Analog Electronic Circuits
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Lecture 23
Problem Session 6 on Frequency Response of Small Signal Amplifiers (Continued) and Differential Equations

Okay this is the 23rd lecture and this is our problem session 6th. I hope the number is correct. On frequency response on small signal amplifiers so will work on one problem and thereby we shall work out a couple of problems on differential amplifiers. The first problem that I consider is question number 3 in tutorial sheet 6 and the problem is this. We had a V s, 10 K is the source resistance, 10 microfarad is the coupling capacitor. Then the base is biased in a peculiar manner.

There is a resistance of 100 K, another resistance of 100 K and the midpoint is connected to ground through a capacitor. Its value is 10 microfarad. The collector is connected to this point and this point is connected to plus 10 volt and the resistance of 3 point 3 K. The emitter is grounded. As you see this is the DC feedback biasing.

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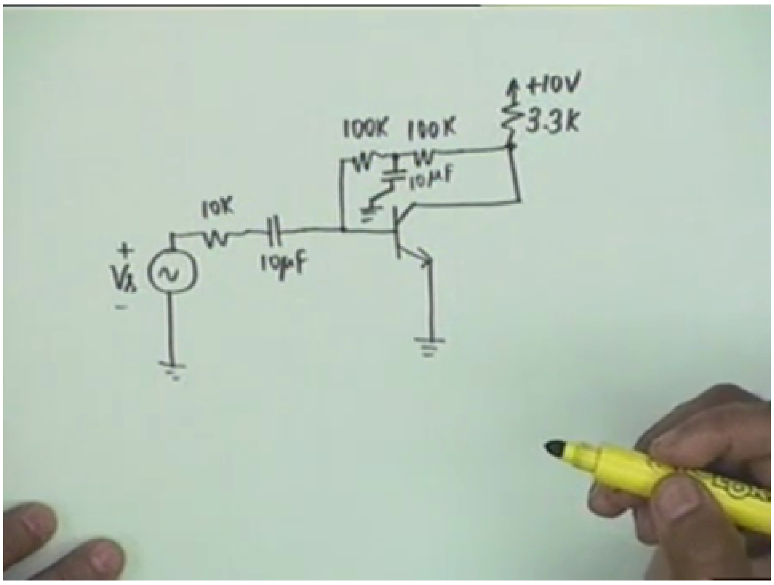

That is the current that flows through 3 point 3 K is I C plus I B and that I C flows here and I B flows here. It cannot flow this path therefore it comes to the base. We have done this kind of biasing. The only thing that was not done was this capacitor which is for obvious reasons to prevent AC feedback. That is input signal cannot go to the collector directly because of this capacitor, output signal cannot go to the base because of this capacitor, okay.

This capacitor is a bypass and then the output is taken from the collector through a capacitor again 10 microfarad. All three capacitors are 10 microfarad and then a 4 point 7 K, this is the actual load and this voltage is V 0.

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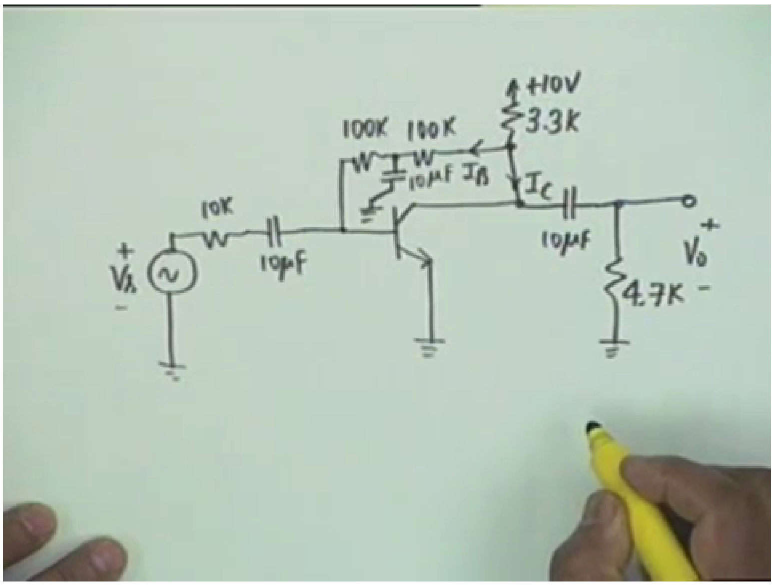

The transistor parameters are beta equal to 100. I do not want that murmur from there. Beta equal 100, V A equals 150 volt, C mu is 2 pars, C pie is 5 pars, C 0 is 0 no stray and r x equal to 100 ohms. Even though r x is given in most of the problems we conveniently ignore it because it increase is our problem of analysis, okay. The first thing we have to do is to find out A v s j omega.

That means we have to find out all the critical frequencies and we shall have three critical frequencies corresponding to the three capacitors here, okay. This capacitor plays the role of C E bypass. You see the usual biasing is if the resistance comes here then we require a bypass at C E. C E bypass is avoided but one capacitor has to be introduced here. So the low frequency response shall be affected by this capacitor, this capacitor and this capacitor.

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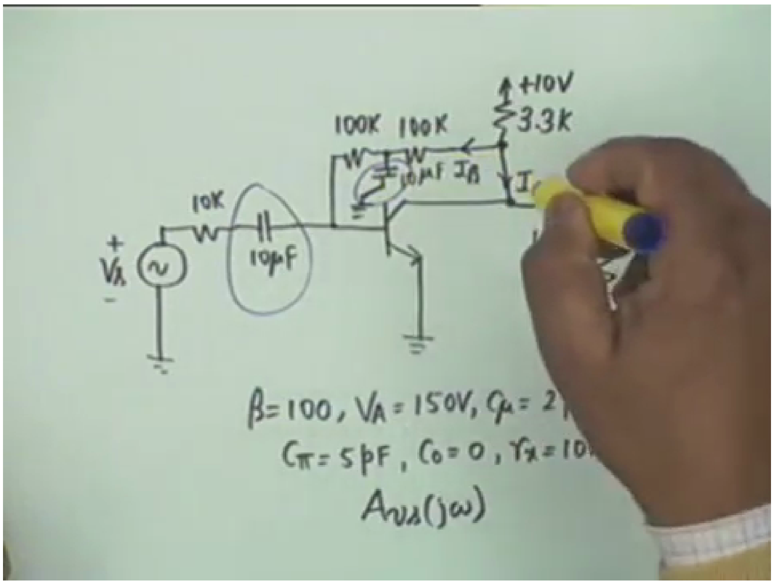

Therefore I expect that there shall be three critical frequencies omega L 1, omega L 2 and omega L 3. Let us call these capacitors are C 1, C 2, C 3. We therefore have three low critical frequencies omega L 1, omega L 2, omega L 3 corresponding to the three capacitances and there shall be two high frequency critical points corresponding to C pie plus C M, the miller capacitance. C pie plus C M will combine them.

We do not want to analyse a three node circuit and the other critical frequency at high frequency shall be due to C mu plus C 0 at the output. C 0 is fortunately zero therefore we expect that omega H 2 corresponding to C mu plus C 0 shall be much larger than omega H 1 due to C pie plus C M. These are the qualitative observations from the circuit. Therefore what we expect is.

Student: Sir why is omega too much critical?

Because the capacitance is 2 pars, it is a much smaller capacitance as compared to C pie plus C M. As you will see C M will be very large, would be about 50 times C pie, okay. We will see this but in general qualitative observation of the circuit reveal that A v s j omega would be of the form A v s o divided by 1 minus j omega L 1 by omega 1 minus j omega L 2 by omega. These subscripts corresponding to the corresponding subscripted capacitors. 1 minus j omega L 3 by omega multiplied by 1 plus j.

You must distinguish between the low frequency and high frequency. It would be omega divided by omega H 1 and 1 plus j omega divided by omega H 2, is it clear? Any more explanation needed? You must be able to write this expression just by looking at the circuit.

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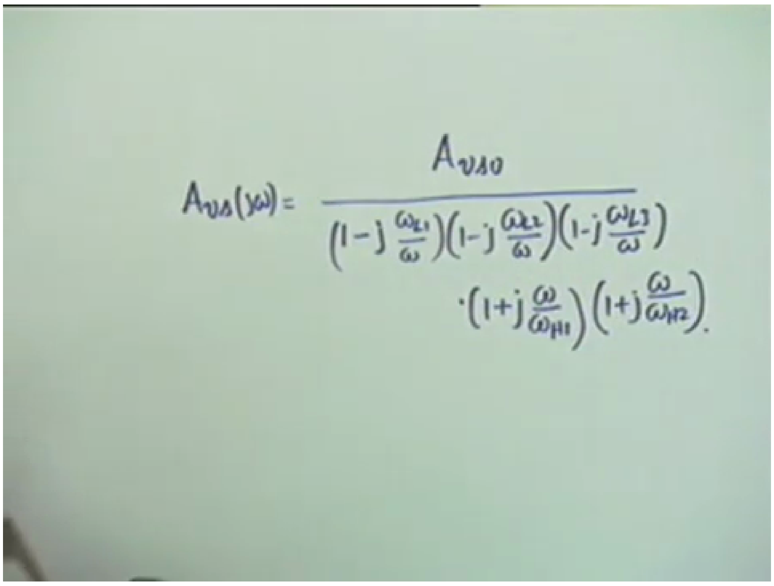

Student: Sir, how are you sure there are no zeros in this?

