Analog Electronic Circuits
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Lecture no 15
Module no 01
Problem Session-4 on Midband Analysis of Amplifiers

This is the 15th lecture, problem session 4 on mid-band analysis of amplifiers. As I had commented last time we would may have a brief discussion on common drain amplifier CD, before we take problems.

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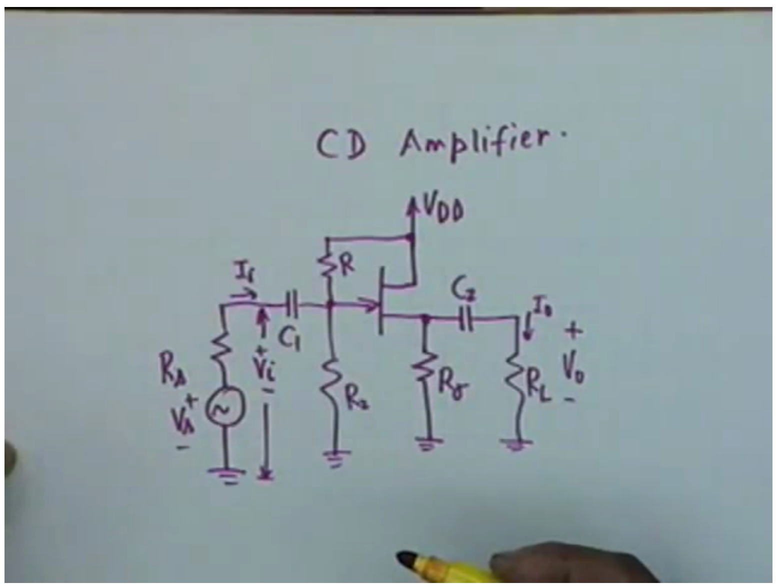

Common drain amplifier and the circuit is very simple, V DD then you have no resistance here at least for AC, common drain therefore D should be V irtual connected to ground as for AC is concerned and obviously the load is to be on the source that is R Sigma, and from here you take the output R L, this is V 0 and this current is I 0. To bias a grid I am sorry the gate G we have 2 resistors as usual R 2 and R 1 and the input is applied here through a capacitor C 1 coupling capacitor C 1 to the source of resistance R S and voltage V S, this is the common drain amplifier and obviously the voltage here is V i and it is this gain V 0 by V i that we are interested in.

If you know this gain then you know the current gain, we have to calculate I sub i, we know the current gain we can calculate the input resistance and also we have to calculate the output resistance but V 0 by V S that is A V s can also be found out okay.

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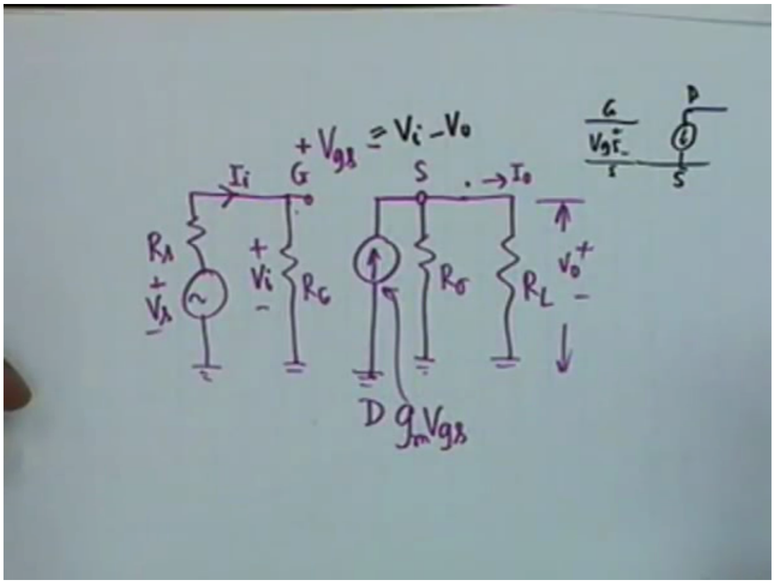

The equivalent circuit here if you go step-by-step if you go step-by-step, R s, V s goes to ground then we have the parallel combination of R 1 and R 2 which will be R G as we have already called it R sub G and this voltage is V sub i, this current is I sub i and then this is the gate terminal the drain is connected to ground so the source terminal will now act as the load, the output terminal R Sigma then R L this is V 0 and this is I 0. In addition from the drain to the source we shall have a current generator, the drain is grounded from the drain to the source so it would be in this direction and value of the current generator would be g m times V gs and V gs is this voltage + - okay, this is the story as far as equivalent circuit is concerned.

But do not you see that V gs, is this direction clear the direction of the current generator? Current generator is from the gate is from the drain to the source, the drain is grounded, I should have actually drawn drain here ground there but the drain now is grounded so from ground to the source okay this is g m V gs.

Student: Sir in that case of common collector amplifier the direction of IC is opposite to the conventional amplifier.

Professor: No it was the same, g m V pi has come from ground to the emitter, it is the same.

You have to remember that our equivalent circuit V gs and then you have g m V gs here. Now S D is grounded, so from D to S from D to S that is why it is taken care. We also notice that V gs is nothing but V i – V 0 is not that right? V gs is V i V G – V s, VG is V i and V s is simply = V 0 okay, that simplifies the analysis because you see that if I write the node equation at source node.

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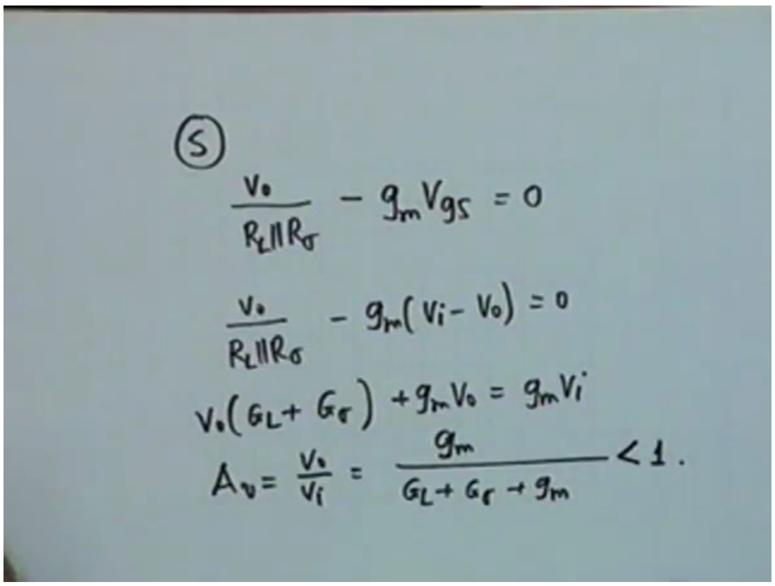

Then I have V 0 divided by R L parallel R Sigma this is the current going to the parallel combination of R L and R Sigma then going current going out and the current coming in so this must be – g m V gs this would be = 0; current through here V 0 by R L, current through V 0 by R Sigma and the current coming in that is g m V gs, but V gs is simply V i – V 0 = 0 and to maintain uniformity you can write the V G L + G Sigma + G L V 0 = g m V i therefore the voltage gain A V is simply V 0 by V i would be = g m divided by GL + G Sigma + g m, obviously this is less than unity as expected. In a common emitter amplifier it is less than unity, in a common drain I am sorry...

