Analog Electronic Circuits
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Lecture No 06
BJT Bias Stability (Contd.)

6th lecture on BJT bias stability continued.

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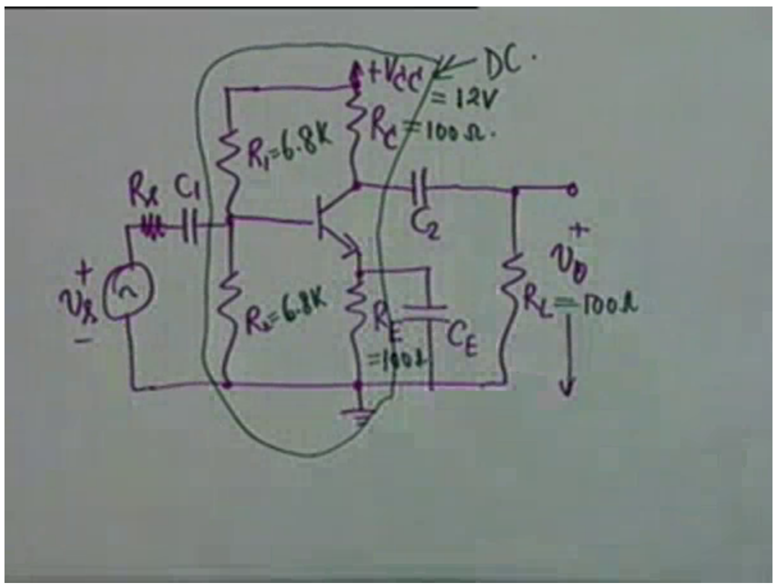

In the last lecture 5th we had discussed this particular bias arrangement which is the most common bias arrangement that is an emitter resistor which is bypassed by a capacitor C E plus V C C this is an npn transistor R C and then we have a coupling capacitor C 2 which goes to load resistance R L. This is the output voltage V 0 and at the input the biasing is done through a potential divider two resistances R 1 and R 2. Then the signal is applied through a capacitor C 1 and a voltage source a signal source V S. V S could have and internal resistance R S. This is the this is the complete C E amplifier and the D C part of the circuit.

The DC part of the circuit is this. DC is not affected by the capacitors, there is a coupling capacitor used as bypass capacitor. Okay we also took a particular example which we shall carry through our discussion in which we had taken V C C as equal to 12 volt I think R C was 100 ohms R L was 100 ohms, R E was also 100 ohms. R 1 was 6.8k and R2 was 6.8K. We have not specified R S, C 1, C 2, C 3, C 1, C 2, C E, because they do not affect our operation at the moment, at the moment bias stabilisation.

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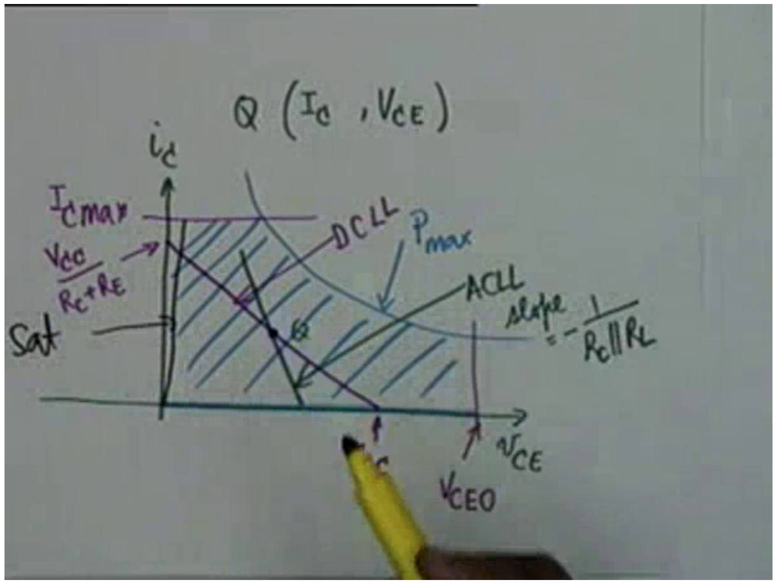

We also discussed that the BJT bias point that is the Q point or the operating point which is the value of I C and V C E. This defines the operating point Q inside a bounded region in the I C V C E characteristic. The bound occurs due to various reasons. Let me use different colors. One is the P D A P maximum allowable dissipation, P max. One is this hyperbola. Second is the breakdown voltage, this is V C E O the breakdown voltage. That is the voltage beyond which you cannot go without the junction breaking down. There is a maximum current limit. You cannot draw more than this I C max. On the lower side there is a saturation line saturation line and finally there is a cut-off line. So it is this region within which the Q point has to lie. And in order that the amplifier is able handle a reasonable amount of signal voltage the Q point must lie somewhere in the middle. Somewhere well inside the region.

Okay if it is close to the cut-off then obviously the dynamic range will be very small. If it is close to P max while the transistor might breakdown because this Pmax is for, his manufacturer specification and you know that even if fabricated by same process steps there are lot of variations between 1 transistor and another from the same lot and therefore you cannot take that risk of operating near Pmax. You can't go to V C E O. You can't go to IC max you can't go to Sat. So the Q point has to be somewhere here. And we showed that the Q point lies on what is called a DC load line a DC load line where this point is given by V C C okay and this current is given by V C C divided by R C plus R E. This is plus R E with a certain assumption.

What was the assumption? That beta is much greater than unity. This is the DC load line D C L L and in addition we also said that there is an AC load line which passes through the Q point, which passes through the Q point but is a higher slope and AC load line is somewhat like this. A C L L whose slope is minus 1 over (())(6:42) which is R C parallel okay. This is this describes what we did last time. Now we start from this point. We said that not only we want to establish a Q point we would also like to stabilize the Q point. We would also like to make sure that if the transistor is replaced by another transistor of same number or if temperature increases or decreases which causes a change of beta V B E and also I C B O all the 3 quantities change or if there is a fluctuation in the power supply V C C changes then naturally V B B also changes and there may be a change in the parameters also. Therefore the Q point not only we want to establish we want to stabilize it. And this what we want to investigate today. Yes you have a question?

