Analog Electronic Circuits

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Lecture – 60
Multi-Transistor Amplifiers (Contd.): Numerical Examples (Part C)

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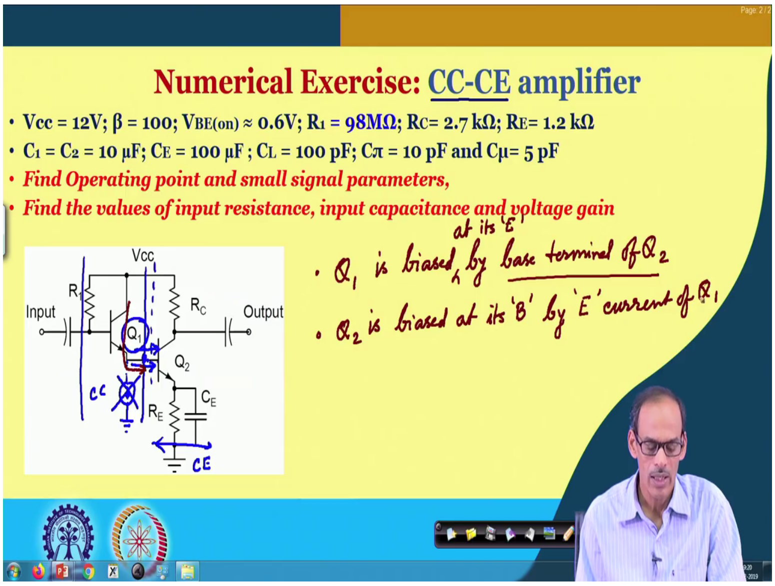

So, now, we do have another example, where we do have the CC followed by CE amplifier. And what we have here it is, the CC stage it is directly getting coupled to CE stage. And you can see here the in the CC stage, basically this part is the CC stage and normally we do have a current sink here for proper biasing; but here we assume that whatever the emitter current we do have out of Q 1 that is entirely getting consumed to the base or base terminal of Q 2. So, now hence we may assume that, this bias circuit is not required.

On the other hand for Q 2 which is forming the CE amplifier, so we do have CE amplifier here and for the CE amplifier while we are feeding the signal at the base, so along with the signal we also require meaningful DC voltage at the base of Q 2. Now again here we assume that DC voltage of Q 1, it is sufficient to feed the signal at the base of Q 2; or you may say that, whatever the emitter current we do have out of Q 1 that is good enough to make a bias of the Q 2. So, in summary what will I like to say that, Q 1 is biased by base terminal of Q 2. So, it is biased at its emitter by the base terminal of Q 2.

On the other hand Q 2 is biased at it at its base terminal by emitter current of Q 1. So, they are, I should say they are helping each other to have a mutual bias and hence we can simplify the biasing arrangements, so that should we do have very simple bias here.

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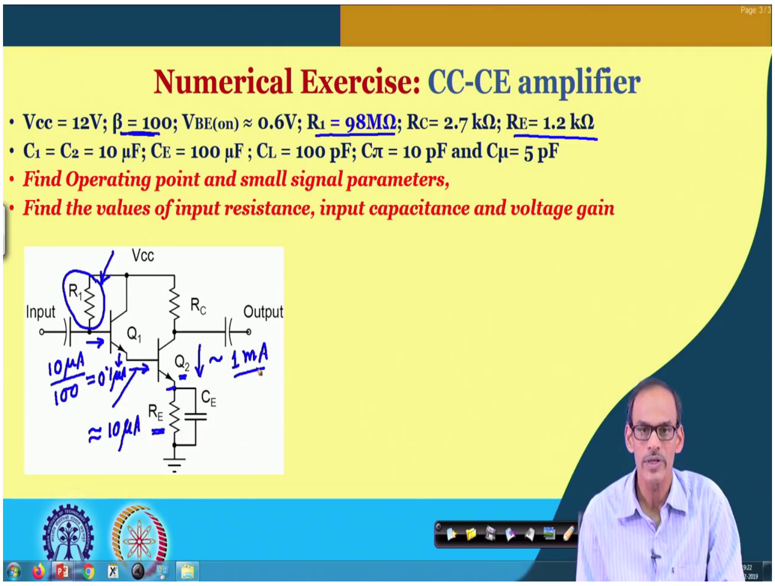

Now, here for comparison with our previous circuits, we are setting the value of this R 1 such that the current flowing through this Q 2 we are expecting that it will be say 1 milli ampere. So, if the I C of transistor 2 it is 1 milli ampere and then we like to retain the same DC voltage at its emitter. So, we are maintaining R E 1.2 k and then now the required current here; since is its beta it is 100, so the required current here it is close to 10 micro ampere. And if I say that this 10 micro ampere current of transistor Q 2 based base current of transistor Q 2, it is equal to the emitter current of Q 1.