How are you sure that there are no zeros? Yes, we understood unless we draw the equivalent circuit. But we have experience in the equivalent circuits of this kind. We have experience already. If C mu was not absorbed in C M, the miller capacitance and the output capacitance that is C mu was not absorbing C 0 at the output then we know there is a zero at plus g m divided by C mu.

We have already done that. But since right from the beginning we look at the complication of the circuit and we say sorry we have to use miller. We cannot use a three node circuit and therefore that zero shall be avoided in the analysis. Anyway this is much farther from any omega H that you can imagine and therefore this zero will not count.

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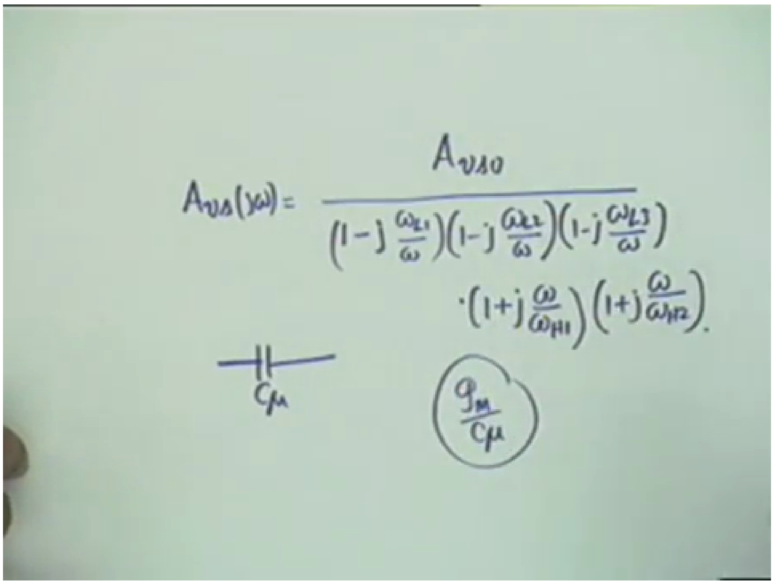

The first thing that one should do is to find the parameters and therefore we require a DC analysis. Let us look at the DC analysis. This is 10 volt and this current is I sub C plus I sub B therefore I can write 10 volt as equal to this drop, drop across 3 point 3 plus the drop across 200 K. These two can be combined as far as DC is concerned plus point 7 and that shall give me I sub B, agreed? So my equation becomes 10 equals to, beta is given as 100 and therefore I C plus I B would be 101 times I sub B.

This has to be multiplied by 3 point 3 K. This gives the drop in 3 point 3 K then the drop in 200 K is due to I sub B and then we have V B E which is point 7. This gives me I sub B as equal to 17 point 4 microamperes. That means I sub C which is 100 times this would be 1 point 74. Therefore I sub C is 1 point 74 milliampere. You must now check because of many hard steps we have passed we have seen circuits behave peculiarly.

We go ahead blindly calculating but ultimately we find that one is cut off and one is saturated as in question number 2 of minor 1, okay. Therefore V C E we must check this. Although it is not required in any of the parameter calculations we must check this routinely and we must see that this is neither negative nor comparable to point 2, okay. V C E is 10 minus the drop in 3 point 3 K which is 3 point 3 K multiplied by 1 point 74 milliampere.

Actually we should have made 1 point 754, okay, because it is I C plus I B but well I did not do it, you can do it. I found this as 4 point 25 volt. This is not critical to include 1 point 754 that is I B also because the voltage is much above the saturation voltage, okay.

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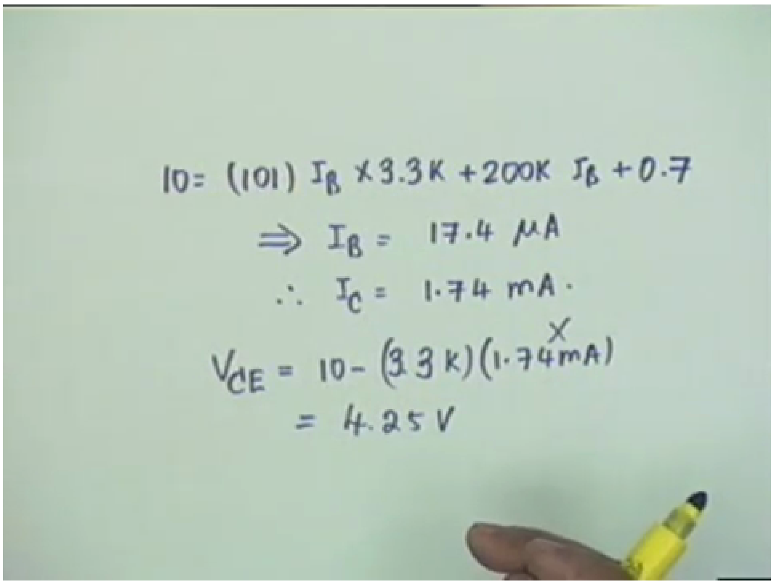

Once we have found I sub C we can find g m as I sub C by V T. You take V T as 26 millivolt then it becomes point 067 volt, okay. Then you can calculate r pie as beta divided by g m. Beta is given as 100 and the result is 1 point 494 K and r 0 can be calculated as V A divided by I sub C, 150 divided by 1 point 74 milliampere and this comes out as 86 K. The three parameters of importance have been obtained. All these three depend on I sub C therefore we had to calculate the DC conditions, okay.

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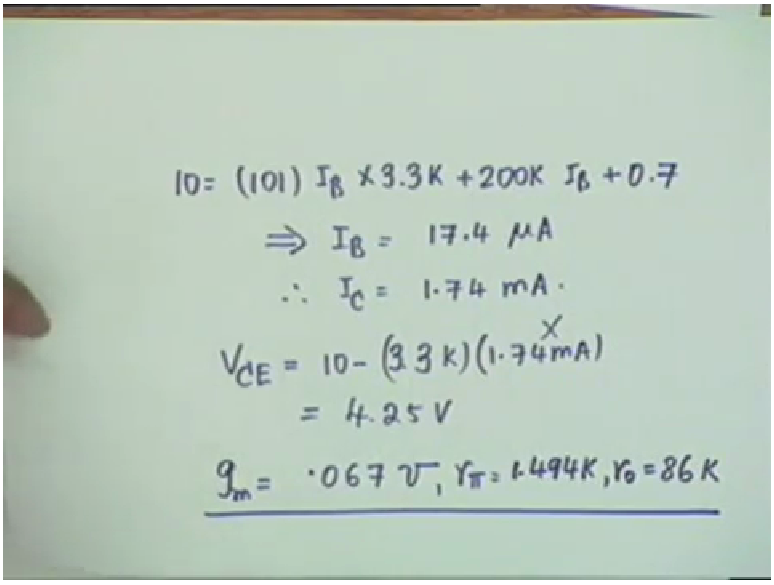

Now let us look at the midband equivalent circuit to find out A v s 0, okay. The midband equivalent circuit would be like this V s, then a 10 K. What would be this resistance? It is not the parallel combination now. At midband 100 K goes to ground, is that clear? Because of the capacitor C 3 it is 100 K. Not parallel 100 K, okay, alright. This point must be recognised then we have r pie which we had found as 1 point 494 K and the voltage across this is V pie with this polarity.

We have the output current generator g m V pie, g m is already found out point 067 volt. Then we have we will combine everything into one resistance. R L prime is R C which is 3 point 3 K parallel, 100 K shall come in parallel from the collector to ground through bias C 3 then we can also include r 0 which is 86 K, this is 3 point 3 K R sub C and this calculates up to 1 point 86 K.

Student: How about parallel 4 point 7 K?

Oh! We must take that into account yes, parallel 4 point 7 K. That is how I get 1 point 86 K, okay.

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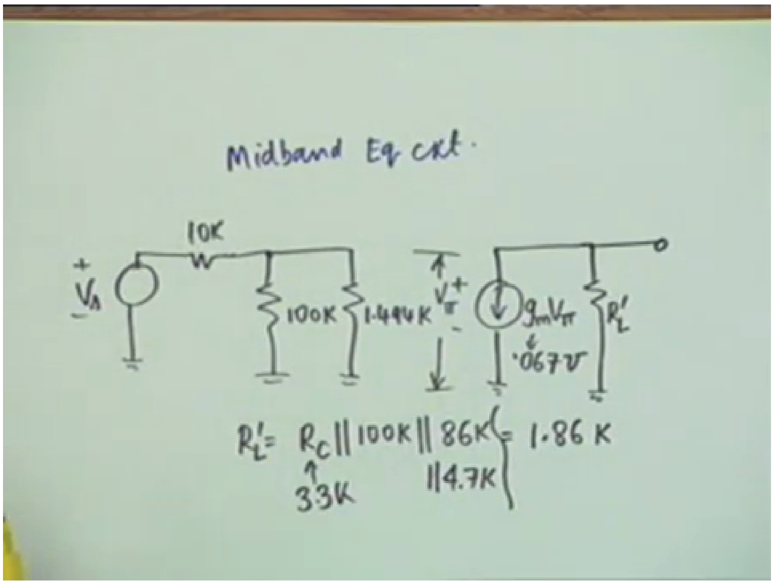

Therefore I hope I did calculate, yes. Now therefore A v s 0 would be minus g m R L prime multiplied by V pie divided by V s, agreed? So this is calculated by inspection and observation, no equations are needed. Let me write this minus g m R L prime, I am writing this separately because I am not writing numerical values right away and I am not calculating because of a specific reason. What is the reason? I need this value. Why? For calculating the miller capacitance so I keep it separately.