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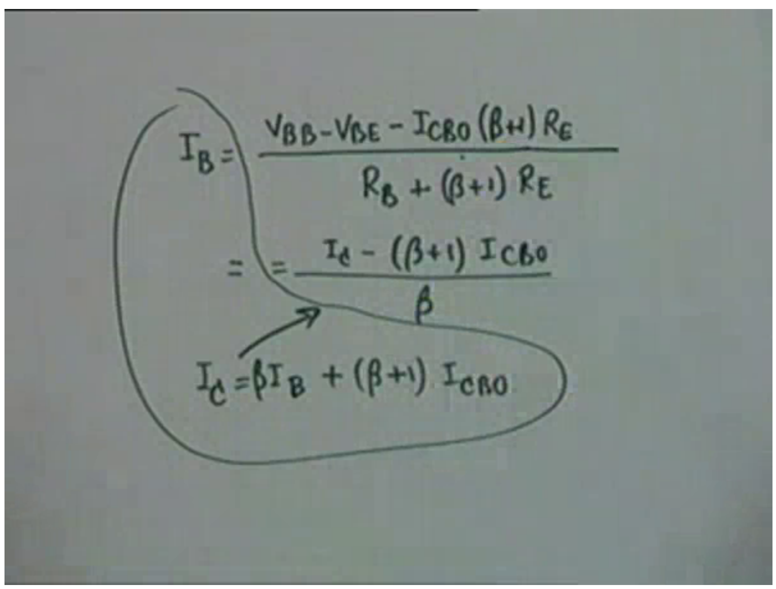

We will establish this relations that I B I B the base current by taking the left loop that is the base loop we establish that this is given by V B B minus V B E minus I C B O beta plus 1. We're not making any approximation, beta plus 1 multiplied by R E divided by R B plus beta plus 1 R E. This is the value of I B that we had established relating I B to V B E to I C B O and beta. These are the 3 variable quantities alright. We also know from the relation that I C equal to I B times beta plus Beta plus 1 I C B O this is the fundamental relation, yes.

Student: Is I C B O same as I C O?

Professor: That's right.

We're using the additional symbol B because of the conventions okay. This is the common emitter and it is used as C B O. You see this is common base then the current that would be effected would be I C E O which is I C B O multiplied beta plus 1 okay. Now if I combine this with this, that if I write this I B as equal to I C minus Beta plus 1 I C B O divided by beta isn't this, doesn't this follow from this relation? Okay, now therefore and I ignore the rest of the quantities then this should be equal to this from this you get a relation between I C the collector current and the other quantity. This algebra after clearing the mess the result is not too complicated. What we get is the following.

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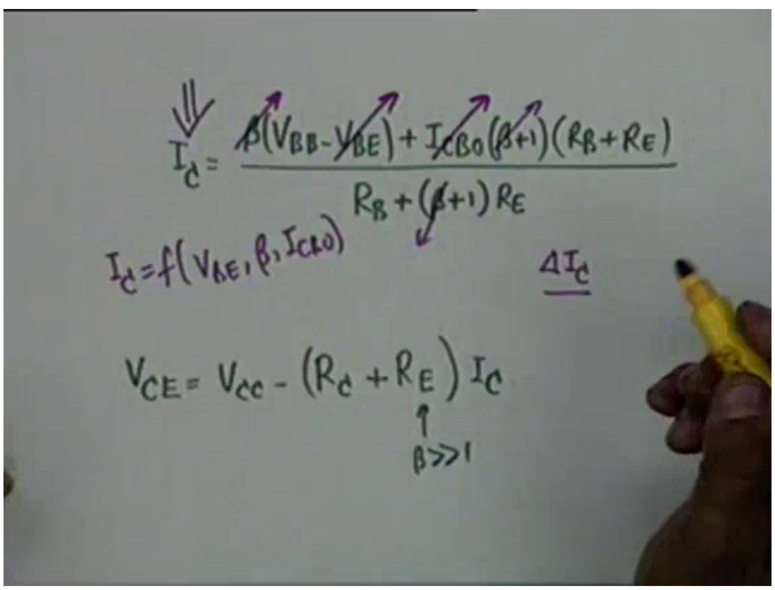

I C is equal to beta times V B B minus V B E plus I C B O beta plus 1 multiplied by R B plus R E divided by R B plus beta plus 1 R E okay. This is one of the coordinates of the Q point and the other coordinate is V C E which is equal to V C C minus R C plus R E with that assumption beta much greater than 1 beta much greater than 1 multiplied by I C. Therefore if I can stabilize I C I have stabilized V C E also. So all we need to do is to focus our attention on this on the stabilization of collector current against variations in beta. Beta varies, V B E varies and I C B O varies beta varies, this varies.

Student: Sir but if our V C C also varies.

Professor: If V C C also varies then you're stuck. V B E will vary then, well if there are ways of compensating for variation in V C C also but what is preferred is that you use a regulated power supply rather than an unregulated power supply in other words you make V C C constant by using a regulated power supply alright. That is relatively easy to take care; if V C C is not constant then you make a simple Zener diode regulator and apply that to transistor circuit. So let's look at the variation of I C which we shall call delta I C due to a change of beta, due to a change of V B E, due to a change of I C B O separately. There are 3 parameters you see I C is a function of 3 variables.

V B E beta and I C B O so let us find out partial I C that is delta I C due to a change of let say V B E and beta and I C B O are held constant. Then we will investigate change due to beta when V B E and I C B O are held constant. The 3 factors separately then you can try to combine alright this would be our procedure. Actually what we should do is, strictly what we should do is that we consider 2 situations. What we should do is the following.

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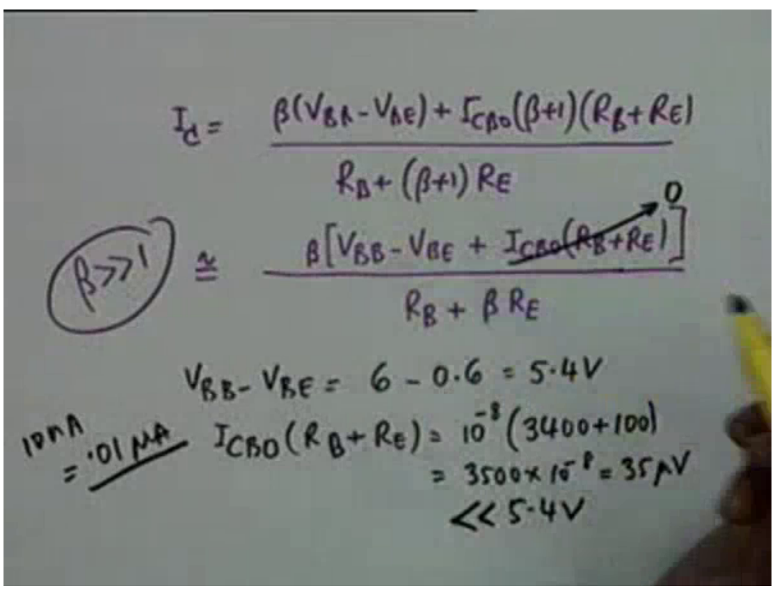

We will consider two situations, in under one situation the collector current is I C 1 which has beta equal to beta 1 V B E 1 and I C B O 1 alright, this may be at room temperature for example. And at an increase temperature since all of them vary let them vary to the following quantities. I C B O 2 and let the result current be I C 2 alright. Then we should find out we should define delta I C as equal to I C 2 minus I C 1 and should find out delta I C as a function of delta beta which is beta 2 minus beta 1. This is simultaneously, that is all the factors considered together. Beta 2 minus beta 1 delta V B E as equal to V B E 2 minus V B E 1 and delta I C B O as equal to I C B O 2 minus I C B O 1.

