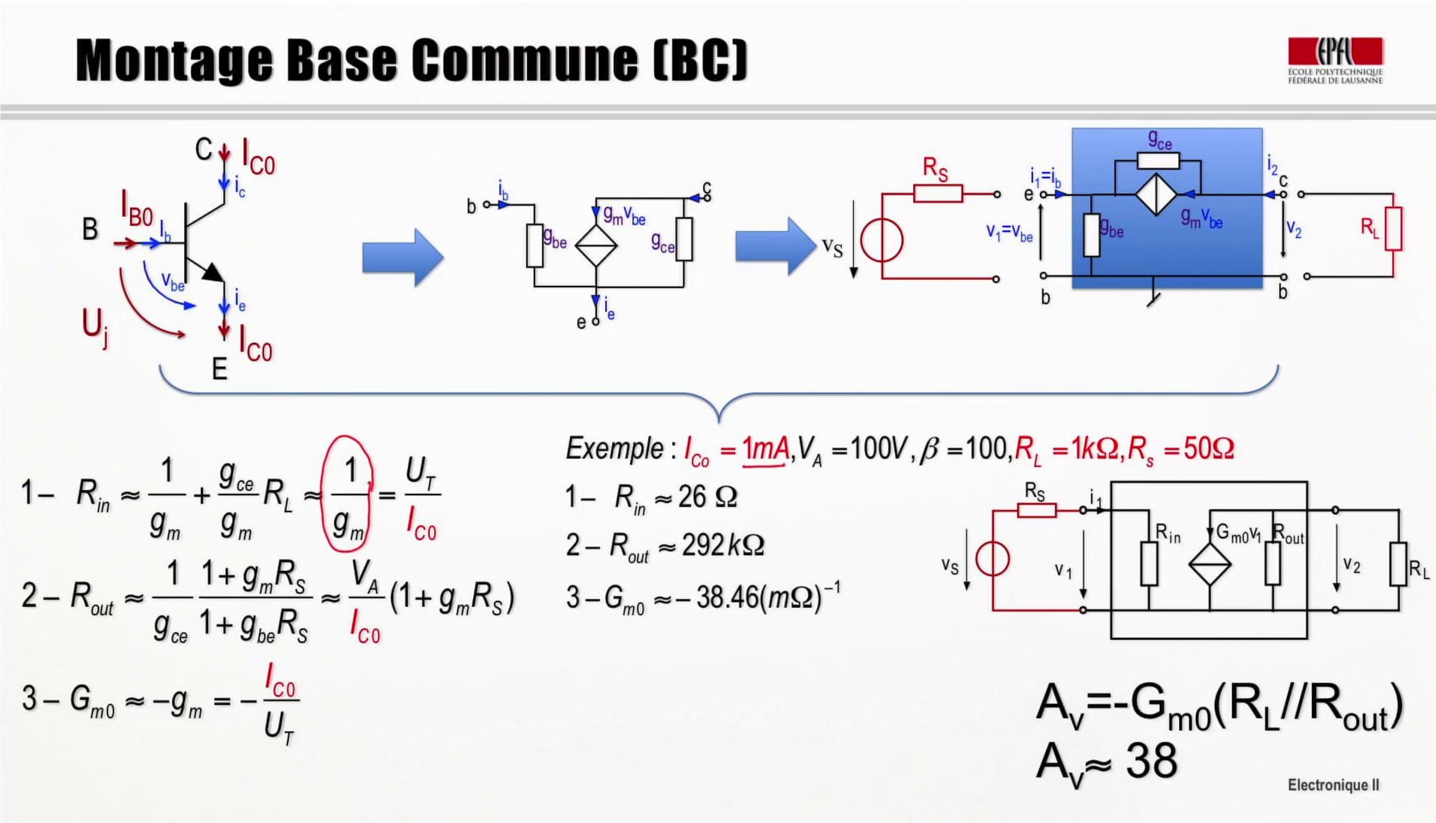


This relationship, first it's like I'm saying Rs is huge. Rs is very large. So this terme and this terme which is a product of Rs times a value, Rs times a value is extremely high, I can say that I can overlook the 1 which adds. This term is large because of Rs. Now if I neglect the 1 GMRS / GbeRs, I can say I simplifie Rs at the numerator, the denominator, that gives me Gm / GbE. And Gm / GbE is simply this term Gm / GbE, it is a β. Gm / GbE equals β of the transistor. So I find that if I can put a source whose resistance is in series of the source which is extremely high, I will find that the impedance of the output is boosted. It is boosted by a β / Gce it becomes β.1 / Gce. Now for the Gm0 when we look in short circuit, we'll see that really the output current, it is this GbE which modulate over Gm but we see that the sign here is equal to a minus sign. So it's a -Gm. I would like to go back a little and remind you aside what I found with respect to the common transmitter. Here I tackled the common base. And I found that the input impedance of a common base is 1 / Gm. The output impedance of a common basis, is β / Gce.