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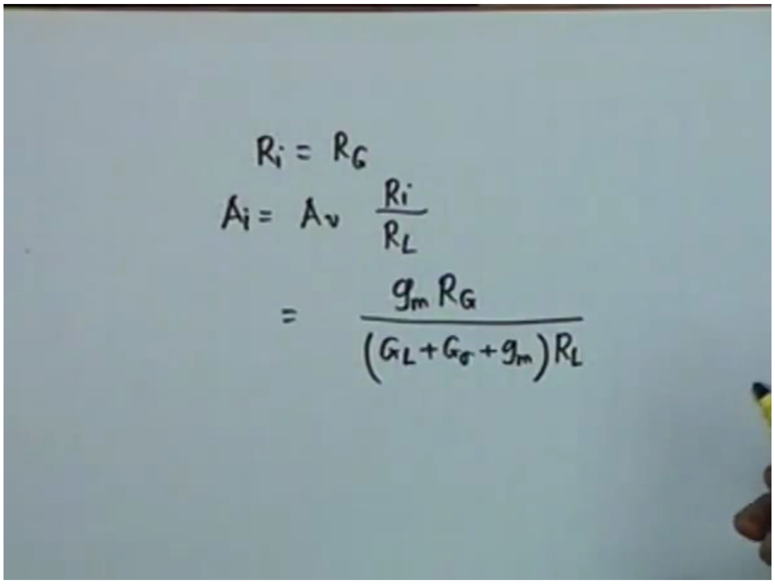

In a common collector amplifier it is less than unity, this is like a source follower exactly like the emitter follower. It is less than 1 but if g m is much greater than these 2 a combination of these 2 then it is approximately 1 okay, so this is also a buffer circuit. Now as far as input impedance is concern you can see that the input impedance is simply R G right, input impedance is simply = R G so R sub I = R G and A sub i which = A v times R i divided by R L would be simply g m R G divided by G L + G Sigma + g m multiplied by R L okay, it must be dimensionally correct it is a dimensionless quantity.

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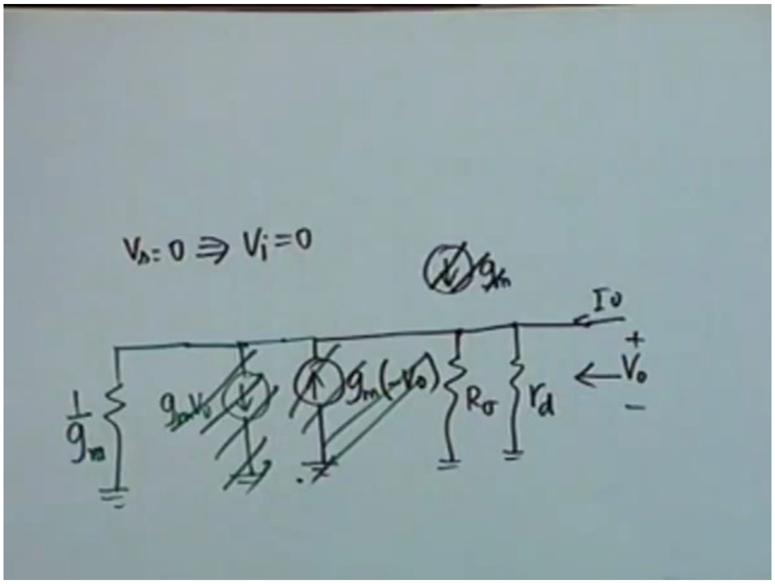

However, to find out the output impedance you have to make a little more thoughts. Now as far as the output impedance is concerned what we have to do is to make V S = 0, if V s if the source = 0 then what is V i? V i is 0 and therefore the equivalent circuit becomes g m it should have g m V i – V 0, V i is 0 therefore – V 0 agreed, this goes to ground then we have R Sigma what else? No R L... We could include... Pardon me… r d we could include r d we did not include it there but r d comes in parallel we could include r d also.

In the equivalent circuit we had drawn earlier we had ignored r d, if you so desire you can include this, let me show you this in this r d comes in drain to source and therefore you could include r d and wherever there is a parallel combination of R Sigma and R L you could include r d also, it does not take any extra efforts to do that I did not do it by not intentionally by mistake okay I should have done it so this is the impedance. Now if you notice, this is my V 0 and this is the current I 0, I 0 will be the sum of 3 currents; one through r d, one through R Sigma and a current – g m V 0, now is not this equivalent to a current which is going out = g m V 0 right agreed, I have simply changed the direction.

Now a voltage V 0 exists across a current generator whose current is g m V 0 so is not this equivalent to simply resistance of value 1 by g m so you can ignore these 2, so I did not write any equation this is simply by inspection and that is the strongest tool that an engineer has; common sense and inspection. Inspection; do not take it in the civiil engineering sense it is observation and there is difference between seeing and observing okay, I will state this later with reference to Sherlock Holmes someday not today. But if you look from here, is not it clear that the output resistance will be simply the parallel combination of r d, R Sigma and 1 by g m agreed?

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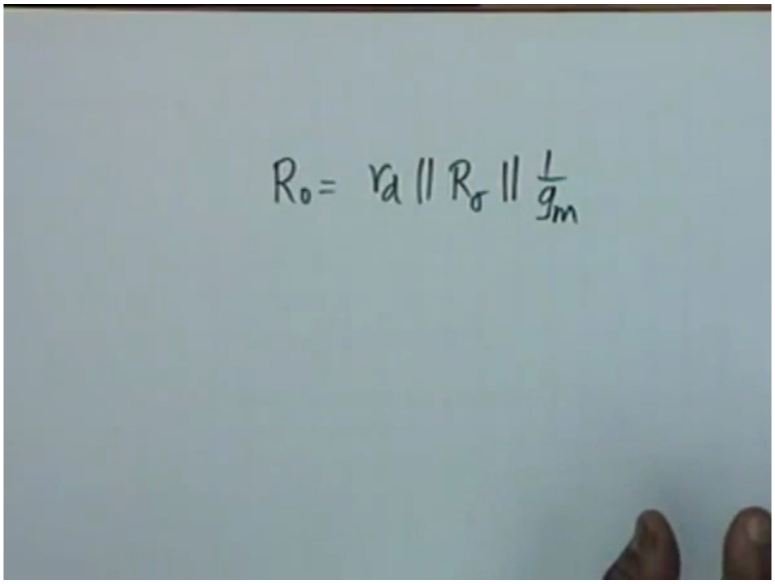

Without any calculation any further calculation I write R 0 = r d parallel R Sigma parallel 1 by g m okay and our calculations are complete.

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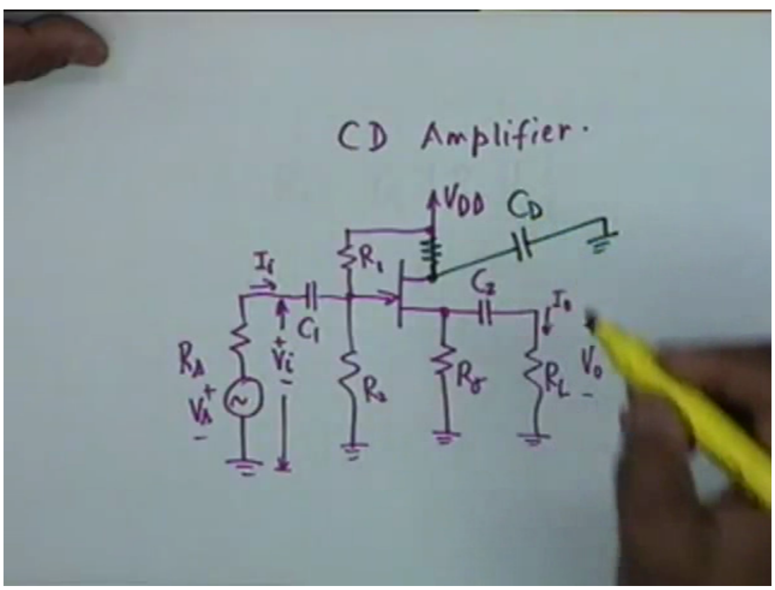

I must point out here that in order to make a proper biasing of the amplifier 1 might be constrained to use a resistance here one might be constrained, exactly like the emitter follower you might be constrained to use a resistance here, if you do that then obviously what you have to do is to collect data distortion by using a CD to bypass this resistance is that clear?

