ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

8.2- Amplificateurs de puissances

Amplificateur classe B & AB

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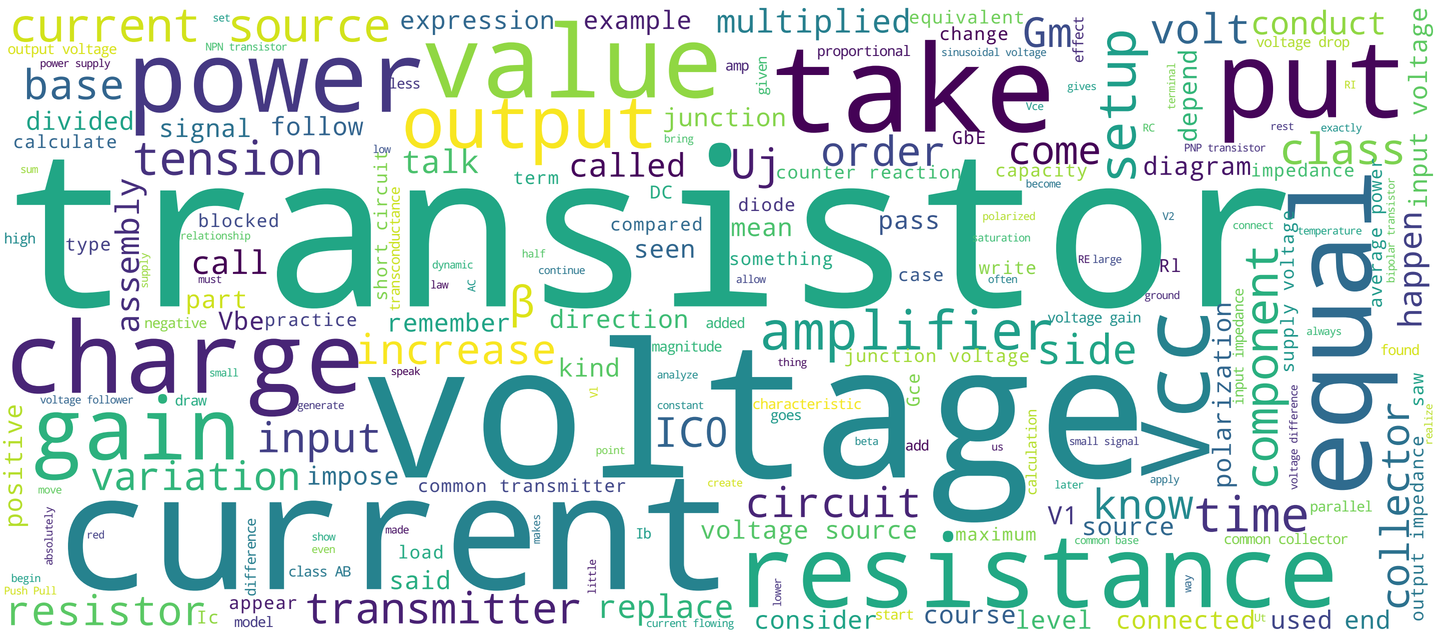
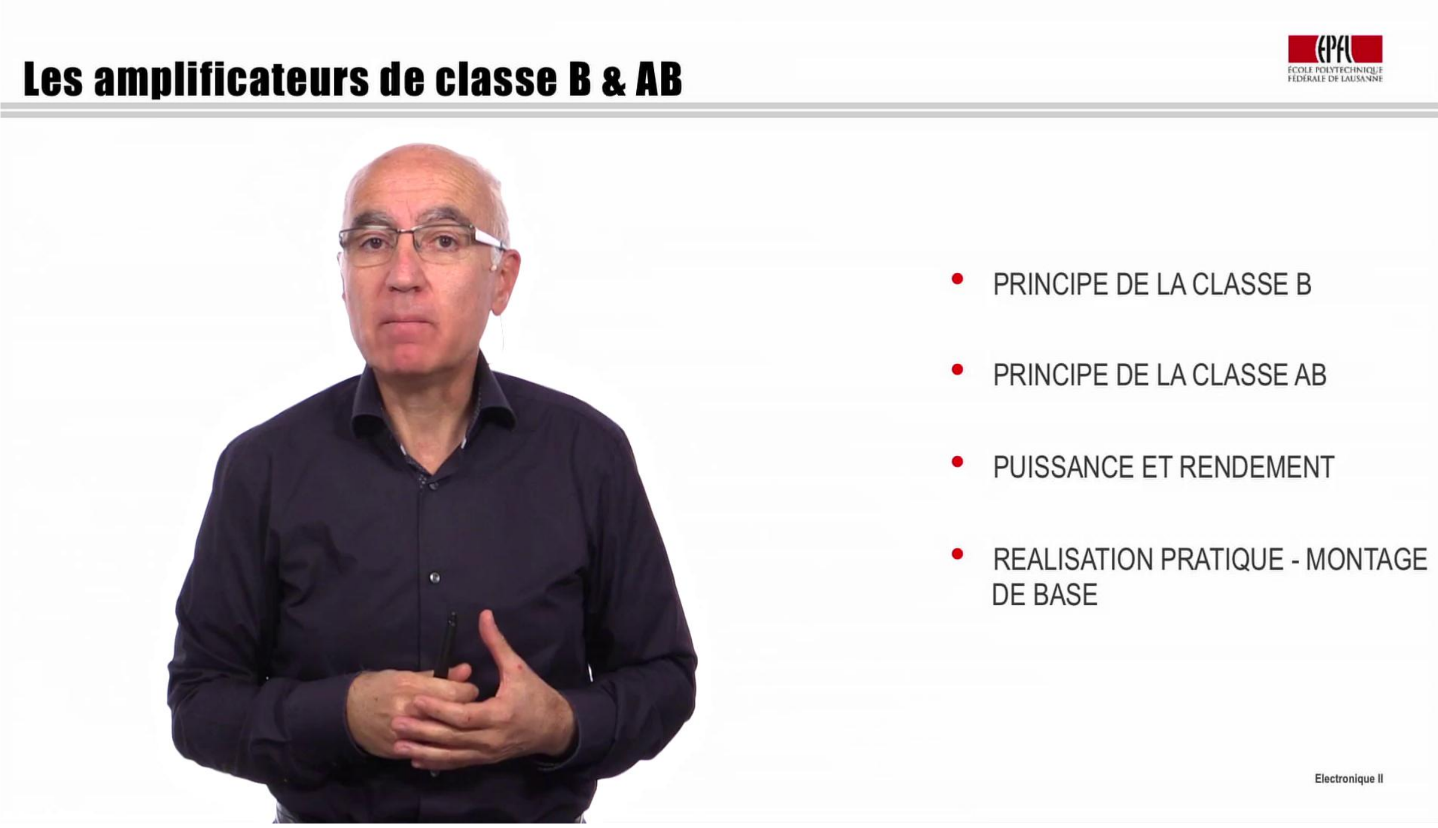


Video

EPFL



Good morning everyone. We'll cover in this video the principle of class B followed by a modification of this class B which will become AB that is to say, we will add a little bit of polarization to the transistor to paste a little bit of current passing in our components. We will call it AB. And we will do performance analysis of a type B or AB setup So I will continue to say either B or AB because there is very little current that will pass and that makes the difference and I end with a practical example of an implementation of a single class B amplifier.

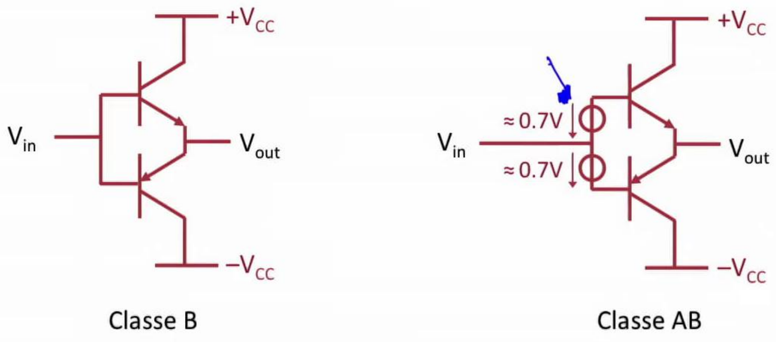
Notes

Summary

0m 04s

Les amplificateurs de classe B & AB

- Etages de puissance à basse impédance de sortie de type "Push-Pull" à Collecteur Commun ou Drain Commun.
- Chaque transistor prend en charge une demi-alternance du signal.



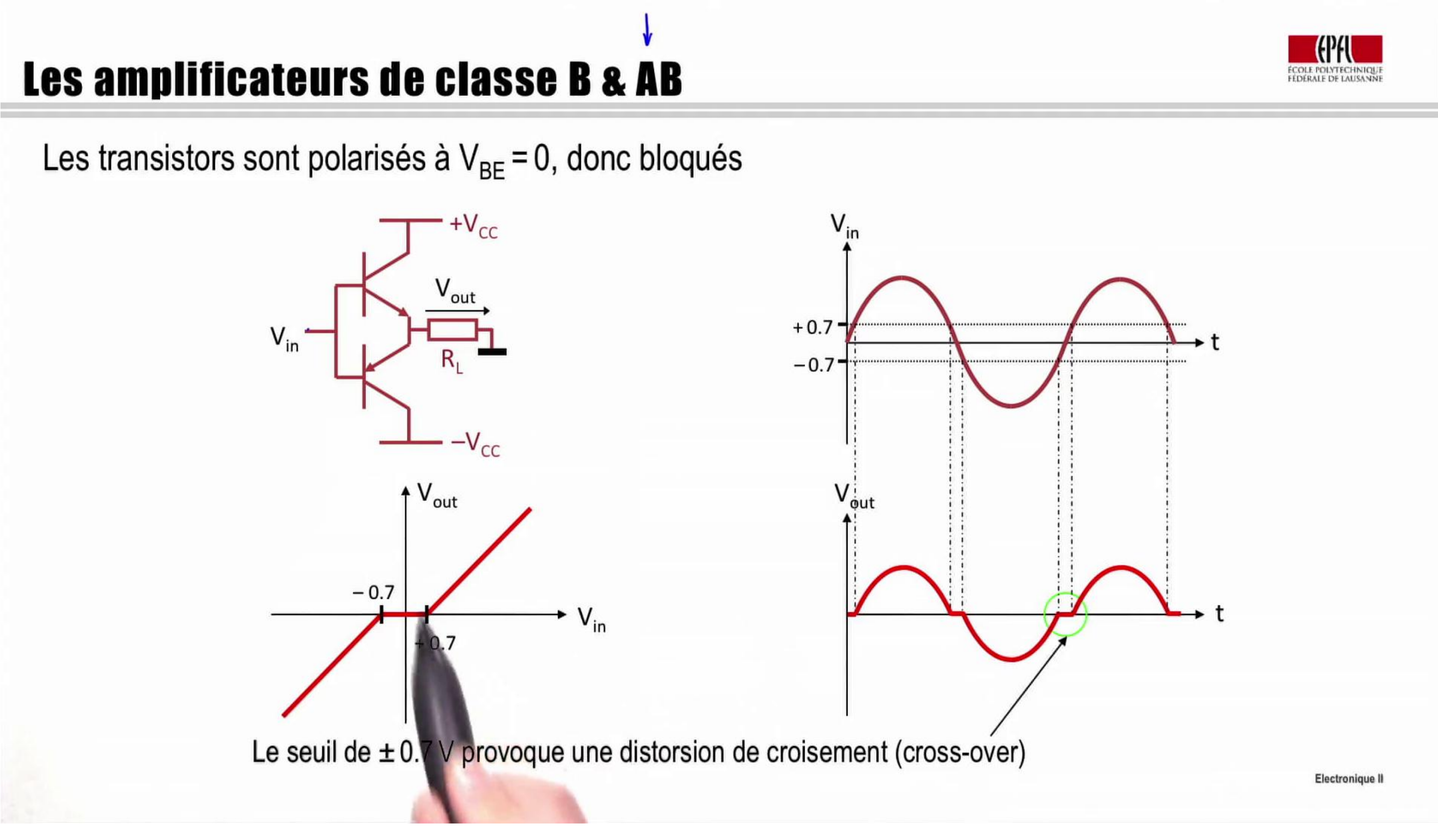
Electronique II

<I> To start the analysis of amplifiers, </ i> <I> we'll just see what that means class B. </ I> <I> Then we will then talk about class AB. </ I> <I> So a class B amplifier, </ i> <I> as we had already said in the previous video, </ i> <I> This is an amp that will take voltage here </ i> <I> convert it into the same voltage </ i> <I> it is a voltage follower so it will be a common collector </ i> <I> achieved by a push-pull setup to have a symmetrical supply </ i> <I> and so that the voltage V out can display </ i> <I> a low impedance. </ I> <I> So the impedance I see from here, </ i> <I> This is the impedance I see </ i> <I> from a transmitter of a bipolar transistor </ i> <I> It means that it is a low impedance </ i> <I> as compared to the one I see from here which is of high impedance </ i> <I> compared to this one. </ I> <I> We call this class B </ i> <I> and this class AB. </ I> <I> The only difference between the two, </ i> <I> is these voltage sources that I added here. </ I> <I> So these pressure points that you see here, </ i> <I> are voltage sources which are supposed </ i> <I> to polarize the bipolar transistor junction </ i> <I> either one or the other, by two voltage sources </ i> <I> for the two tensions that we see at the entrance and exit </ i> <I> are quite similar in DC and AC.

Notes

Summary

0m 43s

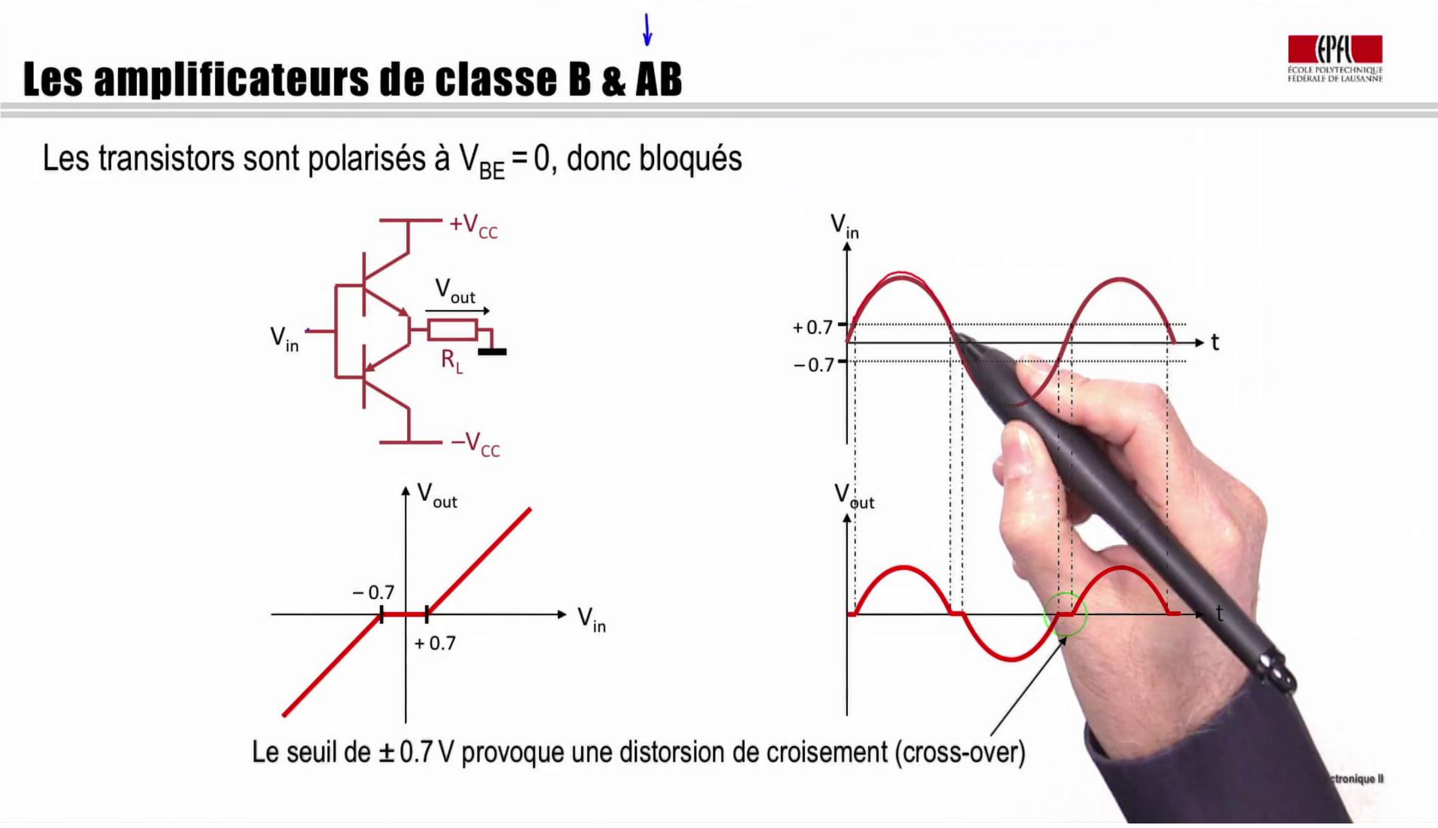


</ I> <I> This is an example of the class B amplifier </ i> <I> that we will immediately turn into AB </ i> <I> and see why we need </ i> <I> this change to get this A </ i> <I> we'll put it here. </ I> <I> So the type of amplifier B </ i> <I> corresponds to this feature </ i> <I> So if I hide this part, </ i> <I> if I just look at the NPN transistor which is above </ i> <I> and I look at the charge connected here </ i> <I> by putting the right hand over, </ i> <I> you'll see that this is indeed </ i> <I> a common-collector type of transistor. </ I> <I> The collector is connected to a Vcc, </ i> <I> the load is connected to ground </ i> <I> and I have an input voltage. </ I> <I> Now if I hide the other transistor, </ i> <I> it is again a common collector </ i> <I> with the load connected to 0 </ i> <I> and the transistor collector is connected to -Vcc </ i> <I> and I have the input voltage. </ I> <I> So I have two transistors that realize </ i> <I> the famous Push-Pull setup. </ I> <I> So the characteristic of an NPN common header, </ i> <I> This is what I see here. </ I> <I> So I see that V out and V in are linearly proportional </ i> <I> as soon as the transistor begins to conduct, </ i> <I> that is to say beyond a junction voltage.

