Analog Electronic Circuits
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Lecture – 53
Common Base and Common Gate Amplifiers (Contd.): Numerical Examples (Part C)

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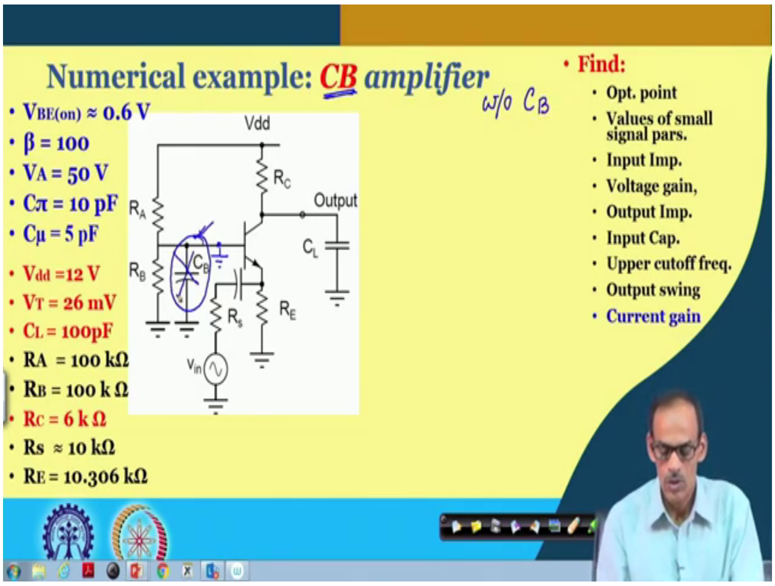

So, dear students welcome back after the break. And before the break we are discussing about Common Base amplifier and Common Gate Amplifier.

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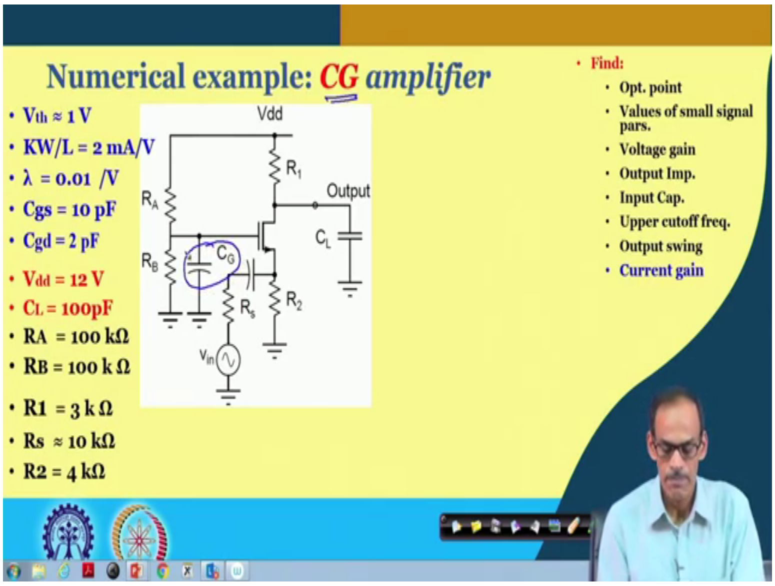

So, this is the example of that common base amplifier. In fact, we are covering the numerical examples and we already have discuss this circuit.

So, likewise we also have discussed common gate amplifier. So, here we do have the common gate amplifier. And next to this common gate amplifier what we are looking for it is; we are you might have observed that at the gate we are connecting one capacitor CG. In fact, if you see the previous circuit.

So, they are also you can see that in common base amplifier in common base amplifier here also we do have the CB that makes the base node AC ground and with that assumption we have done the analysis. Now it is very important to keep this capacitor sufficiently large so, that the base node particularly for the signal it should be working as a ground. And this is important specifically for common base in fact, this is also important for common gate.

But it seems the discussion it will be similar, here we are going to talk about performance of the common base amplifier without this CB without the CB.