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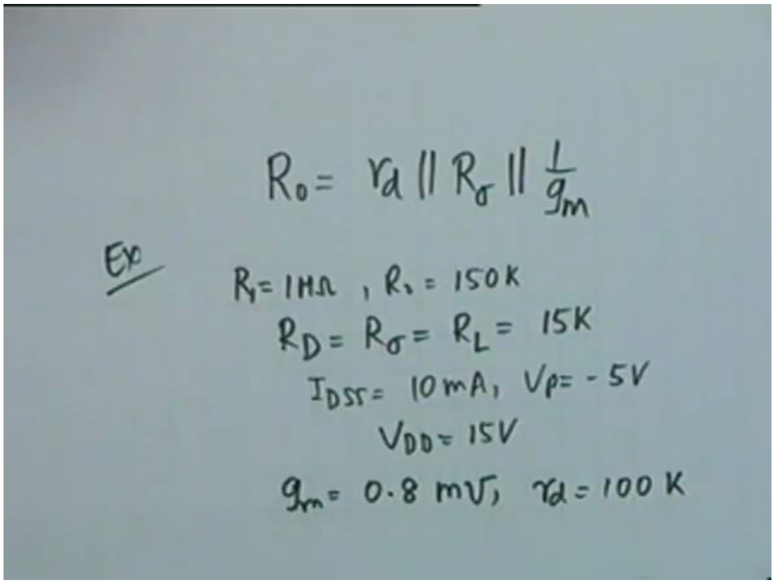

Okay, if we take the same example that we had taken earlier same example in which your R 1 was 1 megh, R 2 was 150 K, R D = R Sigma, R D now has to be bypassed, R Sigma = R L = 15 K that is the value that we took, I DSS was taken as 10 milliampere, VP was taken 5 volts and under this condition we did something more, what else we did? V DD that was 15 volts, and under this condition we found g m as 0.8 millimho and r d was given as 100k. If we make this calculation, please do correct the formulas by including r d including everywhere that R L parallel R Sigma has occurred.

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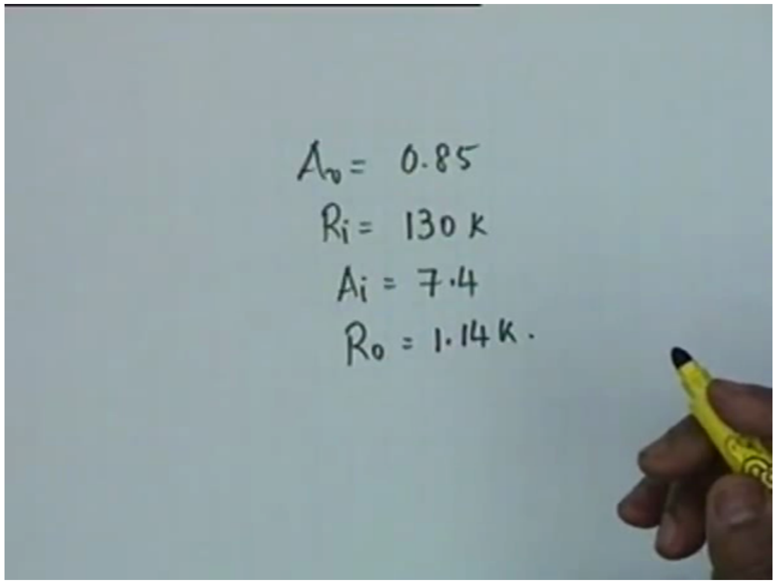

If you do this calculation you get A sub v as 0.85 it is less than 1 as expected, the input resistance is simply the parallel combination of 1 megh and 150K, R 1 parallel R 2 and that comes out as 130K, the current gain comes out as 7.4 which is simply A v multiplied by R i divided by R L and this value 7.4 it has become greater than 1 because R i divided by R L is greater than 1 okay. And R 0 is 1.14k alright, now we will prepare to work out some examples some problems. I must point out some of these problems will require the consideration of 2 or more devices that is 2 or more stages of amplification. Usually what one does is, if you cannot obtain the required gain from a single stage with appropriate input and output impedances then you use multiple stages.

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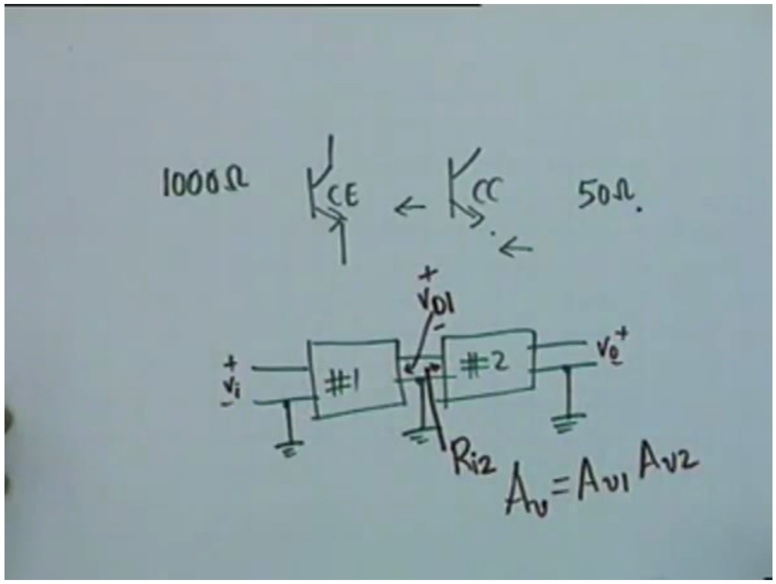

For example, if you have a source of let say 1000 ohms and a node which is 50 ohms and you want matching, obviously if you use a common emitter amplifier is dual use a CE stage, output impedance of CE stage = R C alright, it would be approximately a k or so which cannot match 50 ohms so what you do is, you follow a CE stage by a CC stage okay, you follow a CE stage by CC stage whose 1 by g m = 50 ohms alright so matching is performed, the 2nd stage does not give you voltage gain so the voltage gain has to be obtained from CE but you match by a CC alright. There is current gain in CC and well as CE and therefore there is an overall power gain.

So stages often have to be cascaded that is one fits into another amplifier to get a higher gain to get a matching and in such cases suppose we have amplifier 1 and amplifier 2 okay and you know that all amplifiers are usually grounded, suppose we have a two-stage amplifier alright. Then to calculate the overall performance of this, this is V 0, this is V i, let us call this voltage as V 1 let us call this voltage as V 01 alright output voltage of 1, then so long as V 01 is calculated by taking the input resistance of stage 2 into account okay, the effective load of stage 1 would be its own load parallel by the input resistance of stage 2 so that is taken into account. And say V 01 acts as the source to amplifier number 2 therefore it is obvious that the overall gain A sub v would be the product of the 2 gains A v1 times A v2 alright.

This is true provided your effective load R L1 = R L of the 1st stage which may be simply R C parallel by the input resistance of stage 2 that is R i2. If you if you do that then obviously the gain will be the product of the 2, let us take an example to illustrate this point. Please try to draw with me because it is a quite involved circuit and it is a practical circuit okay.

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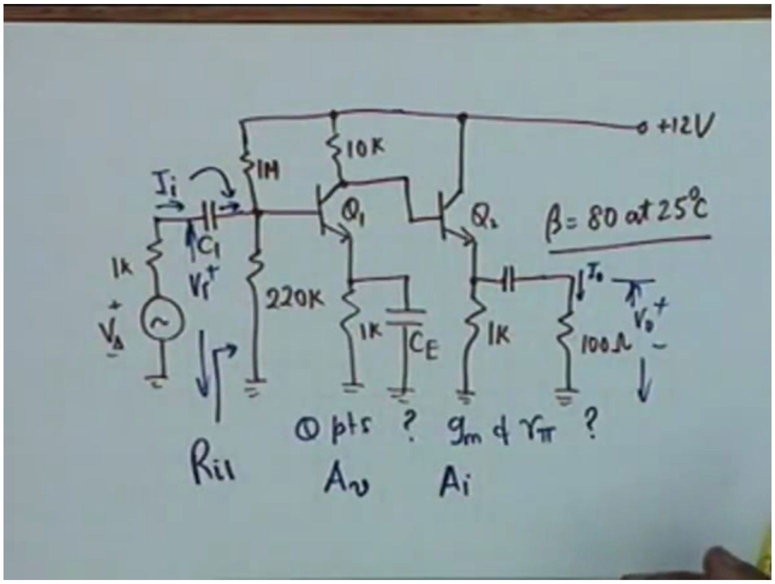

We have a source which is 1K, V s, the coupling capacitor tends to infinity, the First stage is biased by 1 megh resistors in parallel to 220 K this goes to the base of the 1st stage Q1 and the 1st stage has an emitter resistance of 1K which is bypassed which is bypassed C E this is C 1 and the load of the 1st stage is 10 K okay, this is taken to a + 12 volts battery this is the 1st stage. The output of this is taken without a capacitor directly coupled to a 2nd stage, this is intentional that this voltage V c1 shall act as V b2 to supply the necessary base current, let us see if it works.

