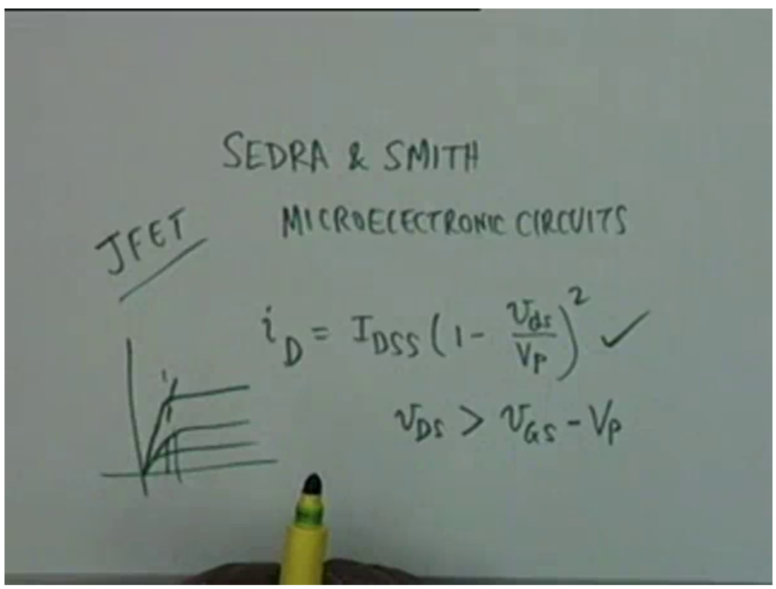
Analog Electronic Circuits
Prof. S. C. Dutta Roy
Department of Electrical Engineering.
Indian Institute of Technology Delhi
Lecture No 04
Problem Session – 1
On DC Analysis of BJT Circuits

This is the fourth lecture and as I had promised this would be a problem session the first problem session on DC analysis of BJT circuits. Before we take this some take the problems, let me mention 2 things that I have discovered another book which is available in the library and it's a good book comparable to Bounce and Bond and Millman and Grabel.

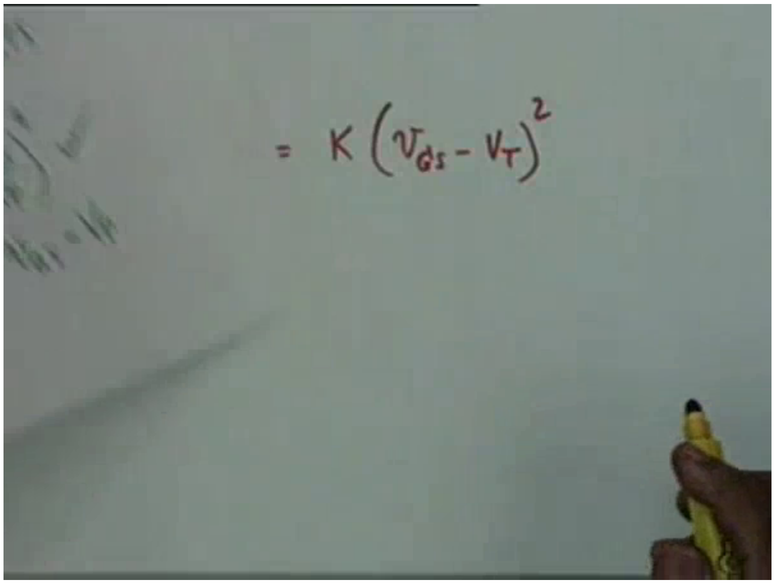
(Refer Time Slide: 1:35)

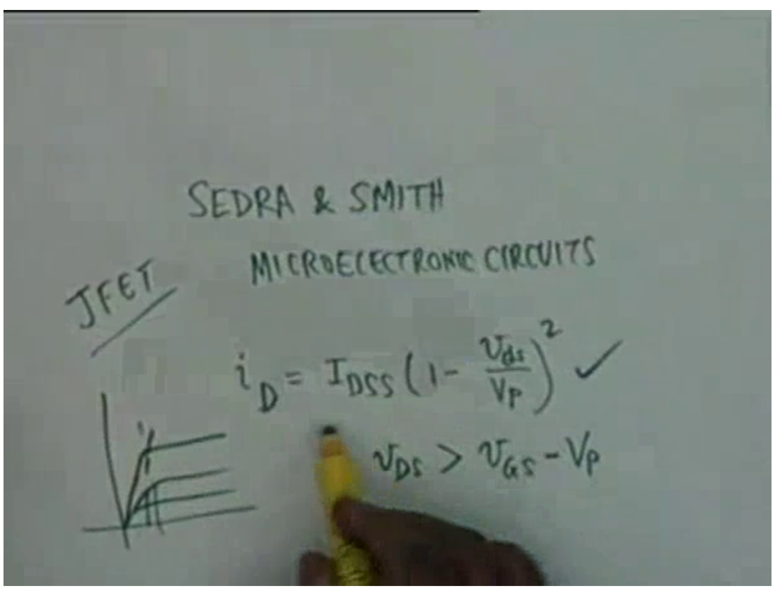


This is Sedra and Smith. This is called Principles of Micro-electronics Circuits or Simply Microelectronic Circuits I think. You have to consult various books there is no other way. The material is so large and so technology oriented, things are changing so fast books become obsolete in a very short time. The other thing tht I wanted to mention is that in FET in the discussion of FET this we will require in solving one problem. Our relation was i D equal to I D S S 1 minus V G S by V P this was d relationship okay, squared. Provided V D S is greater than V G S minus V P okay if this happens. This happens then we are in the saturation region we are in this region okay in the saturation region. This is the relationships okay between current and and the controlling voltage V G S, the relationship is not linear.

This was the store for JFET junction field effect transistor where the story is quite similar with the MOS transistor also. And I just want to mention this relationship before I go solve the problem.

(Refer Time Slide: 3:30)

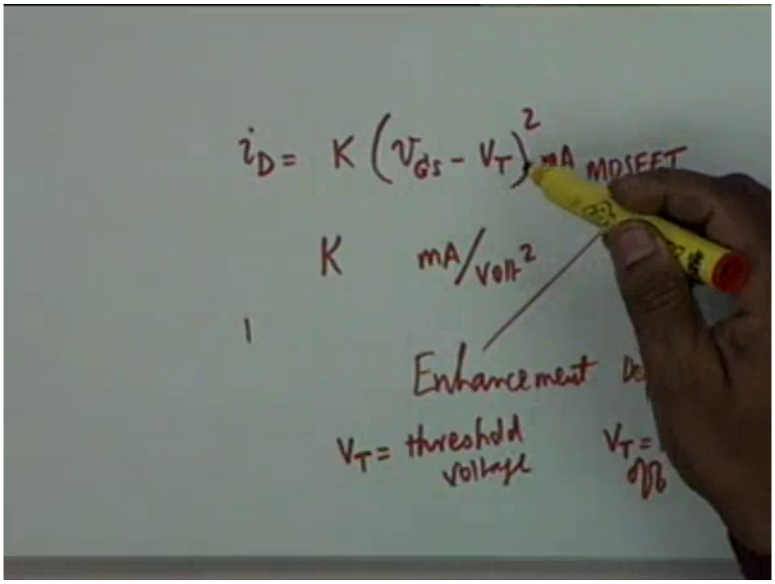




In the junction field and the MOS FET for some reason the relationship is written as some K multiplied by V G S minus V T whole square. If you compare this with this relation. This relation can also be written as V P minus V G S whole square and V P square can be brought out and combined with I D S S alright. And since you're squaring it it doesn't matter whether you take V

G S minus V P or V P minus V G S. So the relationship is exactly the same except that for historical reasons for JFET it is written like this.

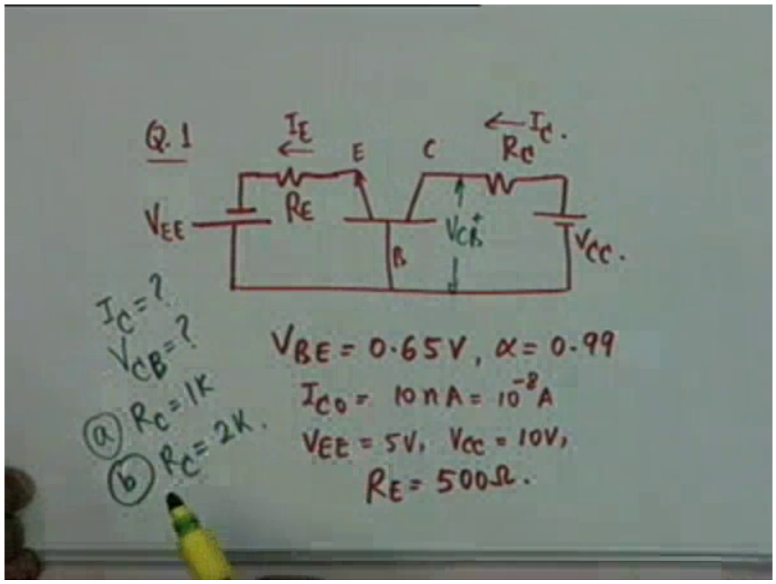
(Refer Time Slide: 4:10)



For MOSFET it is written like this. Instead of V P it is V T because I will explain this in a moment. Obviously this is in amperes or milli-amperes, let say usually it is in milli-amperes. The constant K the dimension shall obviously be milli-amperes per volt square and when there is a problem on MOSFET the value of K shall be given. If it is JFET the value of I D S S that is the drain current under saturation conditions for V G S equal to 0 shall be given. Now the other thing that I wanted to mention is in MOSFET you know there are two types Enhancement Mode and Depletion Mode. For enhancement mode VT has the interpretation of a threshold voltage. This threshold is for saturation again okay. This threshold is for saturation that is beyond this the collector the drain current gets saturated.