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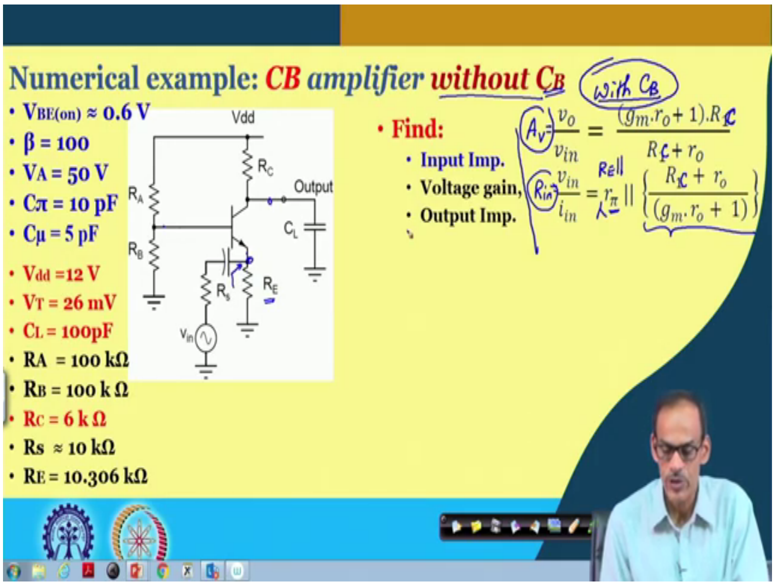

So, in our next example numerical example that is what we are going to do and we will see that what are the performance degradations are happening due to eliminating this capacitor.

So, we can see that the base node we do not have any capacitor and rest of the things it is very similar to whatever the numerical example we have discuss before. So, you may recall the voltage gain if we have the C B connected. So, if I say the expression of the voltage gain with C B it has been enlisted here.

So, this is the voltage gain from the emitter node to collector node and this is the expression of the input resistance of the main circuit looking into the emitter terminal. In fact, if you consider RE we should also consider RE coming in parallel, but what is most important thing is that the main device the we do have the r pi and then we do have the input impedance coming from the active circuit so, that is it is given here and yeah.

So, that is a small notation correction instead of R 1 we should write R C here. So, same thing this is R C this is RC rest of the things are ok. So, this was the this was the expression whenever we are connecting the C B. Now if I remove the C B what will be the consequences on these two important parameters namely the input resistance and the voltage gain and maybe the output impedance also so, that is what we are going to discuss now.

Now let me draw the small signal equivalent circuit, small signal equivalent circuit of the main amplifier, try to explain that what kind of effects are there.

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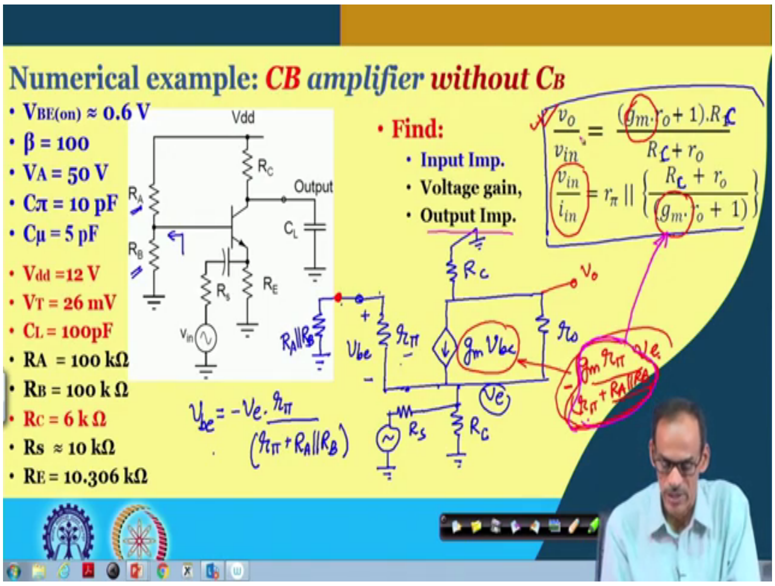

So, this is R C connected to AC ground. So, this is R C this is also R C this is also R C and here we do have g m into v be voltage dependent current source and then of course, you do have the r o and then we do have the RE connected to ground.