You might in circumstances you might overdrive Q2 if you overdrive Q2, Q2 will go into saturation once a transistor BJT goes into saturation it cannot act as an amplifier and therefore you must caution, you must guard against this. On the other hand for FET we require the transistor to be in saturation okay, the differences must be quite clear. Now this stage is a common collector stage it is an emitter follower there is no resistance in the collector so obviously it is being used to reduce the output impedance okay, it cannot be voltage gain it simply reduces the output impedance and this resistance R E2 is 1K and there is a coupling capacitor and the load is simply 100 ohms it could be a combination of loudspeakers very simply 100 ohms.

100 ohms obviously cannot be coupled to 10 K that would be a perfect mismatch no voltage absolutely 100 divided by 10 K + 100 this would have been the potential division and therefore we would have got nothing in the load. But because of the common collector stage because emitter follower you do this almost the whole voltage, if the voltage gain is unity almost the whole voltage in the load. The only thing that restricts it is the output impedance of the 2nd stage which as you know is low 1 by g m alright. Now the question is, this is the total story, beta is given as 80 and 25 degree C beta is given as 80, the questions are the following. 1st is find the Q points of Q1 and Q2 that is I C1 and I C2, V ce1 and V ce2 that will determine the Q point, that will also determine whether the transistor are in active region or not okay this must be checked.

And then g m and r Pi for each transistor g m and r Pi for each transistor and also the overall voltage gain, this is V 0 and this is V i, you shall find out V 0 by V i then you know V 0 by V s also because you have to calculate all that you have to calculate is the input resistance of stage 1 now we shall call it R i1 alright and A i that is I 0 by I sub i. Do you see why I write I sub i before the capacitor? Because after the capacitor there is a DC component okay. Could I write I sub i here? Yes of course because DC flows like this DC flows here it cannot flow via the capacitor so it is the same current here but I cannot write it here because that contains DC component alright.

Now let us look at the circuit carefully and do step-by-step calculation, this is the discipline that one has to follow, you might be smarter to guess the result part my advice would be do not do this at least to start with okay, you can afford to do this when you are a master in... When you have completed a serious course on Analog electronics, not at this stage, there are too many slips in between okay.

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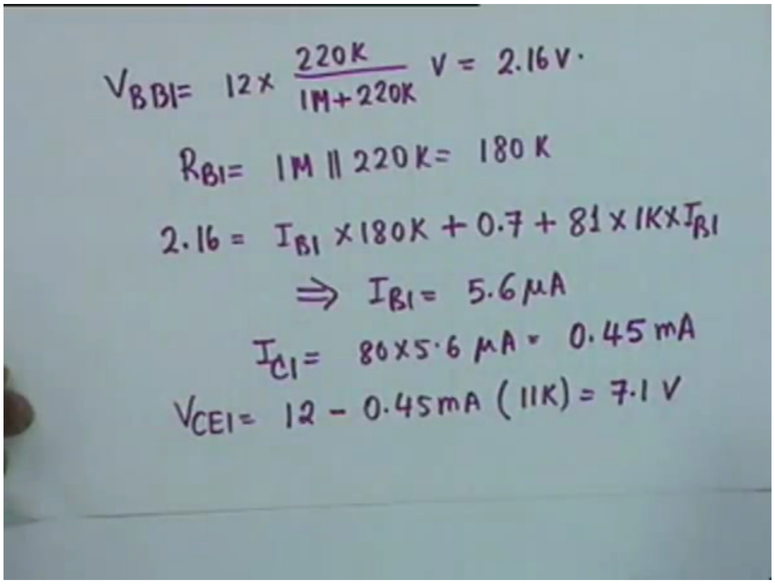

Okay now let us proceed stage by stage, the first thing we will do is to find V BB1, for the 1st transistor V BB1 would be 12 multiplied by 220 K divided by 220 K + 1 Megh so 12 multiplied by 220 K divided by... If you want you can write it as 1000 k, 1 megh + 220k you must take care of the dimensions so many volts, and this comes out as 2.16volts I have calculated up to the 2nd place of decimals till I felt too sleepy okay then I (())(24:19) the calculation for the students. Next thing you find out is R B1 you see our aim is to find R B1 and then I C1 and then V CE1 so this is the discipline one has to follow, R B1 is 1 megh parallel 220k and this is 180k nice figure.

Therefore, 2.16 V BB1 would be = I B1 multiplied by 180 K + this is I B1 times R B1 + 0.7 + beta + 1 is 81 times R E1 that is 1K times I B1 in which the only unknown is I B1 and therefore you can calculate I B1 as = 5.6 microampere. And therefore I sub C1 since I CBO is not given we neglected okay therefore I sub C1 is beta times this that is 80 times 5.6 microampere which = 0.45 milliampere, the current is small 0.45 milliampere. But let us not be worried let us see what is V CE1, V CE1 is 12 volts V CC - 0.45 milliampere multiplied by that is 11 K okay, and that comes out as 7.1 volts that is pretty good.

“Professor–student conversation starts”

Student: Excuse me Sir.

Professor: Yes.

Student: Have we neglected I B2.

Professor: Yeah we are neglecting I B2 that is right.

"Professor–student conversation ends"

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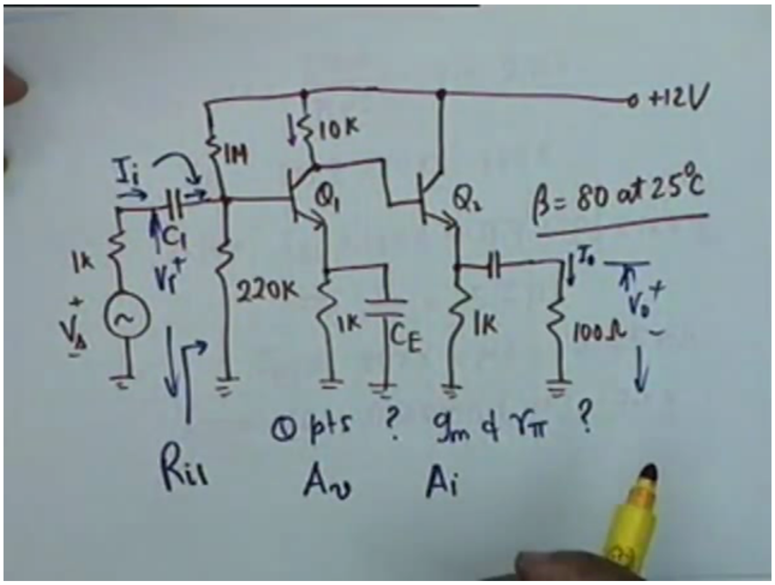

You see in this 10k it is a very legitimate and valid question in this 10k the current that flows is not only I C1 but also I B2 with the beta of 80 we ignore that. And therefore I must put an approximate sign here I must put an approximate sign okay because of this ignoring I B2 component. Now 7.1 volts is a good operating point 7.1 volts 0.45 milliampere is a good operation, it is neither too close to 12 nor too close to 0.2 alright so this is perfectly all right and before we need this why do not we also find g m 1.