On the other hand in the depletion mode once again the pinch-off phenomenon, the same phenomenon and therefore there V T is the same as the as the pinch-off voltage. Nevertheless the relationship is very similar for both JFET and MOSFET. MOSFET whether it is enhancement or depletion only thing that changes is the interpretation of this constant it is either a pinch-off voltage or a threshold voltage. And to denote that this is MOS even if it is depletion mode we use this symbol V T is that clear? Okay, so this is all that I wanted to tell you about MOSFET. Now let's take some problems. The problems have already given to you in the tutorial sheet. And I had asked Mr. Joshi to mark out some of the marked problem, some of the tougher ones I left of the problem session.

(Refer Time Slide: 6:38)



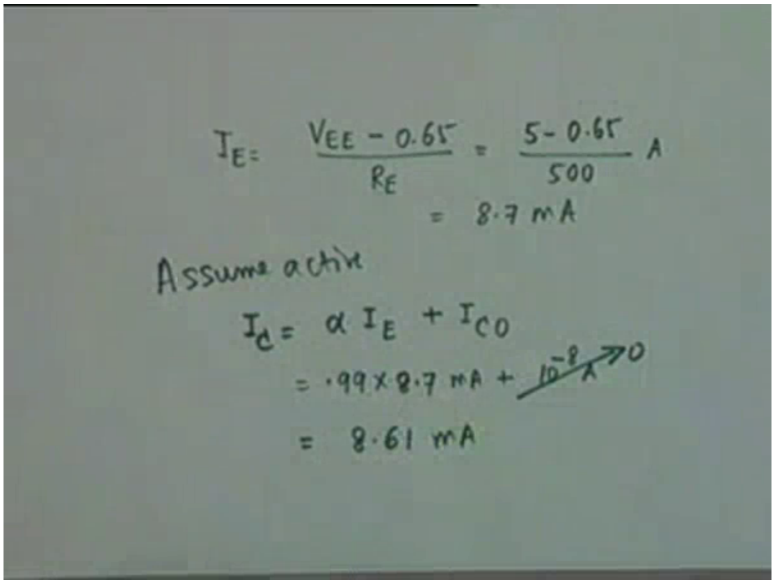
The first problem is that you have a transistor like this it's drawn a bit unconventionally, the battery is like this, this is d emitter, this is the collector and this is the base, it's an npn transistor the arrow goes out. That it's a common base transistor. This is RC R sub C and this is V C C and this current is I E this current is I C and the conditions of the problem are that V B E is given as 0.65 volts alpha is given as 0.99 I C O is given as 10 nano-amperes which means 10 to the minus 8 amperes okay, V E E that is this battery is 5 volt. V C C that is this battery is 10 volts and this resistance R E is given as 500 ohms okay. Then you're required to investigate this circuit under two conditions. That is essentially what you have to find out is the operating point that is the things to be found out is I C and V C E under two conditions. One is R C equal to 1K and second is R C equal to 2K.

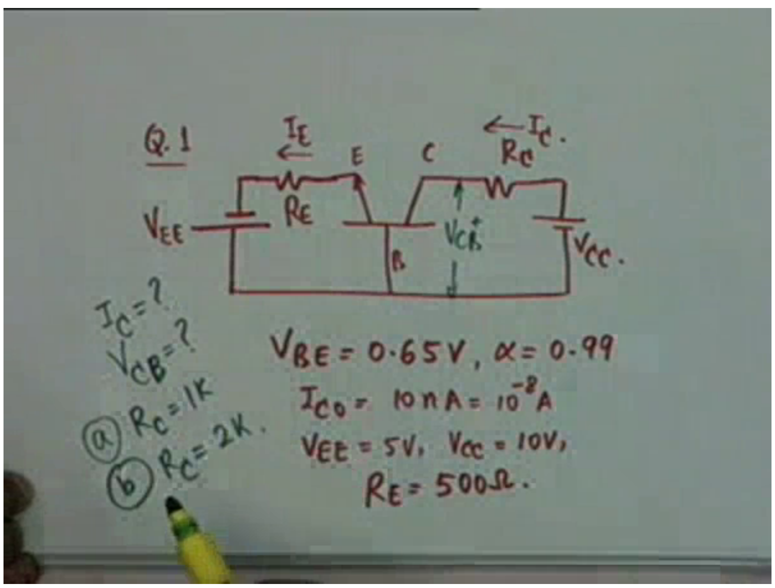
Student: Excuse me, we have to find out V C B.

Professor: Okay V C B that is this voltage, right alright V C B.

Now let's look at the solution is the problem clear? These are the parameters given, you're required to find out operating point I C and V C B under 2 conditions R C equal to 1K and R C equal to 2K. You will see that the operation differs drastically. Let us see what happens.

(Refer Time Slide: 9:18)

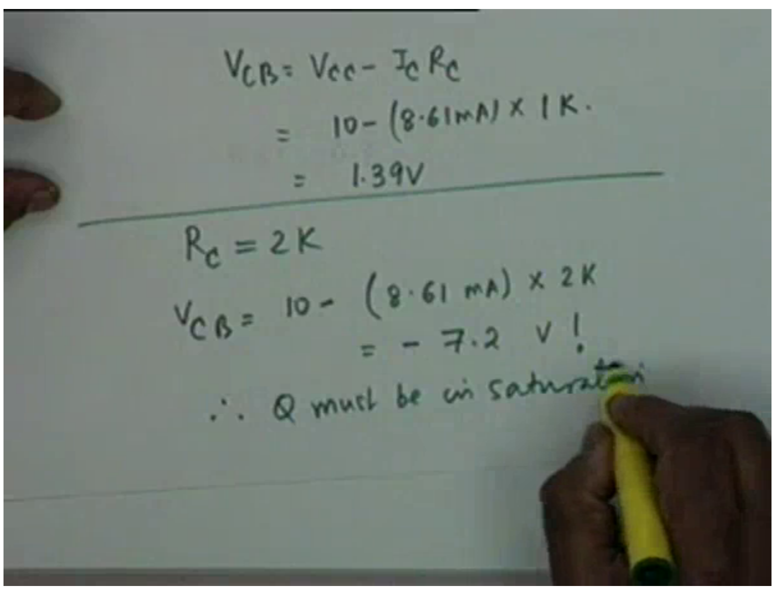


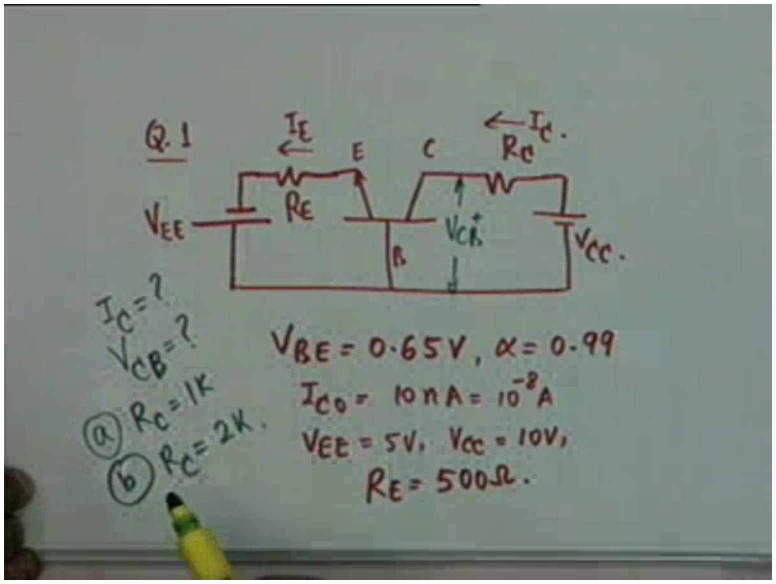


First you notice that I E I E this current. You know this voltage and you know this drop V B E this is 0.65 and therefore I E is V E E minus okay this is V E E minus this drop. I am sorry I must write here. This voltage from here to here is 5 volt and from here to here it's 0.65 and therefore very simple application of ohms law gives you I E and this divided by R E. And if you substitute the values 5 minus 0.65 divided by 500 ohms. So many amperes and this comes out as 8.7 milli-amperes. I have note them out so I will skip the numerical. If I made a mistake point this out to me on a later occasion. My numerical calculations are not very confident about okay.