This is what I should do, you understand what I mean? Take this circuit or take this expression I C, expression for I C find out I C 1, find out I C 2 subtract the two, subtract the first from the second due to the variation of all the 3 simultaneously and then find out the percentage change by dividing delta I C by I C 1 and multiplying by 100. This will be the percentage change in the collector current. This is what you should do. But as you can see the expression itself is quite involved. And if I do that I can get an expression which will fill the whole page or take the next page also but this is not very meaningful and as engineers we don't want to make life more complicated then what is demanded of this situation okay. So we try to make life simple and we shall instead. In one of the tutorial problem we shall work out actually what happens with numerical values which is not too difficult.

Actual value of the percent change in I C but as far as mathematics is concern, general formulas are concern, let's consider variations one at a time, then try to combine. This is the engineers approach alright. Even here we will make a simplification. Let me write this expression I C equal to beta V B B minus V B E plus I C B O beta plus 1 R B plus R E divided by R B plus beta plus 1 R E. One simplification which you can very easily do is, the transistor will be useless if beta is not much greater than unity. So we can assume beta much greater than unity and then this expression becomes beta you see beta is much greater than unity then 1 drops out this 1 drops out and beta can be taken out right.

Therefore what we get is beta V B B minus V B E plus I C B O R B plus R E. Alright bracket closed beta is a common factor of the 2 expressions and in the denominator we get R B plus beta R E. This is the assumption beta is much greater than unity alright. And we would also we would also do another simplification mainly that when you consider variation with respect to beta or V B E we shall ignore this I C B O term okay. Otherwise it's an unnecessary complications we shall ignore this term and to make things look logical let's calculate this term as compared to this term in the particular example that we took.

In the particular example V B B minus V B E was equal to 6 volt 12 6.8 and 6.8 so V B B is 6 volt and V B E is given as 0.6, so this is 5.4 volt on the other hand I C B O R B plus R E is equal to I C B O is typically 0.1 micro amps, that is 10 to the minus 8 ampere which is 10 nano ampere this is the reasonable figure for a BJT. So I C B O R B plus R E is 10 to the minus 8 multiplied by R B is 6.8 parallel 6.8 3400 plus 100 which is 3500 times 10 the minus 8 that is equal to 35 micro volt agreed which is indeed much less than 5.4 volt. Therefore compared to this term, V B B minus V B E you can ignore this term. But as long as you're considering variations with respect to beta or V B E. If you're considering variations with respect to I C B O itself obviously we cannot do that agreed. We also know that I C B O doubles for every 10 degree centigrade rise in temperature. So there may be a temperature at which this term shall become comparable. But as far as beta and V B E variations are concerned, let's ignore this.

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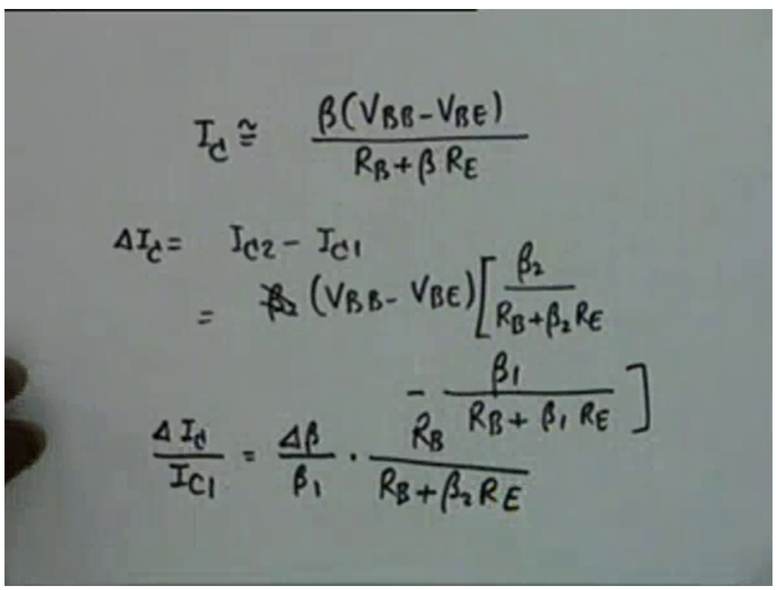

In other words we take the expression I C as equal to beta V B B minus V B E divided by R B plus beta R E alright. So let's consider delta I C, when beta changes beta is beta 1 and when beta 1 changes to beta 2 delta I C which is I C 2 minus I C 1 is equal to beta 2 V B B minus V B E is a constant. I could again take this out. Then beta 2 divided by R B plus beta 2 R E minus beta 1 divided by R B plus beta 1 R E alright. This is delta I C due to a change of beta only. And what I have to do is to find delta I C divided by I C 1 if you clear this algebra and divide by I C 1. While this algebraic simplification I leave it to you.

The expression very simply becomes delta beta which is beta 2 minus beta 1 divided by beta 1 times R B divided by R B plus beta 2 R E. Let me write this again.

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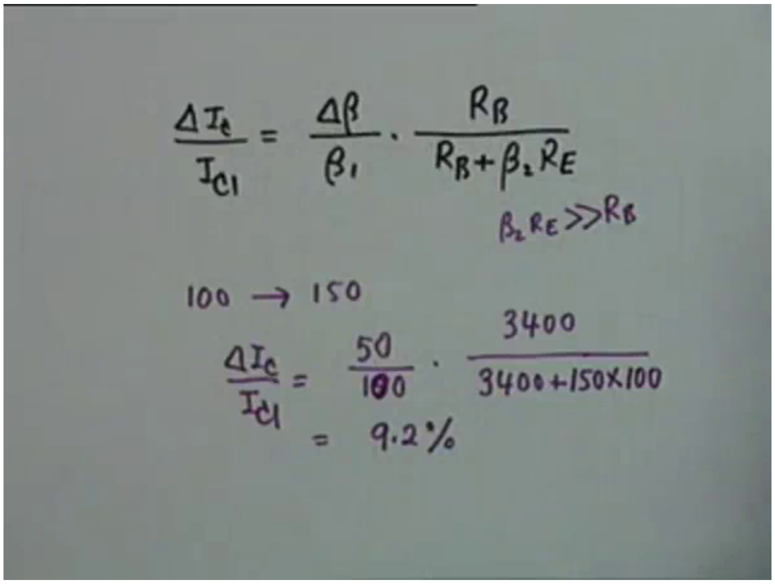

Delta I C divided by I C 1 is equal to delta beta divided by beta 1 R B divided by R B plus beta 2 R E. Now an observation, suppose R E was equal to 0. Someone asked in the previous class why using R E at all? Suppose R E is made equal to 0 then this term becomes unity which means that a 10 percent variation in beta will cause a 10 percent variation in I C isn't that right. In other words one to one even if beta changes to 1 percent I C will change by 1 percent whereas multiplication by this factor which can be made much less than unity how? By making beta 2 R E much greater than R B. If you do that then this quantity would be very small and therefore even a large change in beta will cause a small change in I C and that is what stabilization means, isn't it right?