Notes

Summary

24m 33s

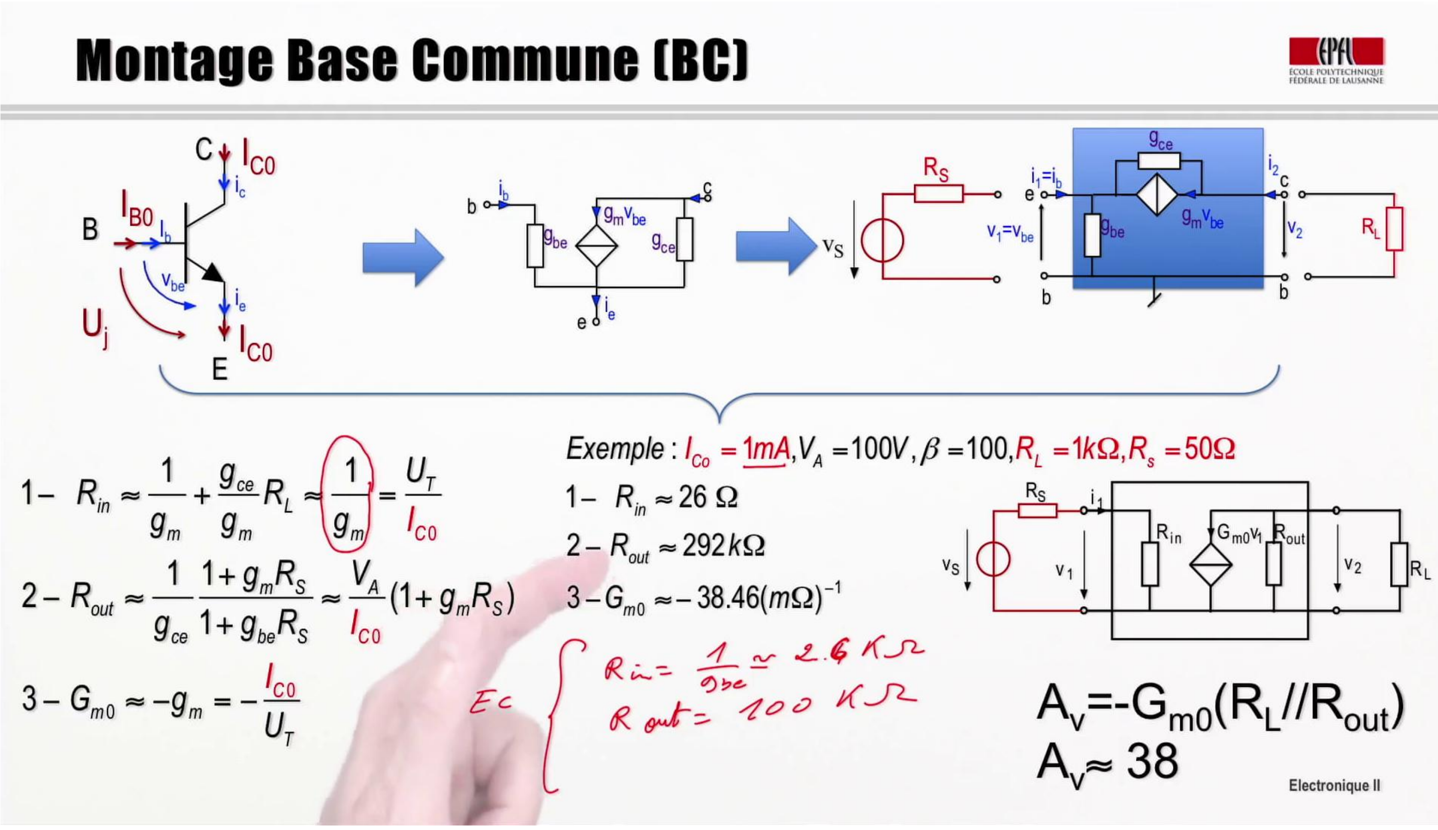


And I just found it is like a common transmitter, the transconductance in short-circuit is equal to Gm, but with a minus sign. And I'll do the case study with values and I'll keep the same thing we had made with common transmitter. That is to say, keep the same IC0 current that we had chosen for the common transmitter, it has 1 mA. I'll keep the same thing and see if I polarize 1 mA, what are the numerical values of these settings and bring them to the quadrupole, the input resistance, the output resistance and the transconductance and we will see what happens. This is a pretty charged slide, but then we need to look at the digital data. I have to apply a current of 1 mA and we keep the same resistance and we used the same transistor as the common transmitter. But this time, I put the base in common between the input and the output. Look what I found in terms of value. The input impedance, I note it next or I note it here. And I frame it, it is 1 / Gm. So this is a Ut / IC0. It is 26 000 mV divided by 1 mA. It is 26 Ω. The output impedance, it is the voltage Early. And there, I have not chosen an Rs which is very large. Rs is 50 Ω. It is not much larger than the 1 / GbE.

Notes

Summary

26m 17s

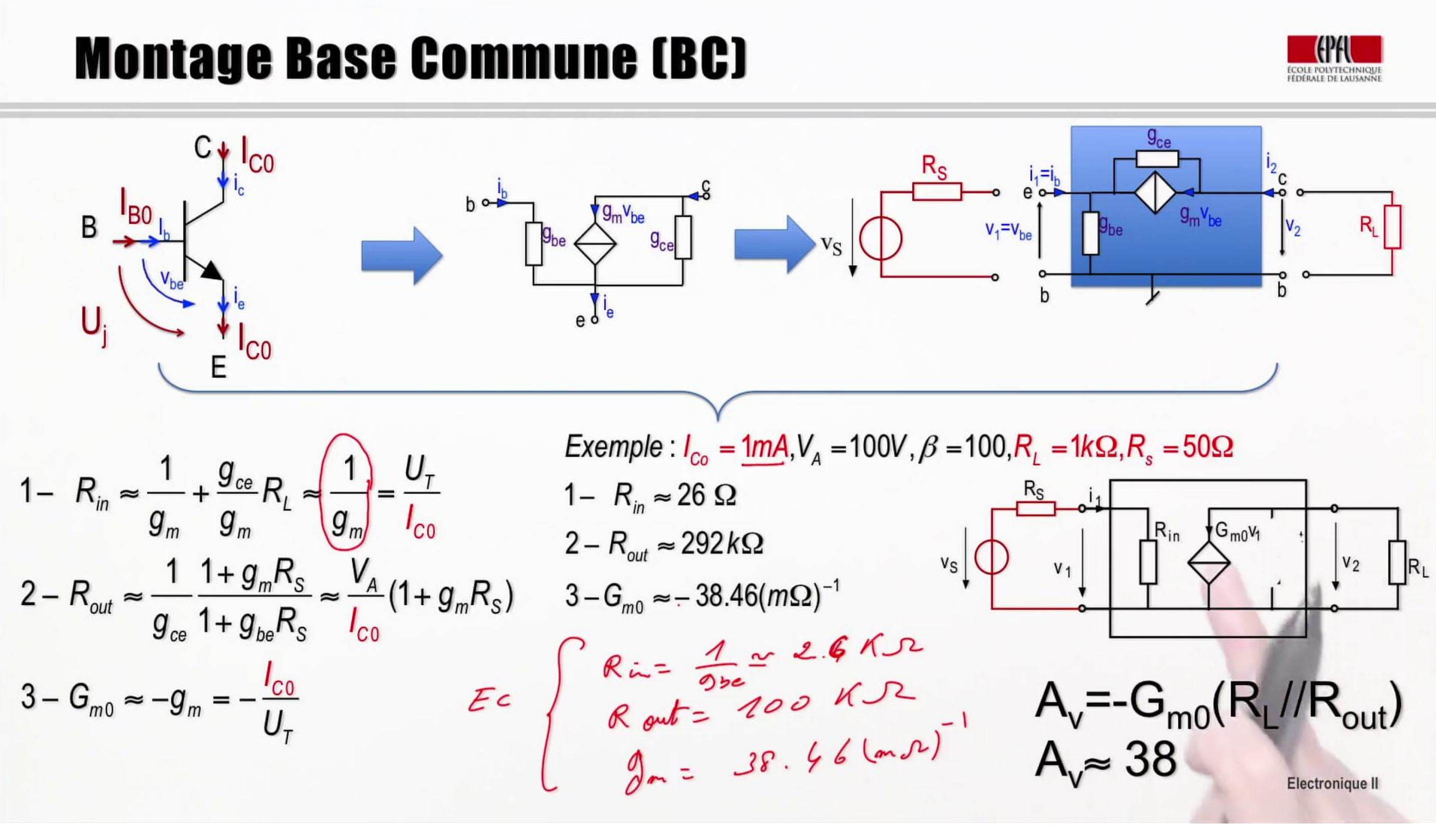


1 / GbE, it was calculated, it is in the order of 2,4 kΩ in parallel with 50 Ω. So it is relatively low. But I observe that the output resistance is still 292 kΩ. And Gm0 with a minus sign is the same as I had found for common transmitter. What can I say about the common base? When I processed the common transmitter with the same values, I found a Rin that is equal to 1 / GbE. And we said, it is of the order of 2.4 if I remember correctly. It's something around 2,4 kΩ. And there I found it, it's 26 Ω. So if you replace, for the common transmitter the same values and you take the Rout of a common transmitter, we found 100 kΩ. Here I found almost 300 kΩ. So that's three times greater. Here is, I think this is 2.6 if I am not wrong, check it. So when you look at the report I can say that the impedance input of a common base setup that is much more smaller than the input impedance of a common transmitter circuit. The output impedance of a common transmitter circuit is smaller than the output impedance of a common base. So the common base has an output resistance quite high compared to the common transmitter.