And at the emitter node we are feeding the signal through the signal coupling capacitor and let we have its source resistance is also there see R S. Now what is the so, this equivalent circuit we already have discussed. In fact, we will also have discussed that the voltage across this r pi it is v b e. So, this is plus and this is minus.

Now earlier this node it was a c ground but if you look into this circuit we do have R A and R B they are together namely parallel connection of R A and R B they are forming the terminal equivalent resistance and for the small signal what we have to do? We have to consider this R

A in parallel with R B. But then definition of the v be still it is the voltage across this r pi. Now as I said that if we are considering C B then we do have this expression.

And if you see here the basic difference here the v be, v b e it is not same as whatever the emitter voltage we are having. In fact, earlier in presents of C B the emitter voltage it was same as minus v be. On the other hand the v be it is of course, it is the function of this emitter voltage namely v be equals to minus v e multiplied by r pi divided by r pi plus R A in parallel with R B.

In fact, if you if you look at look at this circuit carefully if we have v e here and the voltage available across this r pi it is nothing, but the potential division of whatever the emitter voltage you do have. And due to this whatever the g m into v be we do have, this part can be replaced by g m into r pi divided by r pi plus R A in parallel with R B and then of course, we do have the emitter voltage v e with a minus sign. Earlier whenever we are having a capacitor at this node, we have considered this R A parallel R B it was 0 and then we have considered this current it was minus g m into v e which means ok.

So, this is the output voltage which means that whatever the derivation we do have in this derivation if we replace this g m if we replace this g m by see g m into r pi divided by r pi plus R A parallel with R B, then this equation itself it can give the voltage gain and same thing for the input resistance also if we replace this g m by this part namely g m into r pi divided by r pi plus R A in parallel with R B.

So, if we replace this g m by this equivalent g m, then we can get the expiration on the both input resistance, then voltage gain and then the output impedance also. So, if we if we recall see ok. So, let me let me try to erase this board and try to plug in this expression in the expression of v o divided by v in to get the affected voltage gain.

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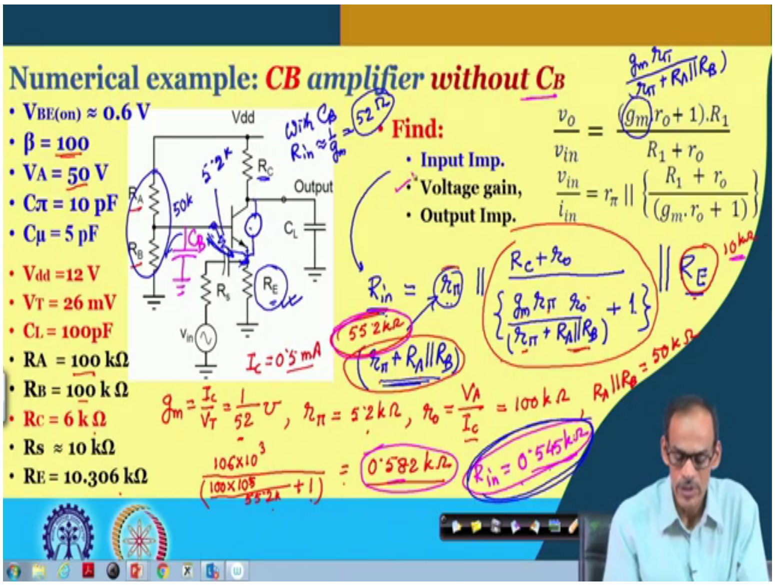

So, what we said is this g m will be replacing by g m r pi divided by r pi plus R A in parallel with R B. So, from that we can say that input resistance R in if I ignore RE and if I consider v in by i in. So, directly we can use this equation and we can see that this is r pi in parallel with R 1 is basically R C. So, R C plus r o divided by g m into r pi divided by r pi plus R A in parallel with R B right multiplied by r o plus 1.