These are tricks of the trade. Otherwise we will have to go back and calculate it again. So I did it in one step. Then my V pie over V s is 100 K parallel 1 point 494 K divided by R s which is 10 K plus this resistance 100 K parallel 1 point 494 K and this comes out as minus 125 multiplied by this value and I calculated this to be equal to minus 16, okay.

I do require this value 125 because I have to calculate C T. Let us calculate in one step, C T the total input capacitance is C pie plus C mu 1 plus g m R L prime. I know everything C pie, I know C mu, I know g m R L prime, this becomes 257 pars. This is the equivalent capacitance.

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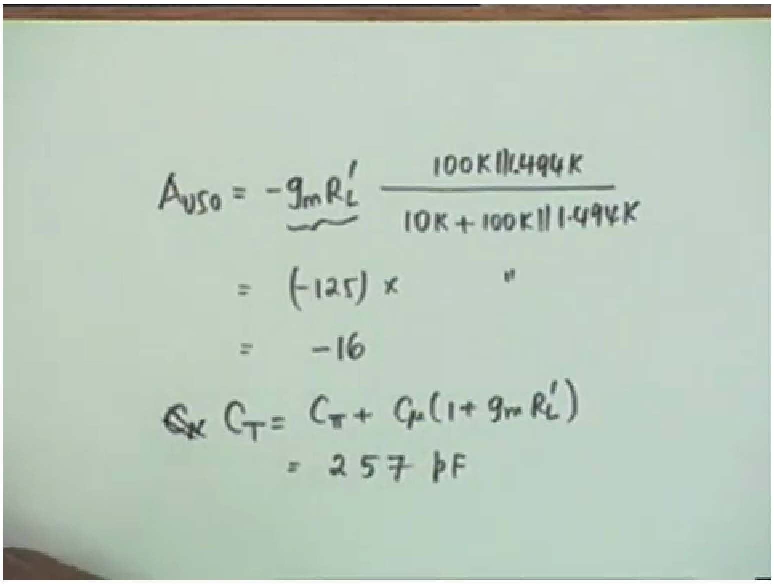

And therefore the omega H 1 due to the input capacitance would be given by 1 over C T 257 pars multiplied by the equivalent resistance across it which is 10 K parallel 100 K parallel 1 point 494 K and my calculation gives this value as approximately 3 times 10 to the 6 radians per second. The other high frequency critical point due to R L prime and C 0 plus C mu which is at the output is equal to, is this clear or I have to show the circuit again?

Student: No sir it is clear.

It is clear, so this would be C mu which is 2 pars multiplied by, I have calculated the equivalent resistance as 1 point 86 K and this is greater than as you can see very easily 250 multiplied by 10 to the 6 rps. So omega H 2 can be ignored if you so desire and omega H the high frequency 3 degree point would be approximately 3 times 10 to the 6 radians per second. But since the question asked is to find A v s j omega, you must include this, okay. You must include a factor 1 plus j omega divided by 250 multiplied by 10 to the 6.

Is the question clear? The question I did not ask find the high frequency 3 degree point, no. I asked find an expression for A v s j omega and therefore this must be included. If the question was to find the high frequency at 3 degree point this is perfectly alright, okay.

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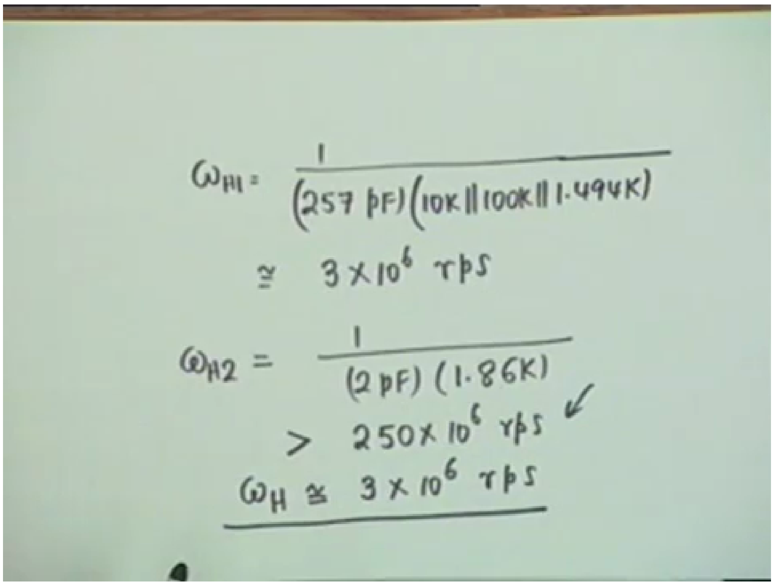

Now let us go to the low frequency.

Student: (())(18:30)

No, the time comes constant method, okay, that is a good question. Let me answer this question. You see the only way that this equivalent circuit differs from the high frequency, if I want to convert it to high frequency I apply this approximation of C T and this is C 0 plus C mu. Now it is no longer the method of time constants and the analysis are exactly the same. If you write V pie over V s this critical frequency will come. If you write minus g m times this the other critical frequency over here is (())(19:18).

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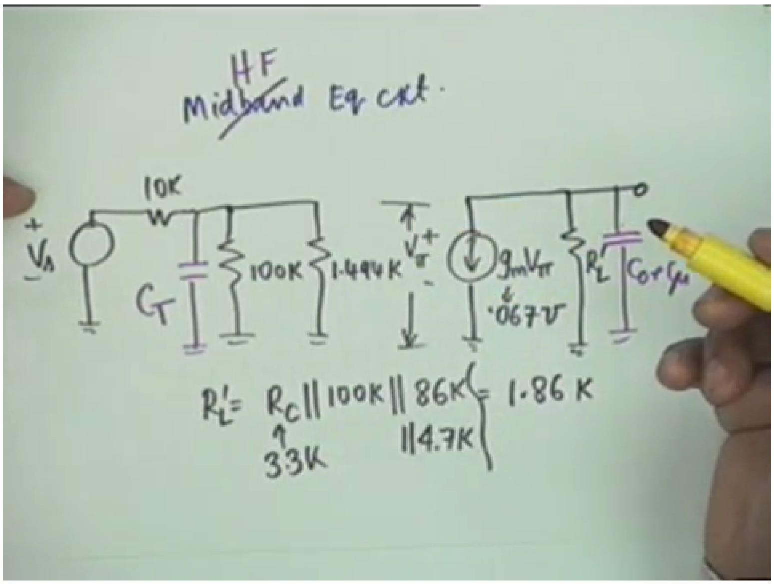

So after the approximation the method of time constants and the method of analysis are the same. As it is said the method of time constants has to be used when there are many capacitors. This is as good as analysis. It gives you same result as method of time constants and this is what was used to validate or give confidence regarding the method of time constant. That in simple case the results are identical. In complicated cases no sorry they are not identical, they differ, okay.

Now the low frequency equivalent circuit as I said in low frequency equivalent circuit there are three capacitors now and they are coupled to each other and therefore there is no other way but to consider the effect of each at a time. Fortunately here you can consider the effect of C 1 and C 2 in one go fortunately. So first you assume that C 3 is short circuit. Let us see what the equivalent circuit is. Equivalent circuit as long as C 1 and C 2 are decoupled from each other, the method of time constants and the method of analysis are the same.

And fortunately we can do that here. You draw the equivalent circuit V s. It is always good to draw the equivalent circuit, 10 K, then you cannot miss anything, 10 K, 10 microfarads, this is C 1 then we have the parallel combination of 100 K and 1 point 494 K and this voltage is V pie. Then we have the g m V pie. We do not require the exact values of this because g m does not determine the time constant.

Then we cannot combine 4 point 7 K here because we are considering the effect of C 2. So 10 microfarad this is equal to C 2 and we have a 4 point 7 K. So this resistance is the parallel combination of r 0 which is 86 K parallel R C which is 3 point 3 K parallel 100 K, anything else? No. That is it and this calculates up to 3 point 08 K.