Now the transistor I don't know whether the transistor is in the active mode or saturation mode. I don't yet know. So in these problems one does not proceed blindly. One assumes a mode, let us assume it's in active mode. If there is contradiction then we shall investigate the other mode okay. So let's assume that the transistor is in the active mode. It is also suggested by the fact that this voltage is 0.65 however there is nothing sacred about it, because as you know there is a small variation from transistor to transistor. So let us assume an active mode. Assume active mode, if that is so then I C the collector current would be Alpha I E plus I C O and you see that alpha is 0.99, this is given I E is 8.7 milli-amps plus I C O is 10 to the minus 8 ohm. And therefore we can safely ignore this, we can safely ignore this compared to the other one. And this comes out my calculation is that it is 8.61 milli-amps okay. Then under this condition we have found I C, the other thing to be found out is V C B.

(Refer Time Slide: 12:12)

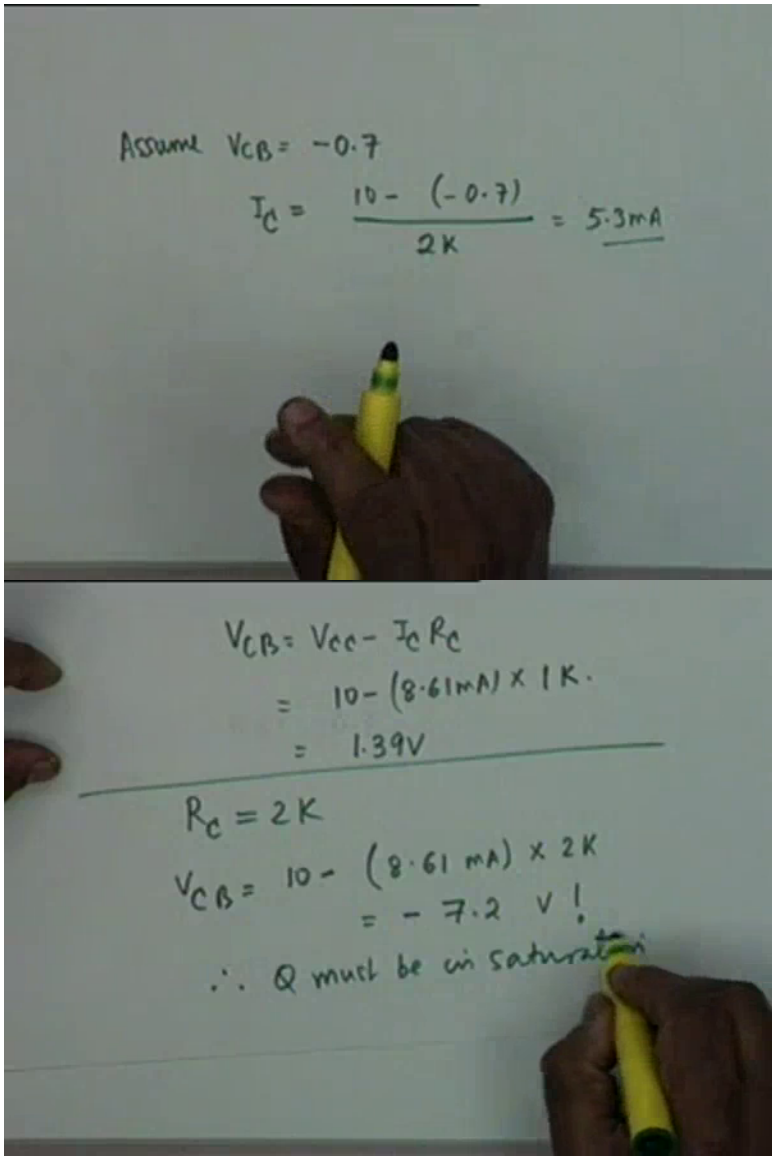


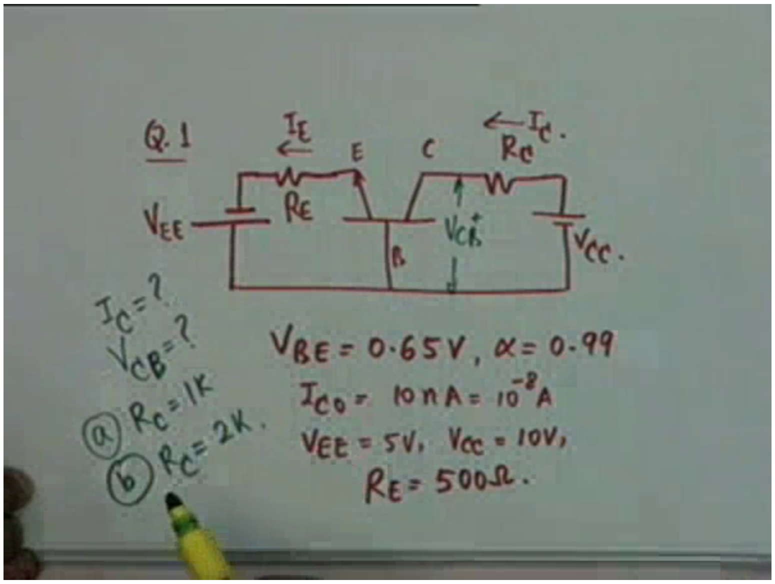


And as you see V C B is nothing but V C C minus I C R C. So V C B is equal to V C C minus I C R C and this is what was V C C 10 minus 8.61 milli-ampere multiplied by R C is given as 1K R C is given as 1K. And this comes out as 1.39 volt. Which means that the collector base junction is in the reverse biased. V C B is 1.39 volt, collector is positive with respect to the base negative and therefore our initial assumption of active region is justified. Okay now let's see what happens when R C is changed to 2K. If the same conditions are valid alright then our V C B should be 10 minus 10 minus 8.61 milli-ampere multiplied by 2K, which becomes minus 7.2 volt. Which indicates that the transistor is no longer in the active region it is forward biased.

And if it is forward biased then it cannot exceed 0.7 approximately okay. If it is forward biased V C B we're talking of not V C E. V C E is approximately 0.2 V C B is actually the junction voltage. So if it is forward biased, let's assume that it is equal to 0.7 volt. Therefore V C B is equal to minus or plus? Minus 0.7 you're conclusion at this point as soon as we find out V C B is negative you should say therefore Q must be in saturation. Q must be in saturation alright, let me write it down. Q must be, Q is the transistor. We don't use capital T, why not? T is used for absolute temperature. But then Q is also used for something else but traditionally this is gone in.

(Refer Time Slide: 14:42)





So V C B is minus 0.7 if that is so then I C, this is an assumption, you can assume 0.8 or 0.6 also, because it varies from transistor to transistor. When I C shall be, this is interesting let's go back to the to the circuit. How is V C B 0.7 volt okay? We have found out that V C B if we assume an active model then V C B comes out as minus 7.2 now a diode a forward biased junction diode cannot more than 0.7 that's why we said 0.7. Okay now what was the other point. How do we find out now I C? You see V C B is minus 0.7 and therefore it adds to V C C.

Student: As the relationship V C E equals V C B plus V B E volt.

Professor: It has to KVL cannot be violated.

Student: But in this case V C E approximately 0.2 volts. (())(15:53) 0.65

Professor: V B E cannot remain 0.65 anymore because it's in saturation, it will change agreed? It will not remain 0.65, it will change. But that is not a condition of a problem. Here we don’t require to take of. If we have to take care then we have to find out. If we assume V C B is minus 0.7 V C E is plus 0.2 then the resulting voltage will be V B E, V B E will change. Is the point clear? Now how do I find I C. This voltage is 10 volt and there is a positive to negative no I am sorry. Negative to positive and therefore I C would be 10 minus V C B which is minus 0.7 is the point clear? Okay that divided by 2K R C has changed to 2K so this comes out as 5.3 milli-amperes, alright. This is the condition, this is the solution to the problem for part B any question?

Student: How can you can take V C B as only 0.7, it is in active uhh saturation region should be 0.75.

Professor: We took a good figure 0.7 you can take 0.75, it's not specified and therefore but it has to be in that region, 0.5 0.6 to 0.8 this is the region. You can assume any value. Any other question?

Student: Under normal thumb rule condition we take V B E and the saturated to be about 0.75.

Professor: Correct.

Student: And V C E as 0.22.

Professor: That’s right.

Student: But in such a case V C B becomes 0.55 minus 0.55.

Professor: Okay.

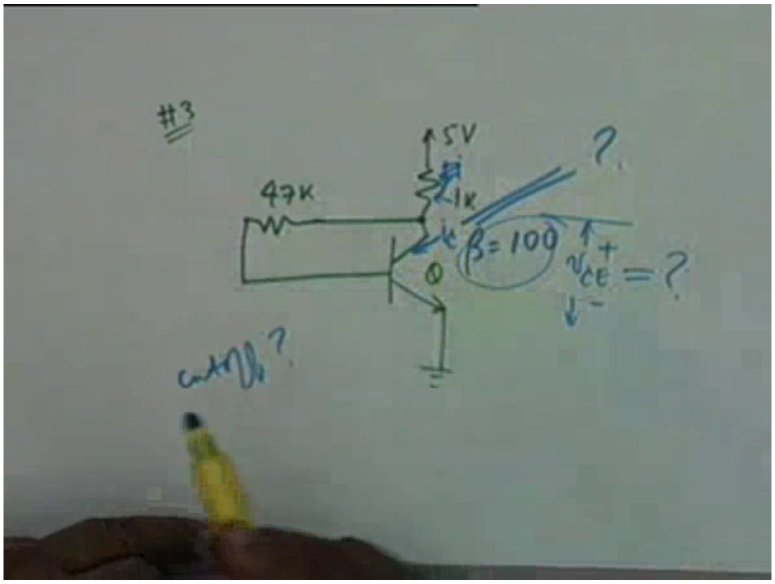
Student: So 0.7 isn’t it bit larger than what.