Even if beta changes by replacement of a transistor which let's say beta is was 100 earlier and it is 150 now. Even if that large change 50 percent change in beta we want to make I C as stable as possible. For example in the particular example that we have take suppose beta changes from 100 to 150, nothing else changes. Then the right hand side becomes 50 delta beta divided by 150 no I am sorry, beta 1 that is 100 okay multiplied by R B is 3400 3.4K divided by R B 3400 plus beta 2 which is 150 multiplied 100. R E is 100 ohms.

So this would be delta I C by I C 1 and it calculates out to 9.2 percent. How did I get percent? I multiplied by 100 okay. Now look at this even a 50 percent change in beta has caused a change of I C by a quantity less than 10 percent. So this deduction is almost 1/5th I can make it larger if I have used a higher value of R E. If I used a higher value of R E I could make it larger. Now if you recall why not, why don't you make R E as large as possible okay that is a problem. Let's look at this problem.

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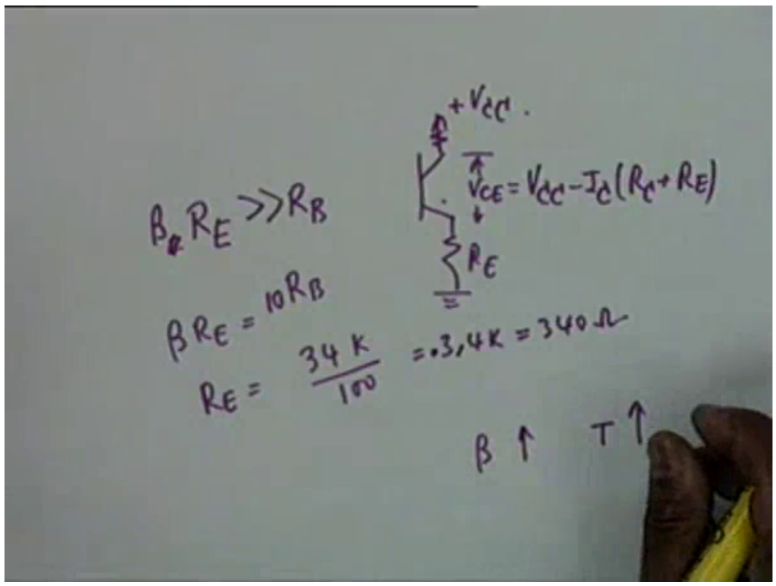

The problem is the following. This is R E okay and this is V C C this R E goes to ground and you know V C E V C E equal to V C C minus I C R C plus R E. If you keep I C a constant and increase R E naturally you will have to increase V C C and there is a limit to which V C C can be increased. Transistors basically are low voltage devices, you don't want to use a supply which is more than 12 volt. If you use a 100 volt supply yes it can be done. But then 100 volt supply itself is a very bulky thing right. So R E cannot be increase indefinite. If we could do that there is one more, there is one more problem. Suppose we use a 100 volt supply. R E is sufficiently large due to some reason, if R E gets shorted due to some reason, due to mis-handling what will happen the transistor will blow up, because it will exceed V C E O. Is that correct?

That high voltage shall come across the transistor it will burn it off. Therefore it is a risky business and R E there is a limit. The limit, well one should always try to make beta R E we don't know at what under what condition beta R E under all condition should be much greater than R B. And as you know 1 is to 10 is electrical engineers much greater. And therefore the thumb rule is beta R E equal to R B 10 times R B. If I make it in this particular case while R B is 34 3.4K then it should be 34K and therefore R E needed would be if beta is 100 it would be 3.4K. Well it's not too bad but you will have to increase your, I beg your pardon. 0.34K that is simply 340 ohms. We used a 100 ohms resistor and 340 ohms can jolly well be used without without increasing a power supply to a large value okay. This is the story about beta, let me also mention that beta usually increase. With increase temperature and the thumb rule is for every 100 degree C beta changes by 50 percent approximately 50 percent. And therefore this change could as well be due to the change of temperature from 25 to 125. Okay, we will take an example complete example at the end. Now let's look at the possible change in I C due to a change in V B E.

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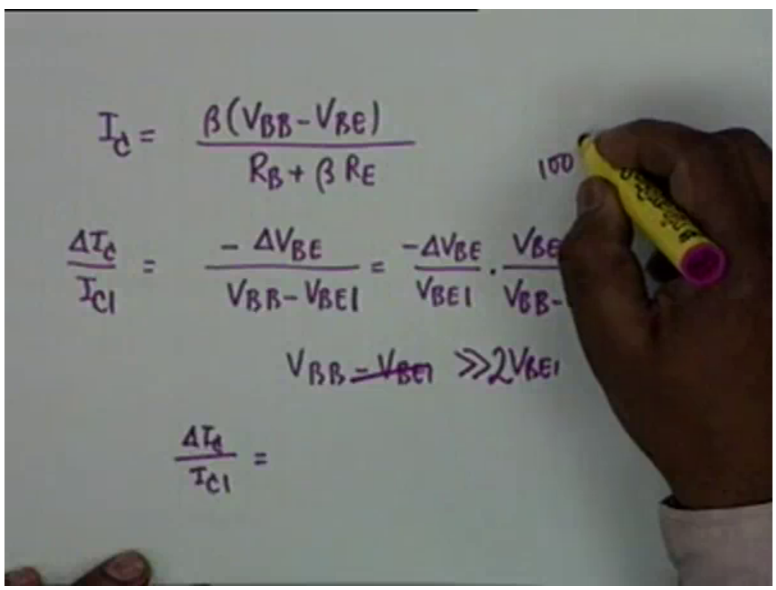

Our expression is beta V B B minus V B E simplified expression divided by R B plus beta R E. Now our change is only in this quantity and if you follow the same procedure that is I C 1 V B E 1 I C 2 V B E 2 subtract 1 from the other and divide b I C 1 it is very easy to see that the expression shall be delta I C by I C 1 shall be equal to minus delta V B E divided by V B B minus V B E. This comes from division from I C 1, it's very simple. Simple to do this algebra which I shall express as minus delta V B E divided by V B E alright. Which V B E is this 1 or 2? 1 that is correct. And therefore I will use this 1 multiplied by multiplied by V B E 1 and intentionally introduced this term to express percentage change divided by V B B minus V B E 1 alright and once again you see that, if this term is unity. If this term was not there, if this term was not there, then 10 percent change in V B E would have caused 10 percent change in I C.