Then again, because the beta of Q 1 is also 100, the required base current for Q 1 it is I should say 10 micro ampere divided by 100. So, that is in the order of sub micro ampere. In fact, so this is equal to 0.1 micro ampere. So, the required resistance here it need to be very high and I just made some calculation and it is observed that, if R 1 it is say 98 mega ohm, then we are getting this current is 1 milli ampere. So, I will show you the simple calculation to get this the emitter current of Q 2 is equal to 1 milli ampere.

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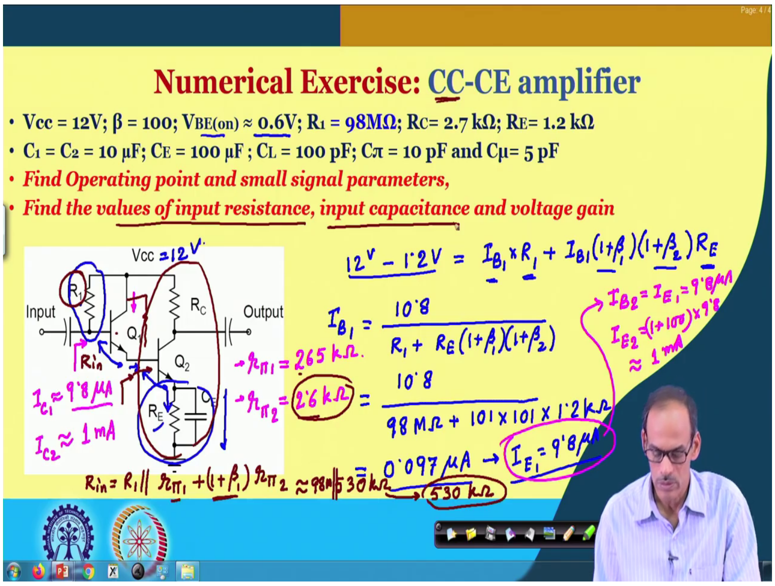

So, if I start from say 12 volt here and then we do have 2 V B E drop here; and if I assume that these two V B E drops are approximately equal to 0.6, then the remaining drops namely a 10.4 volt it is across R E sorry, this across R E and R 1. So, I should say that 12 volt minus 1.2 volt due to the two V B E equals to I B 1 multiplied by R 1 plus I B 1 multiplied by 1 plus beta 1, so that gives the base current of Q 2. And then if I multiply with 1 plus beta 2, so that gives us the emitter current here. So, that multiplied by R E is the drop across this R E.

So, here we know beta, we know R 1 and then R E and from that we can find what will be the I B. So, this I B 1, it becomes. So, this is 10.8 volt divided by R 1 plus R E multiplied by 1 plus beta 1 multiplied by 1 plus beta 2. So, if we put the value of this registers, then what we are getting it is; so 10.8 divided by, we do have 98 mega ohm, then 1 plus beta 1 is 101 multiplied by a 101 multiplied by R E it is 1.2 kilo ohm.

In fact, that gives us close to 0.1, to be more precise in my calculation it came 0.097 micro ampere. And from that we can get I E 1 equals to. So, if I multiply this by 101, we do get 9.8 maybe 9.85 micro ampere and that gives us the base current I B 2 which is I E 1 equals to 9.8 micro ampere 85, in fact to be more precise. And then we are getting R E 1 sorry R E 2 which is 1 plus beta that is 100 multiplied by 9.8 micro ampere, so that gives us 1 milli ampere.

So, now, we have the collector current; so we can say that, I C 1 it is approximately equal to same as this I E, so that is 9.8 micro ampere. And then we also have I C 2, we can approximate that this is by 1 milli ampere. And from that we do get r pi 1 and then r pi 2; r pi 2 it is 2.6 kilo ohm, earlier we have done this calculation. And on the other hand r pi 1 and its current is quite low; so in my calculation it was around 265 kilo ohm, I think around on that.

So, if I am having these two resistances are known, then we can find what will be the input resistance of this circuit. So, what is the input resistance that is what it is very important for this circuit, this configuration; because we like to increase the input resistance by putting this CC stage. So, the input resistance here, R in it is parallel connection of R 1 and whatever the resistance we do have. So, let me use this space here, R in equals to R 1 coming in parallel with whatever the resistance we do have. And what we have, the resistance here it is r pi 1 coming in series with 1 plus beta 1 times r pi 2.