Professor: Take minus 0.55 it's just an arbitrary figure in the trade. If it is specified then you have to use that value. For example V B E is 0.65 specify this is for the active region. We have to take that we have no choice. But if it is not specified assume any value that you like. You cannot assume V C B minus 70 volts, it has to be within small range 0.5 to 0.8 okay. Any other question?

Student: Sir as you're saying it's 0.65 volts V B E then we know that for a diode to be forward biased the voltage should be about 0.6.

Professor: This is what I am saying above, so it can come down also. From diode to diode they vary. This is the rule of thumb. Rule of thumb is V B E Sat is 0.8 V B E active is 0.7 and V B E cut-in is 0.5, this is the rule of thumb. If nothing else is specified these are the values that you take okay. Was question 3 done in the class no for the two classes that we had done?

(Refer Time Slide: 18:57)

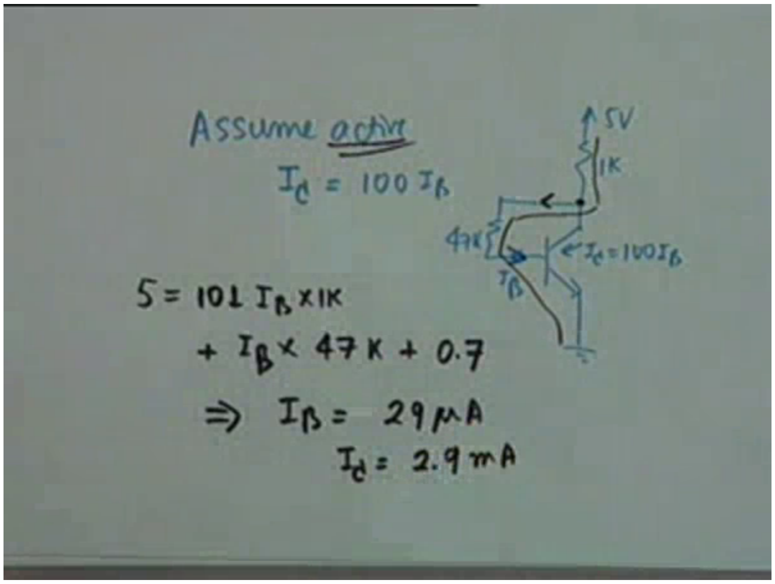


So we will take problem 3. In problem 3 we have a 5 volt source and 1k resistance a transistor Q npn transistor and there is a resistance of 47k here which connects to the base. This is a silicon transistor with Beta is equal to 100 you're required to find out whether Q is active, saturated or cut-off? And you're required to find out I C no I C is here I C and V C E okay? I C has to be found out and V C E has to be found out. Beta equal to 100 is given alright. Here also we will assume, we will assume A condition. Now can the transistor be cut-off, is that a possibility? Cut-off is a possibility?

Student: No

No because I B is not 0, you see there is a 5 volt source connected to this is 1K there is a 47K so there will be some base current and therefore the transistor cannot be cut-off. So it is either inactive or in saturated mode. Let's assume that it's active, let's assume that it's active.

(Refer Time Slide: 20:44)



Let's assume that it is active assume active. Then in the active region I C would be equal to Beta times beta (())(20:55) is 100 I B, let me draw the circuit. This is 1k 5 volt and this is 47k, this is IC, is 100 beta beta times I Because 100 I Because and this is I B I am sorry in the other direction I B. Okay so if I write K here around this loop around this look then obviously 5 would be equal to 5 volt would equal to what is the through 1K? 101 I B multiplied by 1K alright plus the dropping 47K is I B times 47K plus the drop from base to emitter we assume it to be since we assumed active we assumed it to be 0.7. From which you can find I B.

Student: Sir how do you take 101 I B?

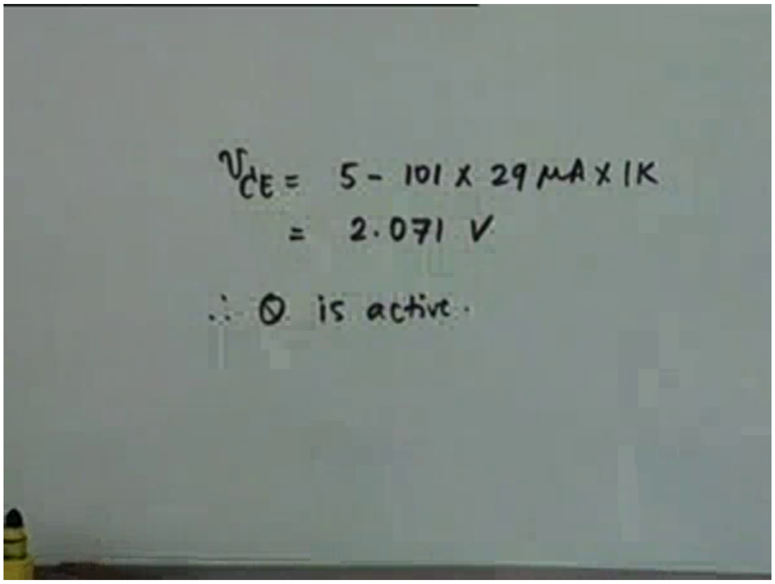
Professor: Because I assumed it active, what is your question? How do I take ohh.

Student: Sir 5 is equal to 101 I B how?

Professor: 101 I B, this is this is 100 I B collector current and this is I B so 101 I B.

What was your question? 0.7 because we assumed active. Alright from which I get I B my calculation gives me 29 micro-amperes. So I C is equal to 100 times this which is 2.9 milli-amperes.

(Refer Time Slide: 23:15)



If that is so then V C E, V C E would be V C E would be 5 minus 101 multiplied by 29 micro-amperes agreed and this comes out as 2.071 volt which means that our initial assumption was valid.

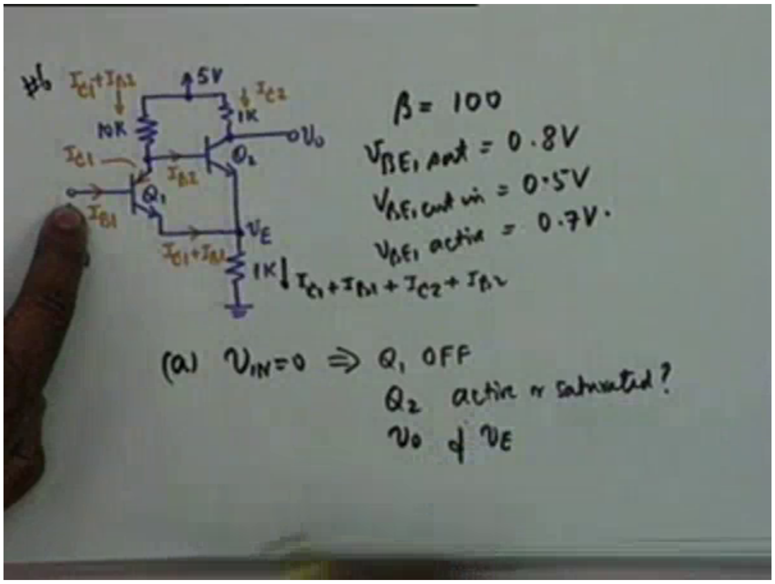
Student: It will be 1k also 101 into 29 micro-amperes.

Professor: Absolutely correct. It must be multiplied by 1k, this is drop. So therefore our initial assumption that Q is active it is true. It is active. And we have also found out, I C and V C E. Next question we are going from tougher to tougher now. 4 5 has been done now will go to question number 6. Any question on this? Question 6 you must pay your complete attention.

Student: Sir what is (())(24:26) V C E voltage for assuming that transistor is in active region.

Professor: If it is in the region of 0.2 then it is saturated. And also you know the test for saturation I C by I B must be less than beta. So there are couple of checking points. Alright question 6 concern this problem.

(Refer Time Slide: 24:55)



This circuit. If you look at this circuit I have drawn it separately because I shall need a number of them, I have drawn it separately. There are 2 transistors Q1 and Q2 both are silicon and it is given that beta for both of them is 100. It is given that V B E Sat is equal to 0.8 volt. V B E cut-in is 0.5 as we have been assuming and V B E active is 0.7 volt. There are 2 transistors Q1 and Q2 and the collector of Q1 feed the base of the Q2 alright and then both the emitters are brought to a common point V E and connected to ground through 1K resistance. This is the circuit. And I have shown in the in the brown color the various current. This current is IC2 this current obviously IC1 plus IB2 simple application of KCL if this current is IB1 then obviously the emitter current would be IC1 plus IB1 and this current this current would be IC1 plus IB1 plus IC2 plus IB2 agreed, okay. Now the question is understood. Not the question the circuit is understood.