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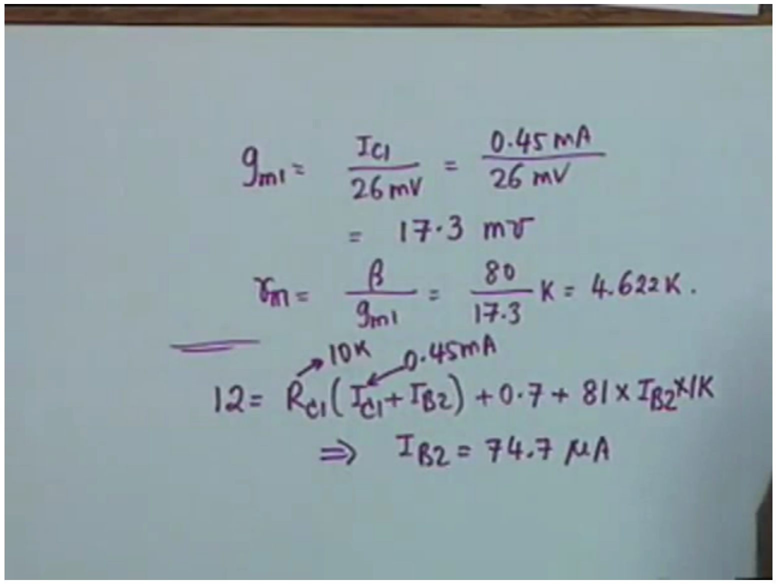

GM 1 is I C1 divided by 26 millivolts so 0.45 milliampere divided by 26 millivolts and that comes out as 17.3 millimho 17.3 millimho. And therefore r Pi 1 = beta divided by g m1 and that = 80 divided by 17.3 K and that comes out as 4.622K alright 1st transistor has been exhausted all everything is known about the 1st transistor. Now take the Q2, for Q2 to calculate the base current let us go back to the circuit. You see this current is I C1 + I B2 correct, since we are calculate in I B2 let not ignore I B2 anymore okay we cannot. Since we are calculating it, well it is a small part I C but still let us not ignore it okay and this is I B2 as far as DC is concerned.

Then you have 0.7 drop and then you have beta + 1 times I B2 times 1K therefore it is not too difficult, what I do is I right 12 volts that is V CC as = R C1 I C1 + I B2 + 0.7 + 81 times I B2 times R E2 which is 1K. Actually I should have substituted values, this is 10k, I C1 we have already found out 0.45 milliampere approximately therefore everything is known in this equation and I get I B2 as = 74.7 microamperes.

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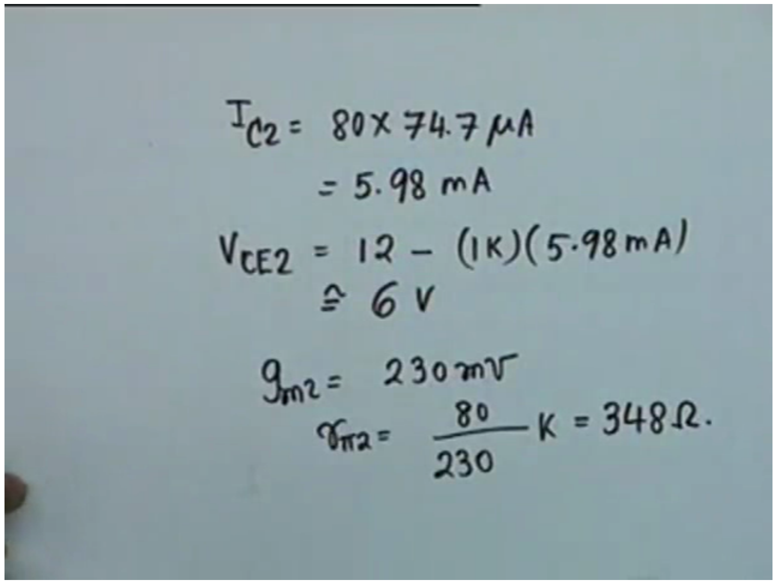

And if I B2 is 74.7 microamperes obviously I C2 okay I C2 would be = 80 multiplied by 74.7 microampere and that comes out as 5.98 milliampere approximately 6 milliampere. And under this condition V CE2 would be = 12 volts – 1K multiplied by 5.98 milliampere that is approximately 6 volts 6 .02, ignore 0.2.

"Professor–student conversation starts"

Student: Excuse me Sir.

Professor: Yeah.

Student: Sir in that true calculation will be V C1 they are different by 0.7 volts because in the 1st case we had ignored I B2 and in the 2nd one we are considering I B2.

Professor: Say it again in the 2nd case…

Student: Sir when we are calculating I B2, I B2 comes out to be 74.7 microamperes.

Professor: Correct.

Student: That still makes a difference of about 0.7 volts in G C1 because it is 12 to 10K resistant.

Professor: That is correct that is correct let me see, 74.7 microampere multiplied by 10k how much is that?

Student: (())(31:11)

Professor: So what is different if V CE1 does it affects V m?

Student: Yes sir.

Professor: V CE1?

Student: No sir.

Professor: Because I sub C1 divided by... But then I sub C1 will also be different slightly, slightly different so these are all approximate calculation and we keep life temple, if we have to consider I B2 also well, it will be a coupled equation a 2^{nd} couple equation we have to solve both simultaneously and an engine does not want that. The reason is whatever you do after all where you get a... you see one of the resistance here is let us say 4.622, if you go to an electrical engineering store and ask him give me an exactly 4.622 kilo resistance he will say sorry okay, so final values they cannot be put exactly.

"Professor–student conversation ends"

Now if you are too fussy then you have to take let us say a dozen of 4.7K resistors and hopefully one of them would be 4.622K, if it does not comes the approximate value 4.6K, so this adjustment you have to do. Number 2, since these are linearize designs linearize models, after you assemble the whole circuit if you have designed for a gain of 100, you may get 98 or you may get 120 then you have to make adjustments anyway. So in these calculations design calculations one need not be (())(32:54) because in the alternate fabrication you do have to tune the circuit this is what is called tuning, you have to tune the circuit or polish the circuit to match what you want okay. That is why otherwise if had been very fussy and do all the calculations with all the (())(33:14) then you fabricate it and you find that it has not been working because you have to change the resistors anyway alright.

V CE2 and I C2 this is also a good operating point; 6 volts and 6 milliampere okay it is a good operating point and you can now calculate g m2, I C2 by 26 millivolts this comes out as 230 millimho and therefore r Pi 2 = Beta divided by 230 so many K and this comes out only 348 ohms 348 Ohms it is a low value. Why does this low value arise? Because the current is much larger it is 12 times larger right, 6 milliamperes it is 12 times larger than I C1 and therefore r Pi 2 correspondingly goes down. Now to calculate to calculate the gain what I should do, as a matter of discipline is to draw the equivalent circuit but let us try to do it by inspection okay just by inspection.

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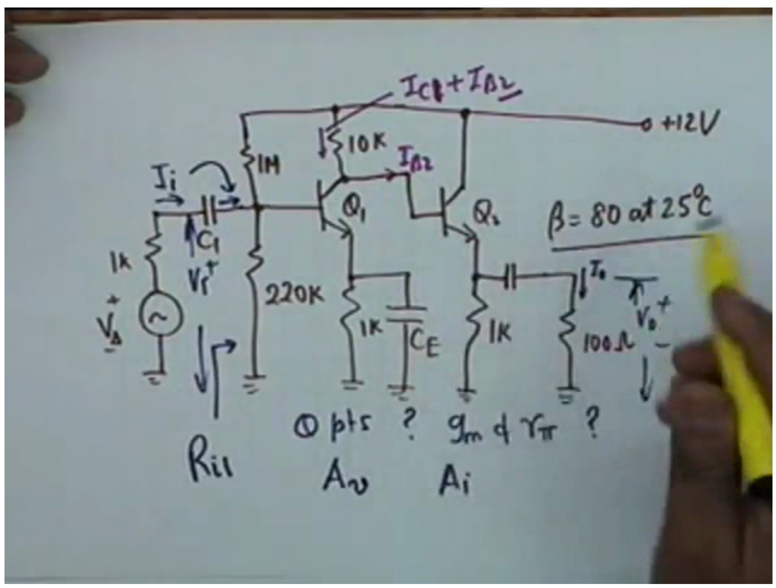

The gain of the 2nd stage, you have to start from the last, why? You cannot start from here unless you calculate R i2 so you start from the last. A v2 this is a common emitter I am sorry common collector amplifier so it would be the gain would be g m multiplied by the parallel combination of R L, R E and 1 by g m... no R 0 comes, R 0 can be ignored because it is a small resistance.