Notes

Summary

1m 54s

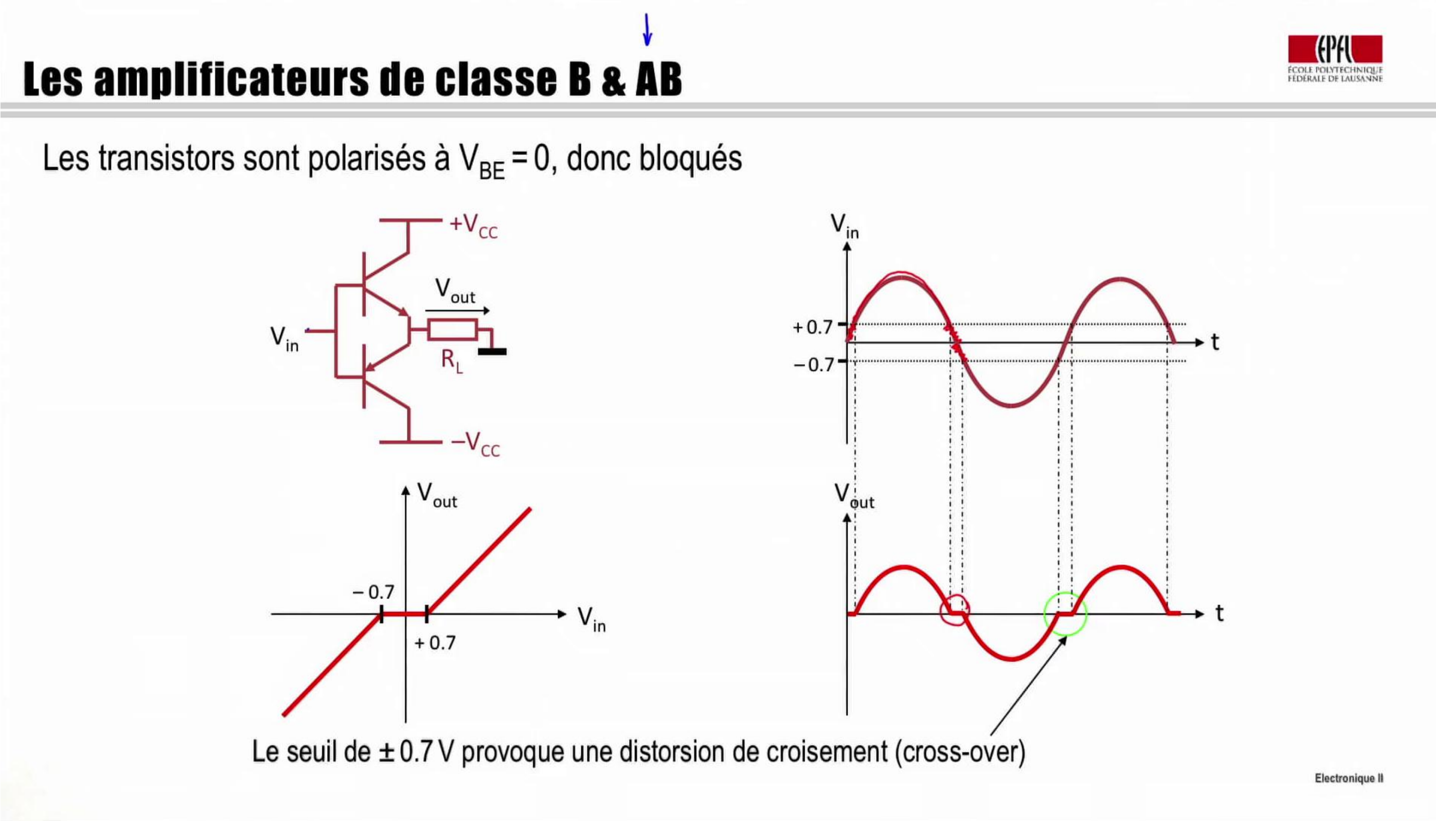


</ I> <I> I look at the voltage at the output </ i> <I> when the input is negative. </ I> <I> I see that I have a negative voltage. </ I> <I> Of course, it's the same story for the PNP transistor: </ i> <I> When the transistor starts conducting, </ i> <I> I'm going to have a linear law. </ I> <I> So we see that the linearity is from here to there, </ i> <I> from here to there. </ I> <I> But the two transistors are blocked between more or less </ i> <I> a junction voltage for both. </ I> <I> So when we talk about this junction voltage </ i> <I> which is about 0.7 volts... </ i> <I> So we have 0.7 volts, both transistors are blocked</ i> and this will create a crossover distortion <I> called cross-over. </ I> <I> So when looking at the input voltage </ i> <I> and looking at the output, </ i> there is still a distortion clearly identified here. <I> When the input voltage exceeds the voltage of junction </ i> <I> that's where our transistor will conduct. </ I> <I> So we will have a transistor that is conductive </ i> right here, just this part here. <I> And here, </ i> <I> between this part here, so that what we see </ i> <I> in both voltages is roughly 0.7, </ i> <I> we'll have the output voltage that will be blocked </ i> <I> where both transistors are blocked.

Notes

Summary

3m 00s

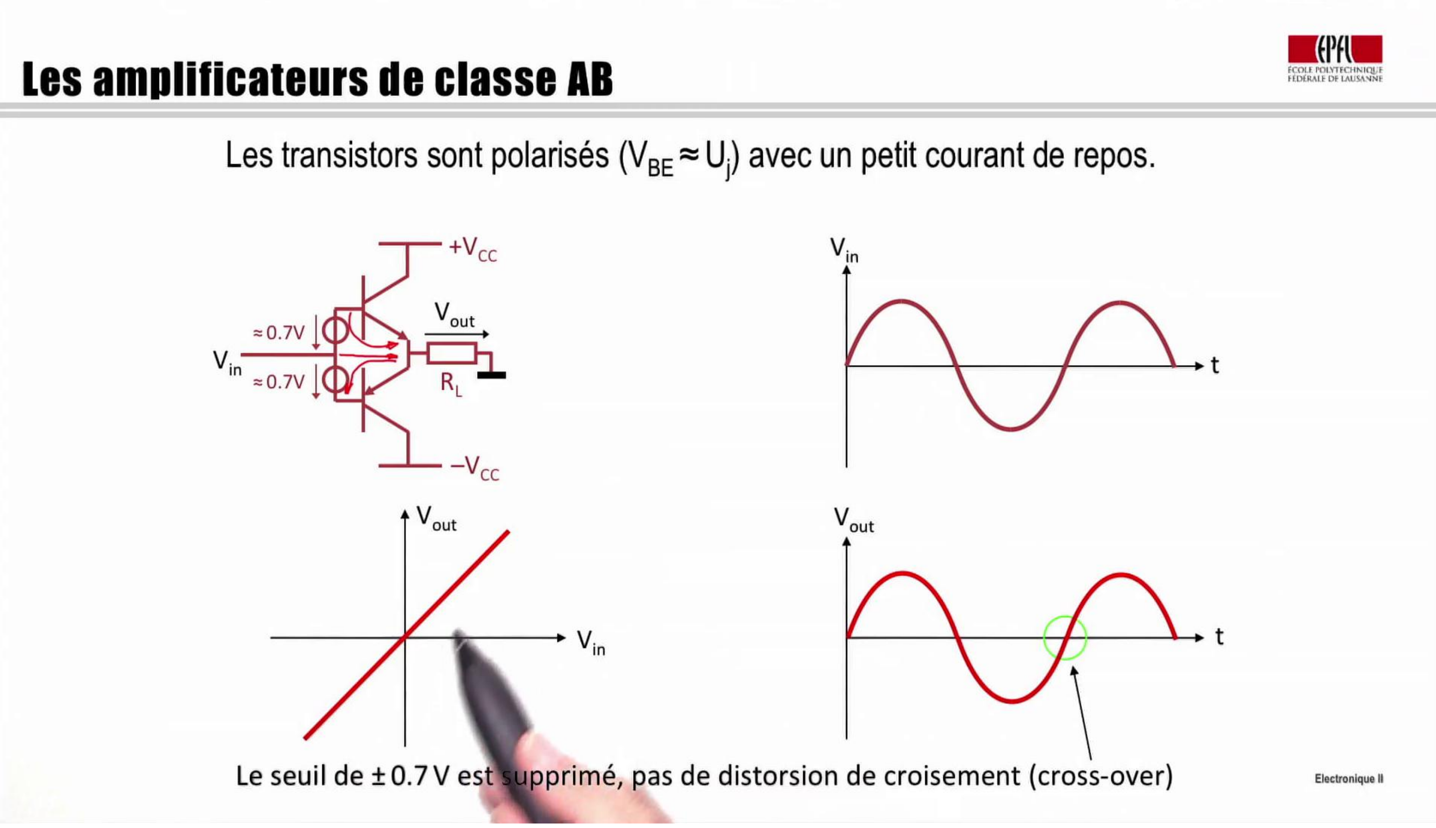


</ I> <I> So we will find to output a voltage equal to 0. </ I> So this distortion here is necessarily audible <I> if it is an audio amplifier </ i> <I> Or if there is another amplifier, </ i> we will talk about a distortion. This is a distortion due to the non-polarization <I> of our components. </ I> <I> So this is what drives us to do class A. </ I> <I> I remind you that the class A, it means that your transistor </ i> <I> was polarized throughout the passing period </ i> <I> of your input voltage. </ I> <I> So we impose only one component </ i> <I> to conduct all along the signal. </ I> <I> Which leads us to move this voltage, </ i> <I> to make it either completely positive or completely negative </ i> <I> and to conduct the transistor </ i> <I> after having polarized the transistor in the in and out area</ i> <I> which we will not do here. </ I> <I> There is no test consumption here </ i> <I> when there is nothing going on here. </ I> <I> We have no input voltage, it would be 0 volts at the exit, </ i> <I> so no current is flowing here </ i> <I> and no current is flowing through the two transistors. </ I> <I> What we are going to change, is to do a little polarization.

Notes

Summary

4m 09s

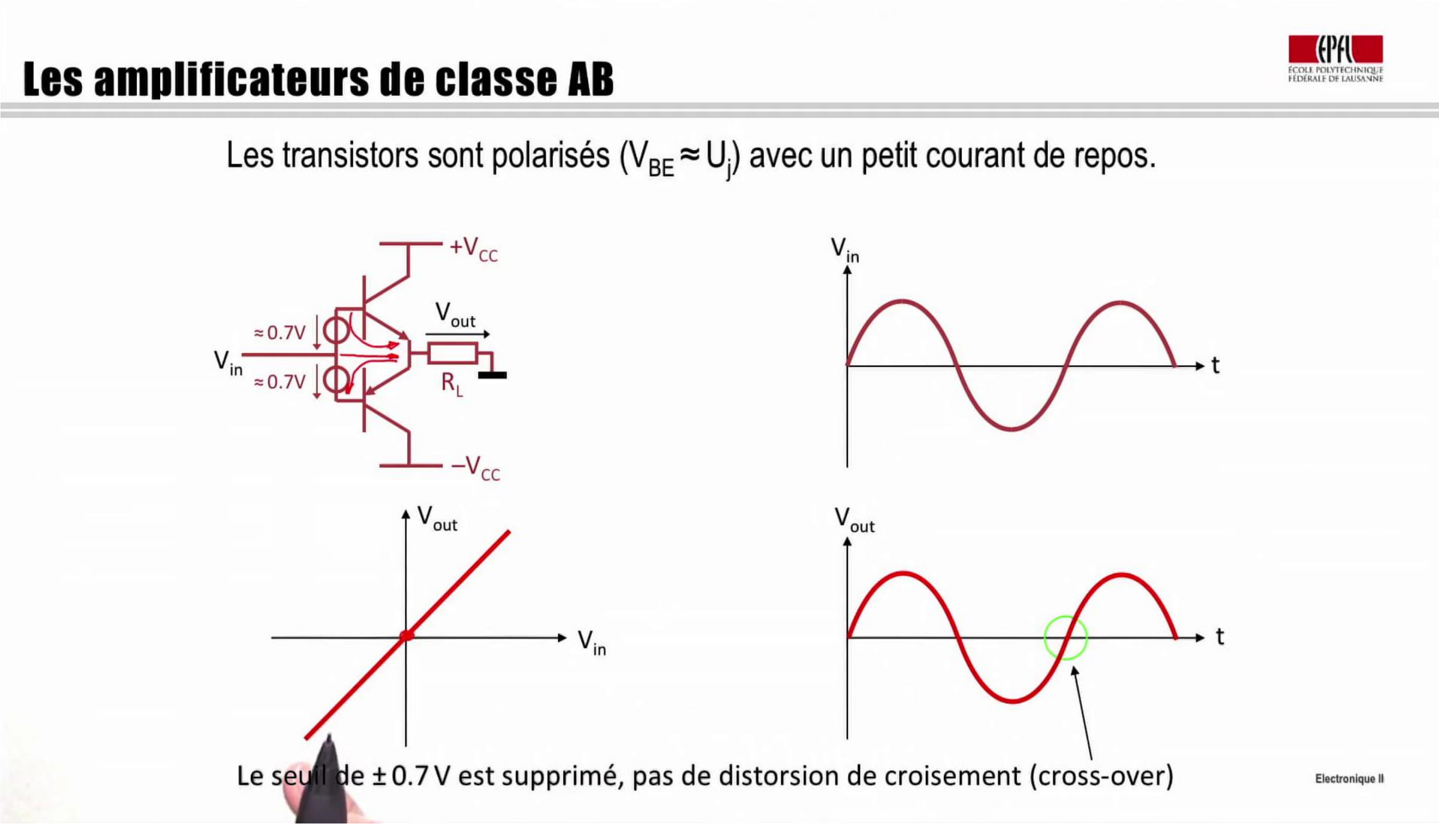


</ I> <I> And we'll call this class AB. </ I> <I> So I'm going to impose a bit of polarization </ i> <I> that is to say there will be a ground that will go to rest </ i> <I> without a signal </ i> <I> which will pass through the two transistors. </ I> <I> What is sent from the NPN transistor will be </ i> <I> will be absorbed by the PNP transistor. </ I> <I> So if you look at this diagram here, </ i> <I> you will see that I had to add </ i> <I> a polarization. I drew it as a voltage </ i> <I> So if you take the 0.7 volt that I added here </ i> <I> and you consider that this transistor here, </ i> <I> it will conduct because we imposed to it 0.7 </ i> <I> and on this side, I have 0.7 volts, </ i> <I> you will understand that the potential difference </ i> <I> from here to here is 0 DC. </ I> <I> So if you put 0 volts here </ i> <I> you will find 0 volts here. </ I> <I> This will result in an alignment </ i> <I>of two characteristics. </ I> <I> This way, even if the voltage source here </ i> <I> V = 0, I am around the origin, </ i> <I> I'll find that Vout = 0 </ i> <I> but as soon as the voltage Vn increases, Vout will follow.

Notes

Summary

5m 18s

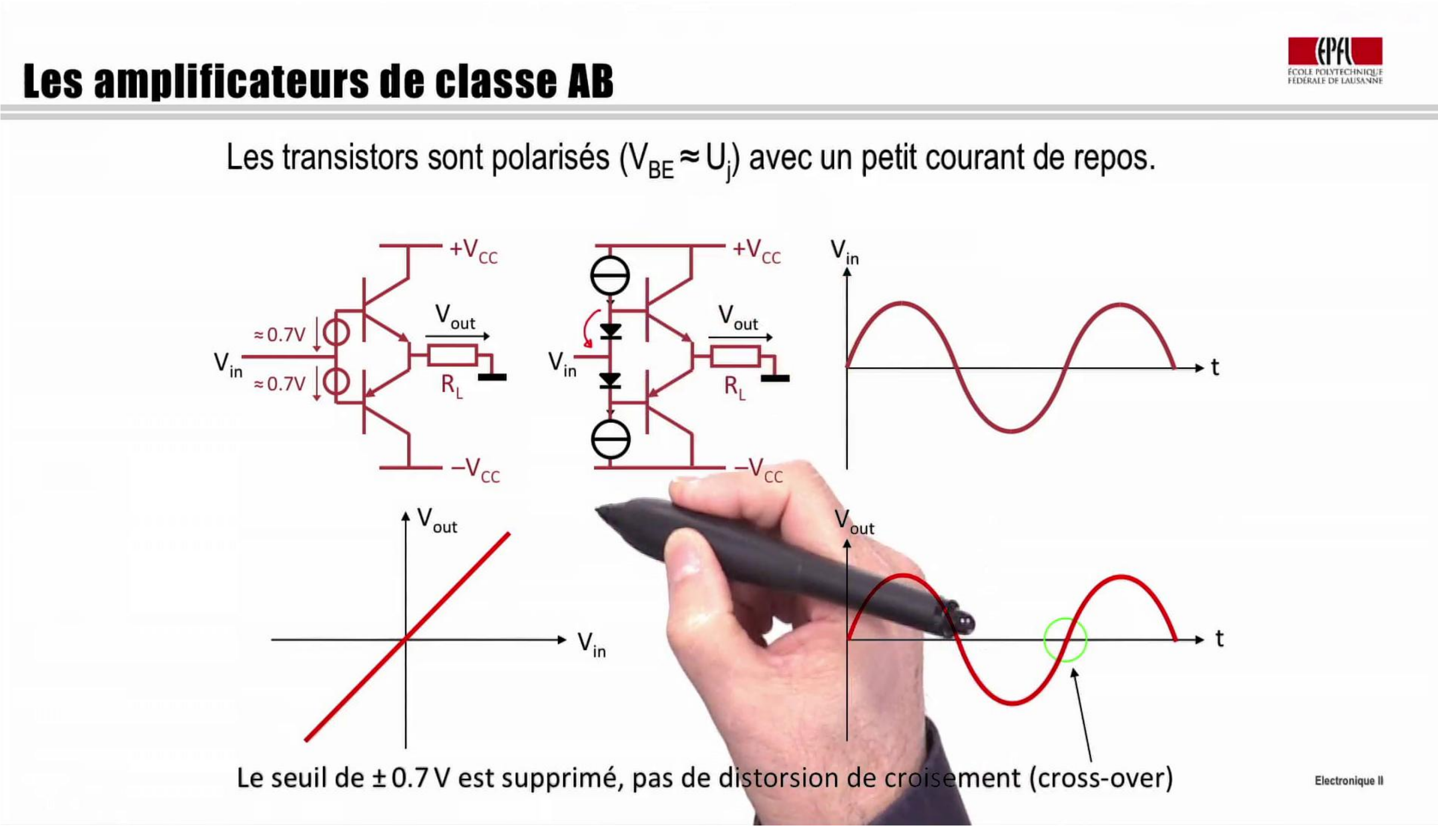


</ I> <I> So I have at rest a voltage difference equal to 0 </ i> <I> and when I start applying a voltage that increases </ i> <I> or decreases, </ i> <I> I was able to eliminate this discrepancy between the two voltages </ i> So I deleted this crossover distortion <I> and the input and output is the true copy. </ I> <I> So what you put here </ i> <I> you find it exactly here in terms of voltage. </ I> <I> So it is typical to a voltage follower. </ I> <I> The input voltage equals the output voltage, </ i> <I> and the current is the current that will pass through the supply </ i> <I> controlled by the voltage variation </ i> <I> either on this junction when we have a positive voltage, </ i> <I> or this junction when we have a negative voltage. </ I> <I> So we will have one of the transistors conducting</ i> <I> and at rest, we will have very less current </ i> <I> And that's how much we put in class A, </ i> <I> that is to say how much we polarized the junction </ i> <I> for there to be current flowing here.