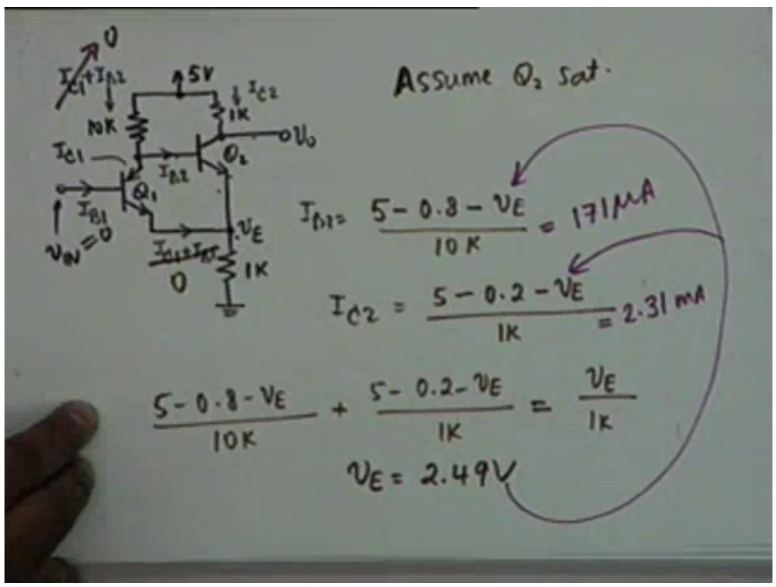
Let's look at the question question says if V IN is 0 that is if this input is 0. 0 means it is not left floating, it's connected to ground. If V IN is equal to 0, if V IN is 0 then Q1 obviously shall be cut-off, there is a base current. So V IN equal to 0 means Q1 is off. Instead of cut-off I simply write off. The question is what is the status of Q2 is it active or saturated? Let's solve this part, then we shall go to the other part. And under this condition whatever Q2 is find out V 0 and V E. These are the two things to be found out. Now we have to make a, whether it is active or saturated we have to make an assumption okay. And as we will see we usually make a, that is a guideline for making this assumption don't proceed blindly.

You see if Q1 is off if Q1 is off no current flows to IC1 obviously IB2 will be large, isn't it right? because all the current that comes from here, this is going to go off here and therefore there is a possibility that Q2 may be saturated. So we assume that Q2 is saturated.

Student: Excuse me sir, in this case the circuit that we are dealing is, is similar to the circuit that we dealt in the previous case?

Professor: No

(Refer Time Slide: 28:37)



Student: If Q1 is off.

Professor: If Q1 is off, this resistance, that creates a difference.

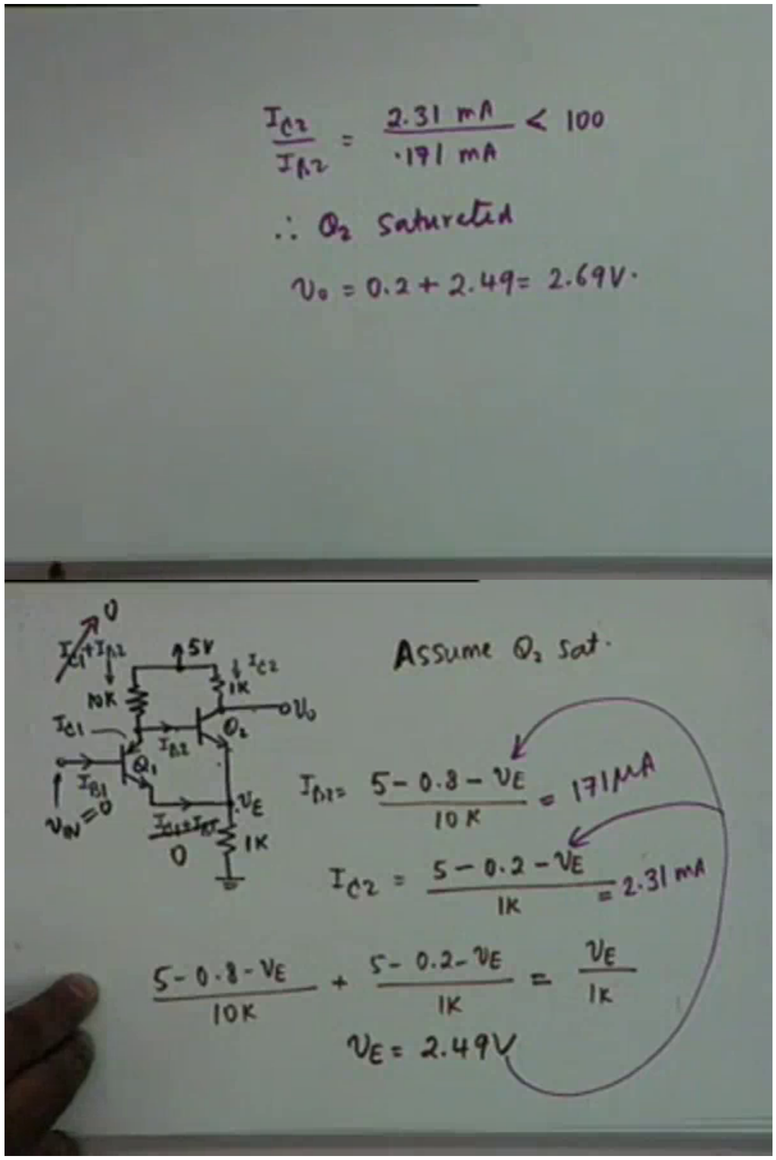
So assume Q2 to be saturated. If Q2 is saturated when this is the same circuit okay. IB1 is 0, this is 0 therefore IC1 is 0 right? Therefore it is only IB2 which comes like this. This is totally 0 okay so 5 minus this is the 5 volt. I want to find out what is IB2. First what is IB2, IB2 is 5 minus if Q2 is saturated this voltage is 0.8. 5 minus 0.8 minus V E whatever that voltage is okay, minus V E divided by 10k is that correct? I have found out IB2 IB2 is 5 minus 0.8 minus VE divided by 10K alright. Then next I want to find out IC2 this current. IC2 would be 5 minus this voltage which is 0.2 minus V E divided by 1K alright and you notice. That the some of these 2 currents. IB2 and IC2 will now float through 1K. And that will cause the drop V E.

So I sum up these two 5 minus 0.8 minus V E divided by 10K plus 5 minus 0.2 minus V E divide by 1K. These two currents this should be equal to V E divided by 1k agreed? The sum of these two currents IB2 and IC2 should be equal to the current through 1K. (())(31:01) in this only V E is unknown. And therefore we know V E. V E comes out as 2.49 volts okay and if I know V E then I can find out now IB2 right? If I know V E and if I substitute here I found out IB2, is the point clear?

Students: Yes Sir.

This is 171 micro-ampere. It works out to. If I substitute this here. On the other hand. IC2 if I substitute again here IC2 comes out as 2.31 milli-amperes agreed. So now my test for saturation.

(Refer Time Slide: 31:56)

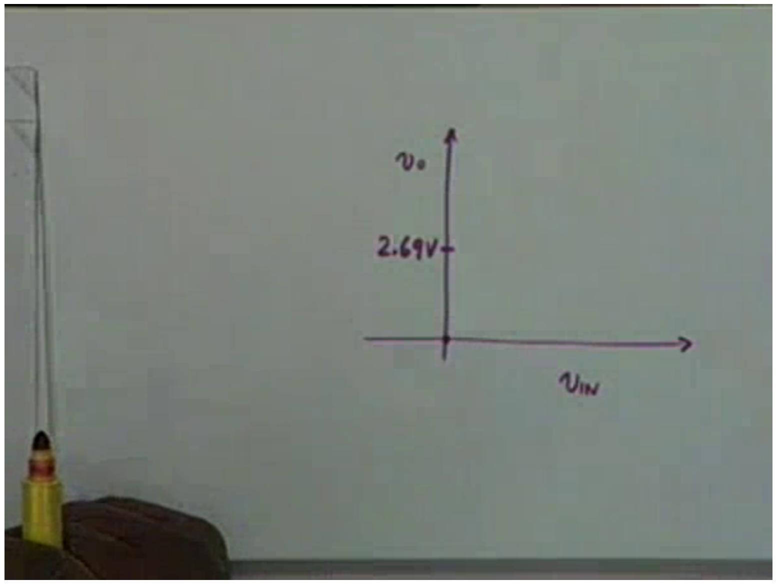


What I do is IC2 by IB2 is equal to 2.31 milli-amps divided by 0.171 milli-amps 171 micro-amperes. So this is less than 100 obviously. If it was 100 the numerator would have been 171 therefore Q2 is indeed saturated. And if Q2 is saturated then what is V0. V0 is this voltage. So it will 0.2 plus V E, how much did you find out V E?