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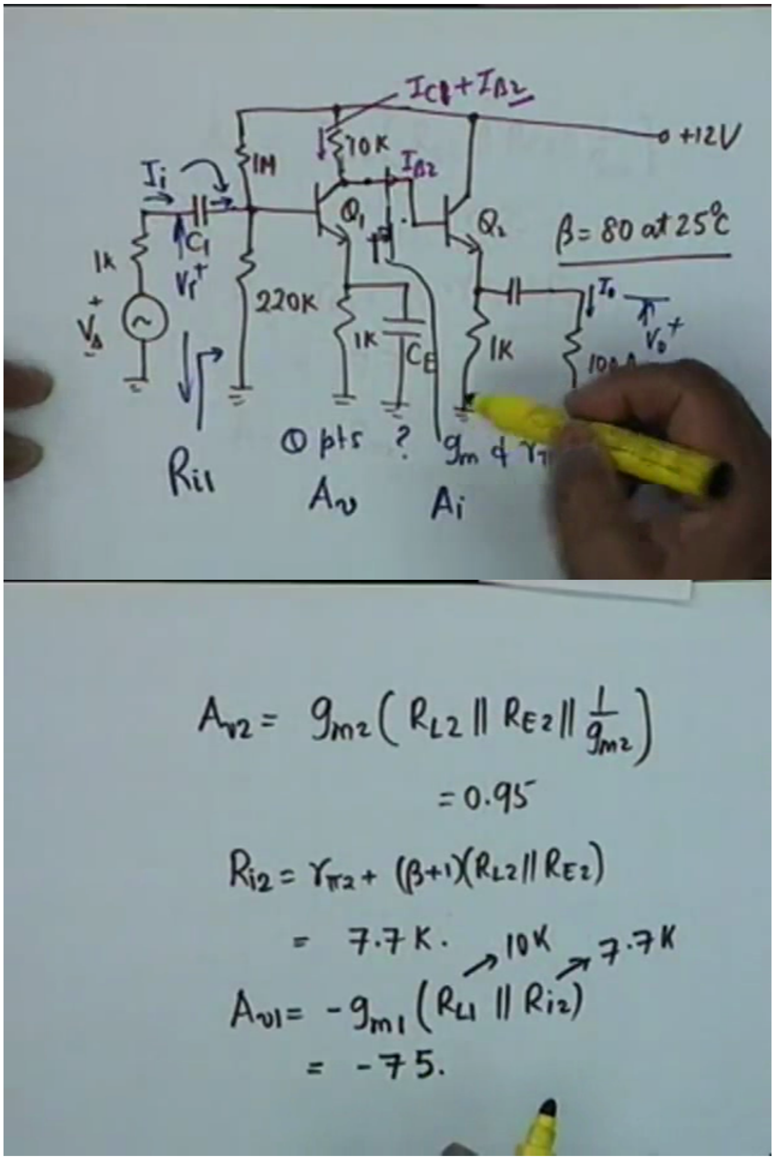

If you recall the common collector amplifier, A v2 is g m 2 multiplied by R L2 parallel R E2 parallel 1 by g m 2 and this is approximately = unity. This comes out as 0.95 in this case, you know g m 2 you know R L 2, R E2 and 1 by g m 2, this comes out as 0.95 which is pretty good okay. And under this condition R i2 that is the input resistance of 2nd stage, let us see what they shall be, it would be r Pi 2 okay from here to here + beta + 1 times effective load here that is 1K and 100 ohms okay. So R i2 is r Pi 2 + beta + 1 times R L 2 parallel R E2, I am doing this by inspection without drawing any equivalent circuit okay and this comes out as 7.7 K this is a high you know resistance okay 7.7 K.

And if I know R i2 then the voltage gain of the 1st stage, R i2 is here therefore the effective load of Q1 shall be 10k parallel R i2 okay, so the gain of the 1st stage would be – g m... pardon me... Oh I want to find the gain of Q1 and the effective load of Q1 is 10k in parallel with what it faces from the 2nd transistor that is R i2 this resistance and this resistance I have already calculated as 7.7 K.

Student: How is that in parallel?

Professor: How is that in parallel? From this point to ground I have 2 paths; one is 10k and the other is through this okay so the gain of the 1st stage would be – g m notice there is a negative sign, it is a common emitter stage there is an inversion, – g m 1 R L 1 parallel R i2 this is 10k and this is 7.7 K and this comes out as - 75 okay – 75 approximately, you see my 7 place of decimal is gradually disappearing okay.

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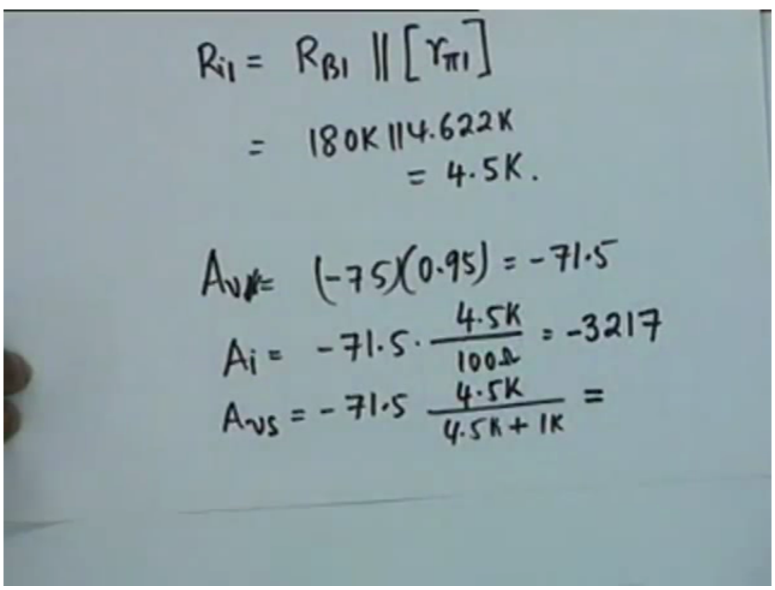

Professor: I must also find R i1 to know completely about the amplifier, what is R i1? R i1 is R B1 okay parallel r Pi 1, anything else?

Student: 1k.

No, this is bypassed this 1k is bypassed so no beta + 1, it is simply R B1 parallel r Pi 1 and that is 180K parallel 4.622K and that comes out as 4.5K, why do I need this? I need this to be able to calculate A vs, A V s is now but I have not calculated A v yet, the total voltage gain is simply the product of A v1 and A v2 so - 75 multiplied by 0.95 – 71.5 and A sub i A 2 that is – 71.5 times R i1 this is where I require R i1, 4.5 K divided by R L what is R L overall R L? 100 ohms and this comes out as – 3217. And finally you can calculate A sub vs, A sub vs = A v that is – 71.5 times R i that is 4.5K so 4.5K + 1K and I did not calculate it for obvious reasons.

Okay 2nd problem, is the problem clear? It is a fairly involved design it is fairly involved analysis but if you keep your eyes and ears open you can do it almost by inspection. Make sure make sure when you make a mistake in absorbing the input impedance of the next stage in the load of the previous stage as long as you do that there is no problem, let us take another example in which in which the 2nd stage is also CE amplifier common emitter and the example is this.

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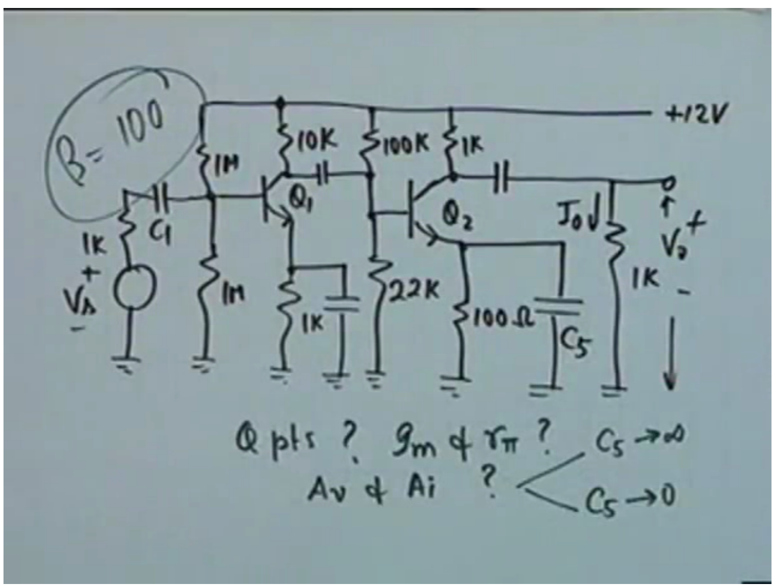

1K, V s, C1, 1 megh and 1 megh, the 2 resistors are equal, this goes to Q1 and Q1, 1K is bypassed, the load here is 10k and this is + 12 volts, the load is 10k then the output is coupled now not directly but through a capacitor to the 2nd stage Q2 which since there is a capacitor here, you must bias the 2nd transistor in the usual manner that is use a resistance here and resistance here okay, I am not supplying from the output of Q1 a DC and therefore I must supply from the power supply. These resistances are 100 K and 22K, the emitter of 2 goes to ground via resistance of 100 ohms and which is bypassed C5, the other capacitors are C1, C2, C3, C4, the capacitor is named C5, why it is being named I will come in a moment.