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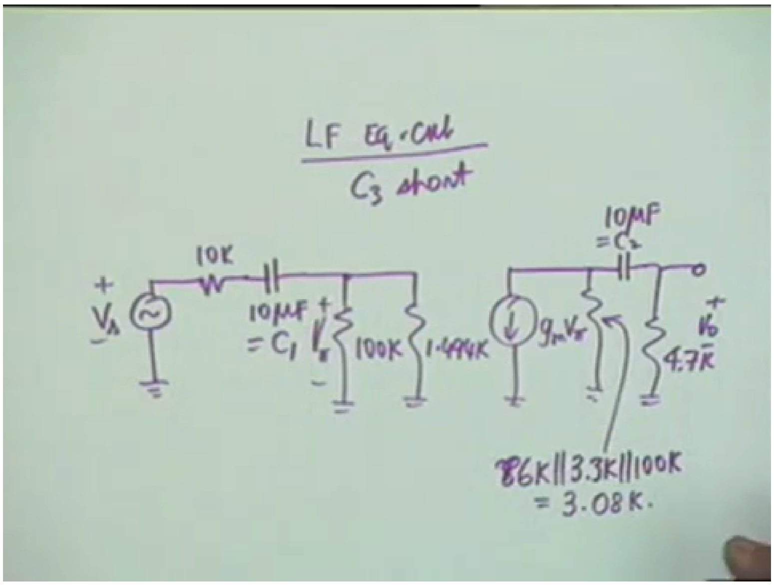

Now here is a point to note. We had to calculate this separately. Why? Whereas we also calculated the parallel this and 4 point 7 K. We could have done it in one step. Anticipating that this resistance will be needed we first calculate this then we calculate 3 point 08 parallel 4 point 7. Rather than putting three resistors in parallel or four resistors in parallel with could have done that just like we calculated A v s 0, alright. These are tricks of the trade with experience you will know that I should not calculate the four together.

I calculate three of them because I require these values separately and then the fourth one, alright. Now you see that C 1 and C 2 are decoupled and therefore the critical frequencies due to C 1 and C 2 can be calculated from this circuit, alright. Omega L 1 for example due to C 1 would be 1 over, the capacitor is 10 microfarad and the minimum resistance not the method of time constants or otherwise it is the same.

Minimum resistance would be 10 K plus 100 K parallel 1 point 494 K and this calculates out to 8 point 7 radians per second. Omega L 2 due to the second capacitor comes out as 10 microfarad once again multiplied by 4 point 7 K plus 3 point 08 K, okay. The current source is opened and this calculates out to 12 point 85 radians per second, alright.

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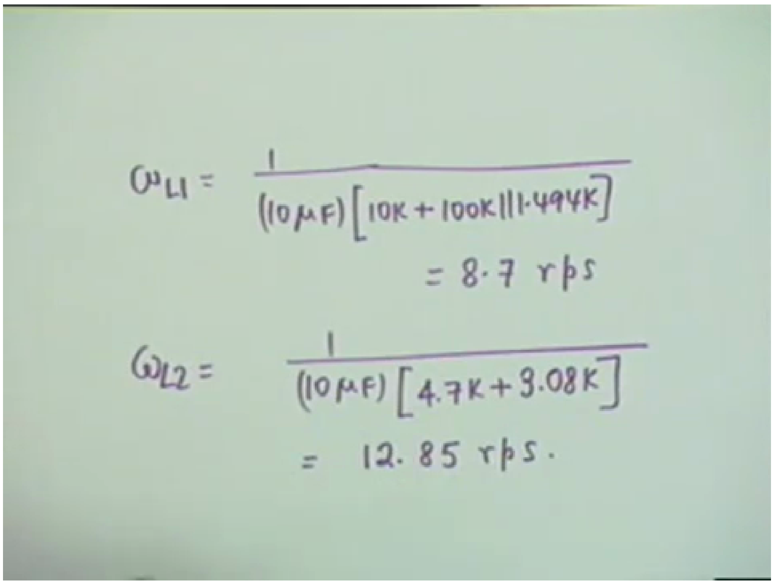

These two are comparable, is not it right? They are comparable. Even omega L 1 squared and omega L 2 squared one cannot ignore because the ratio is simply 1 point 4, okay. However these two are not the only culprits there is a third culprit C 3 which creates a complication in the calculation of omega L 3. And we have to draw that circuit separately and it is instructed to consider how this circuit is drawn. You see as far as C 3 is concerned if C 1 and C 2 are sorted then by equivalent circuit draw this carefully.

We have this 100 Ks like a dumbbell, two 100 Ks on two sides and this is my C 3. This is the provision occupied by C 3. Okay. Let us draw C 3 which is 10 microfarad. Then on the left comes r pie which is 1 point 494 K, this is V pie and comes a 10 K in series with V s, the joint equivalent circuit considering C 1 and C 2 as short and effect of C 3.

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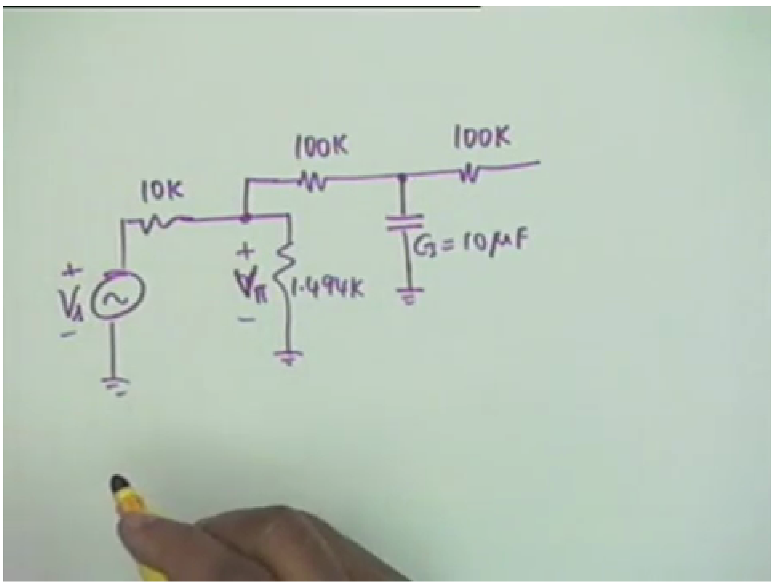

And on the other side we have the g m V pie then in parallel with, how much is this? This now contains 4 point 7 K also. So 1 point, what is the value? 1 point 86.

Student: Sir, then it will not contain 100 K.

It will not contain 100 K, yes, wonderful. It cannot contain 100 K now. Very good. So we have to calculate the value. This gives us another lesson that we should not have calculated those four resistances at one time. We require these three values separately, okay. Who is this boy who pointed out this? Name?

Student: Atul Swaroop.

Atul Swaroop. Okay, it is very good. I appreciate it. We would have made a great blunder if we would have included 100 K. Why great blunder? Because r 0 is comparable to 100 K, is not it right? That 86 K suppose r 0 was not there, if it is simply R C parallel R L then the error would not have been much by ignoring that, okay.

So we have to calculate this and now the problem is that looking from C 3 what is the resistance that it sees and therefore what we have to do is to find out the equivalent we have to short this and then we have to replace this by means of a voltage generator V and calculate the current I. Then V by I shall give equivalent resistance.

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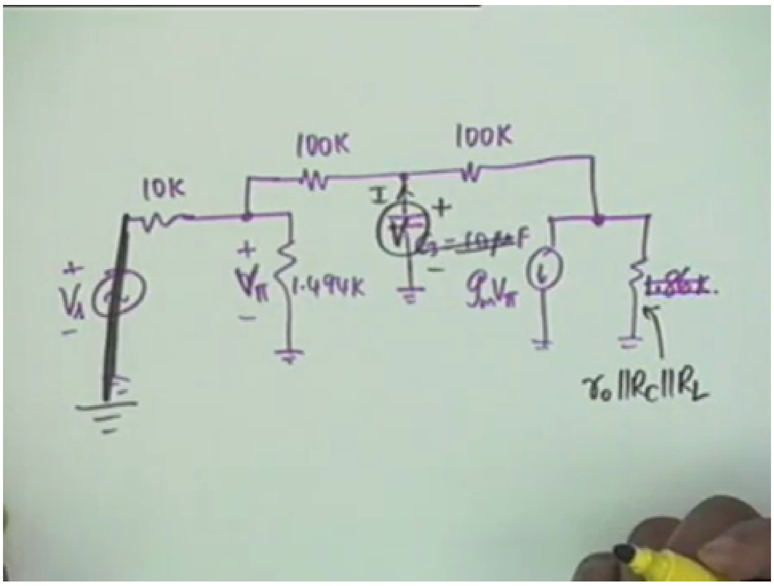

It cannot be obtained by inspection unfortunately. So let us draw a clean circuit on a clean slate and then proceed. We have a V and this current is I, on the two sides there are two 100 Ks then we have a g m V pie. You cannot open it because this is a controlled source. V pie is not zero, okay. What is V pie? V pie is the potential division between 100 K and the parallel combination of 1 point 494 K which is r pie and R s which is 10 K. So this is V pie and V pie is not zero therefore we cannot make this open.

And in addition we have the parallel combination of r 0 parallel R C parallel R L. What we have to do now is to write. Okay, I think write V pie in terms of V by inspection, correct? This would be 10 K parallel 1 point 494 K divided by 10 K parallel 1 point 494 K plus 100 K multiplied by V.

So V pie I know in terms of V then I have to write a node equation here, okay. I have to write I as equal to, what is this current? This current is V pie divided by this parallel resistance so V pie divided by 1 point 494 K parallel 10 K, it is this current, okay. Then this current is if I call this voltage as V 1 is V minus V 1 divided by 100 K.