However because of the presence of this term which is less than unity, because V B B is typically less than 6 volt and V B E 1 is 10 times less 0.6. Therefore this quantity is less than unity and therefore a 10 percent change in V B E will cause a much less change in I C. And as you can see this sensitivity to V B E can be reduced drastically if you could make V B E V B B minus V B E 1 much greater than V B E 1 which means that V B B should be much greater than twice V B E 1 okay. So if you could make, if you could make V B E is 0.6 if you could make V B B approximately 12 okay then you could have a reasonable stabilization of the operating point. But the situation that I have shown you, is not too bad. As you can see if I take that example in our example it is uhh delta I C by I C 1 is equal to minus delta V E suppose there is a 100 degree centigrade rise in temperature.

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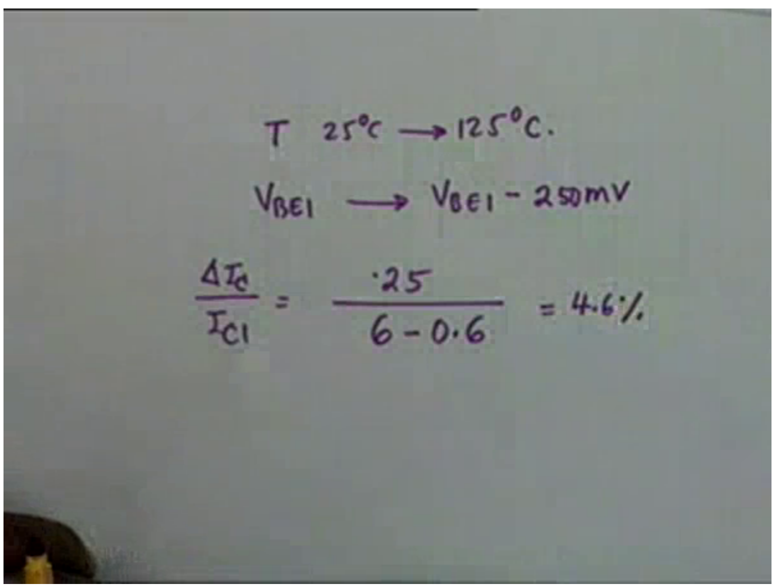

Suppose temperature goes from 25 degree centigrade to 125 degree centigrade. Then V B E changes from V B E 1 to V B 1 minus or plus? Minus it decreases. So it is minus how much? 2.5 milli-volts per degree centigrade therefore minus 25 milli-volts alright? Is that okay? 2.5 milli-volts per 250 yes. Okay 250 milli-volts, therefore delta I C by I C 1 would be equal to minus delta V B E which is 250 milli-volts which is 0.25 alright divided by V B B is 6 minus 0.6

agreed? This is the expression. And this comes out as 4.6 percent so it's not too bad 4.6 percent. Finally we consider the change in I C due to a change in I C B O.

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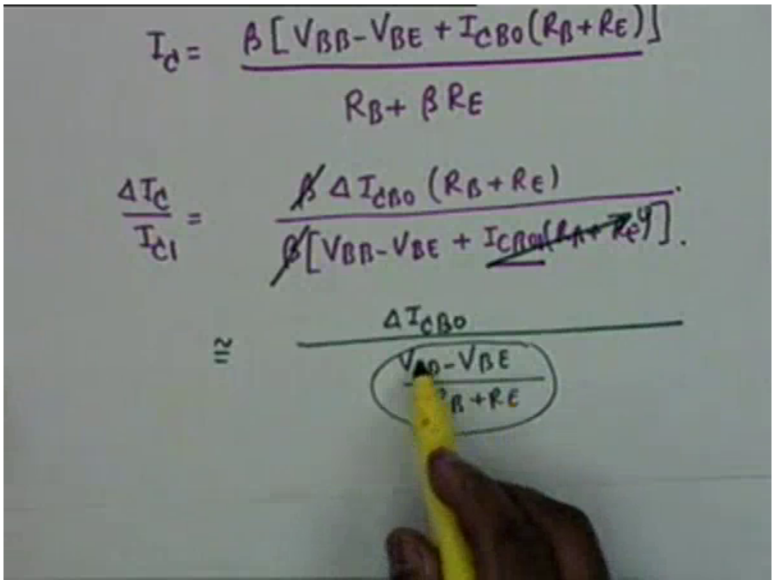

And here we have no escape we will have to use the expression which contains I C B O alright otherwise otherwise we cannot we have ignored the variation. Our approximate expression is V B B minus V B E plus I C B O times R B plus R E. Again I C B O may have changed due to a rise of temperature alright. Divided by R B plus Beta R E we did the same thing we take I C 1, V, I C B O 1, I C 2 corresponding to I C B O 2 subtract one from the other and do this algebra then delta I C by I C 1 keeping all other parameters constant this algebra simplies to the following. Beta delta I C B O times R B plus R E divided by beta V B B minus V B E can you tell me why this comes? It comes because of division by I C 1 right, plus I C B O times R B plus R E. Now we had take care of the variation of I C B O I C B O 1 thank you. This is important, it should be I C B O 1. This is delta I C B O this is perfect one.

Now we had take care of the variation due to I C B O and therefore at this stage when we are numerically calculating, pardon me. Wonderful beta does get cancel that simplifies the expression further yes very correct. Well at this stage,

Student: Excuse me sir?

Professor: Yes

Student: Sir in the first case when we considered the variation with I C due to variation in due to beta.

Professor: Correct.

Student: And then we have taken simplified expression in which we assume that the beta is much greater than (())(34:21) So if beta is somewhere near unity, this greater than 10.

Professor: If beta is somewhere near unity we will throw the transistor in the dust bin. It's not useful at all. If it freezes, if circuit is taken to Antarctica and due to temperature beta goes down near unity we will not, the circuit will not work. And therefore we will use the beta, we will use the transistor whose beta was 1000 points up. We will use a super beta transistor okay so beta much greater than 1 unless that is so the circuit is not useful. There are ways, if you need to have a lousy transistor which a beta of let say 10 I can increase it to 100 by making a circuit connection. We will see the circuit connection, we will have to use 2 transistors we will what is called a darlington connection and that increases beta to 100 beta 1 beta 2 betas get multiplied we will see these circuits later okay.

Now in this expression as I say once I had achieved the expression now I can I can ignore this term. Compared to this term, I have already done so I have already taken account of I C B O variation. This term will be very small compared with the first term so we ignored this. And therefore my expression becomes, delta I C B O divided by note the way of writing this expression divided by V B B minus V B E divided by R B plus R E okay. You see the percentage change now no longer are we dividing delta I C B O by I C B O 1 did you notice this. This is not required okay number 2. So it is not a percentage change, it is the absolute change, the absolute change in I C B O reflects itself in terms of a percentage change except for a deduction factor that is division by this quantity.