Notes

Summary

27m 48s

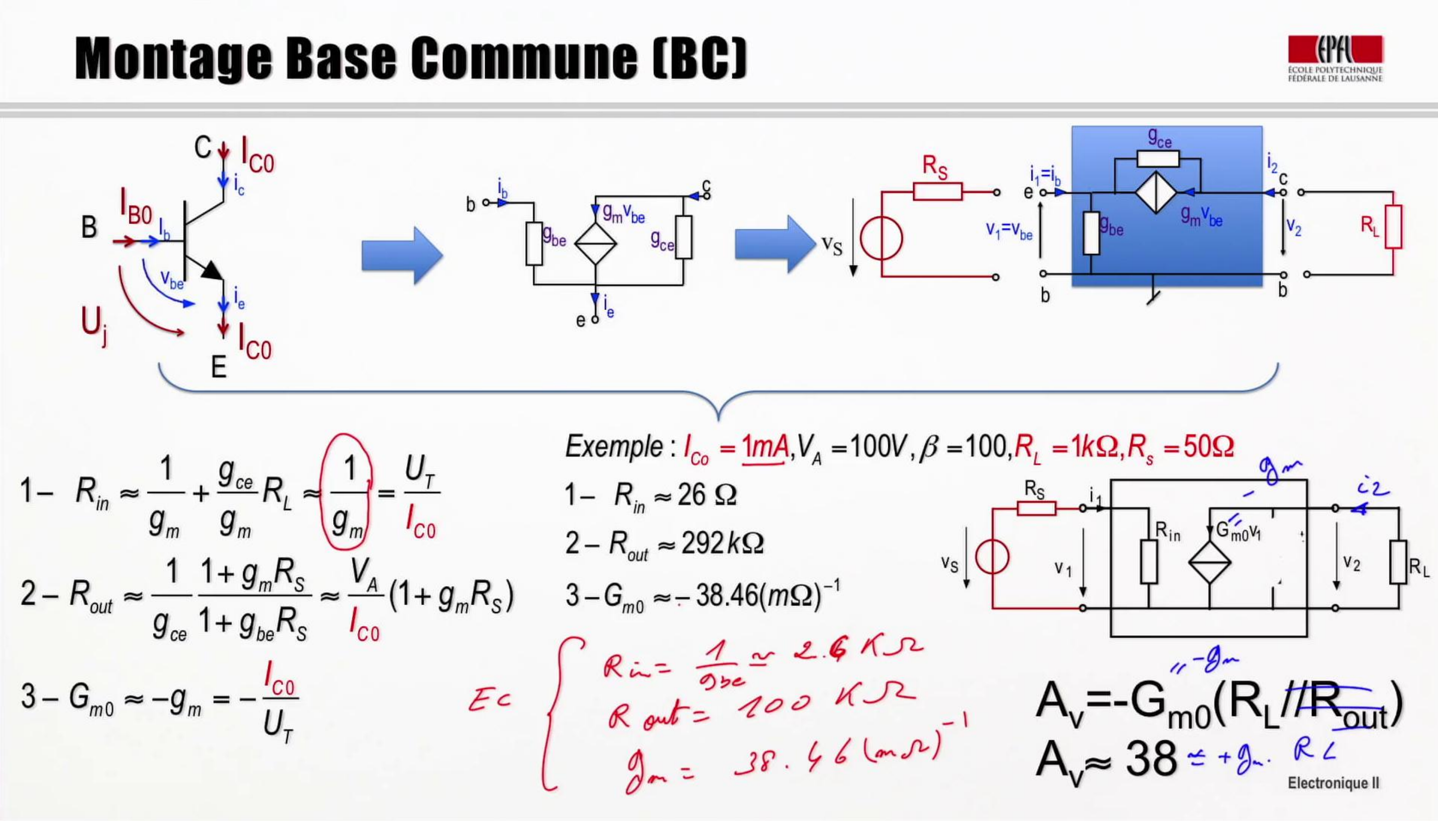


And of course, if I had put Rs with the discussion we had made before, if Rs was big enough, there we took 50 Ω, if I had put maybe a megohm, you'll see it immediately becomes much larger than the common transmitter. So this term, it will explode. This technique is called the amplification of the impedance output, it is called in English gain boosting for output resistance and is used in setups where we want to make extremely high gains. I look at the Gm0. I find it's the same value as the common transmitter that was found, 38.46, but something that is without the minus sign. Here, there is a minus sign. Here, there is a plus sign. So it's the same transconductance, but then the input impedances and the output impedances, there are things to do. And that's what would allow us later to use a setup in the place of the other. It is these values that you are noting and it is those values that you will consider later. So when I plug Rout and I see these 292 kΩ, and I connect a parallel resistance of a kΩ, I can, without hesitation, replace or say this resistance, I can overlook it. It's like it does not exist. I have a resistance Rl. So this current one, it is converted to voltage by Ohm's law.