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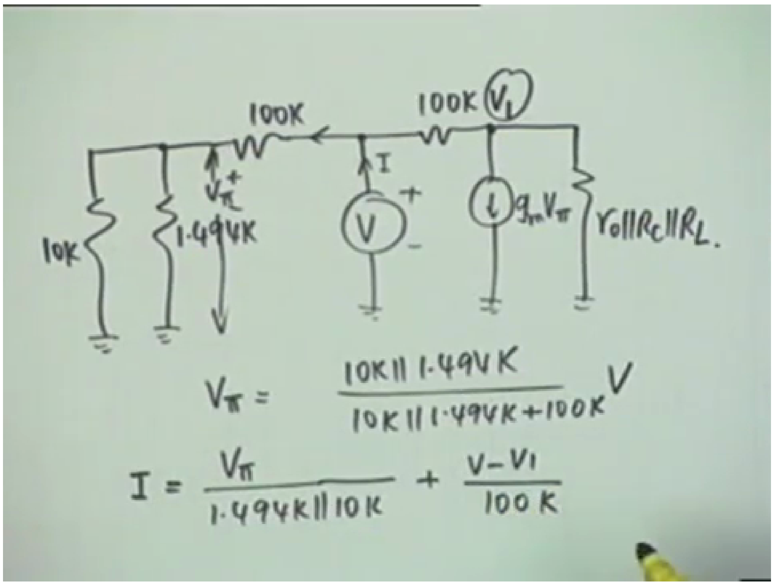

I now want to know what is V 1? Okay. We also see that this current is equal to g m V pie plus the current through r 0 parallel R C parallel R L so my third equation would be V minus V 1 divided by 100 K equals to g m V pie plus V 1 divided by r 0 parallel R C parallel R L. There are three equations now and the systematic way to proceed is to replace V pie. So we have one equation, second equation and this is the third equation.

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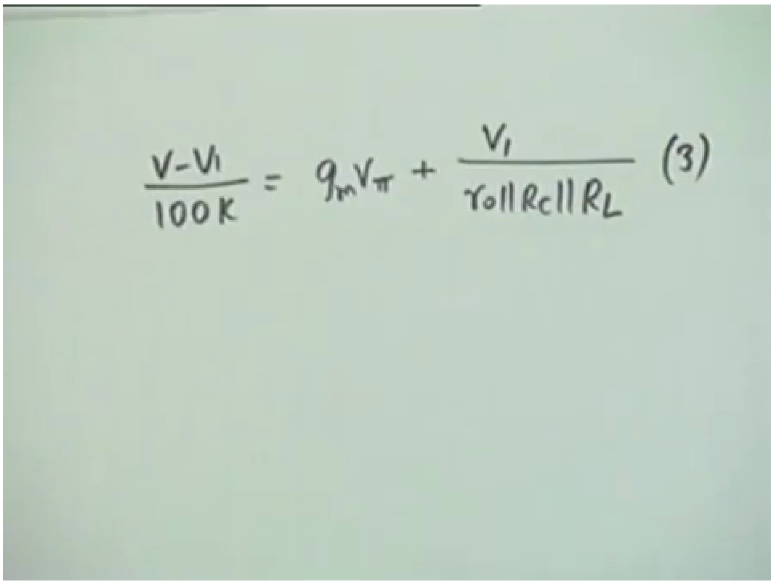

From one I replace V pie. Wherever V pie occurs I replace V pie, alright. And then from the third I get V 1 in terms of V and then I substitute in this equation.

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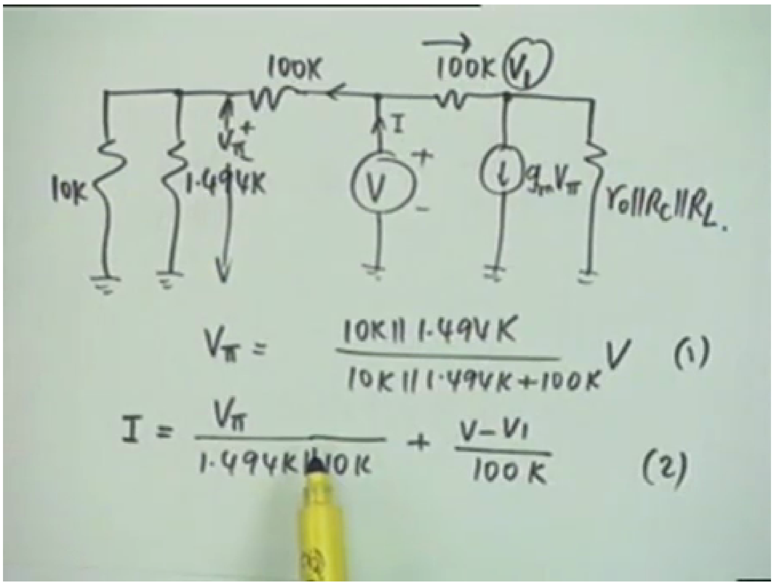

I divide both sides by V that is the input conductance reciprocal of which is the input resistance. It sounds complicated but it is not complicated because we work in terms of numbers. I have not simplified this but I must assure you I have calculated and my calculation after some calculator approximations and sleepiness approximation my calculation gives omega L 3 as approximately equal to 2 rps. So 2, 8, what was the other? 12 point 85. So who controls?

Student: 12 point 85.

No, this is the answer I was expecting and I wanted to correct you. No, it is the highest but even that does not control 12 point 85 because there is a frequency close to it. So this is a freak case. This 2 radians per second can perhaps ignored compared to other two 8 and 12 because one is four times one is six times.

Student: (())(32:12)

Well we have calculated r 0 plus R C parallel R s. Yes, 100 K comes here. This we have to calculate independently. That is what I said that we learnt two lessons that we should not go ahead calculating the equivalent of four resistances because equivalent of three resistances are also required so it will do in two steps, okay. So who controls the low frequency response?

Omega L is controlled by omega L 1 omega L 2 because omega L 1 by omega L 3 is approximately 4 and the square is 16 and omega L 2 divided by omega L 3 is approximately 6 the square is 36, okay. But the total A v s j omega now has to be written in terms of what we found out for A v s 0.

Then 1 minus j 2 divided by omega (())(33:29) 1 minus j 8 point 7 divided by omega, 1 minus j 12 point 85 divided by omega multiplied by 1 plus j omega divided by, what was omega H 1? 3 into 10 to the 6 and 1 plus j omega divided by 200. I did not calculate that. I saw it is greater so we put that value whatever value. This is the complete answer. Yes?

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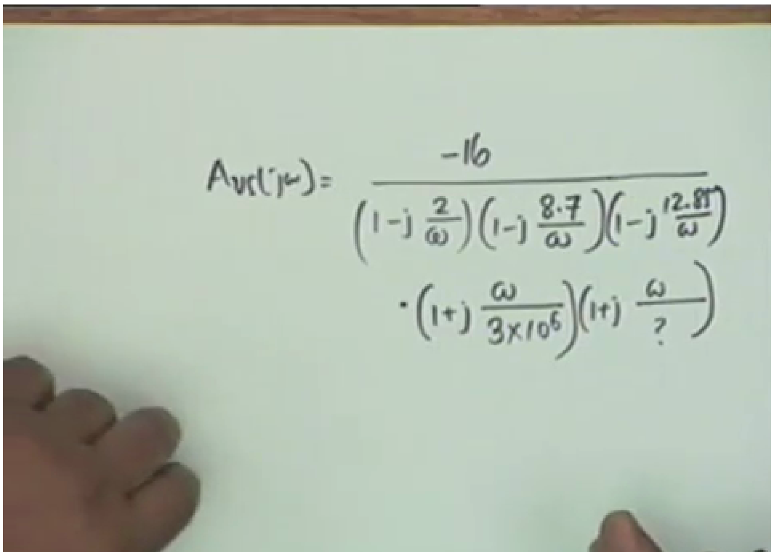

Student: Sir, in order to calculate the low frequency (())(34:14).

That is right.

Student: Sir, what do I do?

What you do? You ignore, okay. Good question. How do you calculate omega L? What you do is you ignore this, you ignore this and you ignore this. If that a high frequency then you have two cut off frequencies and therefore you have to write the equation A V square of magnitude of this is equal to 2 and solve for omega L, okay.