Notes

Summary

6m 24s

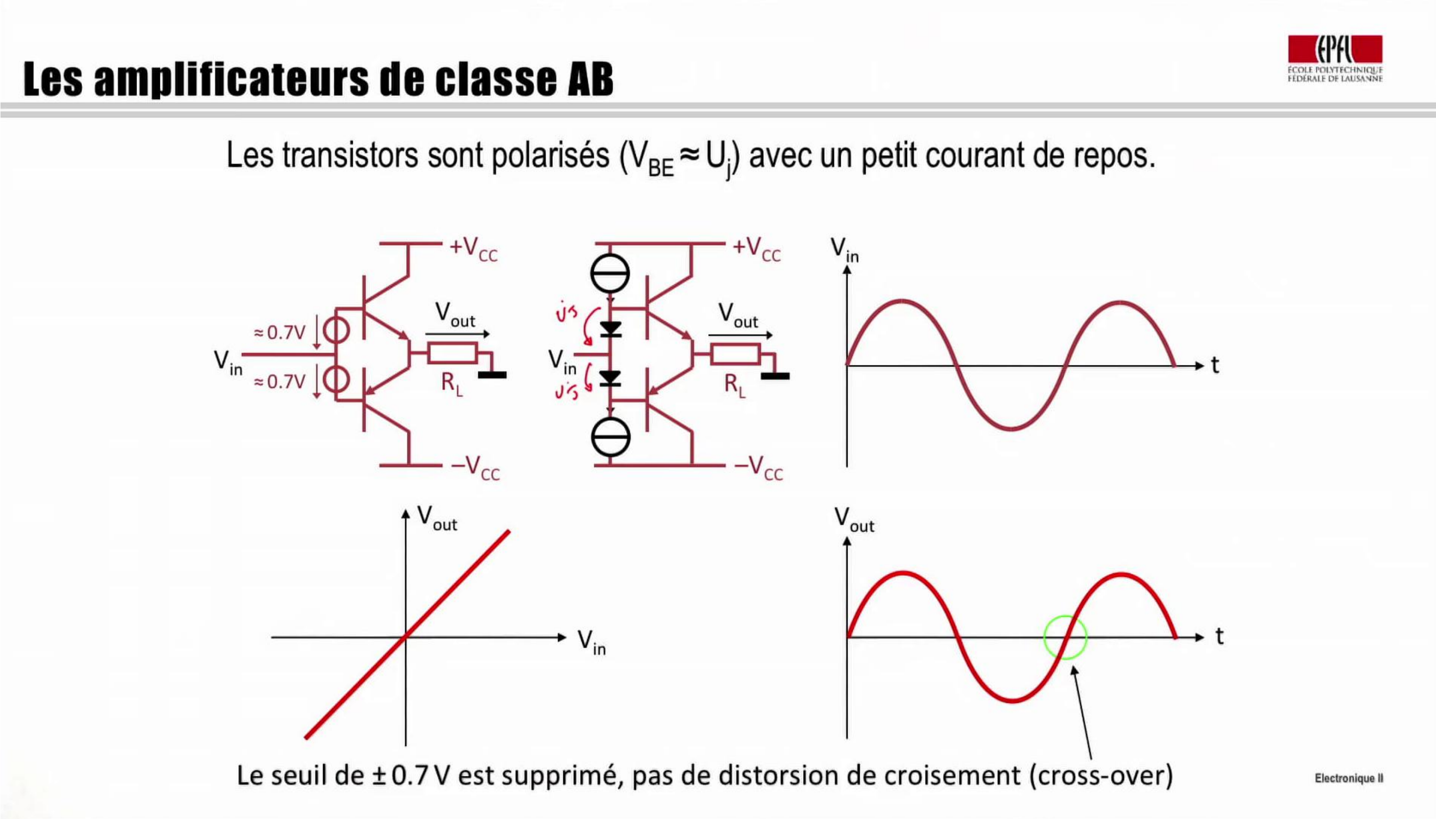


</ I> <I> So theoretically, if the two transistors are the same </ i> <I> and we impose a voltage that conducts both </ i> <I> exactly so that the voltage generated by one</ i> <I> is absorbed by the other, </ i> <I> we will have 0 current in the charge</ i> <I> which is in practice extremely difficult to do </ i> <I> because we have two complementary transistors </ i> <I> that are not of the same nature, the other an NPN PNP. </ I> <I> So in practice, </ i> <I> we will have a lot of trouble to avoid that there </ i> <I> be a little current going through the charge. </ I> <I> But the more we add polarization current in both transistors </ i> <I> the better the compensation around this passage </ i> <I> by 0 of our feature. </ I> <I> To do this, </ i> <I> One technique is to use this kind of setup. </ I> <I> In this kind of setup, we see that we used the diode </ i> <I> to generate the voltage of Ube. </ I> <I> So I take a junction voltage </ i> <I> I impose myself through a diode. </ I> <I> I need to create a path for the current </ i> <I> It is necessary that the current flows in that direction. </ I> <I> So I will have to connect a positive potential.

Notes

Summary

7m 18s

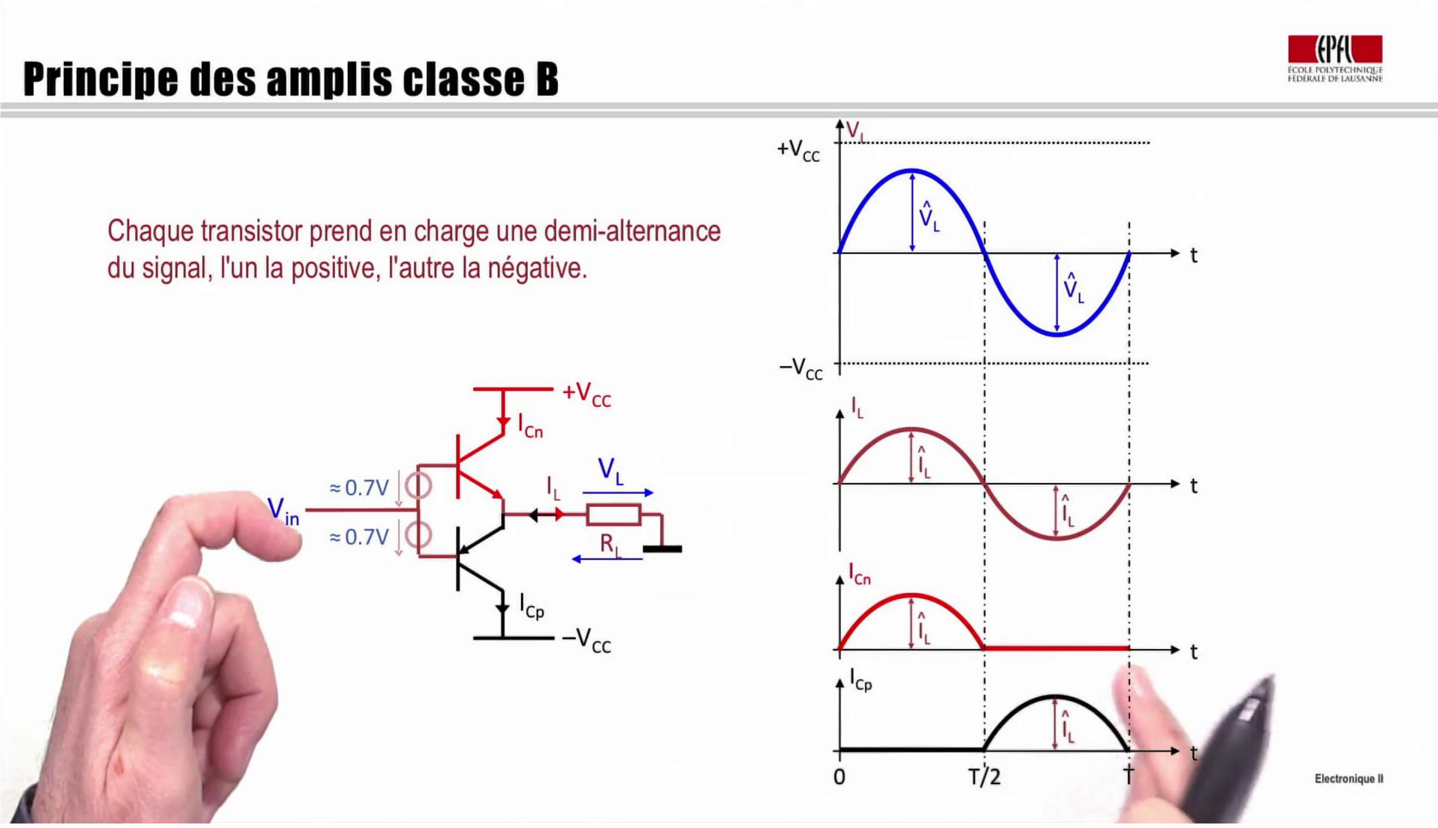


</ I> <I> Here, I showed that I made it by current sources. </ I> <I> This is a theoretical way to show that </ i> <I> I have an almost zero voltage from here to here </ i> <I> I have an almost zero voltage from here to here </ i> <I> because there is a supply source it is current even if the difference </ i> <I> in voltage is equal to 0 </ i> <I> and you will be able to impose a current </ i> <I> which passes through the two diodes </ i> <I> and this current then depends on the current you have put </ i> <I> which will generate junction voltage </ i> <I> across a diode </ i> <I> and the same across a diode </ i> <I> that are expected to generate two junction voltages. </ I> <I> It's that we fall back at this moment</ i> <I> in this situation</ i> <I> and we get a practical implementation </ i> <I> for the creation of polarization of the output level. </ I> <I> And there, we can find what we saw earlier </ i> <I> that is to say an input voltage equals the output voltage </ i> <I> and a gain is 1 in this kind of setup </ i> <I> with a current gain which is extremely high </ i> <I> which is proportional to β gain of the bipolar transistors </ i> <I> we used. </ I> <I> That is to say, the current entering here </ i> <I> corresponds to β times the current that goes out of the other side.

Notes

Summary

8m 22s

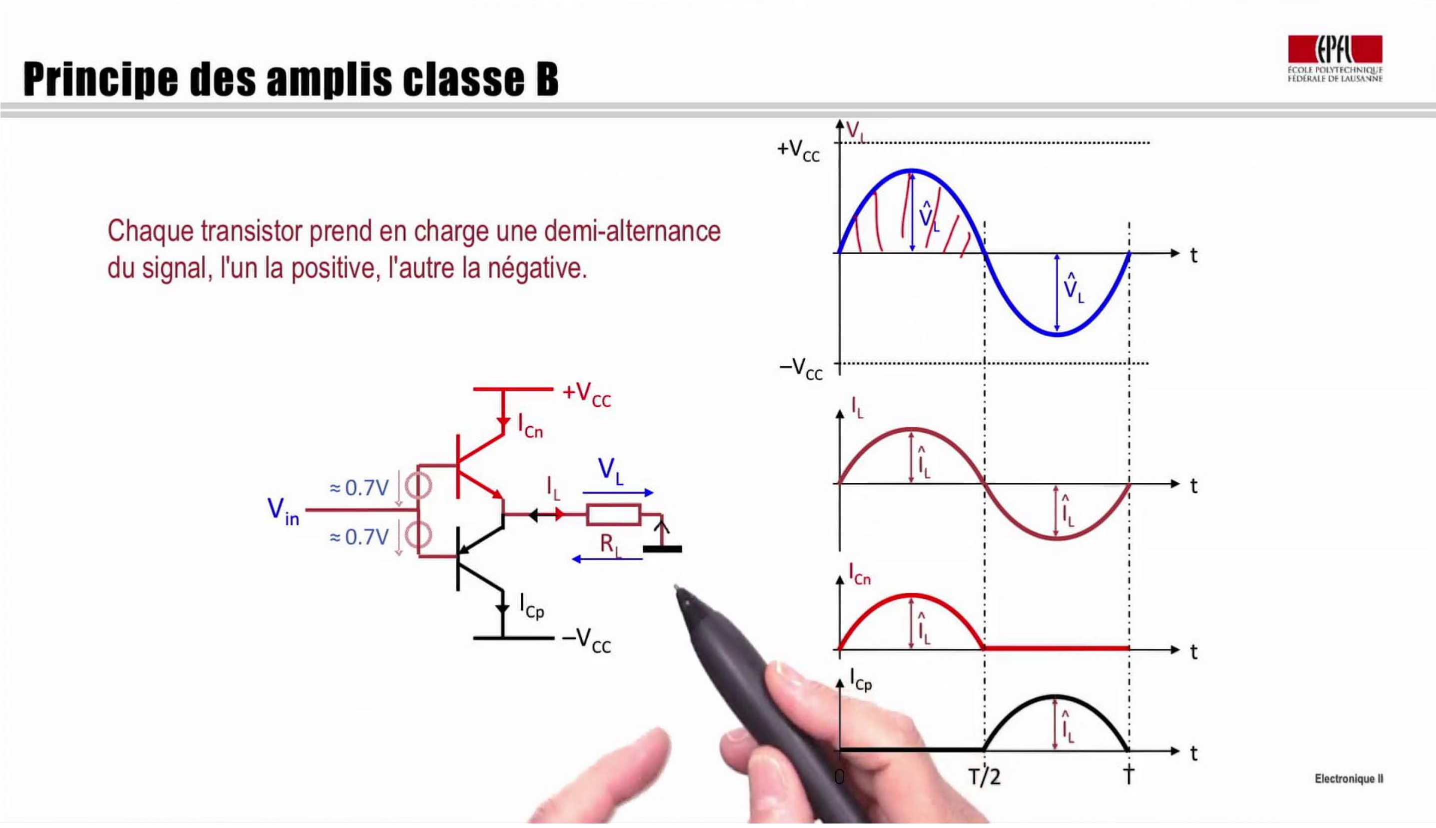


</ I> <I> I'll analyze this setup in more details </ i> <I> to understand what will happen in terms of power. </ I> <I> So each transistor supports </ i> <I> a half-alternation signal. </ I> <I> One, the positive alternation, the other, a negative alternation. </ I> <I> So if you take the input Vin </ i> <I> and you this voltage here. </ I> <I> We imagine it is a voltage of this style. </ I> <I> What will happen? </ I> <I> You'll have your transistor in red </ i> <I> that will begin to conduct current </ i> <I> that I've drawn in red. </ I> <I> So there will be a collector current </ i> <I> of the NPN transistor that will </ i> <I> always be in red in the charge. </ I> <I> So the voltage VI, if this voltage increases, </ i> <I> this current will pass into the charge. </ I> <I> This voltage will follow it in the same amount. </ I> <I> I drew this in this way. </ I> <I> I have shown that for the positive alternation</ i> <I> so when you we're here, </ i> <I> I'm going to draw, shade this in red, </ i> <I> I see that there is a current that will pass through the transistor N </ i> <I> and will go to the charge and then, </ i> <I> I'll get to block this transistor </ i> <I> when I lower this voltage.

Notes

Summary

9m 30s



</ I> <I> Because when I lower the voltage, </ i> <I> this transistor here blocks. </ I> <I> I have a junction here that will have a voltage</ i> <I> and this voltage then begins to follow rather this one </ i> <I> that begins to be negative. </ I> <I> So when I lower this voltage, the transistor here </ i> <I> will start to conduct and it is the black arrow </ i> <I> So I'm having a black current</ i> <I> that will pass through the charge like this</ i> <I> and will continue its path </ i> <I> and it will generate a voltage </ i> <I> will be positive in this direction in the charge. </ I> <I> So current flows through the PNP transistor, </ i> <I> This is the current that is here. </ I> <I> The sum of the two currents, </ i> <I> is the two currents that will appear in the charge. </ I> <I> So if I take... sorry, I'm talking of the sum </ i> <I> If I speak of the sum while considering the arrow </ i> <I> I now speak in terms of voltage </ i> <I> The voltage will reflect the current II x R </ i> <I> When the current is positive in this direction. </ I> <I> So I will see that VI will be positive in that sense. </ I> <I> Otherwise, as I power to -Vcc, I will have a current flowing </ i> <I> in that direction and VI that will be negative in this direction.

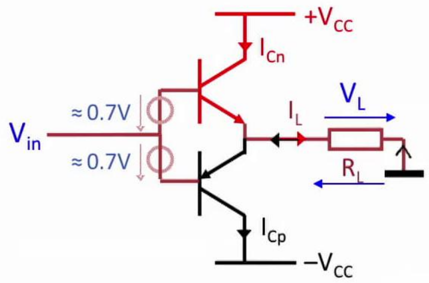
Notes

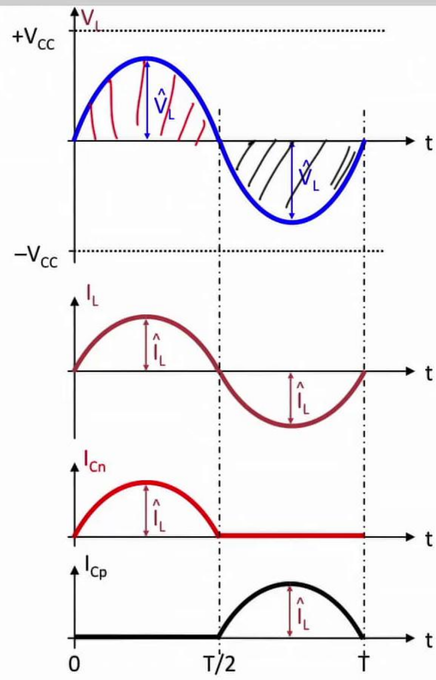
Summary

10m 41s

Principe des amplis classe B

Chaque transistor prend en charge une demi-alternance du signal, l'un la positive, l'autre la négative.