Students: 2.49

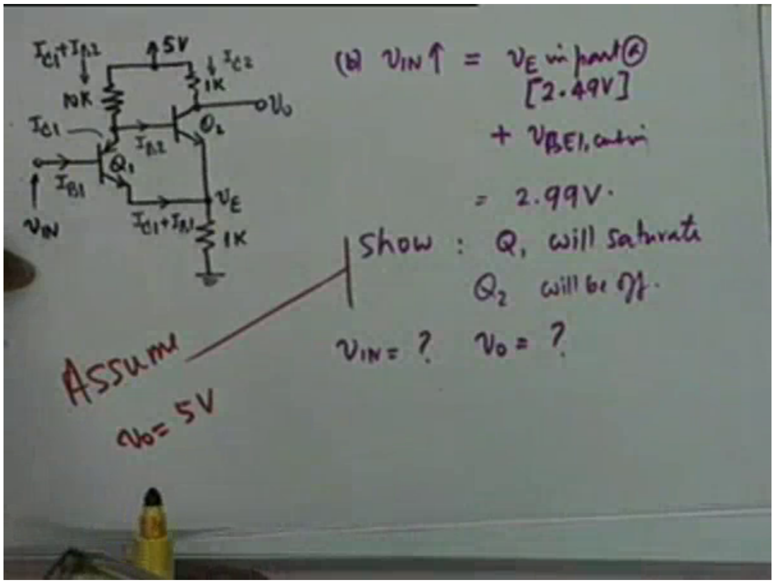
2.49 so this is equal to 2.69 volts and the problem is solved okay. First part of the problem. If I, I want to have your complete mind in this, because I am going to do some uhh interesting plots now.

(Refer Time Slide: 33:17)



If I plot V0 versus V IN. V IN equal to 0 leads to V0 equal to 2.69 volt. Let's say somewhere here. Let say somewhere here. 2.69 volt alright. Obviously if I want to change this state if I want to make Q1 conductive then I have increase V IN. Let's do that. The part part B of the problem says.

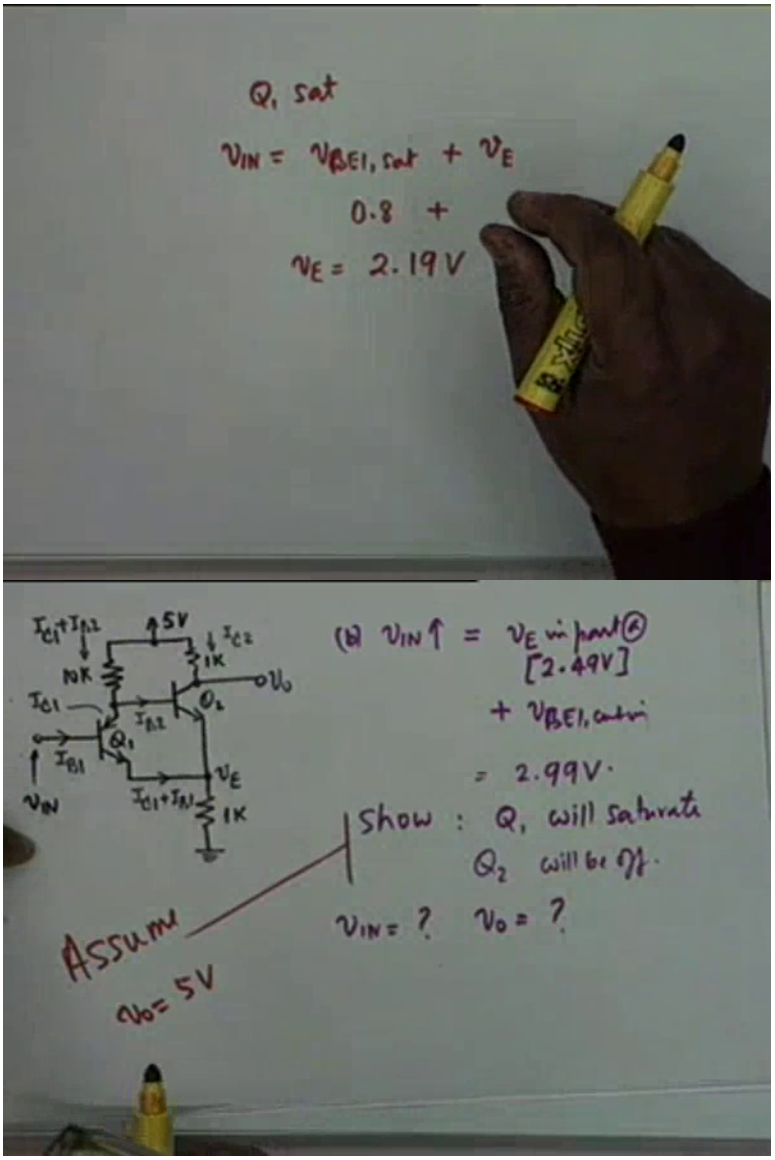
(Refer Time Slide: 34:00)



If V IN is increased V IN is increased instead of 0 we should have connected you connect a source a voltage source there, to a value of V E in part A this voltage what is this? 2.49 volt plus how much do I need for conduction of Q1? 0.5 cut-in cut-in. So V B E 1 cut-in, that means equal to 2.99 volt. If V IN is increased gradually to 2.99 volts then Q1 will start conducting and it says so that Q1 not only will start conducting it will saturate. Show that Q1 will saturate and Q2 will be off and under this condition and under this condition you will have to find out V IN we have already found out. Find V IN and resulting V0. Alright this is what we have to find out.

So assume that it is so. Is the problem clear? In the previous case, in the case A V IN was 0 now you are V IN lid out of ground and connect it to a voltage source and increase the voltage. Obviously Q1 cannot conduct till the voltage V B E1 which is cut-in which means that V IN has to be the cut-in voltage plus whatever V E was. During this process of increasing the V IN, V E remains the same because Q1 remains cut-off. As soon as it starts conducting it takes no time to go into saturation. Let us see whether it goes or not. So assume assume that this is true, if there is contradiction then we will say sorry Q1 is not saturation. So assume that this is true and if this is true then obviously V 0 if Q1 is off I am sorry if Q1 is saturated and Q2 is off then assume this. If we assume this then what is V0? 5 volts. Because Q to up means that there is no I C, agreed. So what else do we have to find out. We have to find out? We have to find out, under this condition what is V E? I must take another page.

(Refer Time Slide: 37:53)

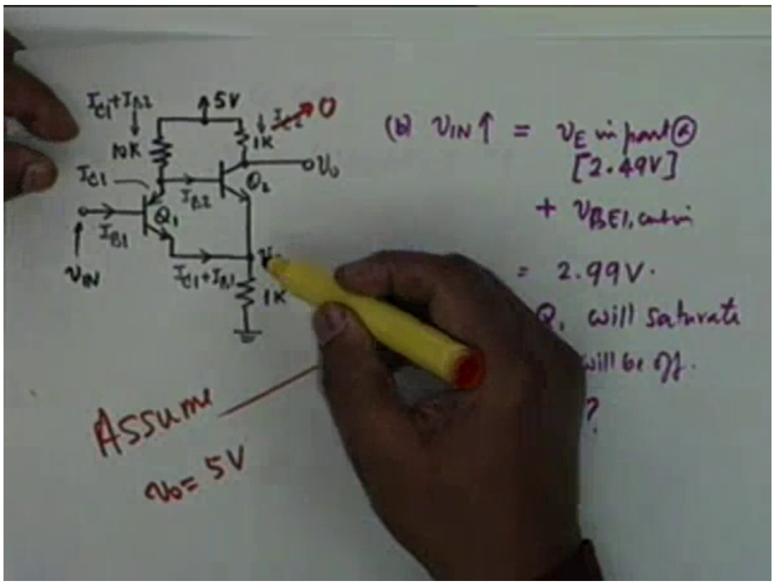


If Q1 is saturated and Q2 is off? V IN was made 2.99 volt to make Q1 conduct. But when it is saturated, what is V IN? When Q1 is saturated what is V IN? V IN would V B E 1 saturated which is 0.8 plus V E. So the new V E, previously V E was 2.99 volts I am sorry 2.49 volts. And then we added a 0.5 to it, so as to make Q1 conduct and Q2 is put off. Now when Q1 is saturated it's V B E increases from 0.5 to 0.8 and therefore V E shall also change. Therefore V E becomes 2.99 minus 0.8 which means 2.19 volts as the point clear?

Students: No Sir.

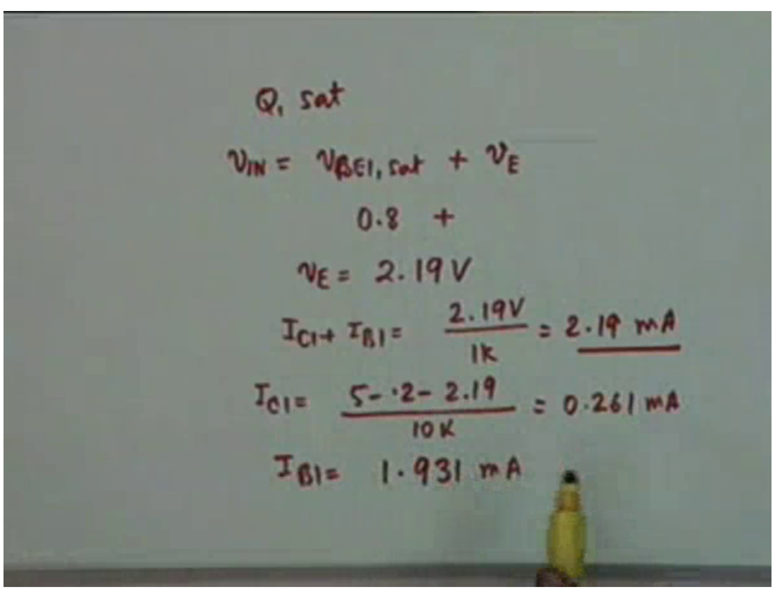
Okay you see as soon as Q1 starts conducting. In no time it goes into saturation. V E cannot change instantaneously so it remains at 2.99 so if does so what changes is the voltage across the base emitter of Q1. It changes from 0.5 to 0.8 therefore V E shall now change to 2.19 because the input remains the same input remains at 2.99 alright. So this is 0.8 and therefore this becomes 2.19. If it does become 2.19 then, what is the current, I must go back to this figure.