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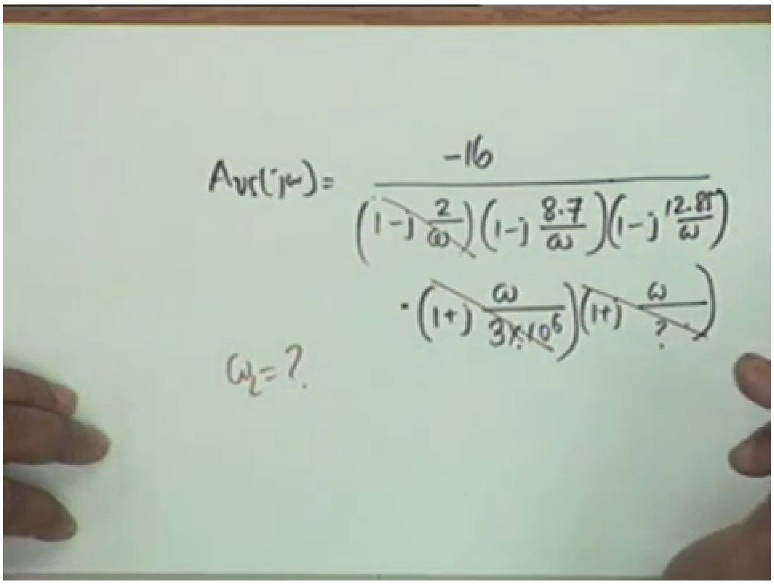

That is it. Exactly like the question number 3 in the minor. Now in the rest of the time we work out a couple of problems on differential amplifiers because I find that you will come to differential amplifiers only in the next week. So let us do some differential amplifier and you will see that this is a different brand of calculation. Even the DC calculations are somewhat different from what you have done so far.

The first question (())(35:28) a simple problem R sub C, R sub C, this is 10 volt and R sub C is given as 100 K, not the large value of R sub C. This is a microcircuit. It is an integrated circuit. This R sub C is not a lumped resistance it is a, what is it? It is another transistor. It is a current source with output input as 100 K but that we will see later. Suppose it is discrete, even in discrete differential amplifiers what we are interested in is voltage gain not power again.

Not voltage level or current level and therefore your signals can be microvolt order and your I sub C 1, I sub C 2 can also be in the range of microampere, alright, because it is voltage which is of importance, okay. So R sub is large. We have two transistors. It is a discrete circuit let us say, okay. We will calculate this as a discrete circuit. There is an R sub E E and the current through this is 100 microamperes. This is equal to I sub E E and this is taken to minus 15 volt which is minus V E E.

This is plus V C C and of course because it is a differential amplifier, the two inputs B 1 and B 2 they are left as terminals to be connected to sources. The differential voltage is to be connected between these two. As far as DC is concerned unless the source resistance is specified this would be considered as grounded, okay. So that forms the heart of DC calculation. Now the question is capital T is given as 25 degree C that is the normal room temperature which means that you can use V T equal to 26 millivolt.

V A is given as 100 volt which means you know what is r 0. R 0 has to be combined with R sub C and they are now comparable, okay. So V A can never be ignored. Beta as I said you must require very high betas for these transistors. Beta is 200 and the question is to calculate Q points of each transistor. Naturally Q point of any one transistor will suffice because the two are identically biased. Q points of each transistor, you require the value of R E E to be able to support a 100 microampere current.

What value of R E E is needed if these two supplies 10 volt and minus 15 volt? Note that they are not identical. In ICs usually they are identical but to bring variety to experience we assume that to be non identical and we also want the value of R i d, the differential input resistance. We require the value of A sub d, the differential mode voltage gain. And fifth we require the value of a common mode voltage gain A sub C, okay. This will completely analyse the amplifier.

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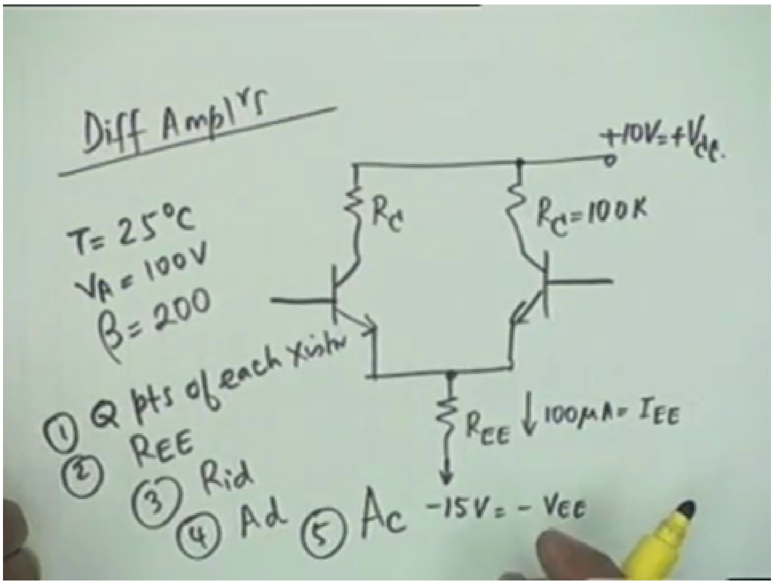

So the first thing that you should do, you should check the Q point that is find out I sub C and V C E. Now to find I sub C our procedure would be slightly different from what we were using earlier. You see what we do is first we write 10 volt equal to, do you know this current? How much? R C is given. R C is 100 K. This must be half of this, 50 microampere because beta is large, okay. So I know R C, I know 50, I know the current and therefore I know the drop here.

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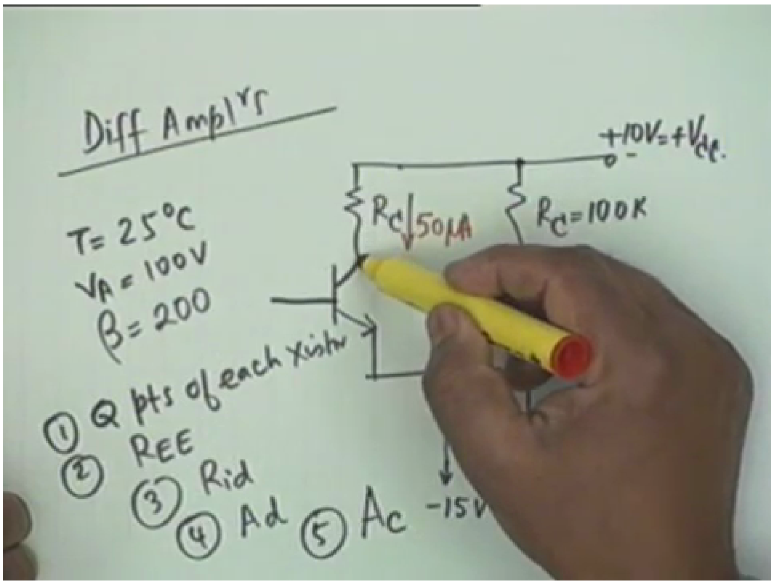

Then what I want to find out is this V C E, okay. So 10 volt is equal to the drop in R C plus V C E then we could have gone through this but we did not. We go via this because I know as far as DC is concerned this point is grounded, so this voltage is point 7 with minus and plus agreed?

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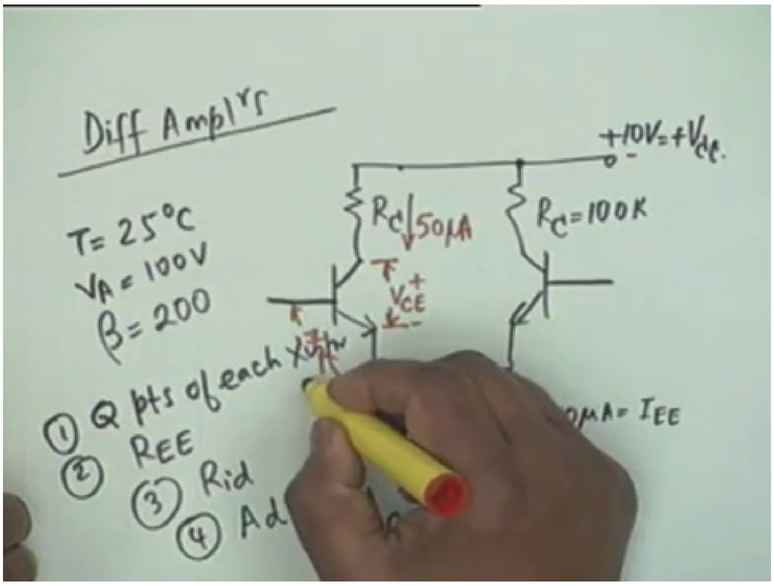

That makes a shortcut. I do not have to go through this. So my DC equation becomes 10 equals to 100 K multiplied by 50 microampere plus V C E then minus point 7 because I go from the emitter it to the base which gives me V C E as equal to 5 point 7 volt. Wonderful, so 5 point 7 volt and 50 microampere is the Q point of either transistor. Now to find out R E E. Yes?

Student: It is not clear.

It is not clear? Okay, 10 volt how is this connected? Plus 10 and negative ground so 10 volt is equal to the drop in R C plus V C E that come here when I go to ground that via the base of transistor 1. That is why minus point 7. This voltage is point 7 volt, okay. And I found out V C E.

Student: Sir how do we get 50 microamperes?

How do I get 50 microamperes? This current 100 microampere is approximately twice I sub C. I sub C 1, actually it is I E 1 plus I E 2 but since beta is large this is approximately I C 1 plus I C 2 are identical and that is why it is half.