The load the R sub c of this transistor Q2 is 1K and this capacitor is a coupling capacitor and the load is 1K, this is my V 0 and this is I 0. The problem is a fairly involved problem but we will solve it. The problem is to find out 1st Q points, beta is given as 100 beta is given as 100 for both the transistors, we have to find out Q points and g m and r Pi for each transistor that is written you must do it the same way except that you have to calculate I d here from V DD2 and R d2 for the 2nd transistor, it was not required in the previious case but it is required here okay g m and r Pi. Then you find A v and A i for 2 cases; one is for C5 tends to infinity which means that it is bypassed this 100 ohms is bypassed and other is C5 tends to 0 that means it is not bypassed alright.

"Professor–student conversation ends"

Professor: If it is not bypassed if C5 if C5 is 0 roughly what will be the voltage gain of Q2, just looking at it can you tell me what it will be?

Student: 10

Professor: No sorry... it is a silly question. The question is, if C5 is 0 if it is not bypassed what will be approximately the gain of this stage?

Student: 5.

Student: 5.

Student: 1.

Professor: 5 is the correct answer, it is - 5, negative of effective R L, 1K and 1K come in parallel, 500 ohms divided by R E which is 100 so 5, you should not expect a gain greater than 5 from here if C5 tends to 0

"Professor–student conversation ends"

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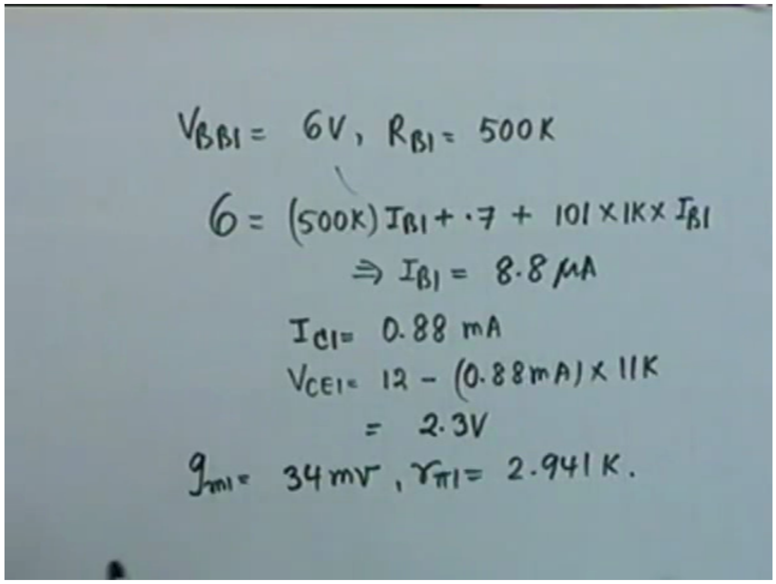

Now let us say let us solve this problem stage by stage, since these calculations are retained, I will simply write V BB1 it is obvious that it = 6 volts 1 megh and 1 megh and R B1 obviously is 500 K alright so 6 would be = 500 K times I B1 + 0.7 + 101 multiplied by 1K multiplied by I B1, which gives you nevertheless if you do not understand this please stop me and tell me to repeat or to explain okay I B1 = 8.8 microamperes therefore I sub C1 = 0.88 milliampere multiplied this by 100 and therefore V CE1 would be = 12 – 0.88 milliampere multiplied by 10k + 1K so 11 K and this becomes = 2.3 volts that is not too bad. Then g m 1 would be 0.88 divided by 26 and that becomes 34 millimho and r Pi 1 therefore beta 100 divided by g m 1 and that comes as 2.941K alright so far so good. Any questions?

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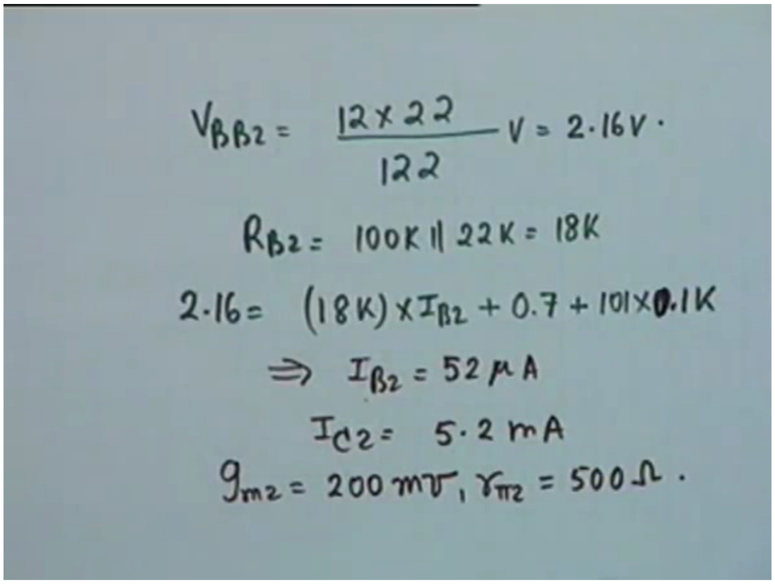

Before we go to equivalent circuit or calculation of gain let us find out for the 2nd stage also. V BB2 now becomes 12 multiplied by 22 divided by 122 so many volts and that becomes = 2.16 volts. R B2 = 100K parallel 22K = 18K good figure. So 2.16 = 18K divided by I B2 + 0.7 + 101 multiplied by 1.1K; 1K is 100 ohms, 100 ohms is 0.1 K I hope right? 1K is here... 0.1K it cannot be 1K it can be 1.1K we are calculating V CE2 that is where 1.1 but this is 0.1 simply that 100 ohms comes into the picture okay. And let this be I B2 as = 52 microamperes therefore I sub C2 which is multiplied by 100 is 5.2 milliampere and then g m 2 is 5.2 divided by 26 that is 200 millimho and r Pi 2 which is 100 divided by 200 millimho is obviously 0.5 K that is 500 ohms. All done now you are ready to calculate the gain okay.

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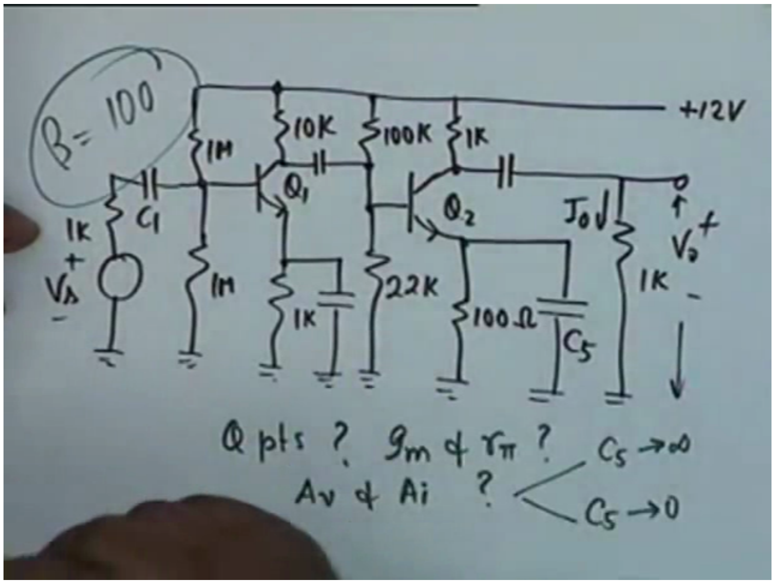

Now in calculating the gain let us look at the circuit again I am not drawing another equivalent circuit if you so desire then you draw it but gain of 2nd stage last stage Q2 if this is bypassed if this is bypassed then the gain would be - g m 2 multiplied by effective load which is 1K parallel 1K.