Notes

Summary

29m 23s

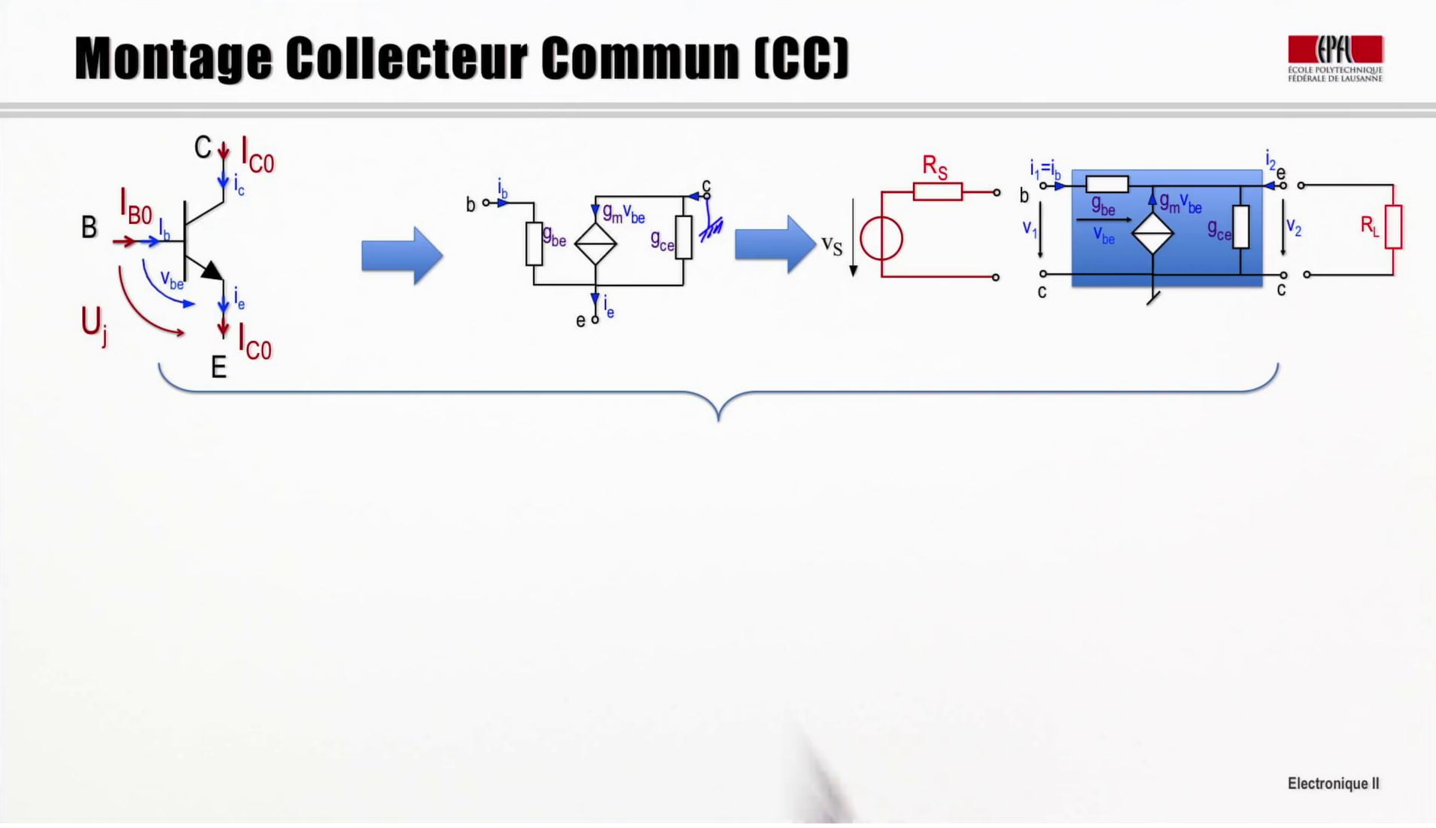


A current that flows into the resistance, but remember not only in this case, you have the Gm equal to -Gm. So I have a minus sign. Watch the tension, it is positive that way. I have the current that has been defined, by convention, positive in this sense. I have a Gm sign. So here when I put -Gm and I write this Gm equals -Gm. So this gain is equal to + Gm.Rl and I say approximately because it's Rout, I have not considered this impedance I just erased. And we find that the gain of a common base setup and common transmitter setup is exactly the same. One inverses, this is the common transmitter and another that has a positive gain of the same value, with the same values of components and the same polarization which is equal to 38. So we begin to understand what it will serve all this and begin giving qualifications of electronic nature of these setups. Let's find the common collector setup.