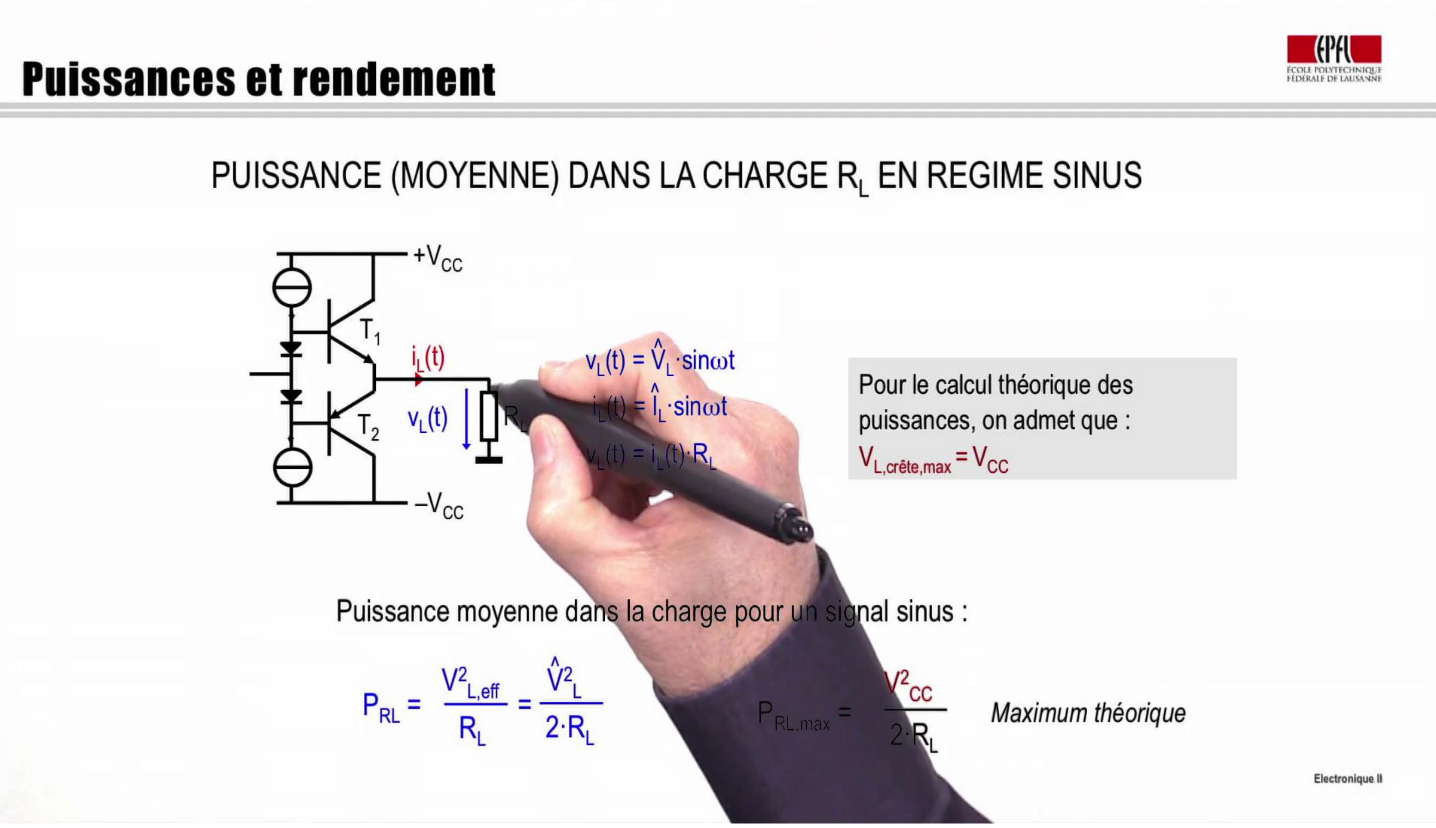
Electronique II

</ I> <I> So I will have Vl that will be positive and negative </ i> <I> which is exactly the image of what I see </ i> <I> about this feature here. </ I> <I> So I have a positive voltage. </ I> <I> I have a voltage that will be </ i> <I> proportional to what I called the black part </ i> <I> that is to say, the PNP transistor which is in the process of conducting current </ i> <I> that goes in this direction, towards - Vcc.

Notes

Summary

11m 44s

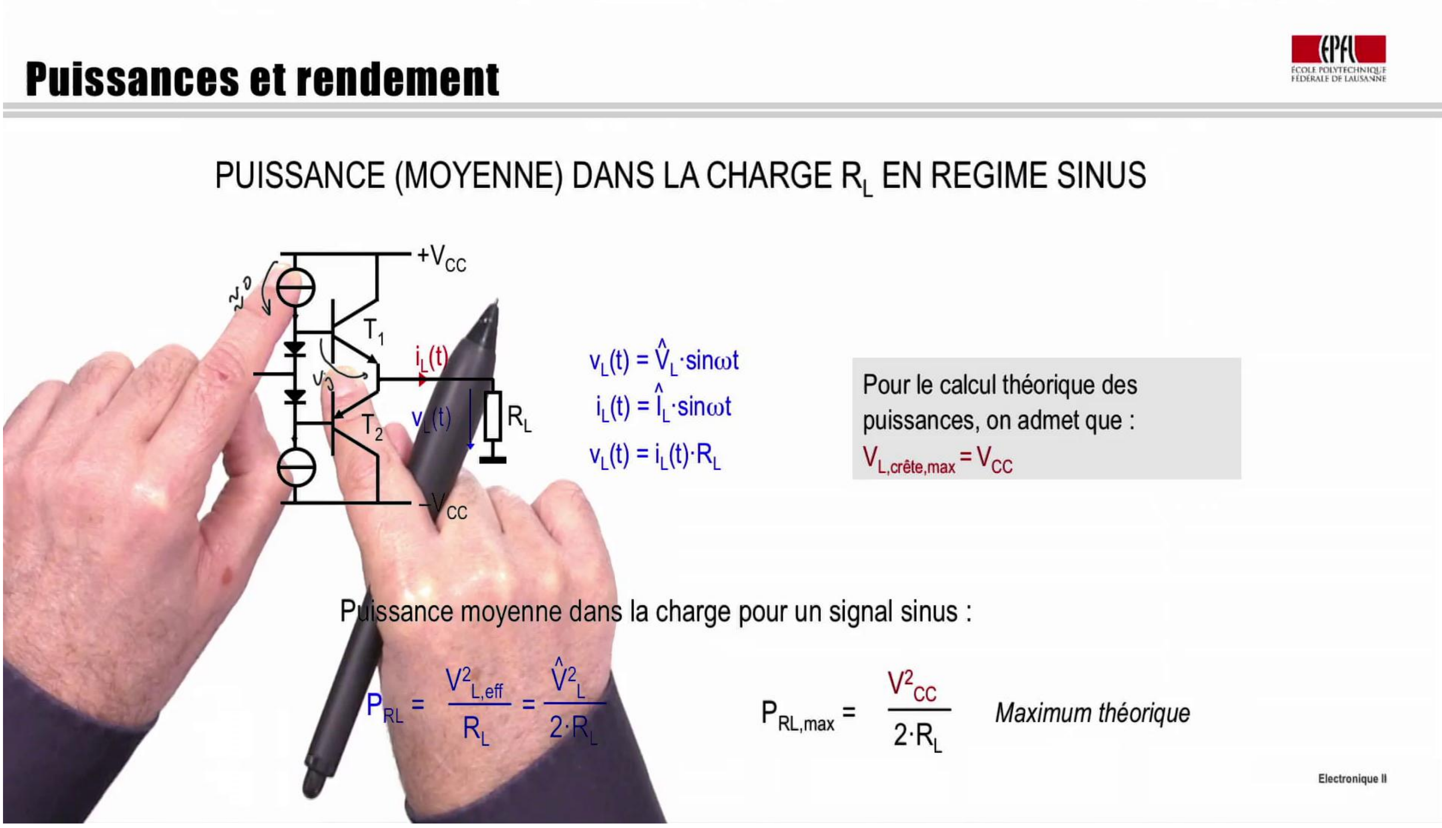


</ i> <I> Coming from the perfomamnce performance. </ I> <I> So the performance of such a setup</ i> <I> and we will take again what we mentioned at the beginning </ i> <I> we will look at the average power </ i> <I> expressing the instantaneous power </ i> <I> and we will look at both the expression of the instantaneous power </ i> <I> then, calculate the average power. </ I> <I> So I start with a medium voltage </ i> <I> with a voltage... </ i> <I> pardon, the value of the average power </ i> <I> with a sinusoidal voltage. </ I> <I> I applied to the input a voltage V (t) </ i> <I> that will be the same Vl (t) </ i> <I> since it is the true copy of both. </ I> <I> And we will find that Vl ^ V sinωt </ i> <I> will of course generate a current that will be Î sinωt </ i> <I> and Ohm's law is what will connect </ i> <I> these two expressions together. </ I> <I> to simplify the calculation that will follow. </ I> <I> When I look at a transistor like this, </ i> <I> then I want to see which is the maximum voltage </ i> <I> that appears there. </ I> Remember that this voltage, I look on the transmitter.

Notes

Summary

12m 06s

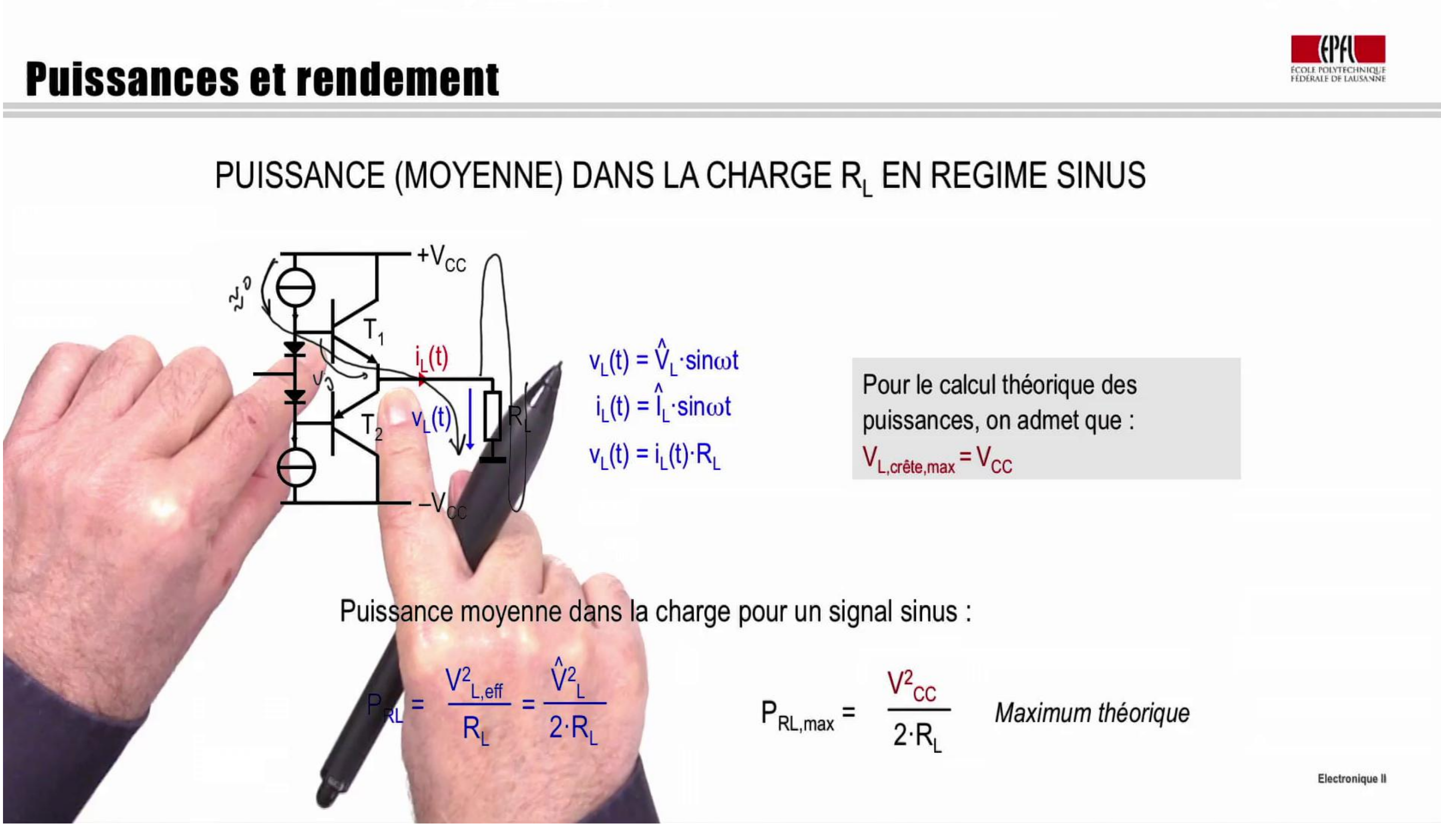


<I> When I look at a voltage on the transmitter and </ i> <I> I consider myself that I have a voltage here </ i> <I> which is a junction voltage </ i> <I> and that this voltage source </ i> <I> or the voltage difference here can be 0, </ i> <I> if it is a current source </ i> <I>therefore I can fully impose a voltage equal to 0. </ I> <I> In practice, there would be here a transistor instead of this </ i> <I> but whose collector is connected here. </ I> <I> That means that I can push this voltage </ i> <I> up to about 200 millivolts </ i> <I> before Uce = 200 millivolts </ i> <I> even if it is said that Uce = 0 the transistor is saturated, </ i> <I> in practice one needs low power transistors </ i> <I> in the order of magnitude of 200 millivolts </ i> <I> so that the transistor does not go into direct saturation. </ I> <I> So if I push this voltage here, </ i> <I> the junction voltage remains the same. </ I> <I> So this one will follow </ i> <I> until I get to saturate this transistor here. </ I> <I> So if this voltage equals 0, </ i> <I> that means, to allow for the maximum voltage </ i> <I> I see here, I have to go through</ i> <I> the feature like this.

Notes

Summary

13m 11s



</ I> <I> That's the way I would have looked to say </ i> <I> what is the voltage Vout max. </ I> <I> Why am I talking about this? </ I> <I> Because I'm going to simplify in the calculation that follows. </ I> <I> This voltage, will rise up to what value? </ I> <I> It could rise to Vcc + </ i> <I> and go down to - Vcc </ i>. <I> In practice, no. </ I> <I> Does it depends on the saturation of this transistor? </ I> <I> Absolutely not. It depends on the junction here. </ I> <I> Look at the way I have to go </ i> <I> when I look from the transmitter. </ I> <I> From the transmitter of a transistor, I have my two fingers which will rise </ i> <I> in the same amount until I saturate </ i> <I> this current source. </ I> <I> And I stop at a difference when this voltage here is equal to this. </ I> <I> So I have a short circuit from here to there, </ i> <I> I have 0 volts. </ I> <I> In theory, i will still have this voltage and this</ i> <I> the equivalent of a voltage Ug. </ I> <I> This voltage max, it will be at Vcc - Ug </ i> <I> In practice, </ i> <I> we must add the equivalent of something like 0.2 volts </ i> <I> when bringing a transistor where the transmitter is connected here </ i> <I> and the collector is connected here.

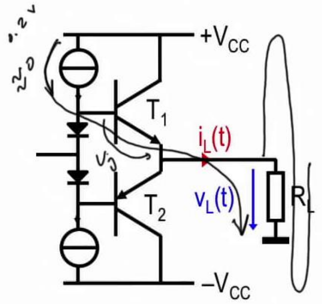
Notes

Summary

14m 21s

Puissances et rendement

PUISSANCE (MOYENNE) DANS LA CHARGE R_L EN REGIME SINUS



$v_L(t) = \hat{V}_L \cdot \sin\omega t$

$i_L(t) = \hat{I}_L \cdot \sin\omega t$

$v_L(t) = i_L(t) \cdot R_L$

Pour le calcul théorique des puissances, on admet que : $V_{L,crête,max} = V_{CC}$

Puissance moyenne dans la charge pour un signal sinus :

$$P_{RL} = \frac{V^2_{L,eff}}{R_L} = \frac{\hat{V}^2_L}{2\cdot R_L} \qquad P_{RL,max} = \frac{V^2_{CC}}{2\cdot R_L}$$

Maximum théorique

Electronique II

</ I> <I> Or we must consider the voltage difference </ i> <I> we have seen on this power source </ i> <I> once achieved with transistors. </ I> <I> So in practice, the maximum voltage </ i> <I> is proportional to Vcc </ i> <I> minus the necessary voltage</ i> <I> for this current source to remain the current source </ i> <I> to which must also subtract the voltage Ug. </ I> <I> But in the calculation that follows, </ i> I will take this into account: <I> I will consider the voltage, </ i> <I>it can rise to Vcc. </ I> <I> In other words, I am saying </ i> <I> I neglect this voltage drop Ug I'm talking </ i> <I> and I neglect this small voltage drop </ i> <I> that I need to reserve for my source. </ I> <I> So I will consider in my calculation </ i> <I> this hypothesis that is written here so not to say all the time </ i> <I> and this Vcc minus the saturation voltage here </ i> <I> minus the voltage Ug of this transistor, </ i> <I> I will approximate this all the time to Vcc. </ I> <I> So by writing the law in the power </ i> <I> or power in charge, </ i> <I> it is a power which is equal to </ i> <I>the efficient value divided by the value of the charge.

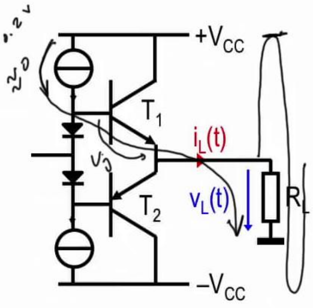
Notes

Summary

15m 25s

Puissances et rendement

PUISSANCE (MOYENNE) DANS LA CHARGE R_L EN REGIME SINUS



$v_L(t) = \hat{V}_L \cdot \sin\omega t$

$i_L(t) = \hat{I}_L \cdot \sin\omega t$

$v_L(t) = i_L(t) \cdot R_L$

Pour le calcul théorique des puissances, on admet que : $V_{L,crête,max} = V_{CC}$

$= -(V_{s,sat} + U_g) + V_{CC}$

Puissance moyenne dans la charge pour un signal sinus :

$$P_{RL} = \frac{V^2_{L,eff}}{R_L} = \frac{\hat{V}^2_L}{2 \cdot R_L} \qquad P_{RL,max} = \frac{V^2_{CC}}{2 \cdot R_L}$$

Maximum théorique

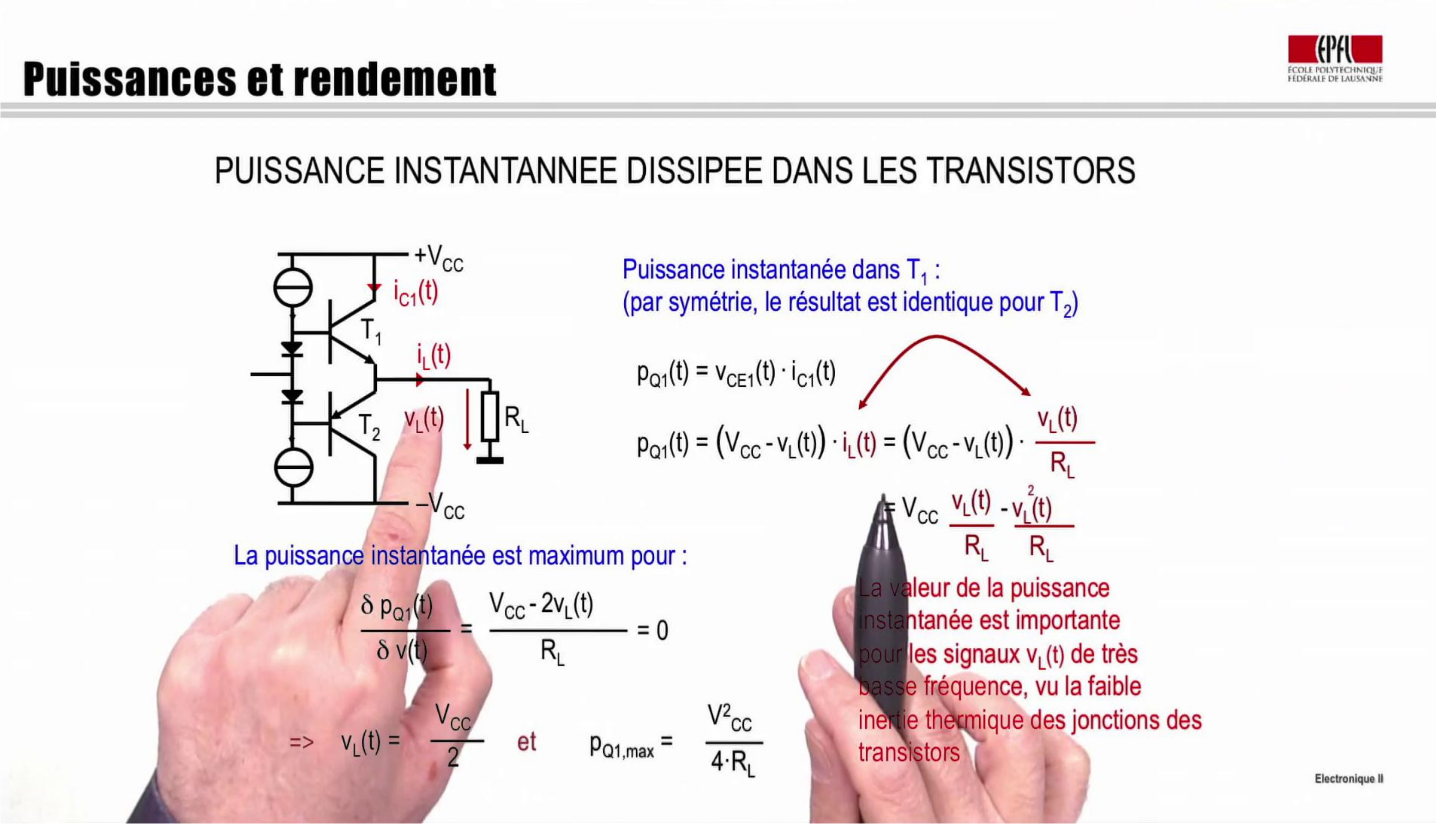
Electronique II

</ I> <I> I always replaces the efficient value by the peak value </ i> <I> because this is what interests me before saturating. </ I> <I> So I want to talk about this saturation voltage. </ I> <I> And then in this case, I' say I can go up </ i> <I> untill Vcc up. </ I> <I> So the maximum power in the charge </ i> <I> is slightly above this. </ I> <I> And theoretically, according to this hypothesis here </ i> <I> it is equal to Vcc divided by 2 ^ 2 x Rl. </ I> <I> So for a quick calculation, I can accept this</ i> <I> if not, I have to calculate where I say </ i> <I> Vl peak= U </ i> <I> we'll call this voltage source </ i> <I> and I'll talk about saturation. </ I> So what is the saturation voltage to allow for this setup <I> less... </ i> <I> Excuse all this plus Ug </ i> <I> and I have to put a - sign </ i> <I> and subtract this from Vcc. </ I> <I> So here I wrote it wrongly. </ I> <I> I will note more clearer the voltage Ug. </ I> <I> So Vcc minus Vc minus the saturation voltage here </ i> <I> plus the Ug I will subtract </ i> <I> to talk in practice about this true peak voltage. </ I> <I> And we will approximate it by Vcc.