Naturally we want this quantity to be as large as possible. As large as possible means we have to make R B plus R E as small as possible. This is contradictory, we wanted R E to made as large as possible and V B E of course we can make large compared to V B B. We can increase V B B. But nevertheless whatever the circuit this is the factor by which the percentage change is reduced that is an absolute change in I C B O causes a percentage change in I C which has a reduction factor of this. And we should aim at making this quantity as large as possible. But as I said this is contradictory to the previous assumption and life is a matter of compromise, transistor circuit is no exception here also you have to make compromise.

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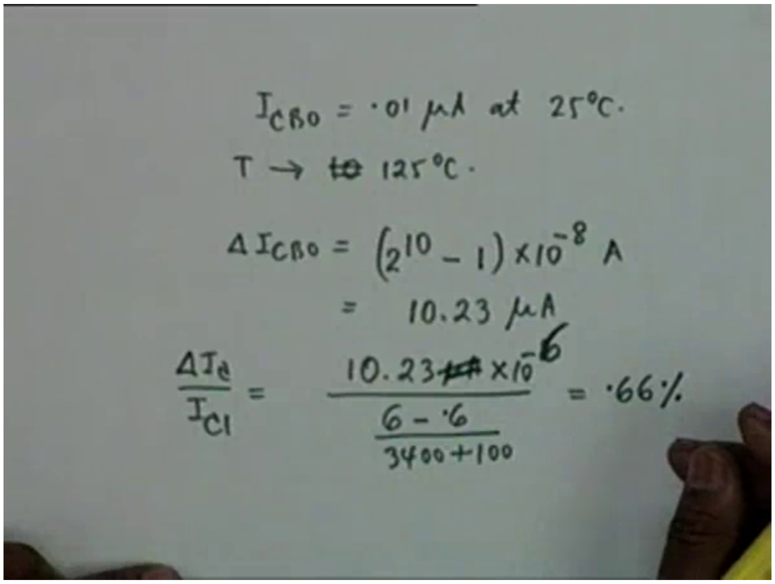

Now let's take an example suppose I C B O the same example is 0.01 micro ampere at 25 C and suppose the temperature increases to 100 125 let's say. 100 degree centigrade rise in temperature causes a delta I C B O which is equal to 10 to the power I beg your pardon. 2 to the power 10 and I am going to consider it as delta I C B O. So 2 to the power minus 1 multiplied by 10 to the minus 8 so many amperes. Which comes which calculates out as 10.23 micro ampere. 1023 and then 10 to the minus 8. 10.23 micro amperes. Therefore delta I C by I C 1 is equal to 10.23 micro-ampere okay 10.23 micro-ampere divided by 6 minus 0.6 divided by R B plus R E use 3400 plus 100 we should actually write this as 10 to the minus 8, because this is going to be a dimensionless quantity right?

Student: 10 to the power minus 6.

Professor: 10 to the minus 6 I beg your pardon.

This calculates out to 0.66 percent only okay 0.66 percent only. Therefore the effect of I C B O variation is not very interesting. Unless the temperature goes very high to furnace temperature for example okay 1000s of degrees. So I C B O is a harmless quantity as far as ordinary discreet transistor circuits are concern but I must caution you that it plays havoc in no current circuits if I

C is in the order of micro-amperes okay no current circuits are the are required in integrated circuits. In integrated circuit we want to make the volume as small as possible and therefore the heat dissipation is a problem so we want to pass as little current as possible. So that there is as little dissipation as possible where I C B O change causes havoc. There are ways of reducing the effect of I C B O in those circuits also. If you will come to at the appropriate time.

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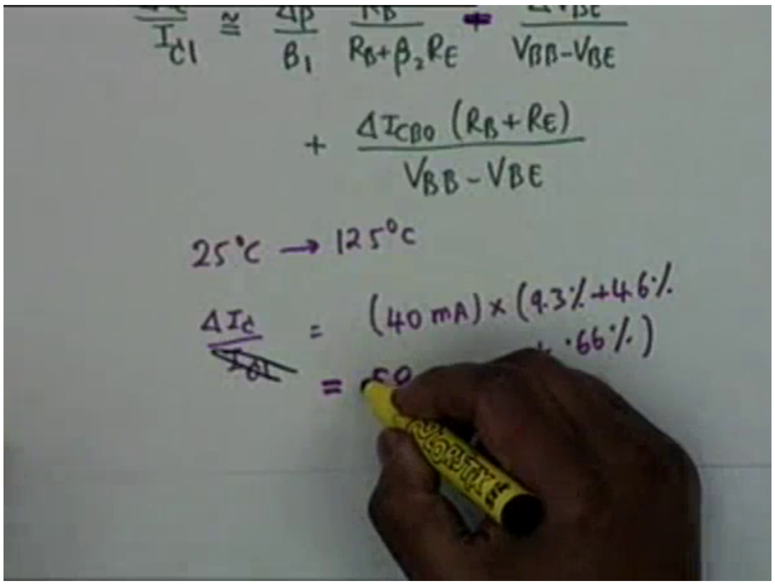

Now I consider, what I considered was delta I C by I C 1 due to variations in individual parameters keeping the other two constant. As you know in the case of a multi-variable function you can talk of partial differentiation and then if you want to find the total change then you shall have to combine the 3. And therefore if that is permitted here, that if the changes are not very drastic are not very large then I can write delta I C by I C 1 due to a change in all the 3 parameters simultaneously as the some of the 3. Delta beta by beta 1 R B divided by R B plus beta 2 R E which was due to beta variation plus delta V B E divided by V B B minus V B E plus delta I C B O multiplied by R B plus R E divided by V B B minus V B E okay.

In the process due to the disturbance I have made a mistake. Can you point out the mistake?

Student: A negative sign in (())(42:08)

Professor: That is correct wonderful.

If I we take the same example that is temperature going from 25 to 125 if I take the same example the rule of thumb is that you can make a combination if the individual percentage change is, mind you this is the rule of thumb, individual percentage changes are less than 10 percent you get more than 10 percent then you cannot do this. Then you have to go back to the original circuit consider the changed parameters, recalculate the current and calculate delta I C by I C 1, is the point clear? If the individual change, each of this changes is less than 10 percent then you can combine. In our particular example they are less than 10 percent. The highest was 9.2 percent and therefore in our example delta I C by I C 1 uhh this calculates out as. You remember what was what was I C 1?

I C 1 was 40 milli-amp the Q point was 40 milli-amps and 4 volts okay. 40 milli-amp multiplied by the percentage change that is 9.3 percent plus 4.6 percent plus 0.66 percent. The positive sign here occurs because of the negative sign here minus delta V B E okay. And this comes out as 5. no I beg your pardon.

Students: Delta I C

Professor: No.

It has been, it has been taken care of here. How did you calculate 9.3 percent. It has been taken care of. This comes out as 58 milli-amperes 9 plus 4 13 yes. Think about it. We have taken care of this in calculating this percentage.

Student: How can it should be dimension..