Notes

Summary

30m 51s

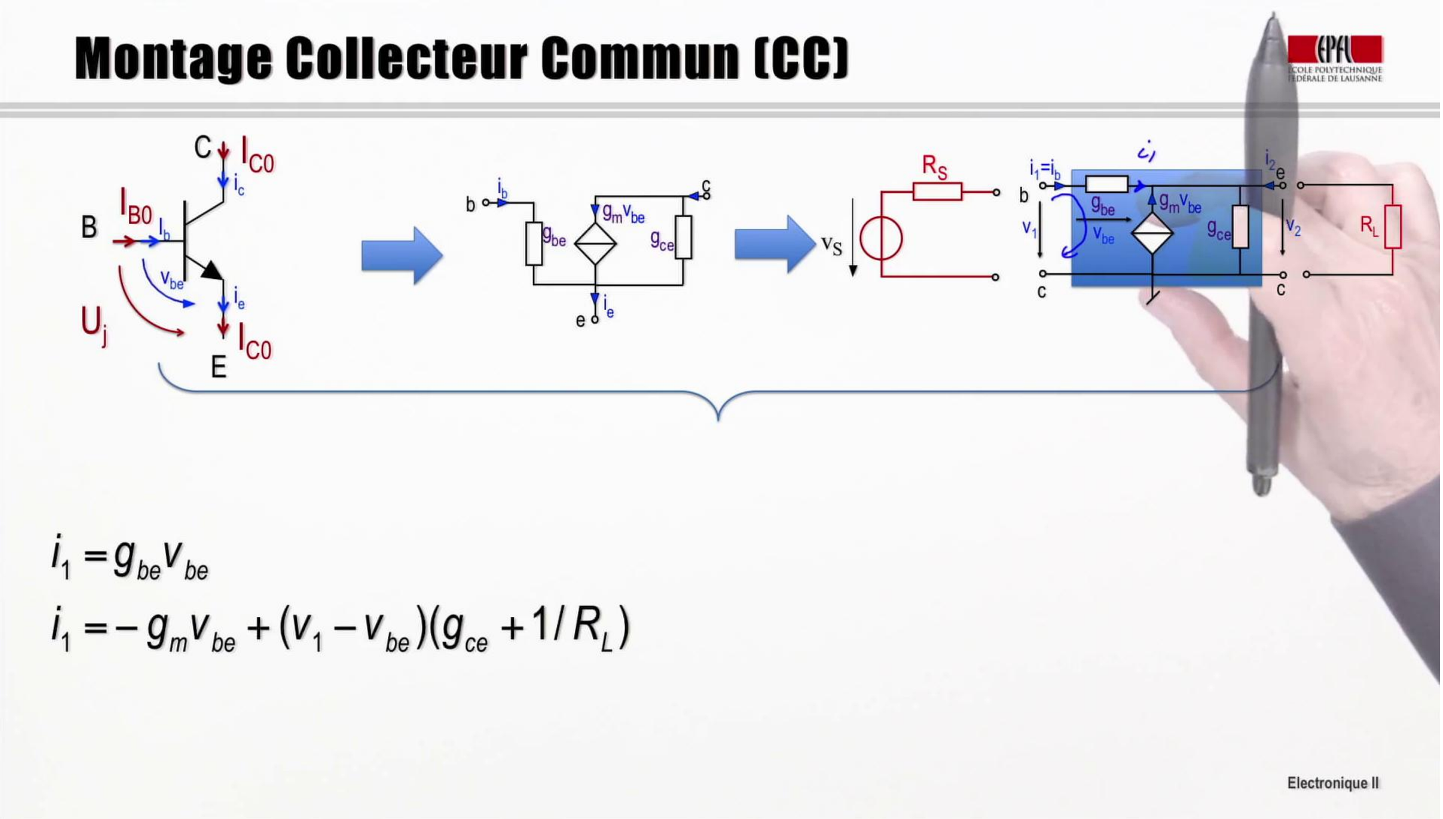


The same story. I will use exactly the same thing. The common colector setup, the small signals diagram of the transistor and the ability to replace the transistor, but putting this time the collector to ground. I'll put the collector in common between the input and the output. I'll enter between the base and collector and exit between collector and transmitter, definitly you will see, we will put a fixed potential on the collector. And we'll see when the output is on the transmitter. So we will later, put a fixed potential and here, we put our charge RI. And we will connect our source here between the base and the collector, so every increase here is exactly that which will appear here, but we will have the opportunity to see it later. I take this pattern and then I draw. Look at the transmitter, it is here. The collector, it is here. So that, I pivoted to rotate it and draw it like this. Current flows from the collector to the transmitter so it is GmVbe. The input current, there is always the same error that I will immediately correct, here too. So it's just, it's I1 equal Ib. So there, the current through the base, I1 equal to Ib.

Notes

Summary

32m 04s



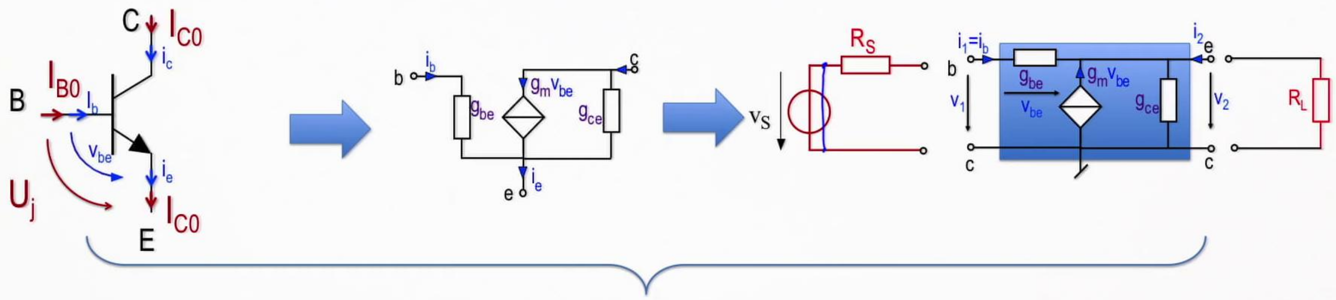
And I see again a setup equivalent to the common collector setup that I will take and make in place of this standard quadrupole with an input resistance I defined as V1 / I1, an output impedance I defined as V2 / I2 and I have to calculate the transconductance which appears here. I go in my calculation. So I have this diagram here. Again, I have to calculate the current I1, express it. I see this current one, it is a base current. That is Vbe and that's Gbe. Therefore the current flowing through a GbE conductance is equal to Gbe multiplied by the voltage Vbe. I note it. This same current, it comes from here. So that's the same current I1. This current here, will be proportional to this current and the current flowing to both sides. So I express it. So this is the GmVbe, what I see here with a minus sign. And the voltage I see at the terminals from here to here, this voltage here to here, I express it as a function of this. This voltage here, I take this mesh. I have here the Vbe and there, the voltage V2. So I express V1 - Vbe, it gives me the voltage V2. Look at my two fingers here. This voltage here, it is proportional to what I see from here to here and it is equal to this voltage V1 - Vbe.

Notes

Summary

33m 26s

Montage Collecteur Commun (CC)