Notes

Summary

16m 33s

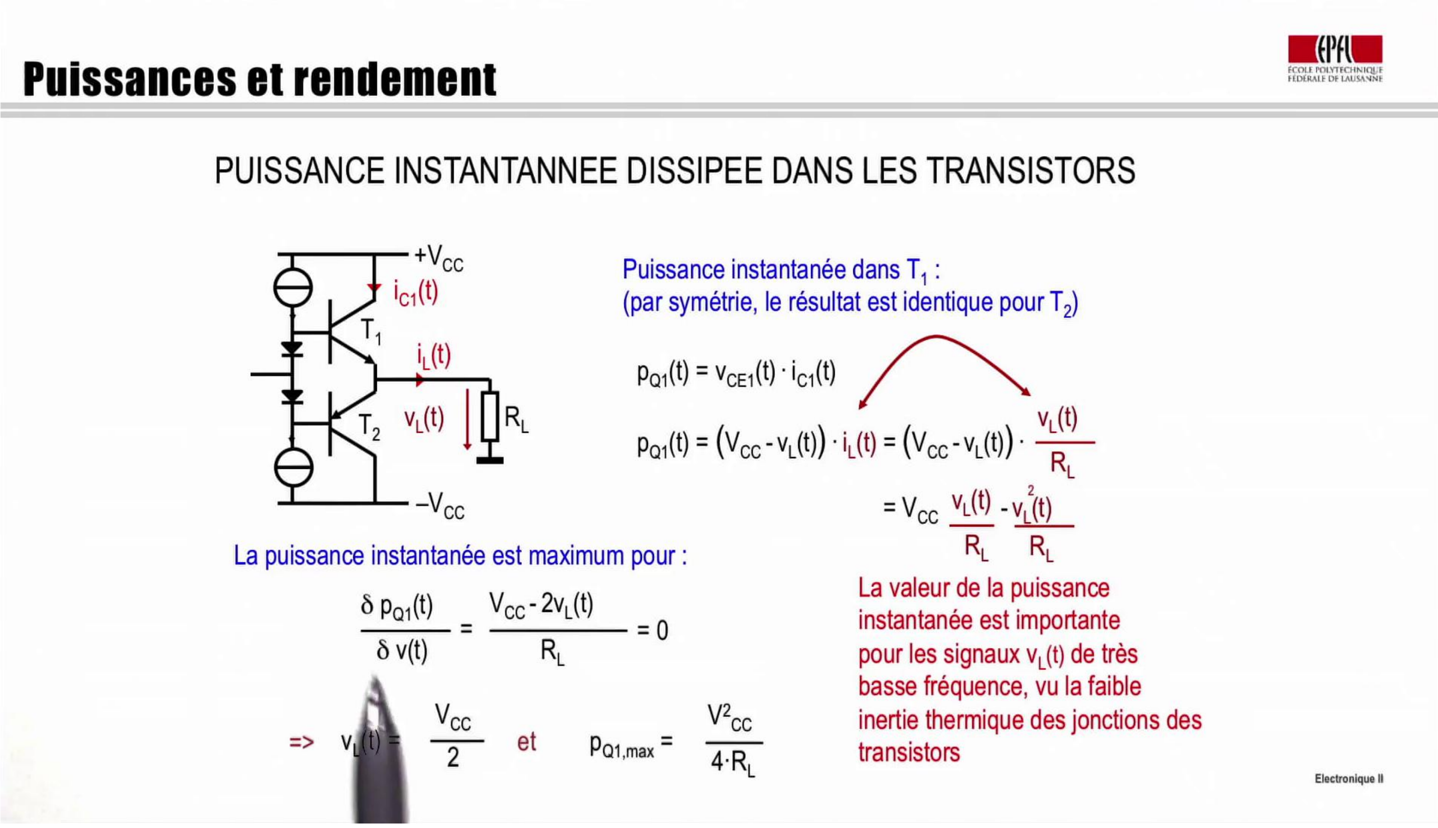


</ I> <I> I will now take the same set up, </ i> <I> realize it as it was </ i> <I> and go into the expression of the power </ i> <I> that will take me to express the efficiency of such a setup. </ I> <I> The power... </ i> <I> I will start by analyzing the power that is dissipated </ i> <I> in the load. </ I> <I> I just saw the one that was in my charge,sorry</ i> <I> This is the expression that I have seen just now </ i> <I> and now I will express the one I see in my transistor. </ I> <I> Take the example of NPN transistors </ i> <I> I can do the same for the PNP </ i> <I> This transistor here </ i> <I> has a voltage difference multiplied by a current here. </ I> <I> So that, it will give me the instant expression of power </ i> <I> I'll dissect as Vcc - Vn </ i> <I> this is the Vce voltage. </ I> <I> So this voltage, is all the time... </ i> <I> The Vce is less tension this voltage I see </ i> <I> across the load, </ i> <I> So it will give me this term multiplied by the current </ i> <I> flowing through the transistor, which is exactly the current charge. </ I> <I> So this current Ic1 = Il. </ I> <I>I know the expression.

Notes

Summary

17m 46s

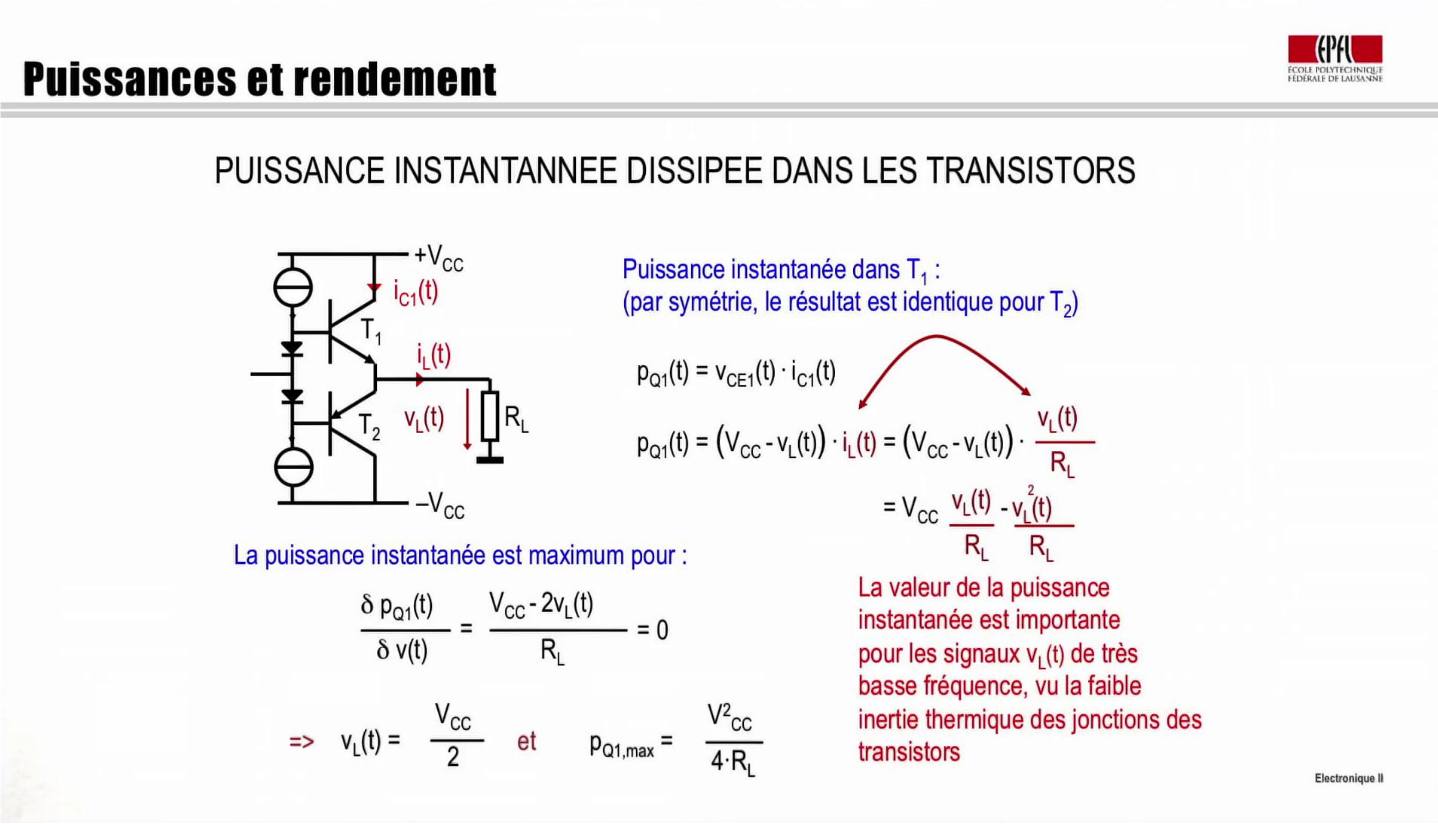


</ I> <I> It is Ohm's law that will give it to me: </ i> <I> it is the voltage across my terminals </ i> <I> divided by the resistance of the charge. </ I> <I> So I replace it with its value </ i> <I> I performs the multiplication </ i> <I> and I found the instantaneous power </ i> <I> dissipated in my transistor </ i> <I>is equal to Vcc when Vi divided by Rl least square value </ i> <I> Vl divided by R. </ I> <I> So I have a square law function of the output voltage </ i> <I> which is the Vl which is X ^ 2 over R with a -sign</ i> <I> an X / R multiplied by a constant </ i> <I> which is the voltage Vcc. </ I> <I> If you consider what happens </ i> <I> in an a setup containing </ i> <I> a signal that varies very little over time </ i> <I> so something that is very very very small in variation, </ i> <I> the instant power, it could be important </ i> <I> when there is a certain inertia </ i> <I>of low frequency </ i> <I> because we have the junction of the transistor that will </ i> <I> eventually heat</ i> <I> and that thermal heating could be of interest us </ i> <I> when we speak of a very low frequency signal. </ I> <I> That's why I'll search </ i> for when does the instantaneous power <I> reaches a maximum.

Notes

Summary

18m 55s



</ I> <I> So looking at this, I see </ i> <I> that the expression I have here </ i> <I> by deriving it in the function of voltage I see </ i> <I> V (t) which is over the charge or on entry </ i> <I> and that I equate to 0 to see the maximum </ i> <I> I see it is when the voltage on my charge </ i> <I> is equal to half the supply voltage </ i> <I> at that time, </ i> <I> I have maximum power </ i> <I> dissipated in one or the other transistor </ i> <I> So this power, is worth Vcc ^ 2/4 x RI. </ I> <I> That is the maximum instantaneous power in a transistor </ i> <I> when the signal is at low frequency. </ I> <I> I will now move to the average power. </ I> <I> So I'll take this phrase that I have here.

Notes

Summary

20m 09s

PUISSANCE (MOYENNE) DISSIPEE DANS LES TRANSISTORS EN REGIME SINUSOÏDALE

La puissance moyenne durant une période P_Q, est égale à la puissance moyenne dissipée dans chacun des 2 transistors durant la demi-période où il est actif.

$$P_Q = \frac{2}{T}\cdot\int_0^{T/2} v_{CE}(t)\cdot i_C(t)\cdot dt = \frac{2}{T}\cdot\int_0^{T/2}\left[V_{CC} - v_L(t)\right]\cdot\frac{v_L(t)}{R_L}\cdot dt$$

$$= \frac{1}{\pi}\cdot\int_0^{\pi}\left[V_{CC} - \hat{V}_L \sin\alpha\right]\cdot\frac{\hat{V}_L \sin\alpha}{R_L}\cdot d\alpha = \frac{2\cdot V_{CC}\cdot\hat{V}_L}{\pi\cdot R_L} - \frac{\hat{V}_L^2}{2\cdot R_L}$$

P_Q est maximum pour :

$$\frac{\delta P_Q}{\delta \hat{V}_L} = \frac{2\cdot V_{CC}}{\pi\cdot R_L} - \frac{\hat{V}_L}{R_L} = 0 \Rightarrow \hat{V}_L = \frac{2\cdot V_{CC}}{\pi} \quad \text{et} \quad P_{Q,max} = \frac{2\cdot V_{CC}^2}{\pi^2\cdot R_L} \approx 0.2\cdot\frac{V_{CC}^2}{R_L}$$

Electronique II

</ I> <I> I will apply a sinusoidal voltage </ i> <I> to this kind of setup </ i> <I> and I'll look at the average power. </ I> <I> This is the one we look at quite often </ i> <I> to watch what the average loss value </ i> in the transistor. <I> We have already discussed this kind of expression </ i> <I> when introducing in the previous video. </ I> <I> So how will I address thist? </ I> <I> I have two transistors. </ I> <I> I know that each of the transistor </ i> <I> will conduct during half the period. </ I> <I> So I just have to take </ i> <I>the average power in a transistor </ i> <I> and multiply by a factor of 2 </ i> <I> what I'm doing here. </ I> <I> So the average power in a transistor </ i> <I> is the voltage times the current route. </ I> <I> I include over half of the period </ i> <I> because this transistor is blocked </ i> <I> So it just goes... </ i> <I> What concerns me is when it sees the current pass </ i> <I> multiplied by 1 / T and I multiply by 2 </ i> <I> I speak of power in both transistors </ i> <I> knowing that each working for half the period. </ I> <I> I take the calculated expression just now </ i> <I> it's here.

Notes

Summary

21m 03s

Puissances et rendement

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

PUISSANCE (MOYENNE) DISSIPEE DANS LES TRANSISTORS EN REGIME SINUSOÏDALE

La puissance moyenne durant une période P_Q, est égale à la puissance moyenne dissipée dans chacun des 2 transistors durant la demi-période où il est actif.

$$P_Q = \frac{2}{T}\cdot\int_0^{T/2} v_{CE}(t)\cdot i_C(t)\cdot dt = \frac{2}{T}\cdot\int_0^{T/2}\left[V_{CC}-v_L(t)\right]\cdot\frac{v_L(t)}{R_L}\cdot dt$$

$$= \frac{1}{\pi}\cdot\int_0^{\pi}\left[V_{CC}-\hat{V}_L\sin\alpha\right]\cdot\frac{\hat{V}_L\sin\alpha}{R_L}\cdot d\alpha = \frac{2\cdot V_{CC}\cdot\hat{V}_L}{\pi\cdot R_L}-\frac{\hat{V}_L^2}{2\cdot R_L}$$

P_Q est maximum pour :

$$\frac{\delta P_Q}{\delta \hat{V}_L} = \frac{2\cdot V_{CC}}{\pi\cdot R_L}-\frac{\hat{V}_L}{R_L} = 0 \Rightarrow \hat{V}_L = \frac{2\cdot V_{CC}}{\pi} \quad \text{et} \quad P_{Q,max} = \frac{2\cdot V_{CC}^2}{\pi^2\cdot R_L} \approx 0.2\cdot\frac{V_{CC}^2}{R_L}$$

Electronique II

</ I> <I> I replace the voltage with a sinusoidal voltage </ i> <I> So sin ω t by replacing ωt </ i> <I> I call a substitution α </ i> <I> to write less... it's not all the time ωt </ i> <I> and I replace the power that I know on the charge </ i> <I> of a sinusoidal voltage that I report here. </ I> <I> This is the value of ^v sin ωt divided by the value of R </ i> <I> that corresponds to the current going through through my office. </ I> <I> And I effect the intergral. </ I> <I> I replaced with the terminals </ i> <I> and I find this phrase. </ I> <I> So the average power dissipated in a transistor </ i> <I> multiplied by 2 </ i> equal to 2 x Vcc x ^ v / π x RI <I> minus^ V / Rl 2 </ i> <I> and I look when will that mean power be maximum </ i> <I> So I drift from the variable that is ^ Vl. </ I> <I> For any value of V ^ of the sinusoidal voltage </ i> <I> that I apply to such a setup </ i> <I> I'm having a maximum average power? </ I> <I> Well I'll find that when Vi = 2 Vcc / π. </ I> <I> It's a calculation to do. </ I> <I> It is taken from the derivative of that expression </ i> <I> and now I look at the power in the transistor </ i> <I> its exact value, </ i> <I> replacing ^Vr value </ i> <I> not its value which is equal to 2 Vcc / π.