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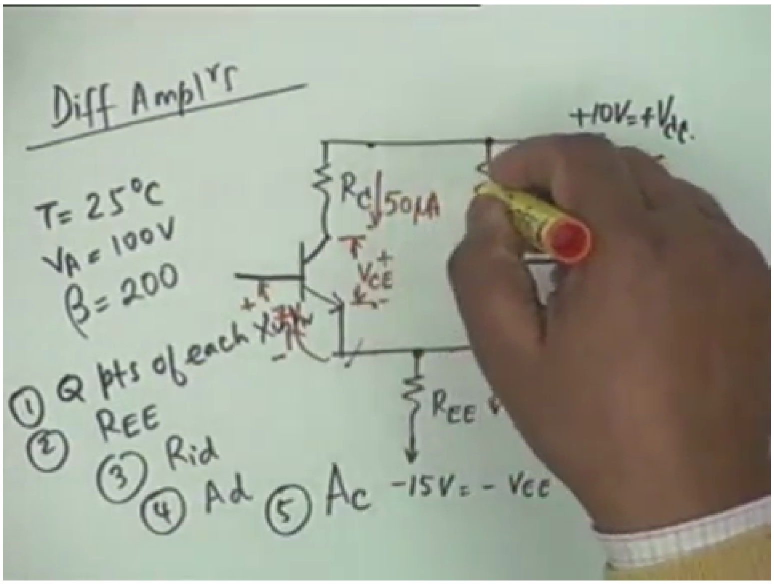

Any other question? Now to calculate R E E what we do is we come from here and go to the negative supply. We write a KVL. So what should I write? Point 7 plus R E E multiplied by 100 microampere then I have to go to ground via this supply minus 15, plus minus, plus minus, then minus plus therefore minus 15 which gives me R E E as equal to 143 K. Is this point clear?

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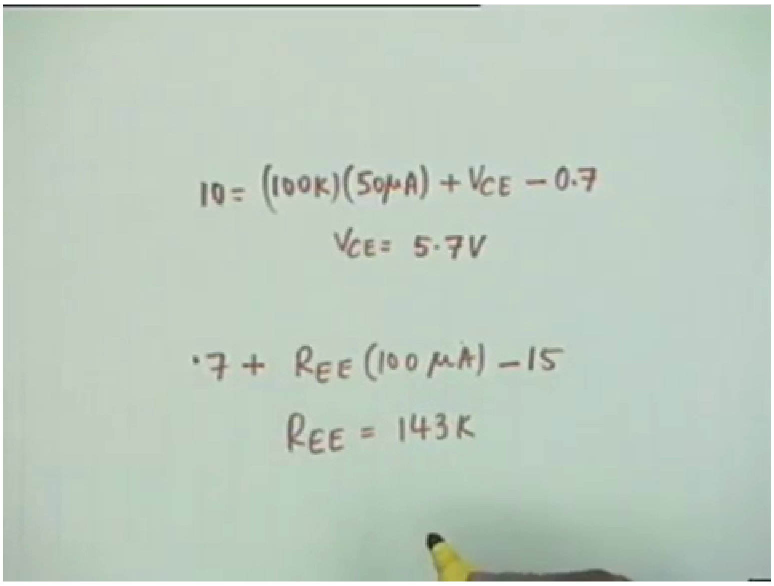

I come from the base of transistor 1 from ground point 7 plus the drop in R E E plus whatever potential this point is at. This is a minus 15. So that is what I write. You have to be careful in these calculations, okay. You have to find shortcut, okay. That is what distinguishes an engineer from a non engineer. I will not say a scientist, a non engineer, okay. So I have found out R E E and once I know these parameters then other parameters calculate very easily.

G m is I sub C that is 50 microampere divided by 26 millivolt and this calculates out as 1 point 92 millivolt. One side of g m then I know A d. A d is minus g m, the differential mode gain, minus g m R C parallel. What? R 0 small r 0. I cannot ignore it. R C is 100 K and what is small r 0. V A was given as 100 volt okay, 100 volt divided by 50 microampere which is equal to 2 megs. 2 megs is 2000 K.

20 times this but even then because of high gain calculations we include this. Be kind to r 0 and do not ignore it. This in my calculation comes out as minus 183, okay.

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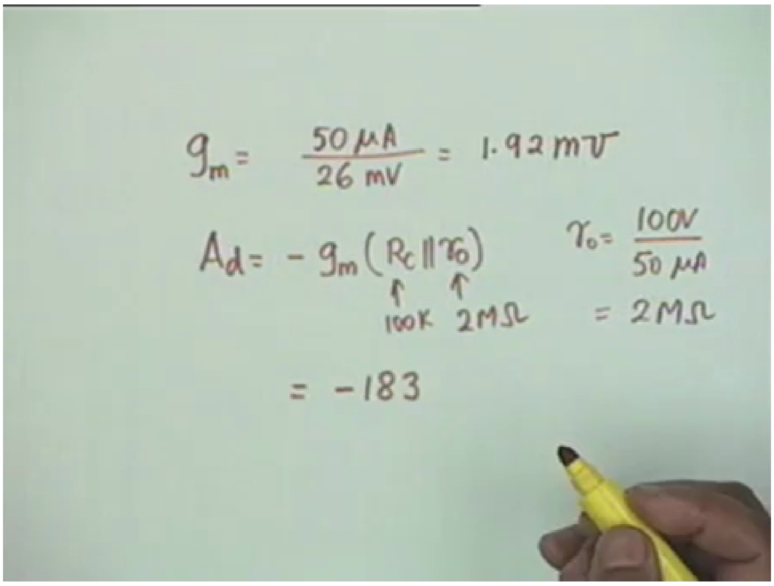

Then I require an R i d which is equal to twice r pie. Now what is r pie? That is 2 times beta is 200 divided by 1 point 92 millivolt. You see how large r pie is. Approximately 104 K. Why does it happen? Because of the low values of collector current, okay. So no longer any of these can be ignored. R x fortunately is a ohmic resistance. It still remains 100 volts. So it does not depend on current that r pie cannot be ignored, r 0 cannot be ignored and this is 208 K. This is high input impedance amplifier.

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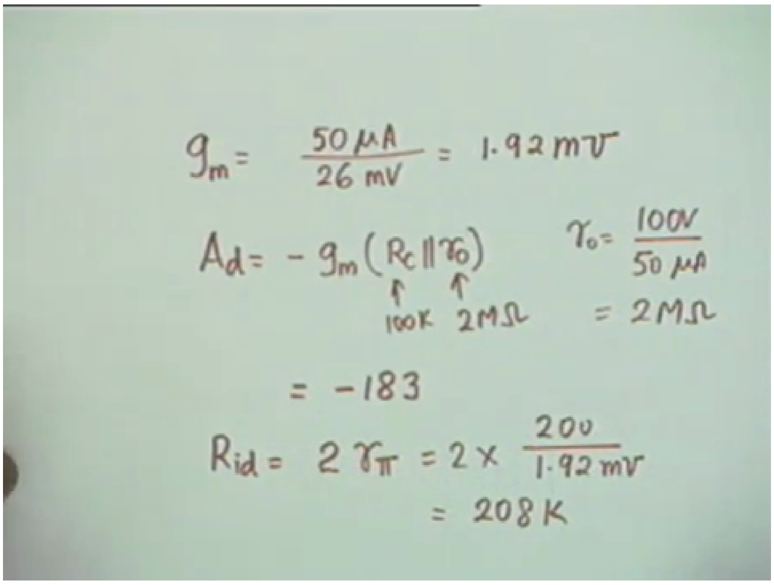

Finally I have to calculate the common mode gain which as you know is minus g m R C divided by 1 plus twice g m times R E E. This is also an approximate expression but fairly accurate. Minus g m R C we have already calculated minus 183, 1 plus 2 into 1 point 92 into 10 to the minus 3, 1 point 92 millivolt multiplied by 143 multiplied by 10 to the 3. Yes?

Student: Sir that is minus g m R C parallel r 0.

Yes, that is correct. Thank you. That is why I used 183. I missed that term. 1 plus 2 g m R E E and how much is this? 143. Approximately point 3. It is a fraction. You see this 10 to the 3, 10 to the 3 cancels. Take this as 4. 4 times 14, 516. So approximately one third, approximately minus point 3. What is this C M R R then? 183 divided by point 3. That is more than 500. C M R R is more than 500, okay.

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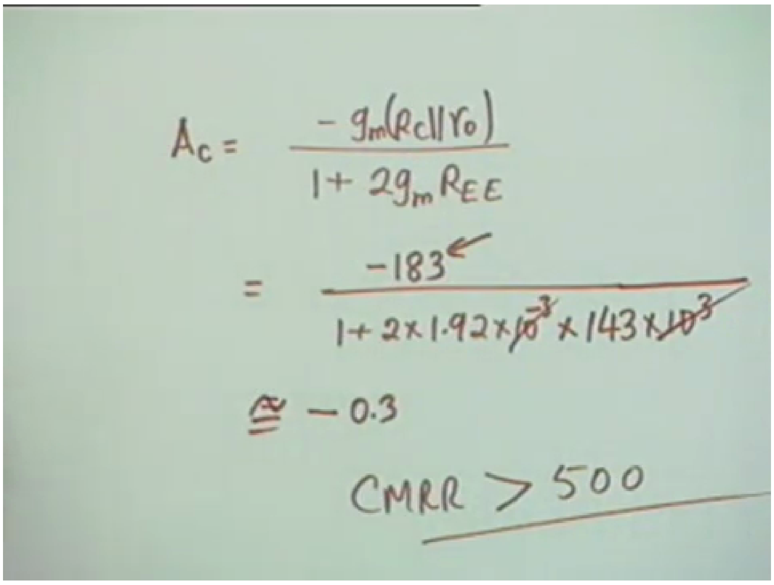

The third question, I will indicate the question and leave it to you to work it out. Third question is design a differential amplifier. Now no longer analysis. What I want is given, you have to give me the circuit. Design a differential amplifier that meets the following specs. I shall briefly discuss how to proceed. Specs are R i d equal to 2 meg. Differential input resistance must be 2 meg. A sub d, the differential gain I require minus 500. C M R R I require 54 decibels.