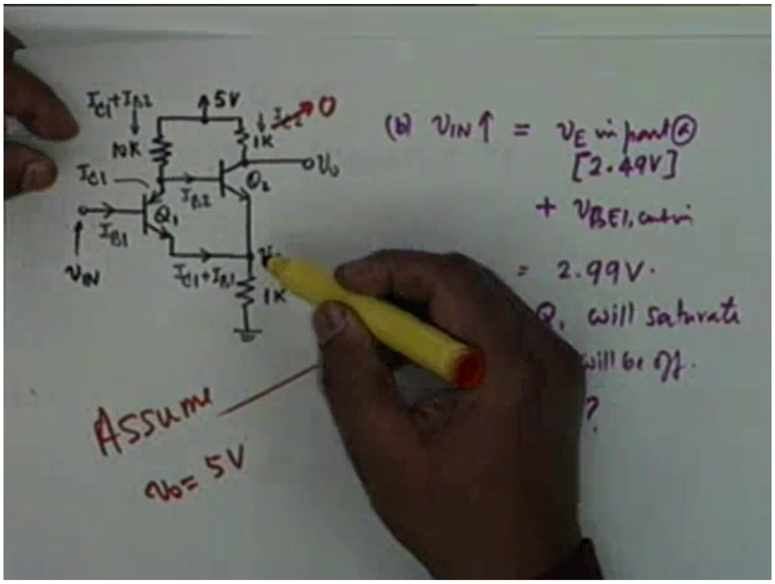
(Refer Time Slide: 39:37)



You see this is off, this is 0 and this current would be I C 1 plus I B 1 and V E is 2.19.

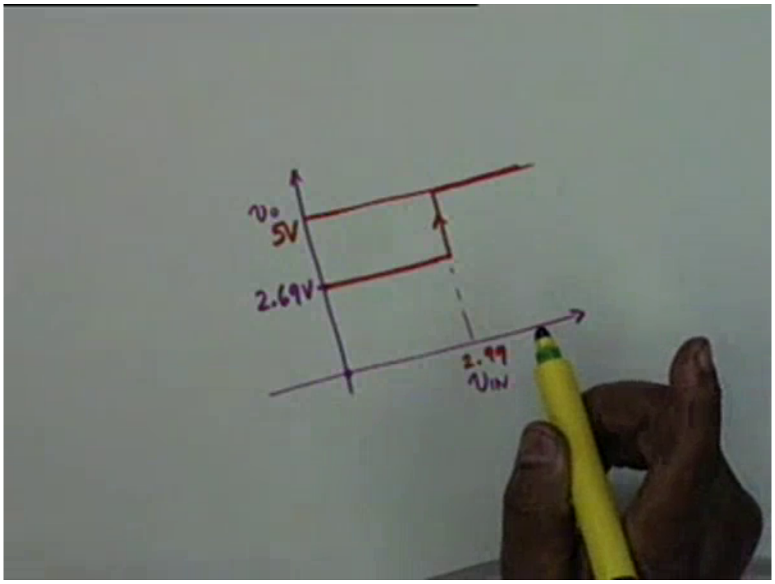
(Refer Time Slide: 39:48)





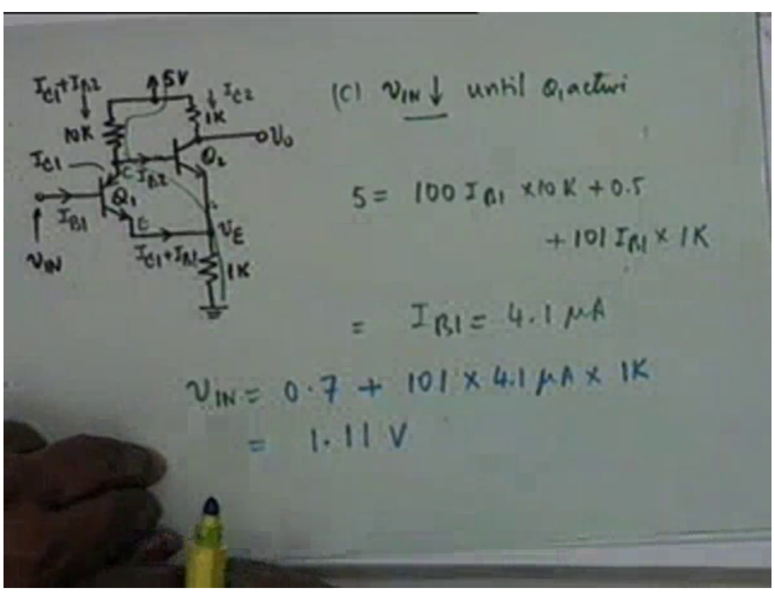
Therefore I C 1 plus I B 1 equal to 2.19 volt divided by 1K, which is 2.19 milli-ampere. I can also find out I C 1 as 5 minus 0.2 minus 2.19 divided by 10K. And this works out 0.261 milli-amperes. Then what is I B 1, this minus this okay? I B 1 plus I C 1 is 2.19 milli-amperes and I C 1 is this therefore I B 1 becomes 1.931 milli-amperes. Is there a doubt that the transistor is saturated? I C 1 by I B 1 is a fraction now, much less than 100 and therefore indeed Q1 is saturated. It takes a little time, it doesn’t occur instantaneously because there is space charge which has to be cleared. If Q2 is saturated there is charge accumulation which has to be cleared and that charge has to come in and damp on Q1 to make this saturated. It does take a little time but for such calculation we don’t take care of this, we take care of this in digital electronics. What times does it takes to switch states? Now you see if I go back to my figure, I do have this okay.

(Refer Time Slide: 41:44)



2.69 when V IN was 0 part B say if I increase V IN to how much 2.99 then what does V 0 becomes, V 0 becomes, 5 Volts so it immediately rises and becomes 5 volt okay. 5 volt and it remains 5 volts. If you increase V IN beyond this because Q1 is saturated there is no change alright. Now suppose you want to back to the original state that is if you want to go back to the original state then what do you have to do, you have to decrease, we have to decrease V IN till Q1 comes to be, which region? It was saturated so first it would come to the active region, alright this is what part C of the problem says.

(Refer Time Slide: 43:02)



Now let me look at part C. Part C of the problem states now to switch back to the original state. V IN must be reduced until Q1 is active, reduce V 1 V IN until Q1 is active that means this voltage reduces to 0.7 volt. V B E 1 reduces to 0.7.

Student: Excuse me Sir now we're been told that while V IN never reach the active state.

Professor: Yes we did. From cut-off it has gone via the active state, but it has reached the saturation very quickly. So quick that in the oscilloscope you won't be able to see the vertical part.

Student: And would we able to see that when we can get down V IN?

Professor: Well you see what happens, see what happens. It has to come through the active region from 0.8 it cannot go to 0.5 or 0.2 it will go through 0.7 okay, now so intermediate state is active V IN must be reduced and keep until Q1 is active. If Q1 becomes active then V B E 1 would be equal to 0.7 and if I want to change this you see Q2 was off earlier if I want to make Q2 conducting then this voltage V B E 2 must be reduced to 0.5 okay. Now what is V B E 2 it is also V C E 1 isn't it right? This is the collector this is the emitter. So V B E 2 is the same as V C E 1 therefore what you do is, you reduce V IN such that V C E becomes 0.5 and immediately Q2 will start conducting alright.

You're required to find out what is this V IN. V IN to be reduced to what value such that this happens.

Students: But both are in active region?

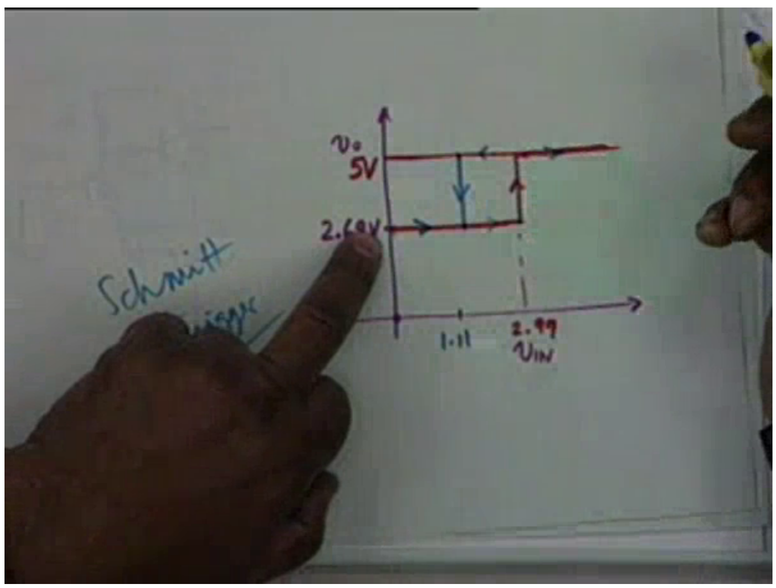
Professor: They will not remain so. They will not remain so as you will see. We will see this.