Notes

Summary

22m 04s

Puissances et rendement

PUISSANCE (MOYENNE) DISSIPEE DANS LES TRANSISTORS EN REGIME SINUSOÏDALE

La puissance moyenne durant une période P_Q, est égale à la puissance moyenne dissipée dans chacun des 2 transistors durant la demi-période où il est actif.

$$P_Q = \frac{2}{T} \cdot \int_0^{T/2} v_{CE}(t) \cdot i_C(t) \cdot dt = \frac{2}{T} \cdot \int_0^{T/2} \left[V_{CC} - v_L(t)\right] \cdot \frac{v_L(t)}{R_L} \cdot dt$$

$$= \frac{1}{\pi} \cdot \int_0^{\pi} \left[V_{CC} - \hat{V}_L \sin\alpha\right] \cdot \frac{\hat{V}_L \sin\alpha}{R_L} \cdot d\alpha = \frac{2 \cdot V_{CC} \cdot \hat{V}_L}{\pi \cdot R_L} - \frac{\hat{V}_L^2}{2 \cdot R_L}$$

P_Q est maximum pour :

$$\frac{\delta P_Q}{\delta \hat{V}_L} = \frac{2 \cdot V_{CC}}{\pi \cdot R_L} - \frac{\hat{V}_L}{R_L} = 0 \quad \Rightarrow \quad \hat{V}_L = \frac{2 \cdot V_{CC}}{\pi} \quad \text{et} \quad P_{Q,max} = \frac{2 \cdot V_{CC}^2}{\pi^2 \cdot R_L} \approx 0.2 \cdot \frac{V_{CC}^2}{R_L}$$

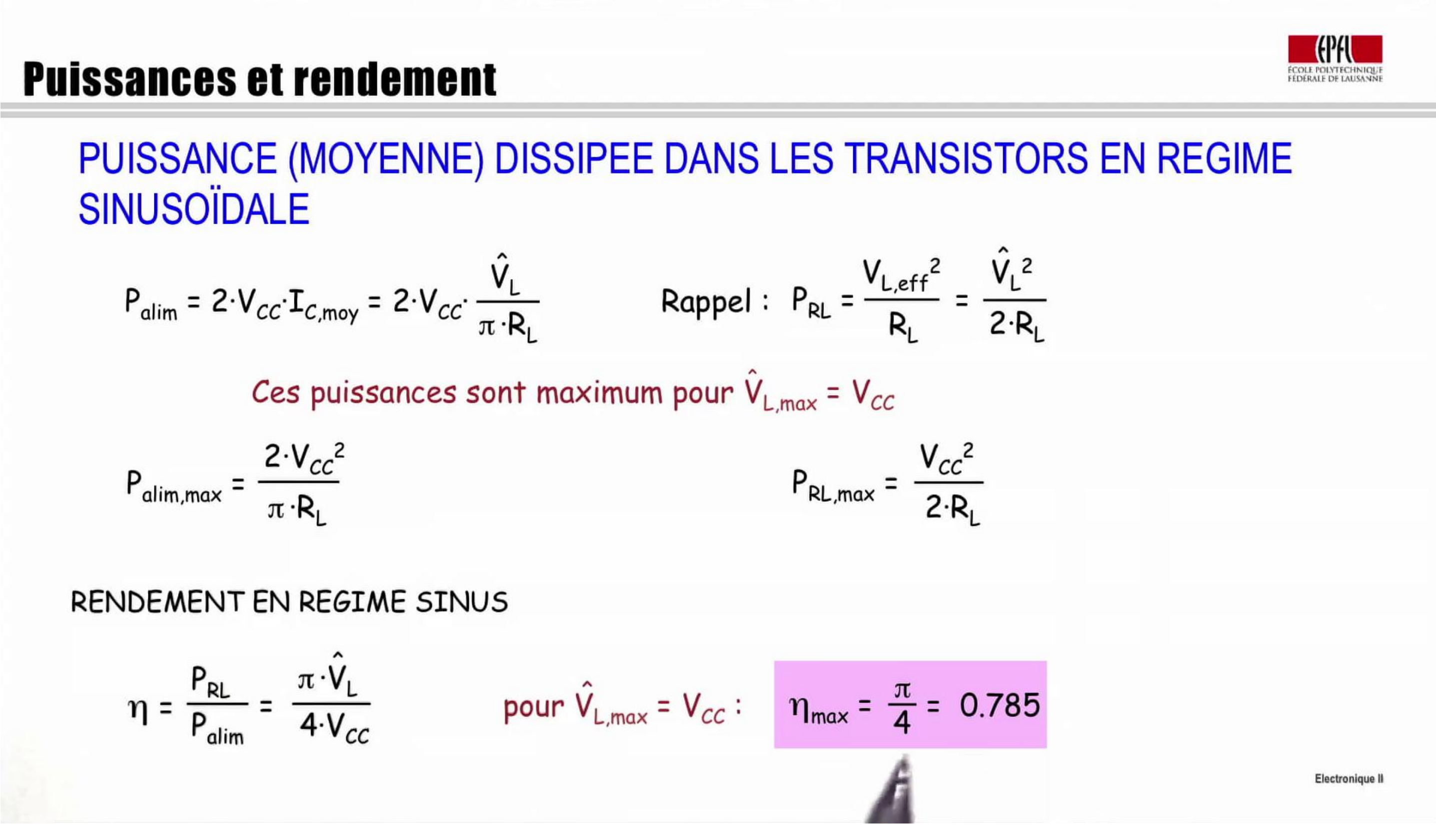
Electronique II

</ I> <I> And this is the average maximum term </ i> <I> in a transistor in the case of a sinusoidal excitation. </ I> <I> This is 0.2 Vcc ^ 2 / RI </ i> <I> assuming of course that ^VI = 2 Vcc / π </ i> <I> and taking into account this term </ i> <I> that has been derived from the average value. </ I> <I>Remember this. </ I> <I> We now see what is the average power </ i> <I> to a sinusoidal voltage in a type B or AB setup.

Notes

Summary

23m 33s



</ I> <I> A short summary to now see the performance. </ I> <I> The supply voltage: </ i> <I> I remind you that we have a more or less Vcc voltage </ i> <I> so I have a voltage of 2 Vcc </ i> <I> multiplied by the current that will be carried by the power </ i> <I>... which is the current share of this power supply </ i> <I> which will be the current that is supplied to the charge. </ I> <I> So what is the expression that we know, </ i> <I> we just saw. It is ^ Vl / π RI. </ I> Knowing that in the charge we have the ^ V^ 2/2 RI <I> and the supply voltage, </ i> <I> So replacing ^ Vl by the value we put the hypothesis </ i> <I> that is to say Vlmax = Vcc, </ i> <I> the supply should provide a setup class B or AB </ i> <I> of the order of magnitude of 2 Vcc ^ 2 / π Rl </ i> <I> so that the load times maximum power </ i> <I> Vcc ^ r / 2 Rl. </ I> <I> So I can calculate my performance. </ I> <I> I consider practically, that polarization takes nothing </ i> <I> and the little A that I put into it </ i> <I> does not count. </ I> <I> I divide this </ i> <I> by this </ i> <I> and I fall back on a value of a maximum perfomamnce </ i> <I> in the order of 80%. </ I> <I> This is equal to π / 4.

Notes

Summary

24m 00s

Puissances et rendement

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

PUISSANCE (MOYENNE) DISSIPEE DANS LES TRANSISTORS EN REGIME SINUSOÏDALE

$$P_{alim} = 2 \cdot V_{CC} \cdot I_{C,moy} = 2 \cdot V_{CC} \cdot \frac{\hat{V}_L}{\pi \cdot R_L}$$

Rappel : $P_{RL} = \frac{V_{L,eff}^2}{R_L} = \frac{\hat{V}_L^2}{2 \cdot R_L}$

Ces puissances sont maximum pour $\hat{V}_{L,max} = V_{CC}$

$$P_{alim,max} = \frac{2 \cdot V_{CC}^2}{\pi \cdot R_L} \qquad P_{RL,max} = \frac{V_{CC}^2}{2 \cdot R_L}$$

RENDEMENT EN REGIME SINUS

$$\eta = \frac{P_{RL}}{P_{alim}} = \frac{\pi \cdot \hat{V}_L}{4 \cdot V_{CC}}$$

pour $\hat{V}_{L,max} = V_{CC}$: $\eta_{max} = \frac{\pi}{4} = 0.785$

Electronique II

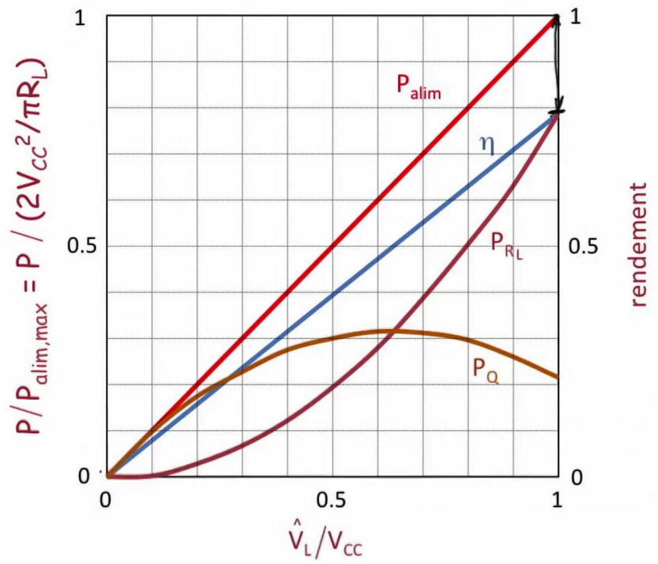
</ I> <I> So this is about the 80%. </ I> <I> So we can say that the setup of type B or AB </ i> <I> has a yield of this order of magnitude, </ i> <I>of 78% of what we give it as energy. </ I> <I> Compared to a class A, it was found was 25% </ i> <I> and there you come across something where you have a loss of 20% </ i> <I> and where it falls on a much better yield </ i> <I> In a class.

Notes

Summary

25m 23s

Puissances et rendement



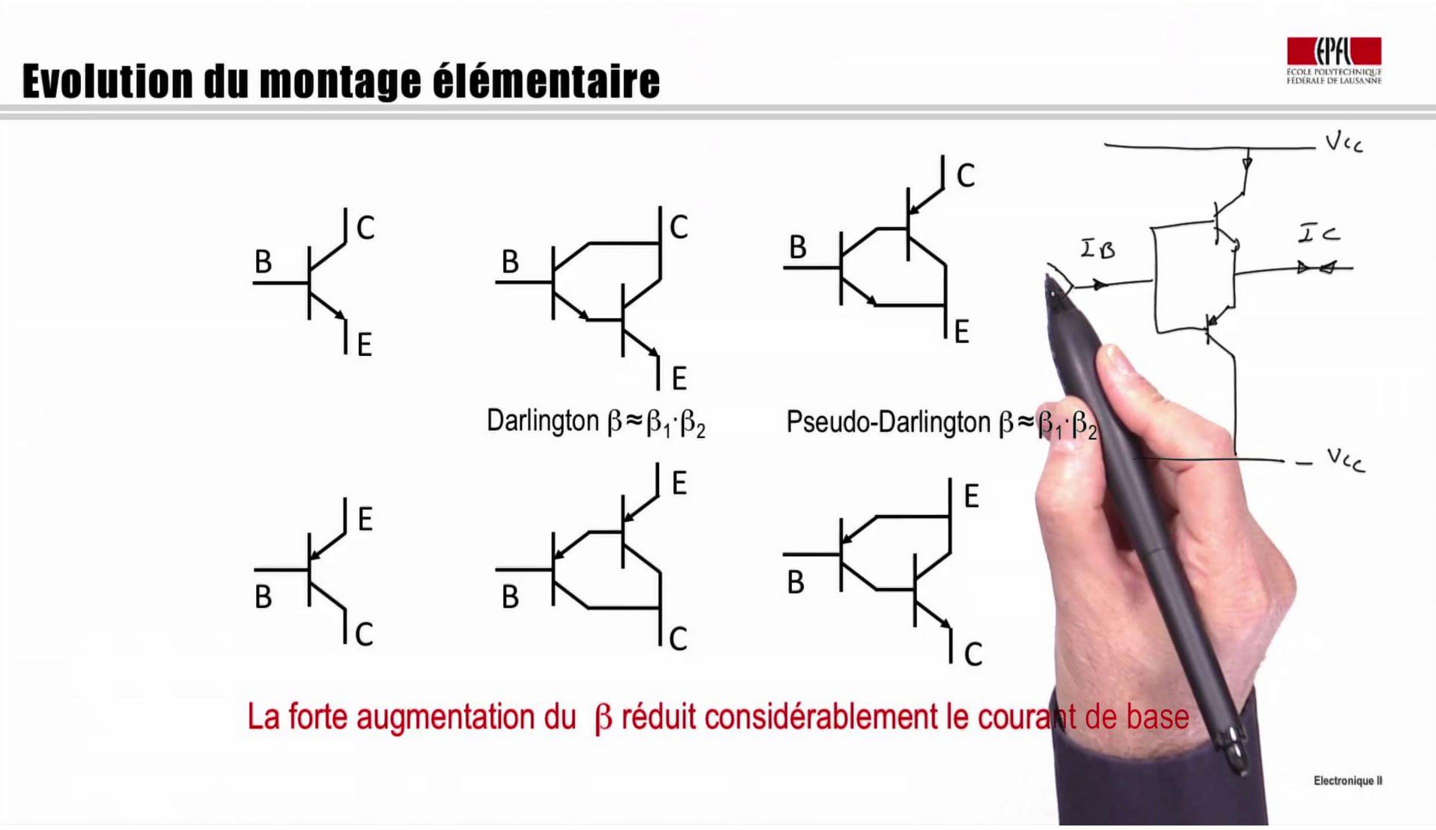
Electronique II

</ I> <I> This curve summarizes what we just saw. </ I> <I> By standardizing the peak value Vcc </ i> <I> that is to say, when I look ^ VI = Vcc, </ i> <I> there on the scale, I have 1 </ i> <I> and normalizing the power </ i> <I> I have both in my transistor </ i> <I> and in both my office </ i> <I> in relation to the supply power, </ i> <I> So I could say that the maximum power, </ i> <I> that's when I have = 1 </ i> <I> since it is the power supplied by the power </ i> <I> which is the normalization value. </ I> <I> I saw that the transistor, </ i> <I> it has a square law </ i> <I> with a Vl ^ 2 with a - sign </ i> And in the charge, the Vl ^ 2 is divided by RI. <I> And the performance, I have a loss from here to here </ i> <I> that the supply gives </ i> <I> and I have all that which is made to the charge </ I> <I> So a visual analysis of this </ i> <I> lets us understand everything that is going on inside. </ I> <I> How the power transistor takes </ i> <I> to a certain value which is of the order of 1/2 Vcc </ i> <I> Then we have the charge that begins to take power </ i> <I> and tends towards the maximum power </ i> <I> we see here. </ I> <I> And it is at that point, we have the maximum yield </ i> <I> that's about 20% loss </ i> <I> with respect to what the supply gives </ i> <I> and compared to what the charge takes as effective value </ i> <I> co power in the charge.

Notes

Summary

25m 51s

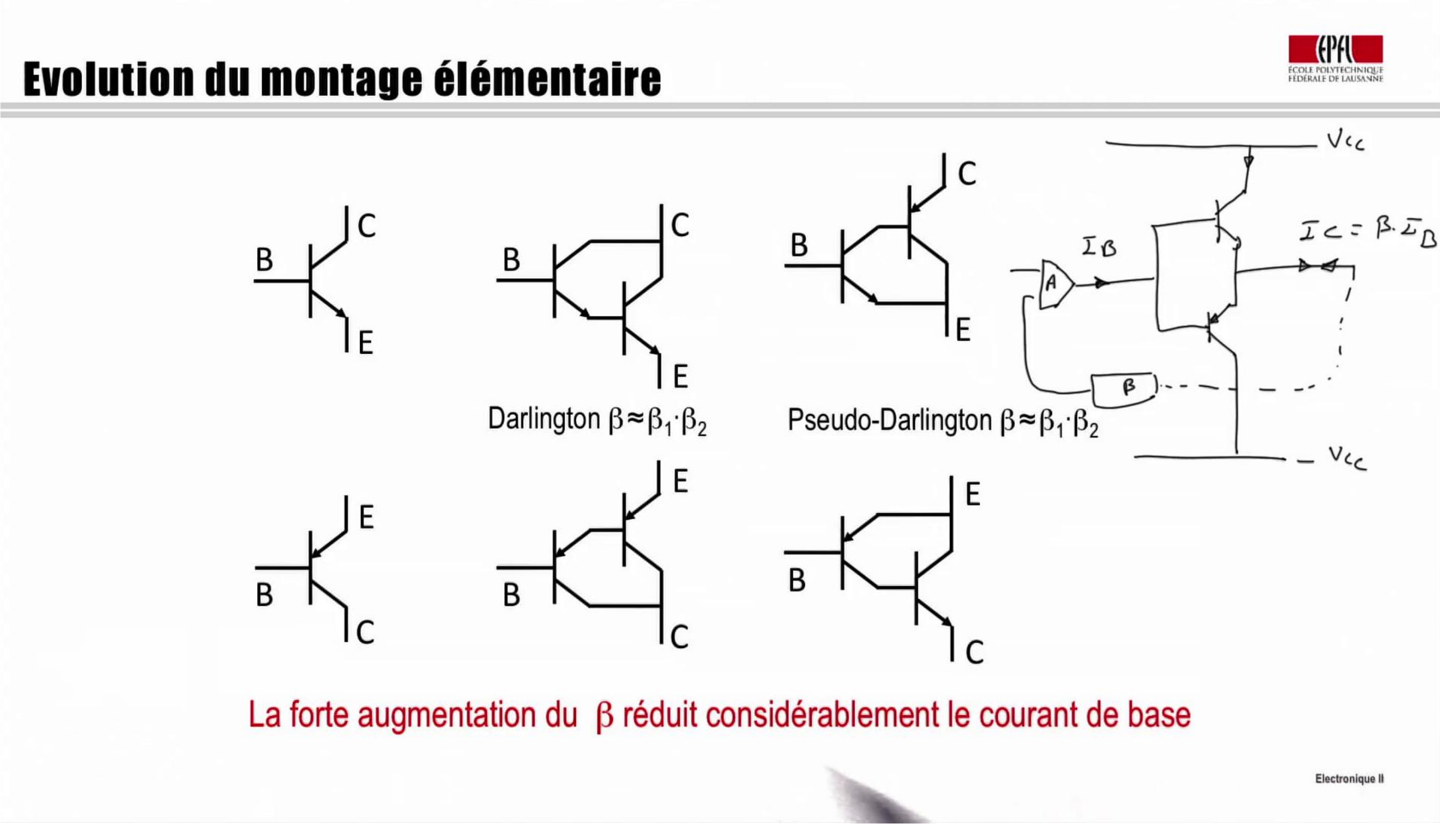


</ I> <I> Let the practical realization. </ I> <I> If you remember our Push-Pull setup </ i> <I> which was with one NPN-type transistor, </ i> <I> 1 PNP transistor type. </ I> <I> Both are connected by their transmitter. </ I> <I> A little polarization here. </ I> <I> I'll take the class B </ i> <I> and a power supply, an outlet, an inlet </ i> <I> and a dual power supply. </ I> <I> The current flowing to the outlet </ i> <I> is the current that we take from the supply voltage. </ I> <I> It is this current that will go in one direction </ i> <I> or another. </ I> <I> Now, the current that we will take </ i> <I> from the level which is just before </ i> <I> the one that provides the voltage to our power amplifier </ i> <I> class B, </ i> <I> it's here. </ I> <I> So that's the current Ib </ i> <I> and that's the current Ic. </ I> <I> What is between the two Ic = β Ib, </ i> <I> such that β is the β of the transistor. </ I> <I> Usually, when we do an amplifier level that comes here </ i> <I> often, we need to achieve a voltage amplifier there. </ I> <I> So here we have a voltage gain </ i> <I> and we do a counter reaction between the output and the input </ i> <I> with a counter reaction rate that would happen like this.