And also you can see whenever we consider input resistance earlier we are having r pi here and the base node it was connect to AC ground and that is why we are taking this r pi. So, now, this r pi instead of r pi we should also replace this r pi by this r pi in series with R A parallel with R B. So, if I replace this replace this r pi by this and then we can get the input resistance. And of course, this input resistance it does not consider it is not considering this

RE. So, if you consider the effect of RE then both this part this part should be coming in parallel with RE.

So, the summary is that this input resistance it is getting modified here and also we do have this RE. Now so, likewise the voltage gain. So, we will see the voltage gain and since we do have this numerical example, let us try to calculate what is the input resistance we are getting by considering the value of the g m r naught and then R C and so, and. So, you may recall for this circuit whatever the conditions we do have collector current I C it was 0.5 milli ampere.

And then the g m it is I C divided by V T thermal equivalent voltage. So, that is 1 by 52 more and also the r pi which is beta times 1 by g m. So, if I use a this value of the g m we can get r pi equals to 5.2 kilo ohm. So, likewise the other parameters see r o which is early voltage divided by I C. So, the early voltage here it is 50 I C it is 0.5 milli ampere. So, that gives us r o equals 100 kilo ohm and then R A and R B they are 100 k. So, we can say that R A in parallel with R B so, that is becoming 50 k 50 kilo ohm.

Now, if I consider the middle term particularly this term and if you see the corresponding numerical value. So, what we have here it is R C equals to 6 k and then r naught it is 100 k. So, we do have in the numerator we do have 106 k 10 to the power 3 and then in the denominator we do have g m into r pipe that is nothing, but beta. So, that is 100 multiplied by this r naught which is 100 k. So, 10 to the power 5 and in the denominator we do have r pi is 5.2 k and then we do have 50 here.

So, which means that this is 55.2 k plus 1. In fact, you may ignored this one part and then you can consider only the first part here. So, this is 10 to the power 5. So in fact, I did I have done this calculation. So, let me share you this information. So, we do have this part it is 0.582 kilo ohm. So, this part is 0.582 kilo ohm and then this part after making this replacement we do have 50 and then 5.2. So, that is 55.2 kilo ohm and then RE it is 10.

So, this one is 10 kilo ohm. So, we do have this resistance, we do have let me use different color, we do have 55.2 k here and then we do have 0.582 k here and then RE it is 10 k. So, finally, what we are getting here it is R in very close to this 580. In fact, again here also I have done the calculation for you.

So, this is 0.545 kilo ohm. So, what is the what is the outcome here? If we are not using this C B, then the input resistance it is quite large now compare to of course, compare to if I use CB. So, with C B the input resistance R in it was 1by g m and that is 52 ohms only. So, if you compare this one and this value it is almost 10 order. So, it is it is it is getting increased by a factor of 10.

So, intuitively what it is happening here it is whatever the stimulus you are putting here voltage only part of the voltage it is appearing across this r pi and major part it is appearing across R A in parallel with R B. So, if you see the potential division it is happening here and that voltage it is coming to g m into this v be part.

So if you see the potential division we do have here it is r pi equals to 5.2 k and these two resistance is together it is 50 k. So, now, it is very obvious that whatever the stimulus we are putting voltage wise only one tenth it is coming here. So, that gives you an intuition that the equivalent g m or equivalent input impedance coming from 1 by g m it is getting changed by a factor of 10.

So, that is how the input resistance it is getting increase. So, the bottom line here it is even otherwise it is not mention explicitly, we have to keep in mind that at the base node we should ensure that this is signal wise this is AC ground. So, unless otherwise you do have a special requirement we must use the C B. In fact, similar kind of conclusion you can get for the voltage gain also. So, in the next slide let me consider the voltage gain also.