Professor: I am glad you insist otherwise we would have made a mistake.

Okay so this whole quantity is delta I C you're absolutely correct.

Student: 5.8

Student: 0.58

Professor: Okay fine, so how much is this 13 no.

Student: 13.9 plus…

Professor: 0.58 or 5.8?

Student: 0.58.

Student: divided by 100.

Professor: 0.58 milli-amp.

Student: No sir 5.8.

Student: 5.8

Professor: Okay

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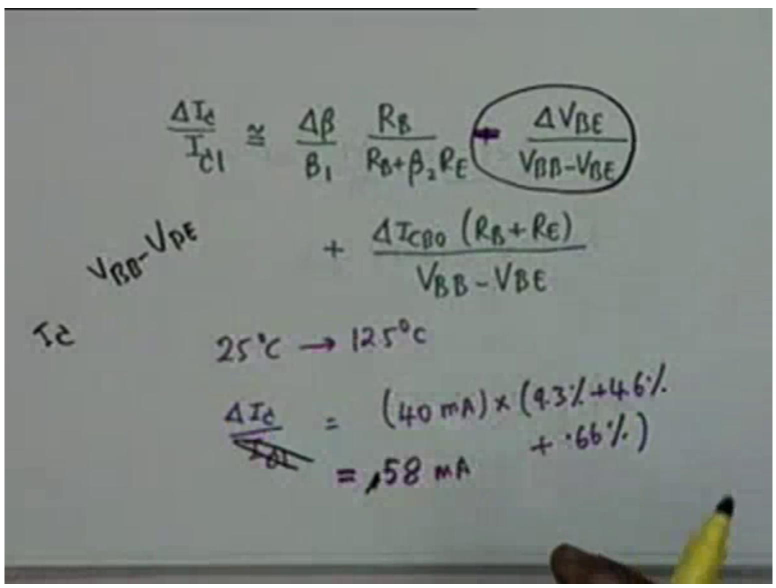

Okay, let's see 40 multiplied by approximately 14 divided by 100

Student: Sir that is 5.8.

Professor: That is 5.8.

You see this change now, delta I C there is a change with 5.8 milli-ampere. It means that the current is now 45.8 milli-ampere instead of 40 okay and this iwas done by calculating the individual changes and adding them up. If we had done it exactly that is by taking the 3 quantities beta 1, V B E 1, I C B O 1 and beta 2 V B E 2 and I C B O 2 then it turns out delta I C exact this has been calculated as 5.7 milli-ampere. So we are not too much off okay, we're not too much off. This procedure therefore is a valid procedure alright. Yes please.

Student: Sir in the calculation delta I C (())(46:33) R L 4.6p percent of (())(46:35)

Professor: That is correct.

Student: Sir then we subtract it.

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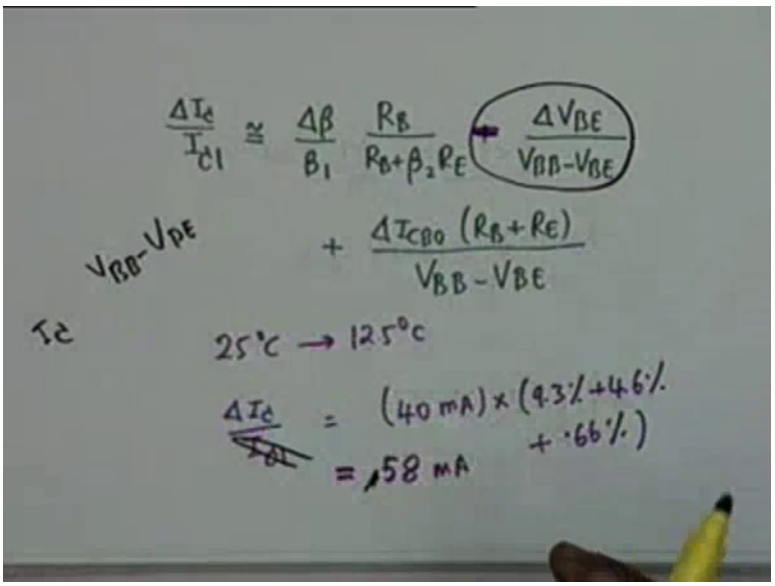

Professor: No No because this quantity minus V B E divided by V B B plus V B E. You see V B E decreases and therefore delta V B E itself is negative. That's why we have added it okay, is the point fitting?

Student: Yes sir.

Professor: Okay.

Student: Sir same point sir.

Professor: Same point?

Student: Yes

Professor: Right.

Student: Sir all the variation should be added and that particular variation will (())(47:06) whether it is positive or negative depending upon whether it increases or decreases.

Professor: That's right.

Student: Then why is the second variation subtracted, that also should

Professor: Because of the expression. What was the expression? V B B minus V B E, I C was proportional to this and therefore delta I C is proportional to minus delta V B E. You see if you if you can say that 3 factors even to one decreases with temperature they conspire to accentuate the error. This is always the case, it's a manifestation of Murphys Law. If something can go wrong it will, here also things go wrong and even if one decreases they conspire so that the error is accentuated. This is always the case and you cannot beat it. We will beat to only a certain extent. All you could do was to limit the change to 5.8 milli-ampere. In 40 it is 6 milli-amperes. So it's not too bad. Now an alternative BJT biasing circuit is as follows.

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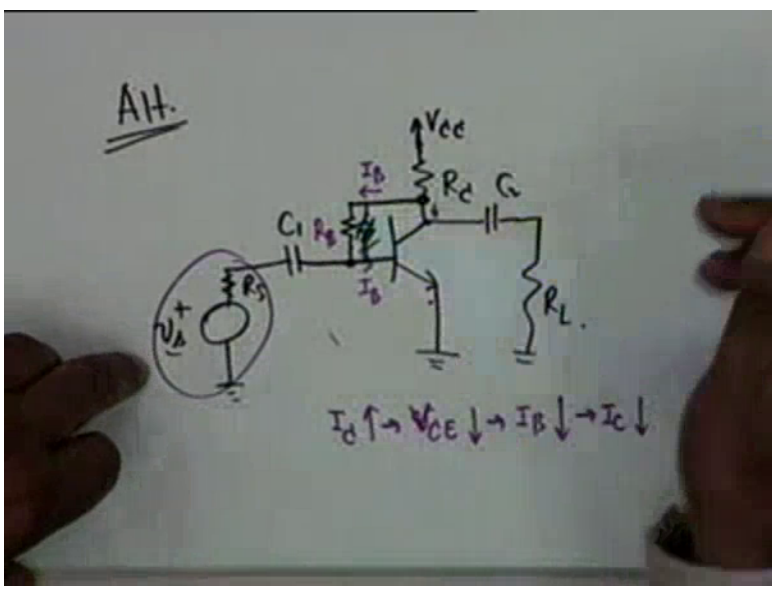

An alternative in which R E is not used R E is made equal to 0, is like this V C C, R C you have this is an alternative. BJT biasing circuit, you have the transistor it goes to ground there is no resistance R E. But the base well this is a signal source, with and R S, V S coupling capacitor C 1 there is a coupling capacitor C 2, R L. The base requires a biasing. Now we cannot do this biasing, we cannot do a potential divided biasing because then the stability would be very poor.