$V_S = 0$

$$i_1 = g_{be} v_{be}$$

$$i_1 = -g_m v_{be} + (v_1 - v_{be})(g_{ce} + 1/R_L)$$

$$i_2 = g_{ce} v_2 - g_m v_{be} - g_{be} v_{be}$$

$$v_{be} = -g_{be} v_{be} R_s - v_2$$

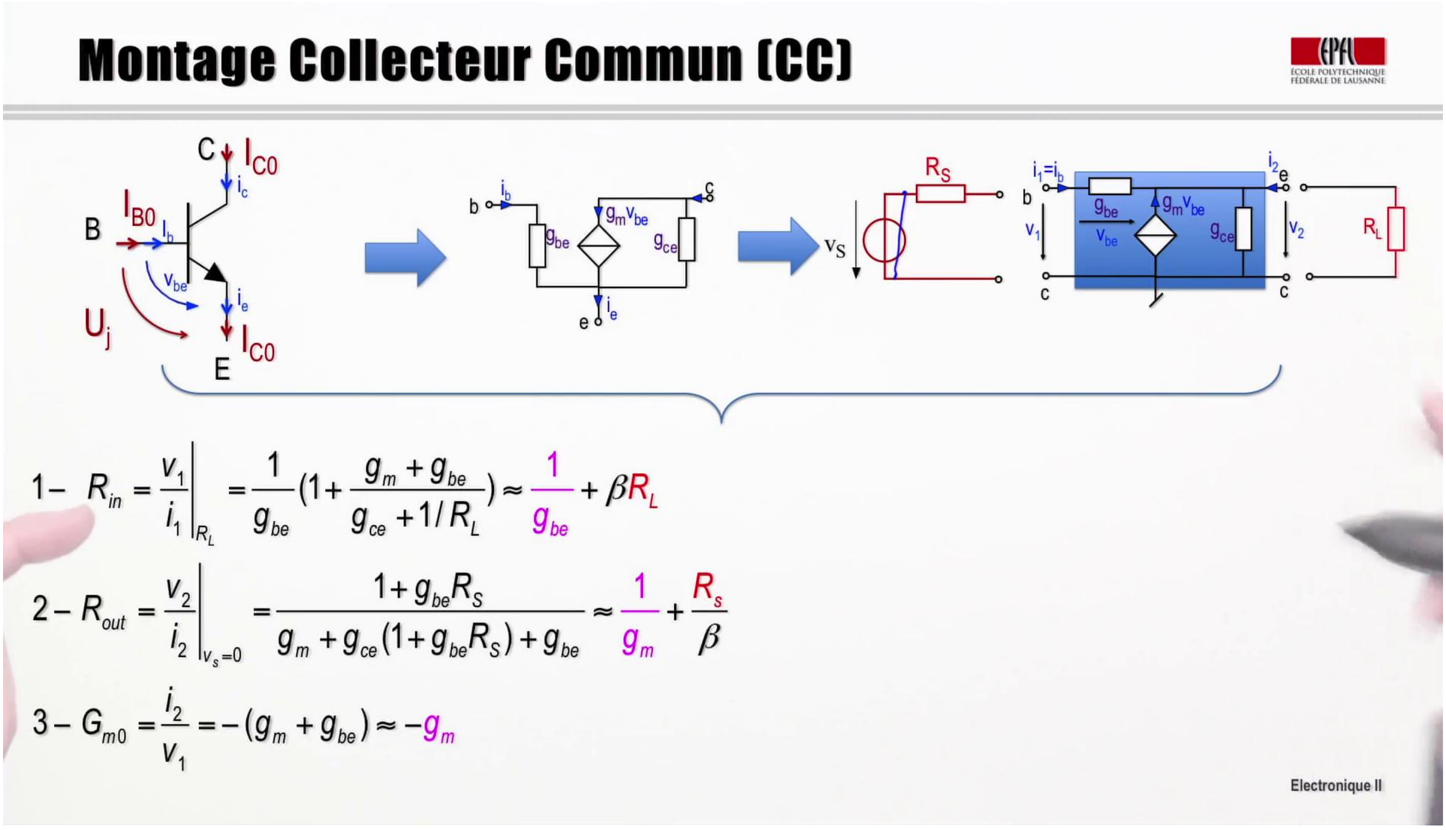
Electronique II

Therefore, V1 - Vbe. So that will give this component that I see here, that I express here. And it will end in parallel with the parallel implementation of two resistors, 1 / Gce parallel with Rl I can write it in terms of conductance. This is Gce + 1/RI. Here, I expressed I1 depending on this. I'll redo the same for the current I2 by replacing Vs by a short circuit. And I will calculate whether the GceV2, so it takes into account the current through here. This takes into account current flowing through here and it will reflect this current that passes by neglecting the series implementation of Rs with GbE and I end up with this expression. And when I short circuit the source, I see that Rs appears here. So you remember when this circuit is short circuited, you have Rs which comes here and here we are reading Vs = 0 because we're looking at the output impedance that appears here. So it gives me this relationship. And I have all it takes to derive the V1 / I1, V2 / I2 and what am going to share with you now.

Notes

Summary

34m 56s



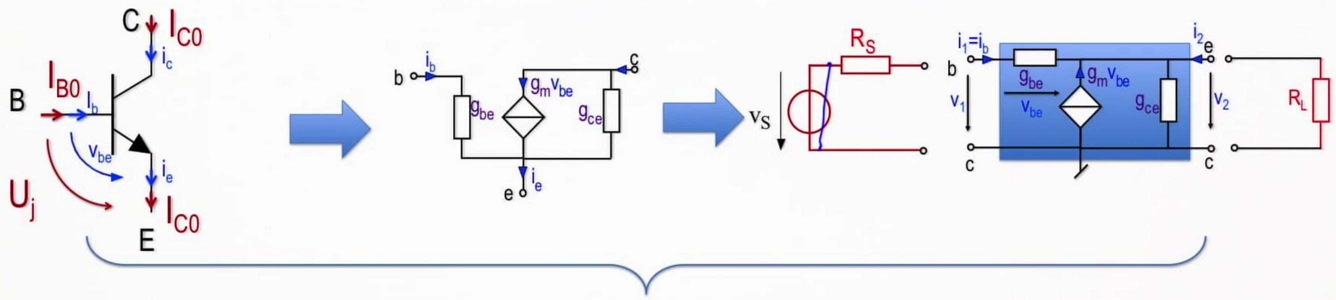
These are expressions of Rin, Rout and Gm0. It's always like we did it all the time. So I do V1 / I1 that will give me an expression in which will appear in Rin the output impedance. Do you remember ? When you look from here, we do not remove this resistance. If anywhere, this resistance contributes to the expression of Rin, it is why we need to keep it. We see it here. Here we are in a common collector setup. When connecting a charge on the transmitter, you see that this charge impacts on the input resistance. Look Rout, you will see Rout when you short circuit this source, there that Rs that will appear here, and you will see that will show of course, it will contribute in the Rout. The Gm is like the common transmitter and common base, it does not change. There is a minus sign it is like the common base it's equal to -Gm. And here are the three expressions. We see what is in pink that depends on the transistor itself. It is these small signals parameters of the transistors that it impacts. We did however see that the input impedance, it is strongly affected by the resistor Rl. So if by chance you come into a common collector setup and you plug an infinite resistance called a power source, it is as if you are putting an infinite resistance to the input.

Notes

Summary

36m 16s

Montage Collecteur Commun (CC)



1− $R_{in} = \frac{v_1}{i_1}\Big|_{R_L} = \frac{1}{g_{be}}\left(1+\frac{g_m+g_{be}}{g_{ce}+1/R_L}\right) \approx \frac{1}{g_{be}} + \beta R_L$

2− $R_{out} = \frac{v_2}{i_2}\Big|_{v_s=0} = \frac{1+g_{be}R_S}{g_m+g_{ce}(1+g_{be}R_S)+g_{be}} \approx \frac{1}{g_m}+\frac{R_s}{\beta}$