So, we are ignoring this r naught here, we consider only this r pi 2 and that gives us roughly; so we can say that, this is 100 and 101 and 2.6 kilo ohms it is getting multiplied by that factor and then we do have 265. So, roughly you can say that this is 530, around 530 kilo ohm in parallel with R 1 which is 98 mega ohm, ok.

So, then you may approximate that this is by 530 kilo ohm. So, if I am having only the CE stage, the input resistance here it was only 2.6 k; but if I am putting the CC stage in front of that, the corresponding input resistance it is getting increased. So, that is why for op amp whenever we like to increase the input resistance, we put the CC stage in front of differential pair; whenever we will be talking about differential amplifier, we will discuss it further. And instead of using this CC stage, in fact people use something called Darlington pair, so we will see that. But before that, let we see the input capacitance of this circuit. So, let me clear again to make the space.

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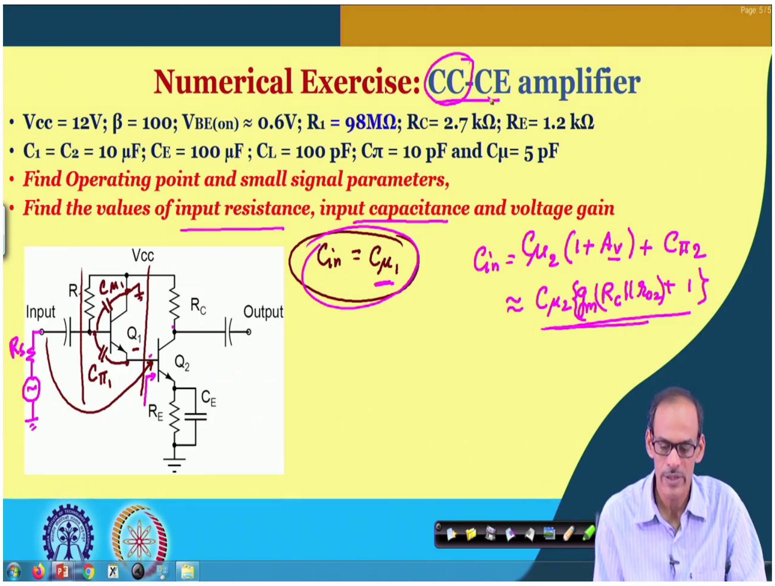

So, C in of the circuit it is we do have C mu of transistor 1. So, we do have C mu of transistor 1 and this node it is AC ground. On the other hand this C pi, it is breezing the input base terminal and emitter terminal of Q 1 and its gain it is very close to 1, so we may say that effect of this C pi it is negligible. So, this is helping us to reduce this input capacitance. And you may recall that if you ignore say CC stage and if you are directly considering this is the primary input, then the input capacitance at this node it was mu C mu 2 multiplied by it is gain, the voltage gain; and the voltage gain here it is we know it is quite high and then also the C pi 2.

So in fact, this is dominating and the A v and C mu, so C mu 2 multiplied by g m into R c that is what primarily we do get, the gain plus 1. So, definitely if you compare this value and this value, this is much smaller. So, again putting the CC stage, it is helping us to reduce the input capacitance and to increase the input resistance; that may be useful in case if you are feeding the signal from a signal source having very high source resistance R s.

I compare to CC CE amplifier, there is another configuration something called Darlington pair and we will see that what is the difference basic difference. In fact, their configuration wise they are very close; but there is a small difference, in the next slide we will be discussing about that.

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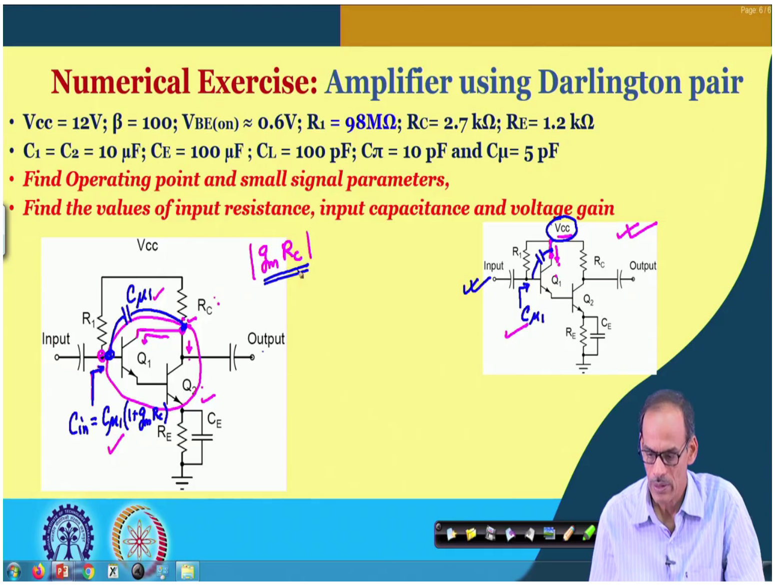