Notes

Summary

27m 28s

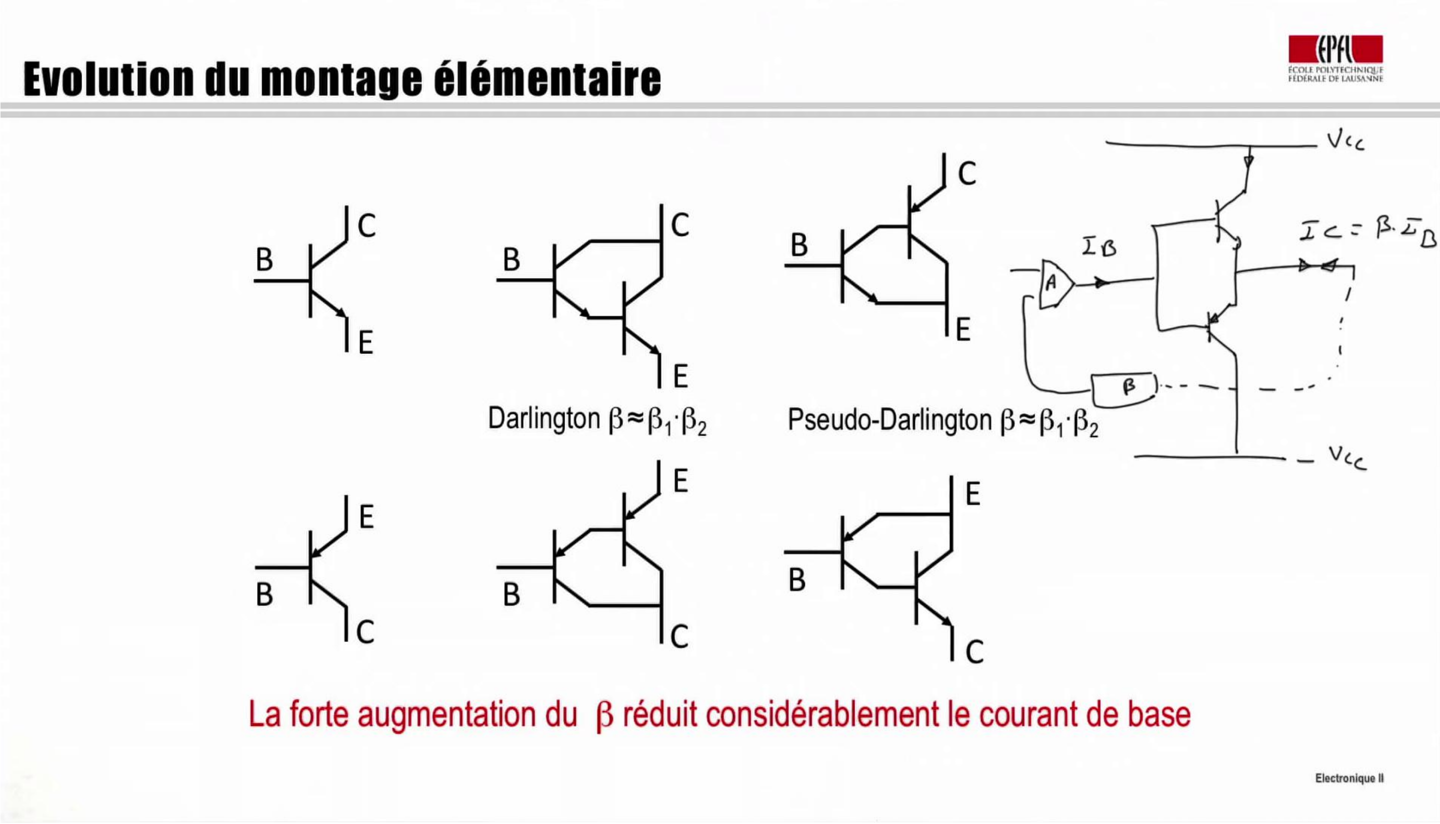


</ I> <I> That is the classical setup of a class AB amplifier. </ I> <I> The power level is of class AB, </ i> <I> plus an amplifier that performs voltage </ i> <I> and counter reaction to cause the output voltage </ i> <I> subtracted from the input voltage and make all these</ i> <I> with a voltage gain proportional to what has been set here. </ I> <I> So the most important thing, </ i> is what is the relationship between Ib and Ic. <I> It goes through the β because it is β × Ib. </ I> <I> When a question arises what is the β value in the transistor </ i> <I> especially as this is a power transistor, </ i> <I> we'll realize </ i> <I> that the β of a power transistor is relatively small </ i> <I> because the base width of such a transistor </ i> <I> can not be very large to have bounds </ i> <I> in quite high voltage. </ I> <I> When you want to subject this transistor </ i> <I> to relatively high voltages, </ i> <I> the β can not be very great. </ I> We have to have transistors <I> whose β is quite moderate or even low </ i> <I> and we require voltage differences </ i> <I> at the terminals of this transistor. </ I> <I> Which brings us to remedy </ i> <I>this β by electronics.

Notes

Summary

28m 52s



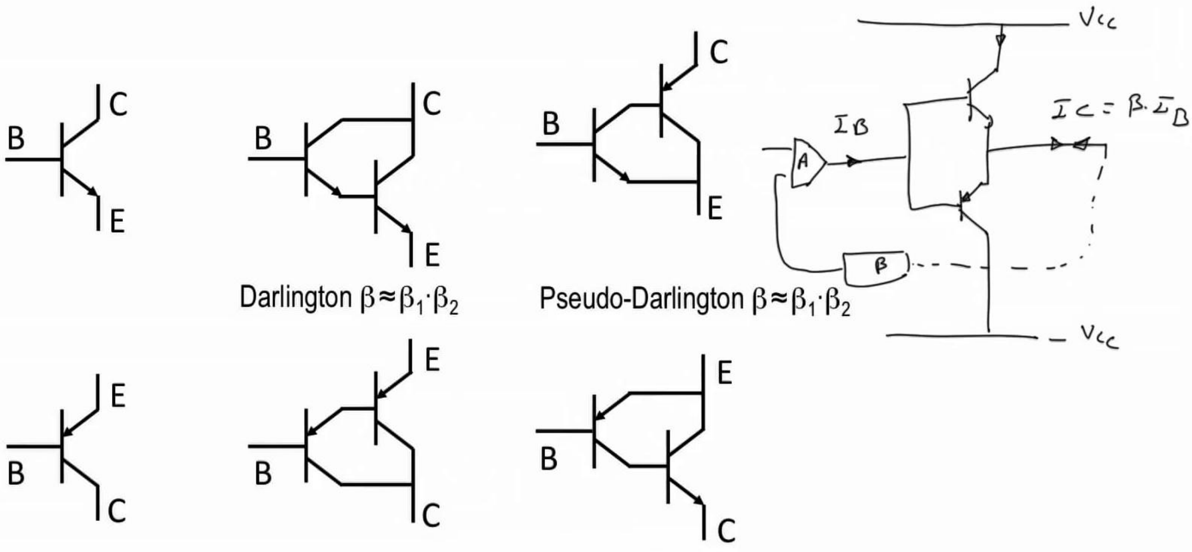
</ I> <I> That is to say, we take our component, </ i> <I> and replace it by a Darlington. </ I> <I> Very often in these amplifiers, </ i> <I> if it's realized with bipolar transistors </ i> <I> the transistor which performs the setup</ i> <I> is often performed by Darlington based fixtures </ i> <I> or pseudo-Darlington </ i> <I> So we see here the two possible layouts. </ I> <I> When you want to make a Push-Pull, </ i> <I> we put this transistor here </ i> <I> and replace it by the equivalent NPN of this. </ I> <I> We can take in the place of the PNP </ i> <I> the equivalent of this and put it below </ i> <I> but we have a β that will be the β1 x β 2 </ i> <I> of two Darlington setups </ i> or using a pseudo-Darlington. <I> So we put a pseudo-Darlington NPN transistor </ i> <I> and the other will be of PNP type</ i> <I> that appears here. </ I> <I> So we can make mixtures in between. </ I> <I> If we wish to have two output stages </ i> <I> of NPN nature </ i> <I> ie this transistor and this transistor </ i> <I> the driver level towards the charge is the same, </ i> <I> we can use instead of this transistor </ i> <I> a Darlington setup of NPN Nature </ i> <I> and a pseudo-Darlington instead of this transistor here, </ i> <I> which makes the two transistors that see the charge the same.

Notes

Summary

30m 01s

Evolution du montage élémentaire



La forte augmentation du β réduit considérablement le courant de base

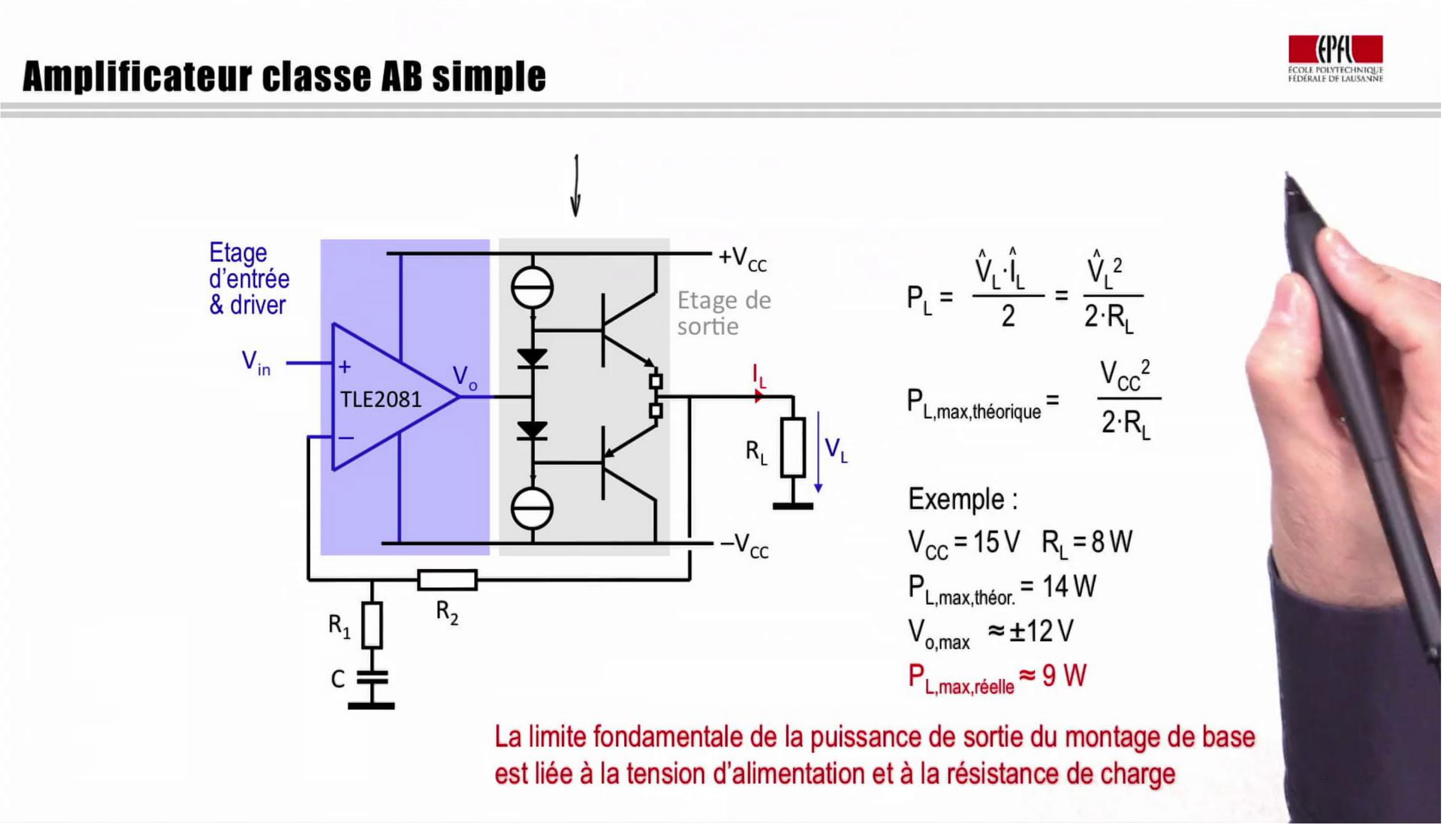
Electronique II

</ I> <I> You can choose the same transistor </ i> <I> that can guarantee a better match </ i> <I> between the two levels.

Notes

Summary

31m 17s

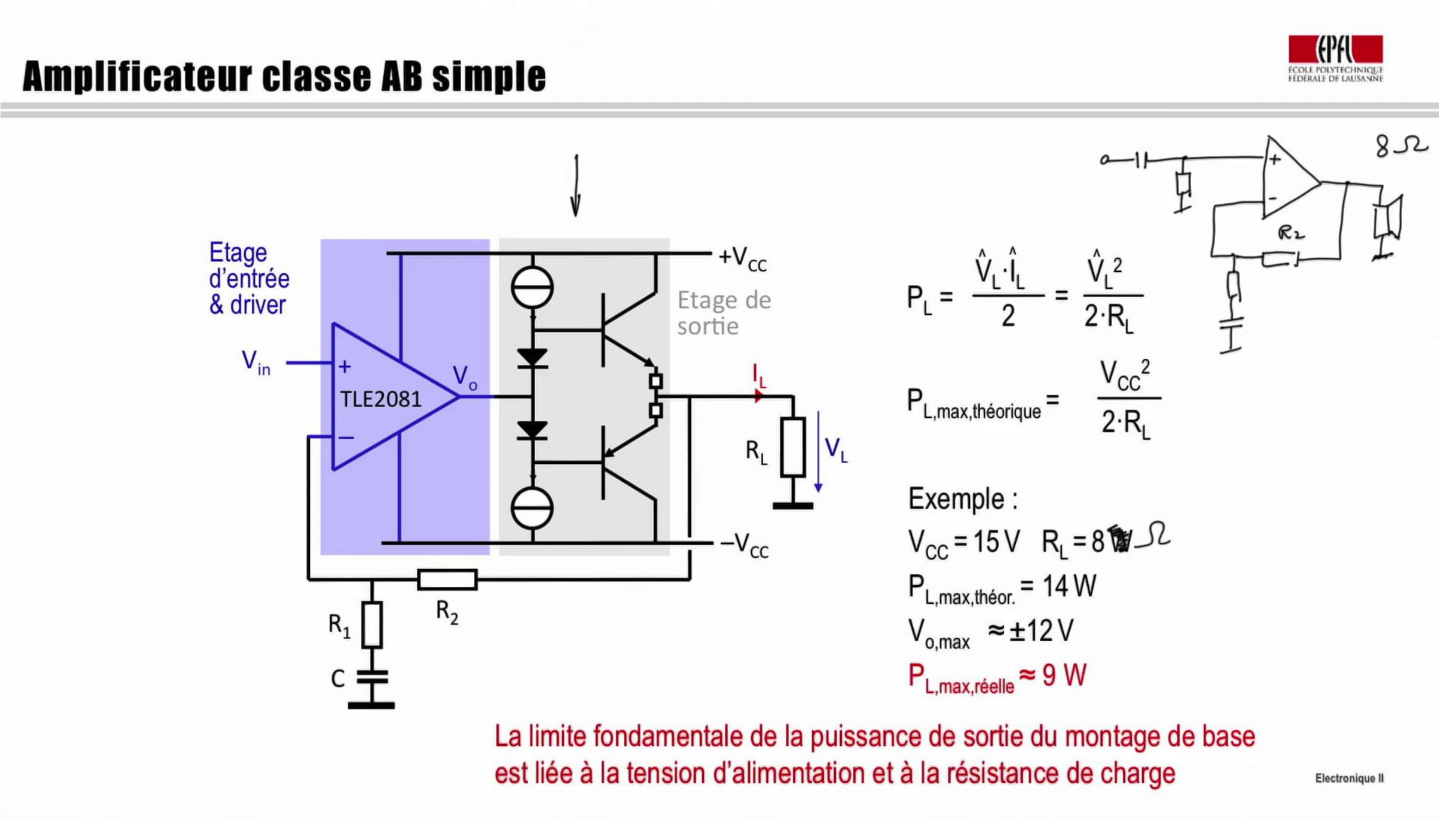


</ I> <I> And finally, </ i> <I> I'd like to give a very simple example</ i> <I> on a simple class AB amplifier </ i> <I> that anyone can go to a laboratory </ i> <I> and plug. </ I> <I> To do this, I have to make the diagram </ i> <I> I have just presented, </ i> <I> that is I have to take my output level </ i> <I> and create a driver level </ i> <I> that will control this level</ i> <I> and that will allow me to make a counter reaction. </ I> <I> So very often, or always the same, </ i> <I> I will need an extra level</ i> <I>that I will add to my amplifier </ i> <I> which is a Class B or AB. </ I> <I> So here in this case, I have a class AB power amplifier </ i> <I> I added a market operational amplifier </ i> <I> which on the inside contains a driver level</ i> <I> that will get me the voltage, </ i> <I> and contains a differential pair of input </ i> <I> to be able to make a counter reaction </ i> <I> from the outlet toward the inlet. </ I> <I> So this is typical to the diagram that we make practically </ i> <I> to make a low power amplifier. </ I> <I> It is equivalent to something like this: </ i> <I> if I take my scheme and I draw on the side </ i> <I> that would give me this: </ i> <I> I have a resistor.