Isn't that right? R E cannot be made equal to 0, so we have to think of something else. What is thought of is this, the base is supplied from here that is from V C E rather than V C C through a resistance alright? So the base current for example can I this resistance is let us denote it by R B, if this is I B then this is I B correct? The base current is supplied from V C E rather than V C C.

Or one could argue why not V C C? Why not V C C? Well, pardon me.

Professor: No, that's not the cause the cause is something different. There will be no stabilization, if it is supplied from here.

Let me tell you why this stabilization occurs. Yes, you see now what is I B? I B is V C E minus V B E divided by R B. If I C increases due to some reason, V C E decreases. And therefore I B decreases and I C also decreases. Let me repeat this. If I C increases then V C E decreases. This causes I B to decrease and this causes I C to decrease. On the other hand if you have taken the supply from V C C then such a thing would not have occurred agreed. Qualitatively you can see the stabilization alright now there is one problem though.

Oh this is the source resistor, signal source resistor it doesn't come into the DC biasing. There is a problem you see because of the occurrence of R B there is a there is a DC feedback. Now it is whatever the current here is, part of the current is diverted here. So from output to input there is a feedback. We don't want this feedback at AC. At signal currents we don't want this feedback. So what do I do?

Student: Stabilizer.

In parallel to R B, shall we use a capacitor in parallel to R B? Let us see what danger.

Student: In series.

Professor: In series. Common make up your mind and tell me what do you want.

Student: In parallel.

Professor: In parallel okay.

Suppose we use a capacitor, when the whole signal will go here, for the signal this is a short and therefore the input signal goes over here. And this voltage, this voltage shall be equal to the input signal. The transistor becomes redundant useless. So we can't do that no. What is done is the following. It's a very engineers solution and suggested by. Now the problem is if I have an R B here then not only not only there is a DC feedback there is an AC feedback also. Part of the signal current also flows through R B which we don't want.

Student: What is the signal current?

Professor: Pardon me.

Student: What is the signal current?

Professor: Signal Current, if the signal is there an incremental voltage here, it will cause and incremental current here. We want the whole of this current to pass through the load. We don't want a bypass, we don't want a detour alright. We don't want anybody to share the signal current, we want the whole signal current to go through the load. So what we do is the following.

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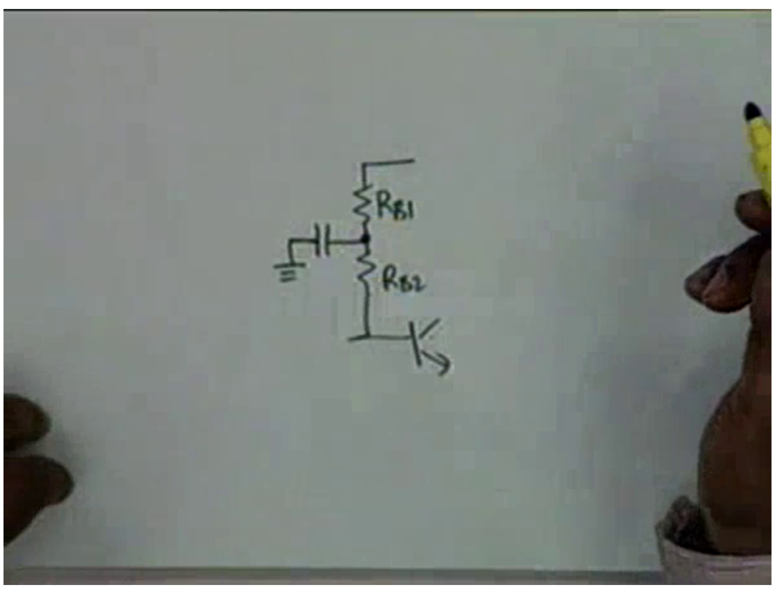

Instead of straight R B, we split R B into two parts, R B 1 and R B 2 okay. We split R B into R B 1 and R B 2 and from the middle point we connect a capacitor a bypass capacitor to ground okay. Then part of the signal current still flows like this but a signal current cannot come to the base. That is there is no AC feedback. We have reduced the AC feedback. Not only that the signal current cannot go to the output because of the capacitor. So this is one of the solutions alright. And this circuit is called collector feedback biasing.

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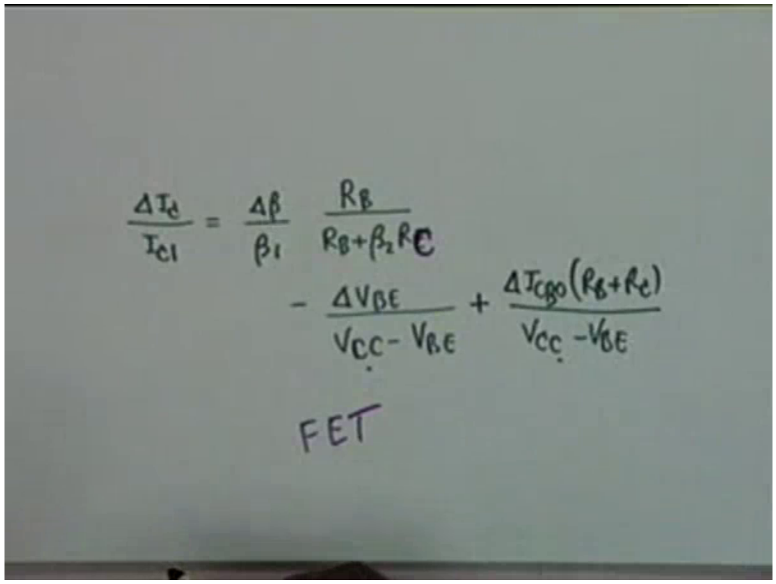

And you can show this will be one of the tutorial problems that if you follow the same type of analysis then delta I C by I C 1 is delta beta by beta 1 R B divided by R B plus beta 2 R E, this is due to beta variation, minus delta V B E divided by V C C minus V B E. In the previous case it was V B B now it is V C C. That is the only change plus delta I C B O, R B plus R C divided by V C C minus V B E. You can show that for this circuit in which R E is absent this is the total expression for percentage change in I C and if notice carefully. I made a mistake I guess. This is R C. If you notice carefully all that changes is that V B B is replaced by V C C here also and R E is replaced by R C. So this circuit is equally affected in stabilizing the operating point except for that modification that one extra capacitor is needed to bypass the middle point of R B 1 and R B 2. In the next lecture in the next lecture we shall consider F E T bias stabilizer.