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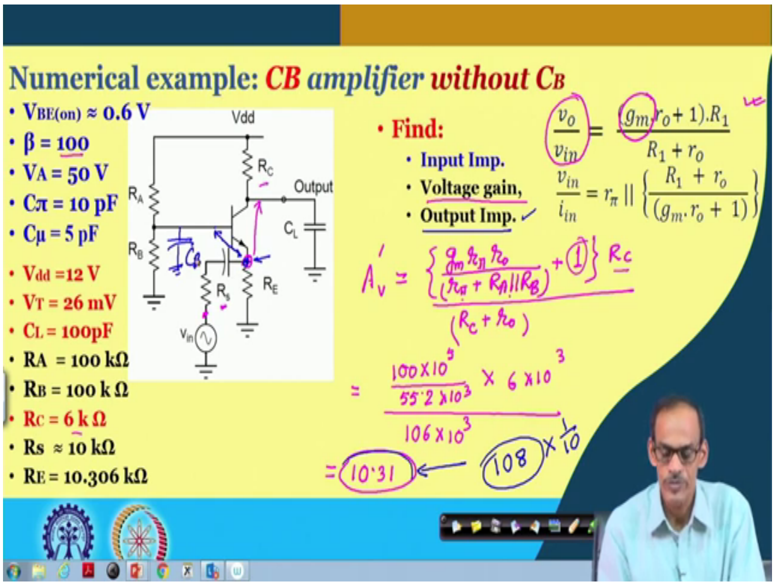

So, here again the if I want to know what will be the affected voltage gain. So, we do have we do have the affected voltage gain. So, what we can get? In fact, directly we can use this equation only thing is that we have to replace this g m. So, let me call this is A v dash and the g m if you replace by g m into r pi into r naught divided by r pi plus R A in parallel with R B then we do have plus 1 and then R 1 is essentially RC.

So, we can put this R C here and then here we do have R C plus r naught. So, again here if you put the numerical value of different parameters. So, what we have here it is g m into r pi. So, that is beta that is 100. So, that is 100 and then we do have r naught which is 100 k 10 to the power 5 and then we do have r pi plus R A in parallel with R B.

So, that is 55.2 kilo ohm 10 to the power 3 and probably we can ignore this one part, then in the denominator we do have 106 kilo ohm coming from r naught and R C. So, 106, 10 to the power 3 and then we do have the R C here and R C it is 6 k 6 into 10 to the power 3.

So, that gives you a voltage gain in fact, you can calculate this one that gives you a voltage gain around ten point something. In fact, I again for this also I have done the calculation for you so in fact, in my calculation it was 10.31. Now of course, this voltage gain it is from this point to this point. So, without considering R S that is the gain and of course, if you consider the effect of R S from here to here we have to consider attenuation.

But also you have to keep in mind that attenuation factor it will be getting change because the input resistance it is not just 1 by g m. But whatever it is the gain of the common base amplifier from emitter to collector it is 10.31 if you recall the corresponding value of this gain with C B it was 108.

So, if you compare again this and this almost it is a factor of 10. Again this factor of 10 it is coming due to whatever the voltage you are applying at the emitter almost only one tenth it is appearing across base 2 emitter terminal which means that we do have a reduced version of the voltage appearing from base to emitter which is finally, getting amplified by this. So, you can almost say that this factor it is getting one tenth and that gives us the gain of close to 10.

So, that is how intuitively we can get. In fact, again the conclusion is that we should keep this CB whenever it is possible. So, similar to the input resistance and voltage gain the output resistance it is also getting affected because the resistance are the emitter it is getting changed if we remove this C B.

So, yeah so, this is the slide to get the corresponding derivation of the r out and the output impedance for this circuit it is this R C I should write here it is R C in parallel with whatever the resistance we do have. And this is the expression we already have derived in our previous classes and there we have assume that the base node it was a ground AC ground and if you if you consider say the same expression we can get the output impedance only thing is that this r pi we have to replace by r pi in series with R A and R B and this is true for this r pi this is true for this r pi.