Notes

Summary

31m 24s

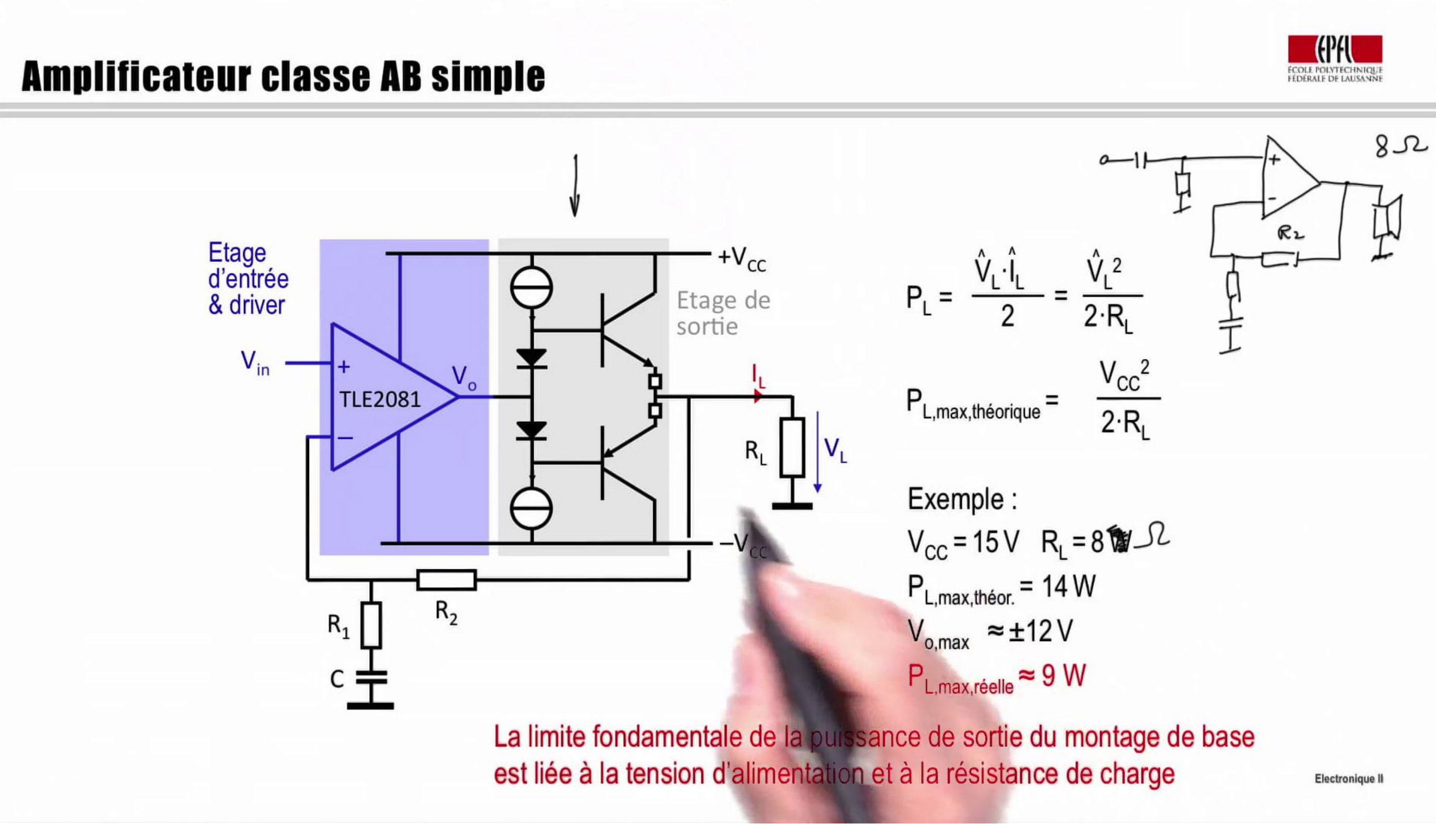


</ I> <I> We'll take a loudspeaker because we will make an audio amp. </ I> <I> I have a counter reaction with two resistors </ i> <I> This one, it is called R2. </ I> With a transfer function we will achieve a filter (inaudible) <I> to avoid if ever there is an offset in my amp, </ i> <I> this offset is not multiplied by the gain and returned. </ I> <I> It is filtered by the capacitance here. </ I> <I> When we have a trial voltage, </ i> <I> this branch here will disappear, </ i> <I> the capacitance is a short circuit. </ I> <I> You hide it, you actually have a voltage follower </ i> <I> a voltage follower which sees at the input </ i> <I> the voltage you are going to put in on Vi. </ I> <I> Very often in practice, it also makes a feed pass. </ I> (INAUDIBLE) up here <I> on passive components </ i> <I> to avoid also that there be a test component </ i> <I> which is superimposed </ i> <I> and appears in the speaker </ i> <I> what we sought to avoid with this kind of amplifier. </ I> <I> So I would take a loudspeaker 8 ohm for example. </ I> <I> Unfortunately here there is a mistake. </ I> <I> So I erase this. </ I> <I> We will write the correct unit. </ I> <I> I have a speaker of 8 ohm.

Notes

Summary

32m 39s

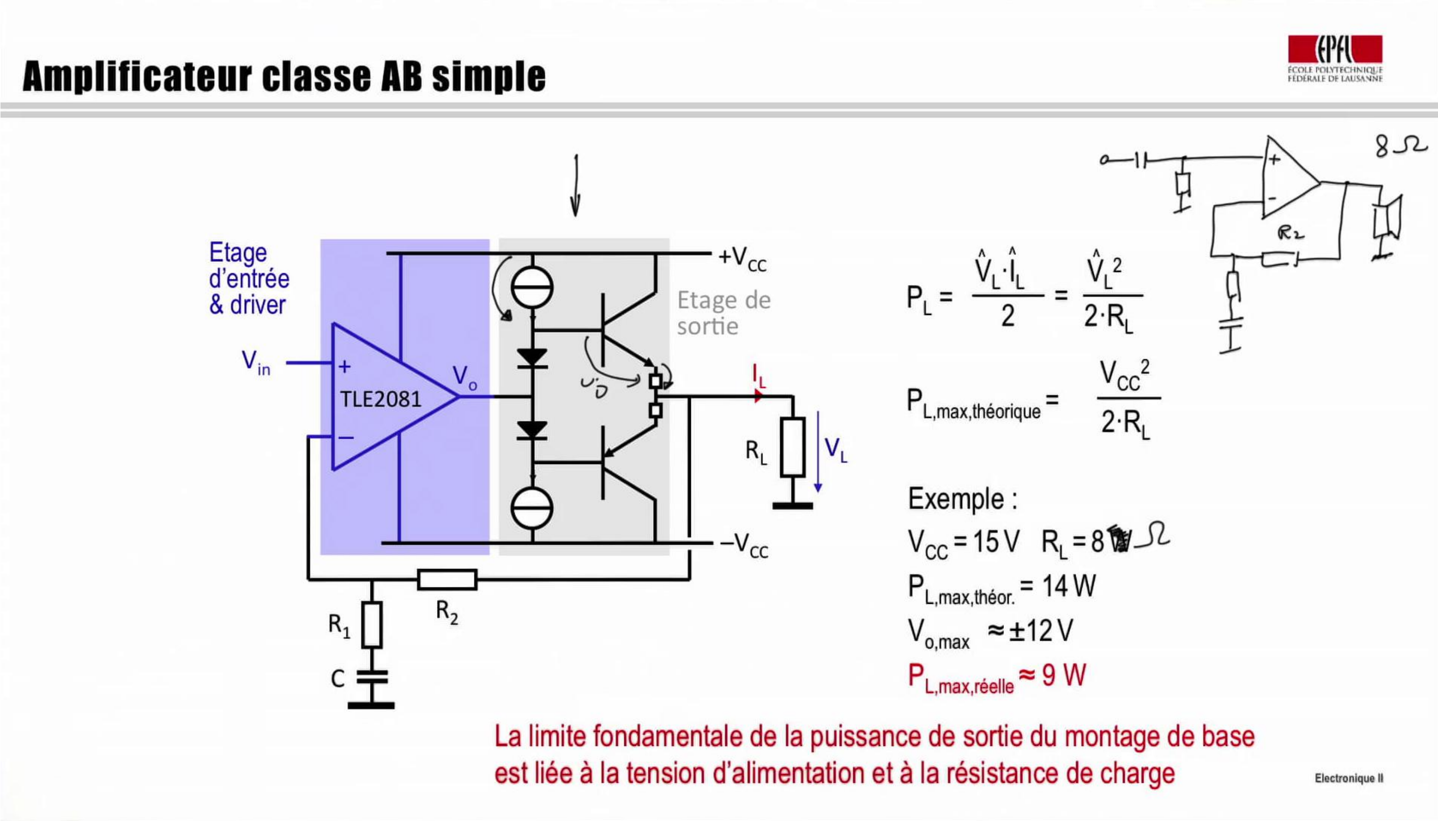


</ I> <I> The first thing we do </ i> <I> when you take a setup of this style, </ i> <I> this is to evaluate the given power as we had said. </ I> <I> Here in this example, I'll do a reverse engineering </ i> <I> on the most I can get in power </ i> <I> when I have a given supply voltage </ i> <I> and I will establish it to roughly 15 volts. </ I> <I> I purchased a component that is powered with about 15 volts </ i> <I> and I will consider it as the Vcc = 15 V </ i> <I> and -15 volts </ i> <I> And I have a speaker of 8 ohm. </ I> <I> What is the maximum theoretical power? </ I> <I> The maximum theoretical power </ i> it will tell you it is the Vcc / 2 x RI. <I> So it will give me 14 watts. </ I> <I> And you remember, we just said </ i> <I> the output voltage may never reach Vcc. </ I> <I> So here in this example, the theoretical power, </ i> <I> I have considered that ^ Vi, the maximum value at the output </ i> <I> is equal to Vcc. </ I> <I> But actually, I have to subtract </ i> <I> a small amount of a resistance </ i> <I>that we add frequently in amplifiers </ i> <I> when there is a level with bipolar </ i> <I> because this resistance of a very, very low value </ i> <I> about 0.2 ohm </ i> <I> prevents or limits the thermal runaway.

Notes

Summary

33m 48s

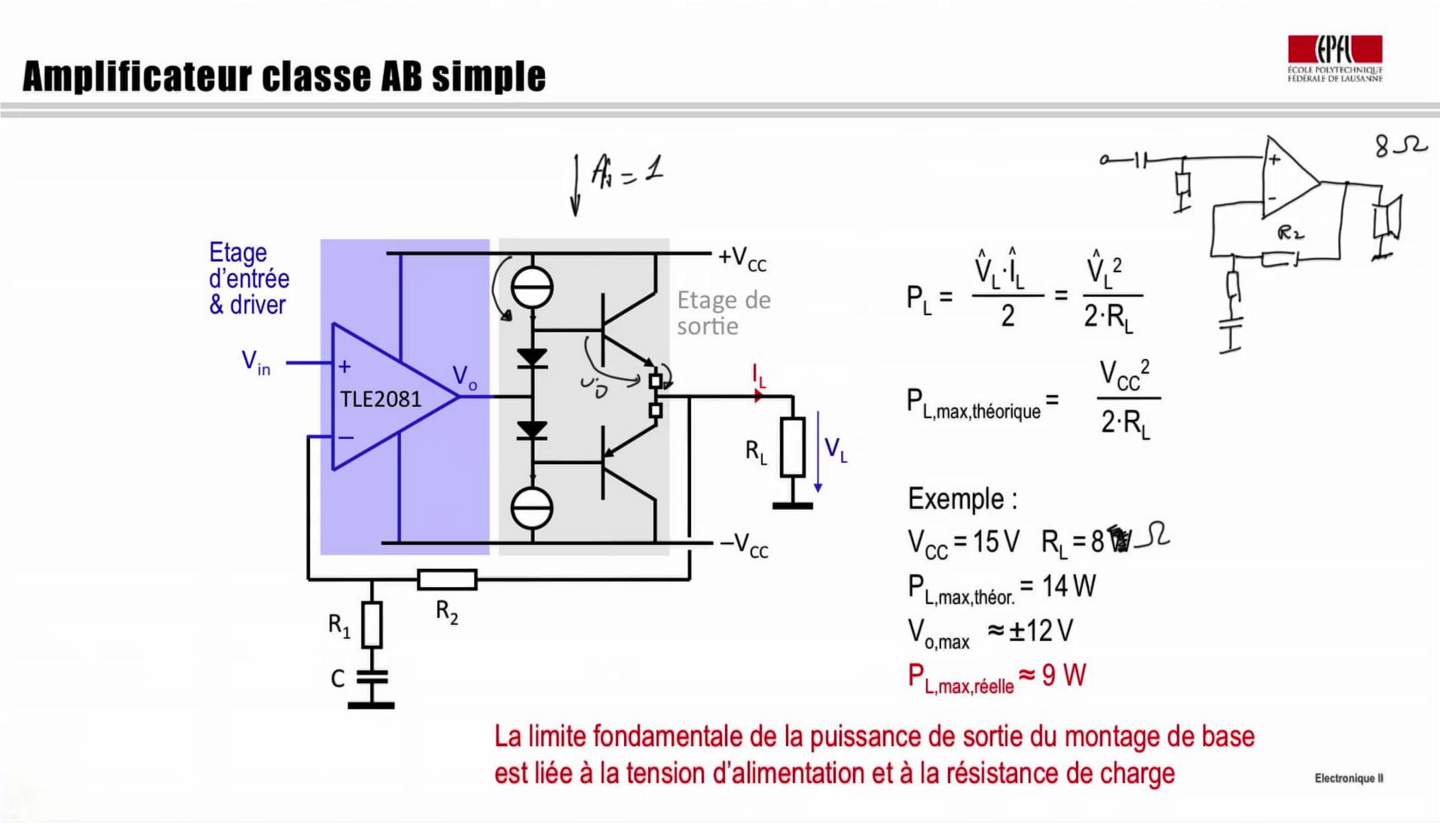


</ I> <I> Now I have a voltage Uj. </ I> <I> And then I have some component that I have to ensure </ i> <I> before my current source saturates. </ I> <I> So I have a voltage drop here, </ i> <I> a voltage drop here, </ i> <I> a voltage drop here that I must subtract from Vcc. </ I> <I> So I can never reach this Vcc = 15V. </ I> <I> So here, I took a example. </ I> <I> Say assuming I have an increase of 4 volts </ i> <I> and I reserve 3 volts for this path here, </ i> <I> I'll end up with something correct</ i> <I> in the order of ± 12 volts </ i> <I> even with a 15 volt power supply. </ I> <I> This brings me to a real max power </ i> <I> about 9 watts. </ I> <I> So that's one example. </ I> <I> For someone who wants to make it in a laboratory </ i> <I> by taking a market speaker </ i> <I> and making an amplifier </ i> <I> and taking a attack level </ i> <I> and a counter reaction level</ i> <I> in a simple amplifier embodying the counter reaction, </ i> <I> could relatively easily plug this </ i> <I> by keeping the power components on the outside. </ I> <I> As this is a voltage follower </ i> <I> you can always imagine that it is part of your amp.

Notes

Summary

35m 01s

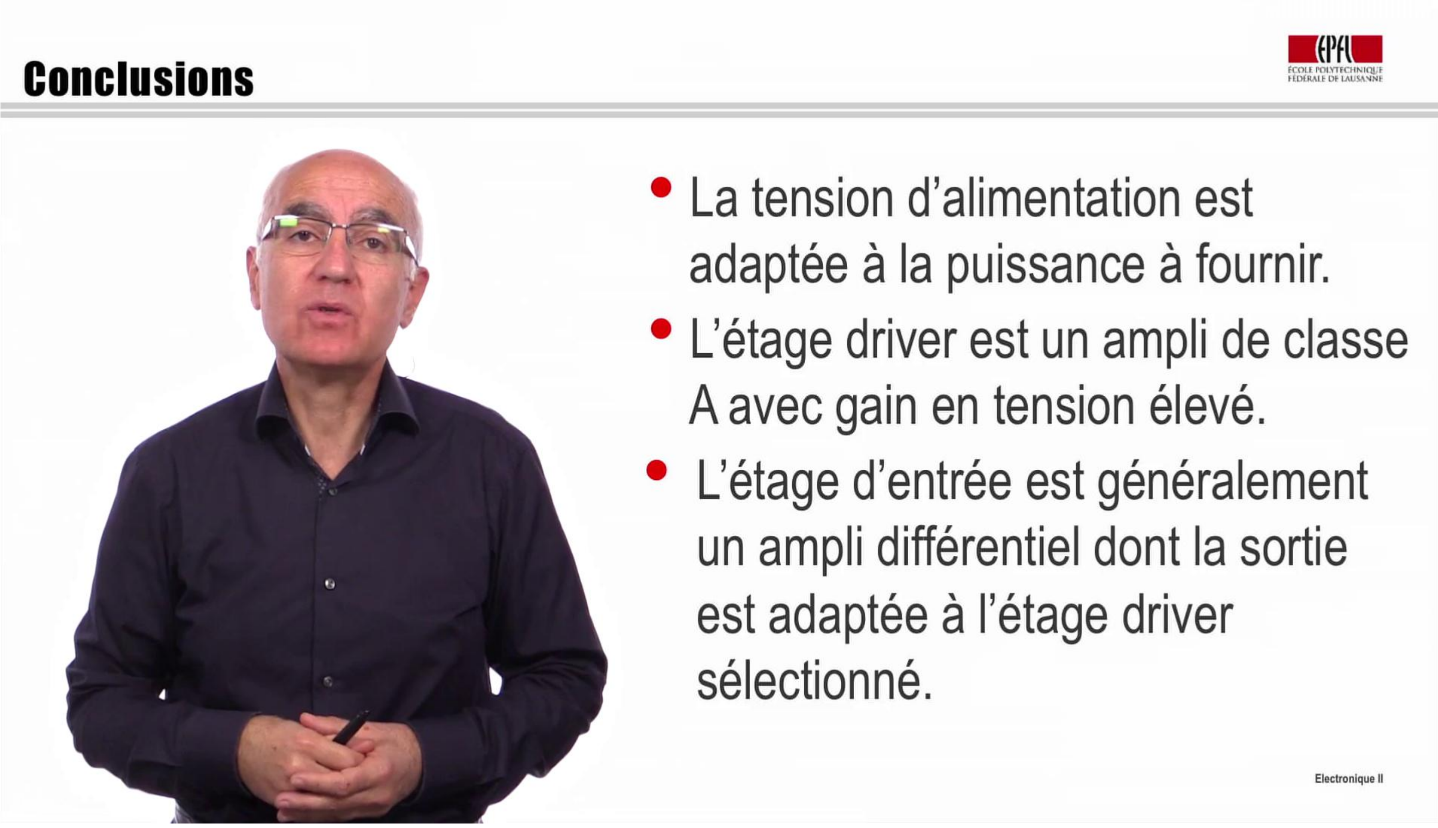


</ I> <I> This tension and stress are the same, </ i> <I> they follow. </ I> <I> So this is a story that makes an Av voltage gain</ i> <I> which is equal to 1. </ I> <I> So we have a voltage gain of 1 </ i> <I> So if we can consider That this and this, it 's comparable </ i> <I> in terms of gain calculation </ i> <I> and it brings us to the real values </ i> <I> of an embodiment of power if not higher than that. </ I> <I> If someone will wish to make a complete amplifier </ i> <I> by replacing this setup by a level of full transistors, </ i> <I> he needs to make a gain level</ i> <I> plus a differential pair. </ I> <I> And that will be part of a detailed exercise </ i> <I> that would be given after this video </ i> <I> that summarizes, for those who realized it, </ i> <I> an excellent summary of all of these courses </ i> <I> you just followed throughout these videos </ i> <I> because whoever happens to achieve the equivalent of a full setup</ i> <I> for delivering power to the output, </ i> <I> then he understood all the possible </ i> <I> and imaginable uses of a transistor and the roles of the various setups</ i> <I> that are in it. </ I> <I> So I strongly urge you to do the exercise that will be given.

Notes

Summary

36m 15s



</ I> To end this chapter on power amplifiers, I would just summarize what we just saw. So we analyzed the class A amplifier. We analyzed the class A, AB and B amplifiers. So with these three types of amplifiers, we can make audio amplifiers. I gave a little more focus on audio amplifiers. I'll give a complete exercise on the achievement of a class A amp and a class AB amplifier and it would be great for a student. What I would like to end with, for the two setups, it is often necessary to consider the supply voltages. So we understand that the power on the charge is done by the level of the supply voltage. Once we calculated the power we would like to have at the output based on the supply, we have a clear idea of the power value to set. Then in both cases, it is the voltage follower setups either A or AB. So we have an attack level and a counter a reaction level which should be achieved either by integrated elements either with components bought in the market which we realize with a large voltage gain and a differential level at the inlet to perform the counter reaction.

Notes

Summary

37m 25s