3− $G_{m0} = \frac{i_2}{v_1} = -(g_m+g_{be}) \approx -g_m$

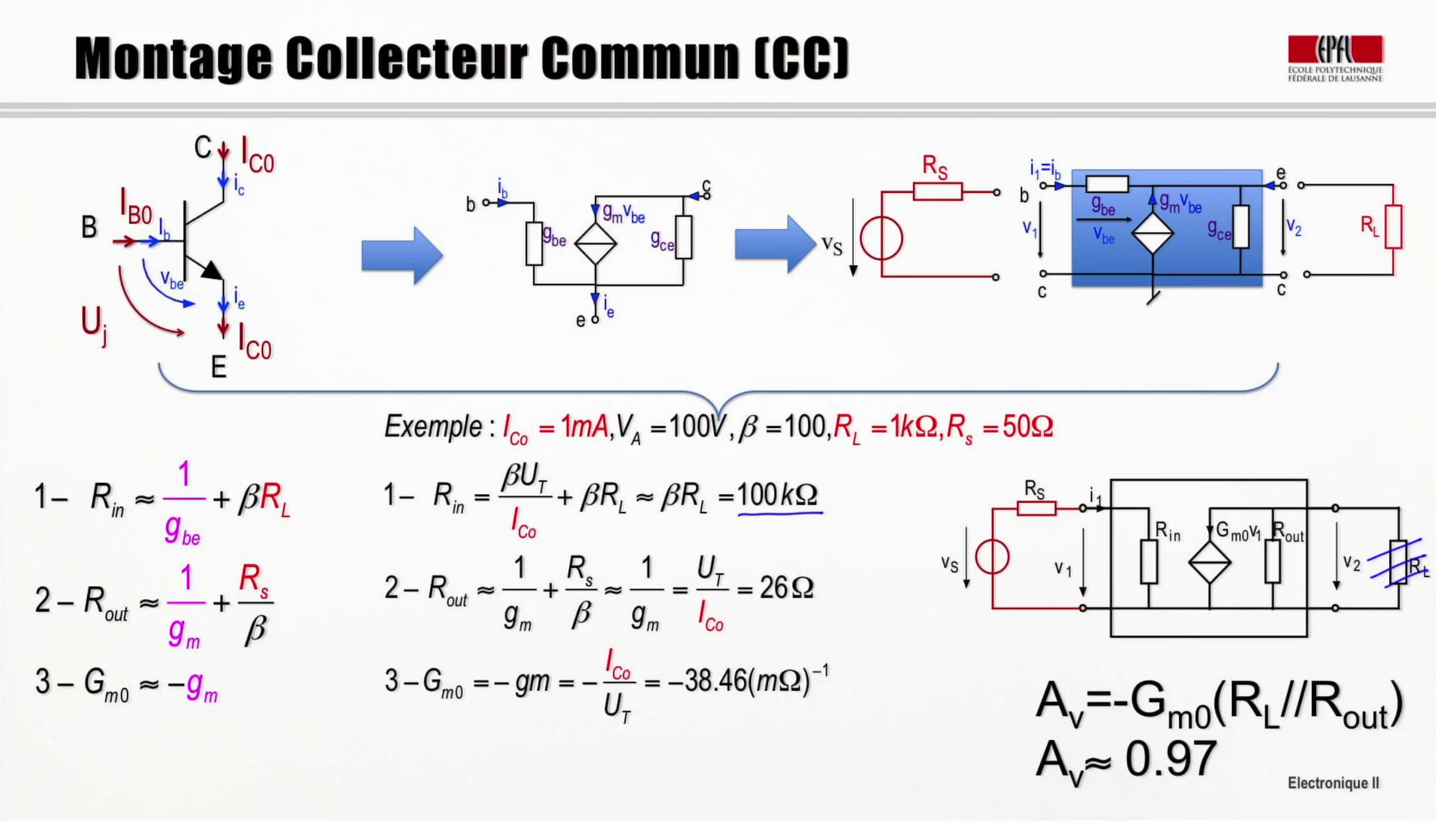
Electronique II

It's like if you really take a quadrupole where there is no resistance, the resistance is infinite, it's great. So if your Rl resistance is very, very big here, it is already multiplied by β. So if you put a resistance of the order of RI equals one MΩ, you have a β equal to 100, you will have an input impedance equal to a hundred MΩ plus a little thing that is a few kΩ that we can practically not talk about. Therefore, input resistance, the common collector setup. The higher the charge resistance is, the higher the impedance is. So you can see an input resistance Rin = β.Rl. That's why I kept the pink color that depends on transistors and I put the components that the user can connect by himself from the outside. Same for the output resistor, which is not here. It is a small order of strength of magnitude of 1 / Gm. If you remember, 1 / Gm is of the order of 26 Ω if you polarize to 1 mA with calculation, but it depends on Rs / β. So of course if your β is very large and Rs is low, you will end up with an impedance output that is very, very low. And Gm does not change. It is a history of signs to be compared.