These are the ways people specify practical specifications and V C E Q that is the transistors Q point must be a very safe value, 5 volt specified. Assume that the transistor beta is 200 that is we are given a lot of transistors. A lot, not many. I mean a lot, maybe a lot of 10 or lot of 12 identical transistors. In it beta is 200 and V A is 150 volt. This is what is given, you are required to design.

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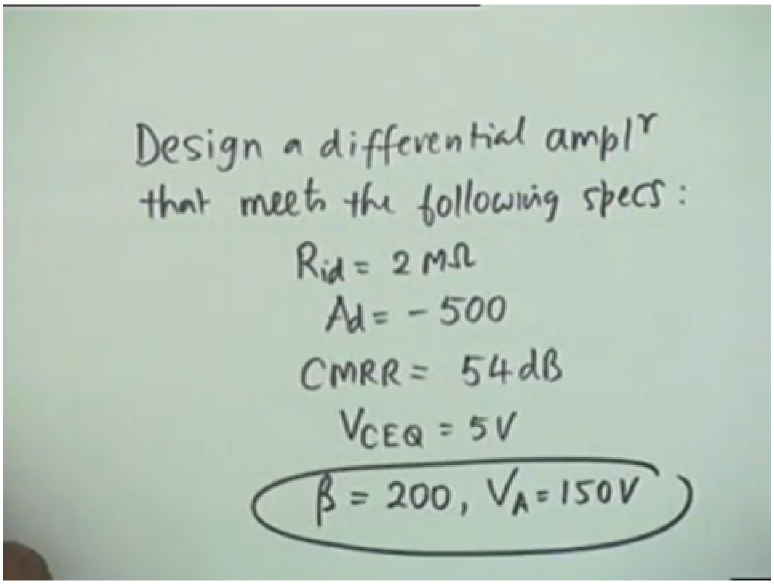

Now what does design mean? Design means you will have to specify V C C, you will have to specify V E E, you will have to find out R E E, you will have to find out R sub C. What else? That is all? That is all there is to you? Okay. How do you proceed? First from this specification we know what is r pie, alright. And if you know r pie and you know beta therefore you know g m.

If you know g m then you know I sub C, the collector current, okay. Agreed? From R i d, okay, let me draw the chart. From R i d find out r pie. Then combine the information on beta to find g m. Combine the information of r pie and beta to find g m. From g m you find out I sub C, okay, alright.

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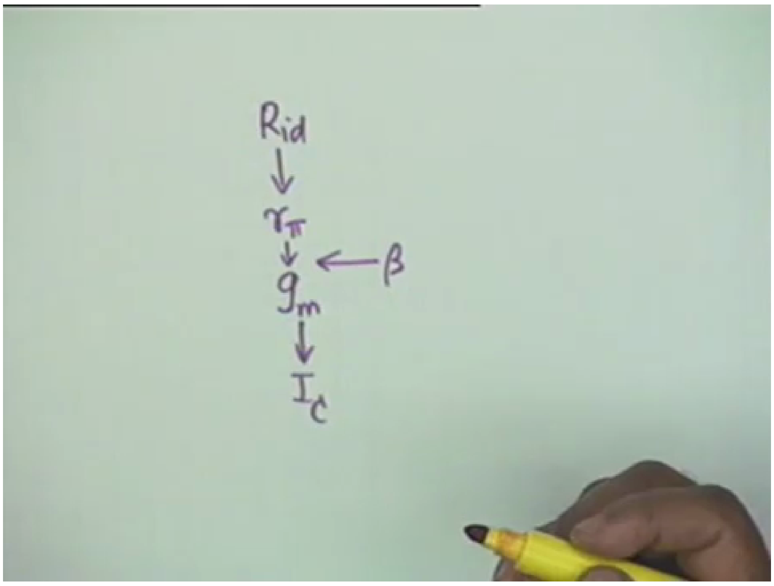

Now V C E Q is given, right? Therefore from V C E Q and sub C now can R C be found out? No, in DC condition V C E is equal to I sub C multiplied by R C plus V C E Q minus point 7 and therefore from this you can find out R sub C, okay. Then.

Student: Sir, we do not know V C C.

Wonderful, so you cannot do that. V C C has to be found out.

Student: (())(51:24)

From the gain A sub d minus g m R C parallel are known. R 0 is known because we know I sub C and V A has been given and g m is known therefore from A d you can find out R sub C. And if you know R sub C then combine this with given information on V C E Q and I sub C to find out V C C. Next how do we find V E E? From this, no wait a second. From this C M R R it is given in dB.

So first we have to convert it to a fraction, a number, okay. First we have to convert that is 54 equal to 20 log 10 of C M R R from which you have to find out C M R R as a number and that C M R R is equal to how much? Twice, this has to be there at the end of your lips.

Student: Sir A d upon A C.

No, you do not know what is A d. It is C M R R. C M R R is twice g m R E E. So if you know the C M R R and you know g m, you know R E E, okay. C M R R was A d upon A C minus g m R C divided by, okay. A C is minus g m R C divided by 1 plus twice g m R E E. Normally load and therefore ratio is twice g m R E E. Since we know g m, since we know C M R R you can find out R E E and if you know R E E finally you find out V E E and the design is complete.

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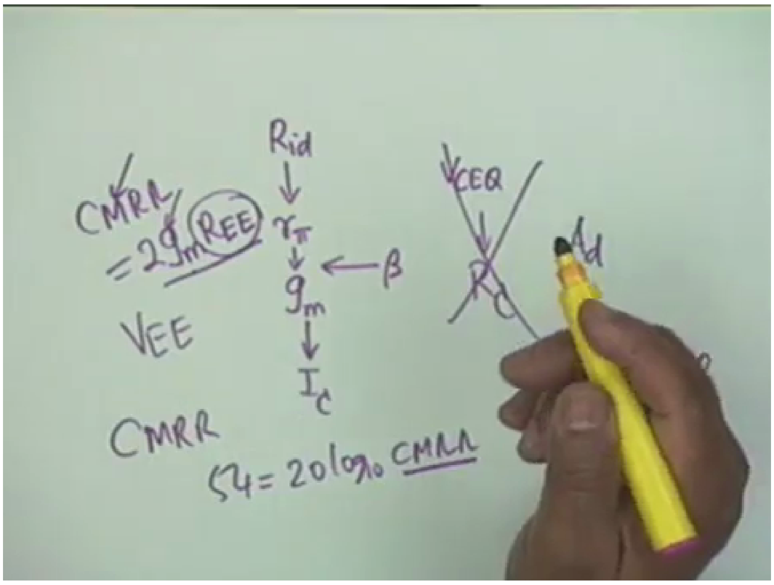

Would you care stop a minute and note down what my calculation get. Okay, my calculation says that R sub C is equal to 2 point 7 meg. Then V C C is equal to 17 point 3 volt, R E E is equal to 1 point 25 meg and V E E is 13 point 7 volt. Not very nice numbers but this is unfortunately what you design.

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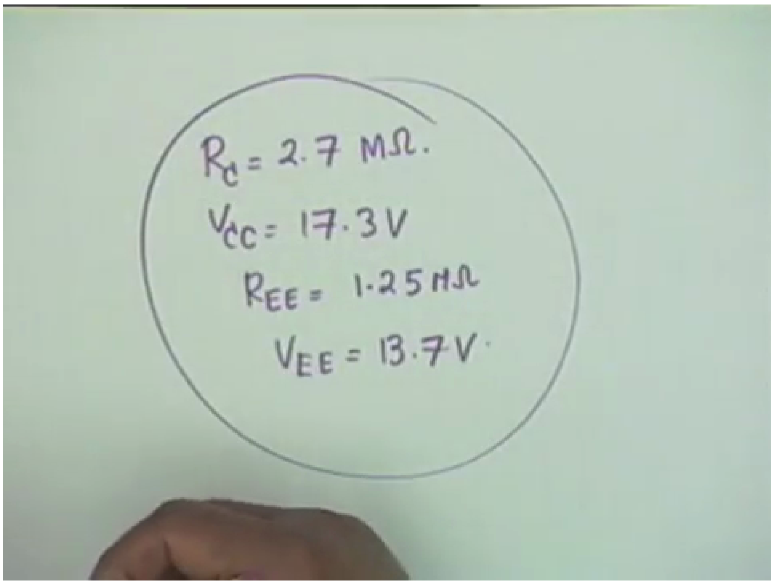

Do you require anything else? Okay, that is all for today.