And also this g m this g m part we have to replace by g m into r pi divided by r pi plus R A in parallel with R B and the logic is same namely the voltage appearing across r pi it is a fraction of whatever the voltage we do have at the emitter node. So, we do have the emitter voltage and then we do have the this is the g m into v be and the v be it is. So, this is r naught and the v be it is it is a voltage across this r pi and now in absence of C B we do have R A and R B coming in parallel ok.

So, that is how we can get the corresponding output impedance and. So, this is R C sorry this is R C in parallel with just now whatever we seen r naught plus r pi plus R A in parallel with R B in parallel with in case if we have source resistance we have to consider R S, then in case if you have emitter resistor basically R 2. So, that also you have to consider then we do have this part.

So, let me write that here we do have r pi plus R A R B in parallel with R S in parallel with RE and then g m need to be replaced by g m into r pi divided by r pi plus R A in parallel with R B multiplied by r naught. So, this is the whole thing that is the expression of this output resistance. So, again here also we can see the numerical calculation and I must see while I am writing this one I must see that due to due to the presents due to the absence of C B, this part particularly this part the dominant part it is getting affected because of this factor and this factor we already have discussed that in this example it is one tenth.

So; that means, from here to here this impedance it is getting changed by a factor of a point 0.1, but then even if it is getting reduced by a factor of 0.1 the still the R C it is smaller than that. So, the output impedance output in parents; however, still it is remaining approximately R C. So, internally the output impedance is getting change in due to due to the absence of C B, but the output impedance it is since it is primarily getting dominated by R C and that is remaining unchanged. So, the output impedance it is remaining unchanged.

So, the input impedance and voltage gain they are getting affected by a factor of 10. So, that is about the common base amplifier and now we will be going for design guidelines. So, what we have seen here it is the circuit already has been designed and it is given to us and we need to find the different performance matrices like this. Now in actual scenario, you may have to rather design this circuit for a given requirement.

So, in the next slide we will be talking about the design guidelines. If the requirement is given to us then we can see how we can proceed to find the values of different resistances.

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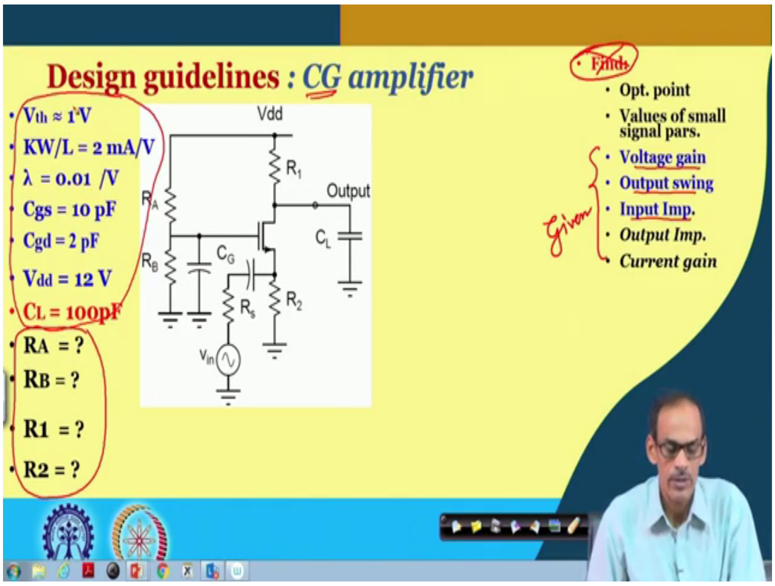

So, the corresponding the circuit here it is for common gate amplifier and so, likewise we also have a common base amplifier and here the task is. So, probably we will be having instead of find probably this these values are given.

So, now we do have the complimentary exercise; namely the voltage gain, output showing input impedance maybe the current gain and output impedance those things are given to us. And we need to find the corresponding by a circuits and assuming the other information it is given to us ok. So, let me take a short break and then we will come back for this design guidelines.