So, here we do have the this Darlington pair. So, you can think of this is one transistor; its base terminal is here and then its collector is here and then emitter it is here. And then if you put this structure or you can say composite pair in C configuration what we can get it is, we will be getting the same gain of CE amplifier namely g m into R c. But the main advantage here it is, the input resistance here it will be quite high.

And for our comparison with the previous circuit, where the collector of Q 1, it was connected to supply voltage V c c; on the other hand here in the Darlington pair, collector of the first transistor it is connected to collector of the second transistor. In fact, both the collectors are connected together. Now DC operating point wise, both this circuit and this circuit are I should say very close to each other; that is because whatever the collector current we are drawing here, which may be flowing through R c now, unlike the previous case, where the collector current of Q 1 it was directly coming from V c c.

But since this current is very small compare to the collector current of Q 2; so we can say that, all practical purposes the operating point of this circuit and this circuit they are same. But the main difference here it is, in the previous circuit C mu of transistor 1 it, the other end of C mu it was connected to the supply voltage which is AC ground. As a result the input capacitance here it was only C mu and that is as is; whereas, for this case the C mu here it is connecting the input terminal to the primary output of the circuit.

And we know that from this primary input to this primary output, we do have very good gain. So, the consequences that, the C mu of this Q 1 it is getting multiplied by Miller's factor and that produces big amount of input capacitance. So, the C in it is C mu 1 multiplied by 1 plus g m into whatever R c.

So, I should say that this circuit is definitely better in case if you are looking for an application where input capacitance is very important; otherwise the other performance matrices they are identical. So, maybe you can calculate the corresponding gain and all offline. But so far whatever the things we like to discuss, namely the main purpose of using CC stage to enhance the performance of CE amplifier that is done.

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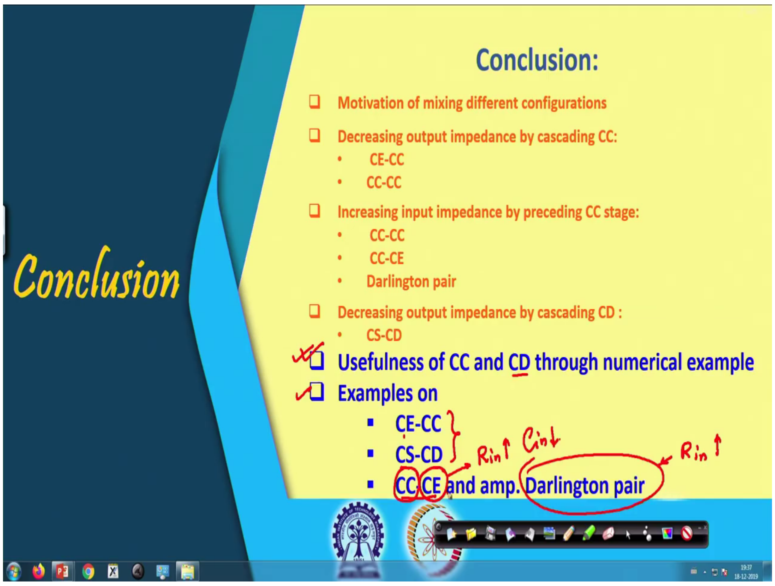

So, in summary what we have covered so far it is that, we have talked about the usefulness of common collector and common drain stage through numerical examples. And those examples are primarily CE followed by CC, CS followed by CD, so these two it was covered before. And just now what we covered it is common collector followed by CE stage; rather this CE stage it is the main amplifier, which is preceded by the common collector stage.

Or equivalently you can say that Darlington pair we can put in amplifier configuration and the then there we have seen that, input resistance it is getting enhanced. This is helping not only input resistance got increased, but the input capacitance also got decreased. I think that is all I like to share.

Thank you for listening.