Notes

Summary

37m 51s

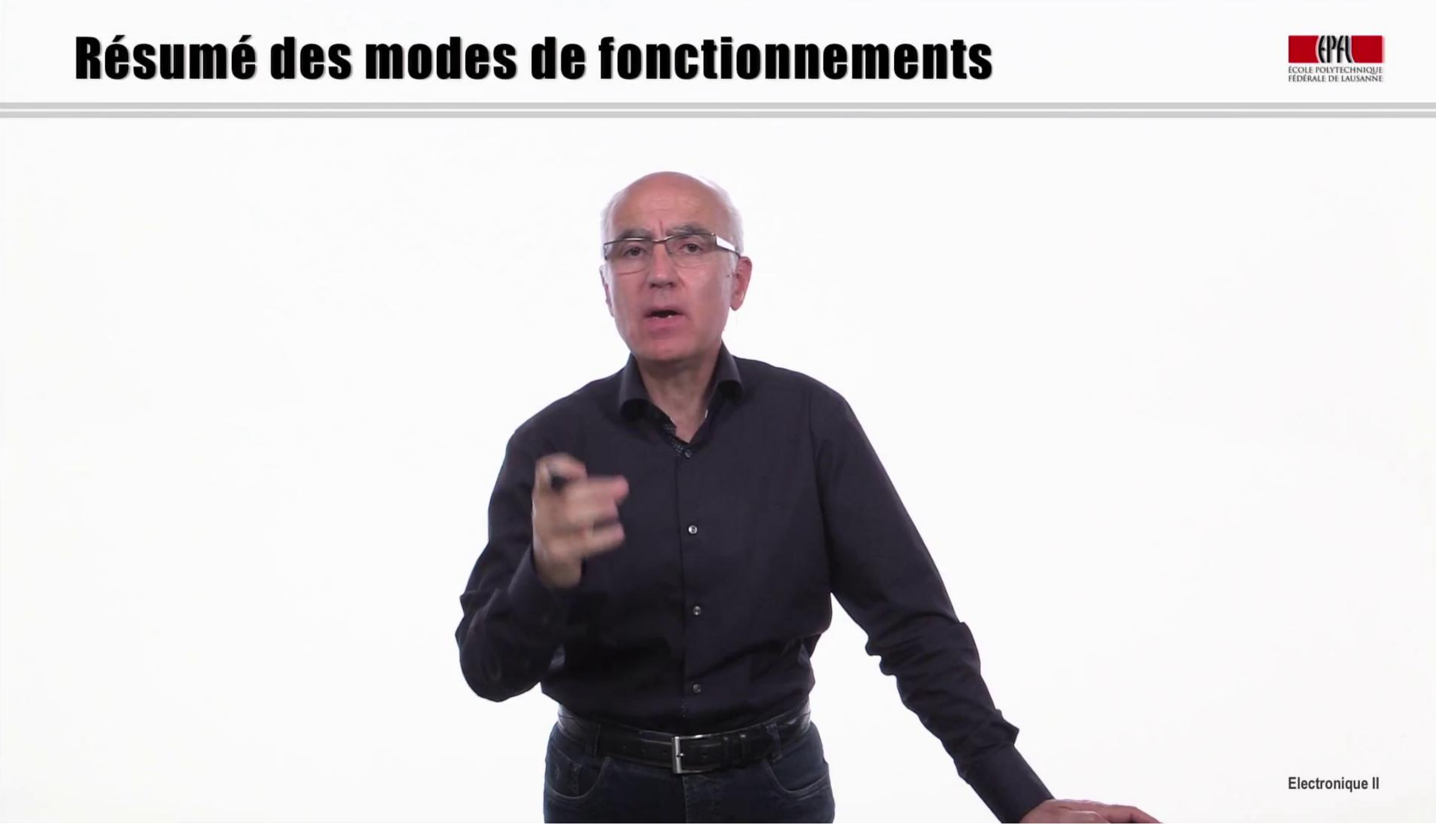


Do the math. Take this polarization of 1 mA and the same transistor that was used, the same charges and the same source. Use the expressions transmitting values. Look at Rin, 100 kΩ in this example. With about 50 Ω as a load, you end up with an input impedance of the order of 100 kΩ, so it's really one of the highest we've ever found with the other two setups. The 100 kΩ as an input impedance that we'll see at the input of a common collector setup is the highest. The output impedance when it tends towards to 1/Gm is 26 Ω. It's low. And when it is low, so it has an output impedance here I see relatively low and the transconductance, it's the same as the others. I will now calculate the parallel implementation of the output resistance in parallel with our charge. It was 1 kΩ here for the resistor RI and we put in parallel a resistor of 26 Ω. So when you put a resistor RI of 1 Ω with a small resistance of 26 Ω, you can almost neglect the resistor RI in parallel with it. So there, it would become a Gm0 V1 multiplied by Rout divided by V1. And it would give you a gain of about 1. So a common collector setup is not a voltage amplifier such as the common base or common transmitter.

Notes

Summary

39m 17s

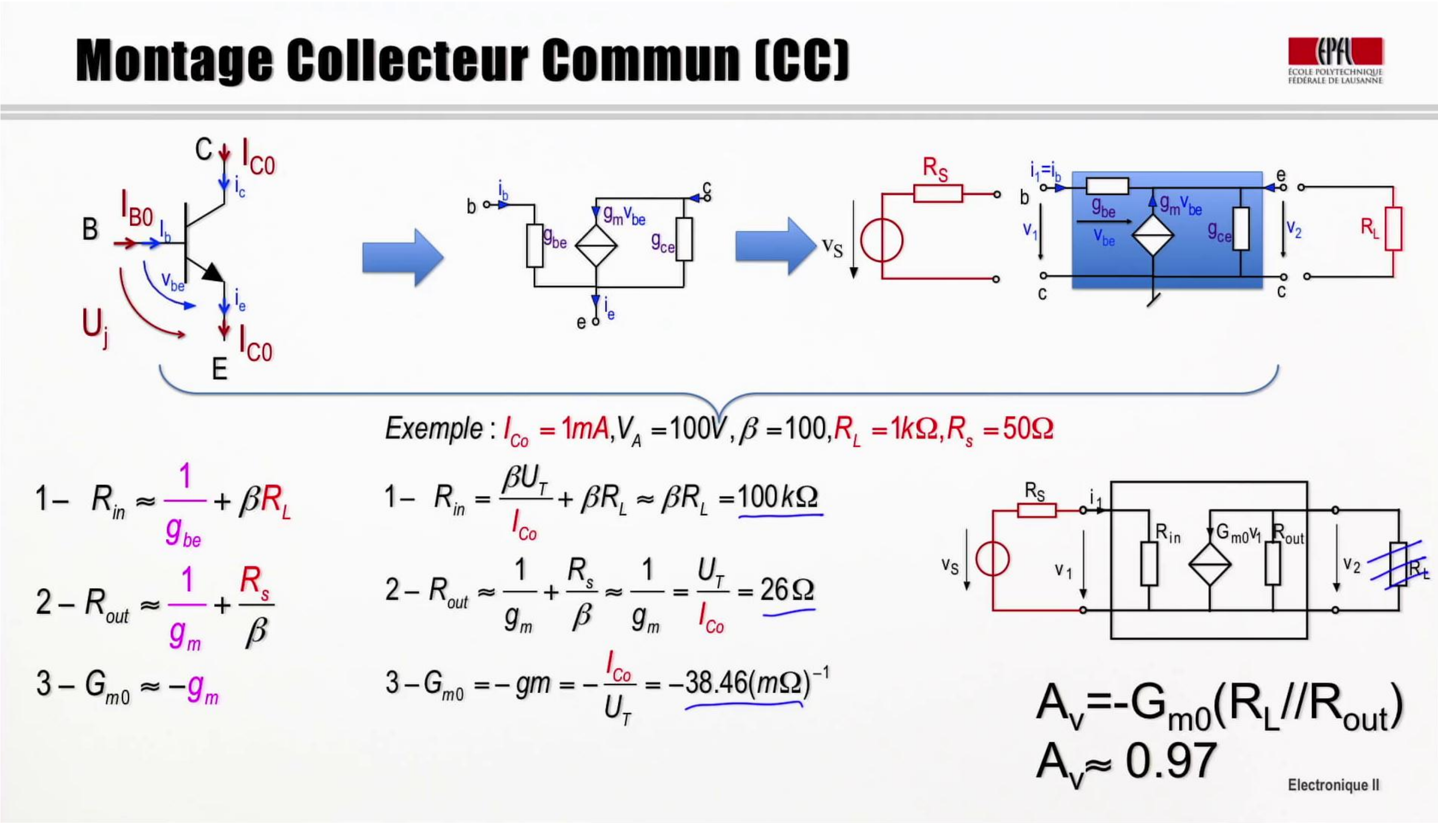


In both cases, we found a gain which was of the order of 38 with a positive sign this time for the common base, negative for common transmitter. There, we find that it is a voltage follower. What we put here, we'll find it in the output voltage. However, in terms of current, ah no. In terms of current it is an amp that takes in the base, a current Ib. It'll send to the transmitter a current β times this current. So it has a current gain that is very high. What I am saying now on the characteristics of these setups is very important. And that's what will ensure or give me the ease to make the right choice between the common collector, common base or common transmitter setup. And I think the example I gave and these values that every time I have commented, this is the most important to give orders of magnitude to someone who would use that and later gradually as we advance in the study of transistors, we'll make the right choice among the three to create complexes circuitries with the set. We just completed this week the essential part of the use of three setups. How do we addressed that? We took the small signal diagram and a transistor.

Notes

Summary

40m 59s



It was turned around itself and each time it was made common one of the legs of the transistors either the transmitter, or the collector or the base. And it was extracted with a quadrupole which shows an input impedance, an output impedance and a controlled current source. From now on, we have a tool that has become very, very powerful because we still calculated an approximation of the input impedances and the output impedances for each of these setups. And here we will do a summary with this. And you will see with this summary, we can go very far trying to juggle the three setups and put one before the other. Create with this voltage gains, current gains, circuits that have low or high input impedances. And same for the output impedances. And it gives us a very, very powerful tool for synthesizing electronic circuitries based on transistors that later will give us the operational amplifier when we correctly use the cascades of these different stages we have just studied.

Notes

Summary

42m 15s