Okay so if I apply KVL and this transistor has just started conducting then obviously no I am sorry. We go to KVL via this, via this okay. When therefore 5 volts shall be equal to, what will be this current. This will be 101 I B 1 alright. This current I C 1 plus I B 2 no I am sorry hold it. Cut-in means what, the Q2 has just started conducting which means that the current I B 2 has just started flowing we will take that current as 0. Then I C 1 would be simply 100 times I B 1. So it would be 100 times I B 1 multiplied by 10K this is the drop here plus cut-in voltage is 0.5 plus V E, what would be V E now. This current has just started flowing. This is still 0. So V E would I C

1 plus I B 1 that means 101 I B 1 multiplied by 1K alright is the point clear. V IN is now reduced until Q2 just starts conducting. When it just starts conducting I C 2 is 0 I B 2 is 0. But a little increase will make both of them non-zero.

So my KVL says 5 volts must be equal to drop across 10K plus the cut-in voltage, plus V E and V E is the 1K drop due to current I C 1 plus I B 1. Now what does this give you. This gives you I B 1 and I B 1 comes out as 4.1 micro-ampere. So what is V IN then? What is the value of V IN? V IN is Q1 V B E 1 which is in the active region so it is 0.7 plus this voltage V E which is equal to 101 times 4.1 micro-amperes multiplied by 1K therefore this V IN is surprisingly 1.11 volt. This is not 0.

(Refer Time Slide: 48:39)



Now if you go back, if you go back to this diagram. You see that V IN at 2.99 it had change state from Q1 off to Q2 off. When you reduce to from 2.99 we have to come up to 1.11 to make it change state. That means Q1 goes to active region and Q2 goes into conduction. Now this state does not remain so. Ultimately what happens is Q1 becomes off and Q2 becomes saturated. That is comes back to this state alright. So if I plot if I show the direction in which I went I increased initially the power supply was put off put on Q1 was off Q2 was saturated and this is the condition.

Then I increased V IN, how did I reach this condition initially. The base of Q1 was connected to ground 0 voltage. Then I connected the battery and continued increasing. If I increase up to 2.99

then suddenly there is a change of state and this state remains like this. If I want to come back then I reduce V IN and I have to reduce up to 1.11 to be able to change again to the other state okay. This is a highly non-linear circuit. And this circuit is called it's so called Schmitt Trigger.

Student: Sir why this abrupt change at 2.99.

Professor: At 2.99.

Student: That will increase from 2.695 over the period of V IN.

Professor: Actually there will be a small slope here as I said because the current takes some time to do that. But V IN it is so fast that you won't be able to see it in the scope. In the scope you will see something like this a rectangle.

Student: Sir won't there be a region where Q1 is active but Q2 is still cut-off?

Professor: It is a very transient region. It is not observable on this scope. It's almost vertical. The time take it can be analyzed. It can be analyzed it will be done in the digital electronics.

Student: Sir in Q2 you took I B 2 as 0.

Professor: In Q2 I B 2 as 0 that's right.

Student: Sir in that case I C 2 will also be 0?

Professor: That's right.

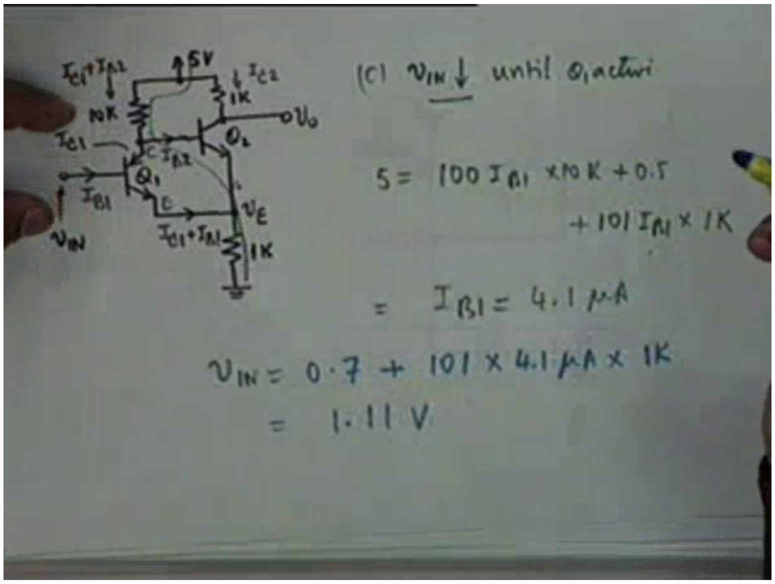
Student: So in that case I E 2 will also be 0.

Professor: I E 2 will also be 0.

Student: Sir V E should be 5 volts.

Professor: No.

(Refer Time Slide: 51:23)



Why s V E be 5 volt. V 1 is 5 Volts.

Any other question, this is one of the experiments that we will perform in the lab class.

Student: In part B we get the conduction of VE is 2.19 volts.

Professor: Right.

Student: To reduce V IN to 2.19 volts then V B E was below 0.5 volts.

Professor: I cannot reduce that you see all control that I have I have no control over V E all control that I have is in V IN.

Student: Yes sir right.

Professor: Correct.

Student: But in B case we are at 2.19 volts V E.

Professor: Correct.

Student: We start reducing it to 2.19 volts.

Professor: Reducing V IN?

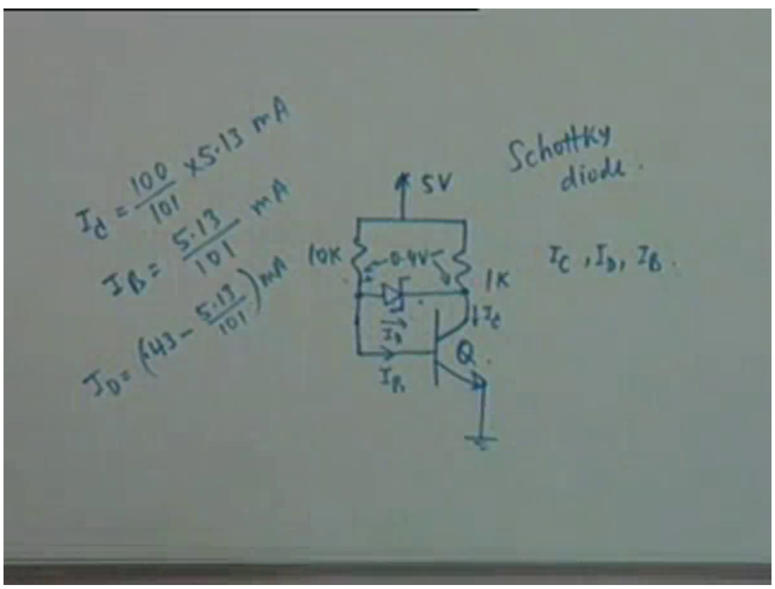
Student: V IN to 2.19 volts.

Professor: Okay.

Student: Then V B E becomes less than 0.5 obviously.

Professor: No it doesn’t happen, because in the mean while Q2 changes it's state. So it doesn’t happen. You see all this phenomenon if you do it gradually you will that suddenly in the oscilloscope if you're observing the output the output as long it is steady it will be kept in the straight line. Suddenly you see the straight line jumps up. And suddenly the straight line jumps up okay, we will actually see these diagram in the laboratory. This is a Schmitt Trigger Circuit and one of the experiments in the laboratory is this. We are about at the end of the time. Whatever the other 2 two problems 7 and 8. 7 has been done. Question 8 I will simply tell you what the problem is and then I will give you the solution.

(Refer Time Slide: 53:14)



Question 8 is there is a 5 volt source 1K there is a 10K here and there is a diode here, a very special diode here called the Schottkey Diode has a drop of 0.4 volt unlike the ordinary diode, which are in active region cut-in 0.5 saturation 0.8 so on and so forth. Schottkey diode is approximately 0.4 volts and this is connected to the base. This is I B and this is I C you're required to calculate. This is I D. You're required to calculate I C, I D and I B. And you're also required to answer whether Q is active or saturated. While the solution methodology is the same that is we either assume it to be active or saturated. I assumed it to be active. If there is a contradiction it will come out. I assumed to be active and I found out.

I will only give you my results. Is that (())(54:49) you apply a KVL that's about all that you do. All circuit problem require an application of KVL and KCL and at the most ohms all. Nothing else these are the 3 equipment that an electrical engineer has to solve almost any problem okay. My solutions are I C no I was too lazy I didn't put them in the calculator it is 5.13 milli-amperes. It is approximately 5.13 101 100 by 101. I B is equal to 5.13 divide by 101 milli-ampere. I assumed it to be active so it has to be the and I D is equal to 00.43 minus 5.13 divide by 101. That is why I calculated the current through this and subtracted I D so many milli-amps. These are the solutions. And since these equations are consistent our initial assumption that the transistor is in active is justified. If it was not consistent then we would have gone and recalculated alright. Our next tutorial or next problem session will be on FET. DC analysis of FET circuits.