Student: Sir we have not calculated V CE2 which is quite close to 20.

Professor: Okay great, I was expecting this question. V CE = 12 - 5.2 milliampere multiplied by 1.1 K how much is this? 6.3 volts this is not known this is okay so we are in business alright.

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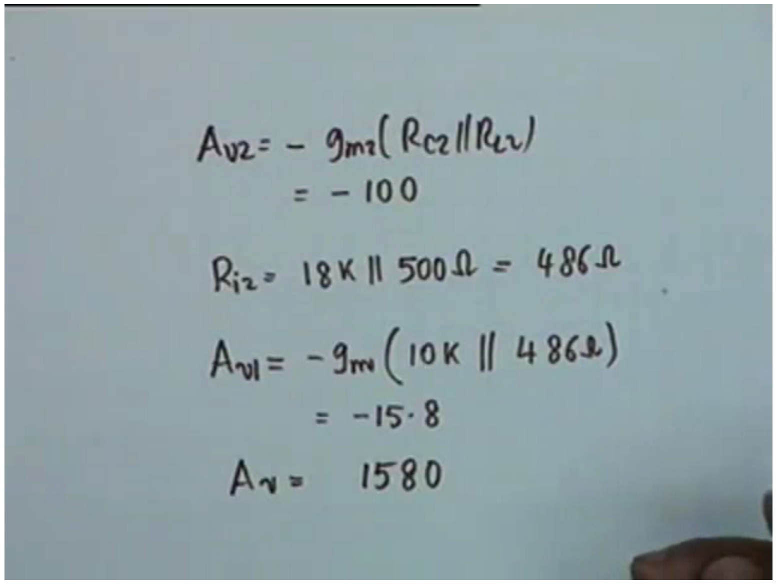

Now let us look at the gain of the 2^{nd} stage, obviously effective load is 1K parallel 1K, 500 ohms and g m 2 multiplied by g m 2 so A v2 = – g m 2 R C 2 parallel R L 2 and that comes out as – 100; 200 millimho and 1K parallel 1K, 0.5 okay this is the gain is – 100. Then the next calculation is I must calculate R i2 I must calculate R i2 should be parallel combination of... 18K we have already calculated R B2 okay, so 18 K parallel r Pi 2 if this is bypassed okay. So R i2 is 18 K parallel how much? That is 500 ohms and that comes out as 486 ohms, the reason I shifted is (())(51:23) 486 ohms okay. Therefore now we can calculate A v1, A v1 would be – g m 1 multiplied by the effective load 10k parallel 486 ohms it is quite low and this comes out as – 15.8 therefore A v would be – 100 multiplied by - 15.8 and that is 1580 okay.

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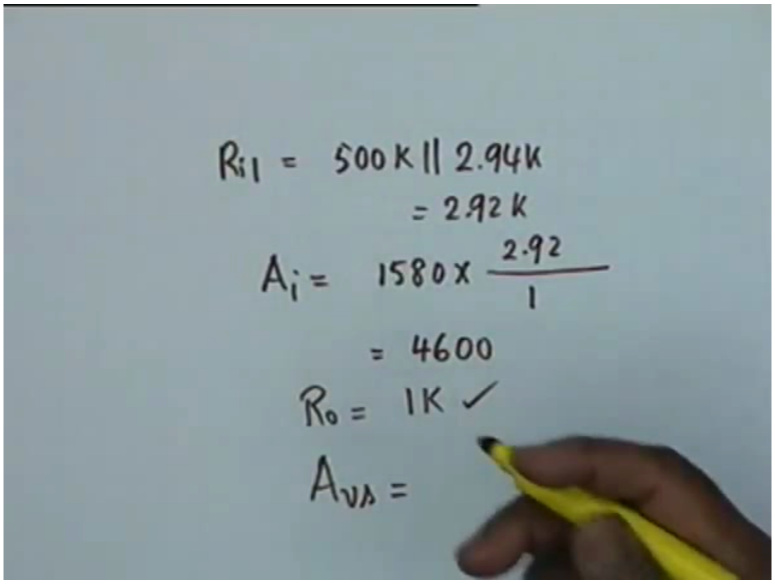

C5 is bypassed here, we will see what happens when C5 is not bypassed okay so this is my A sub v the voltage gain then I require to calculate the current gain we require R i1. R i1 would be = R B1 which is 500 K in parallel with r Pi 1 that is all what is r Pi 1? 2.94K and that becomes 2.92K therefore you can calculate A i which will be 1580 multiplied by 2.92 divided by 1 so this becomes 4600 okay 2 stages have achieved this much of current gain 4600 times and finally you can calculate A V s, what would be R 0 what would be R 0 for this amplifier yes? Output resistance... Pardon me... 1K parallel... No do not make this mistake... No 1 by g m... 1K parallel if you want parallel with something it would be small r subscript small o not g m because this is common emitter amplifier okay.

But if you ignore that, do not make this mistake in 1K parallel 1K because the load now seize load is the master you cannot absorb the load in R sub C no it refuses because you are calculating what the load seize alright so R 0 is 1K if you ignore small r 0 and you can calculate A V s as A v multiplied by R i divided by R i + R s.

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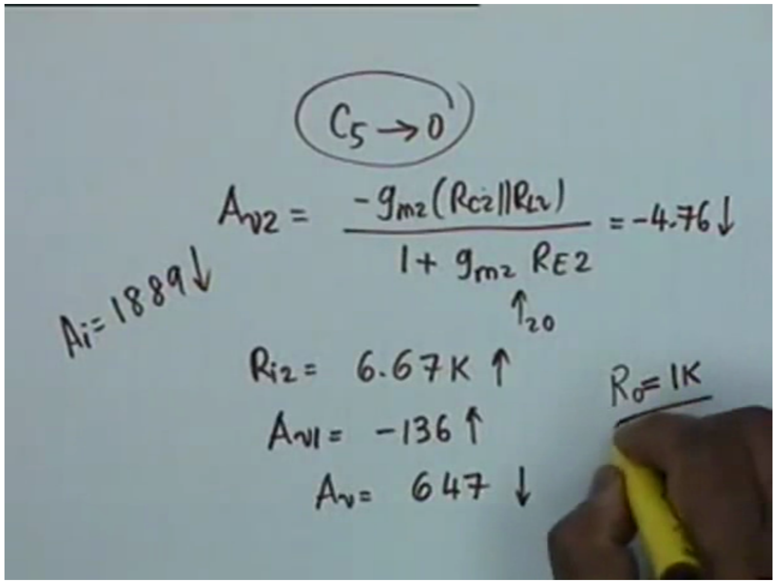

Now 2nd part that is if C5 goes to 0 then voltage gain of the 2nd stage A v2 reduces drastically it becomes – g m 2 R C2 parallel R L2 this is divided by 1 + g m 2 times R E2 if C5 tends to 0. If R E2 is effectively 0 then it is simply this gain so the gain is divided by 1 + g m into R E2 and you can verify that this is 20 this is 20 here so the voltage gain is reduced 21 times and this becomes - 4.76, what did you calculate roughly - 5 so it is a too different agreed it has come down. The input resistance of the 2nd stage would now be R B2 parallel r Pi 2 + beta + 1 times R E2, if you calculate this it increases to 6.7K it increases. A v1 do you expect it to increase or decrease? R i2 has increased and therefore and therefore effective load has increased and therefore A v1 is increased it becomes - 136 I mean the value, take account of inversion later.

So it has increased but lo and behold, A v which is a multiplication of these 2 is 647 it has decreased, previously it was 1508 okay. And A sub i you can calculate A sub i is 1889 this has also decreased this has also decreased but the output resistance now what is the output resistance? Does it change? It is the same it is the same as 1K alright and that completes the calculation of fairly involved 2 circuits. The one that I in the tutorial class I think this is the point where we can close the class.