Electronics for Analog Signal Processing - I
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Lecture – 21
Transistor (BJT) Inverter

In the last class, we discussed this configuration which was nothing but a BJT inverter or what is called as common emitter amplifier configuration. Common emitter amplifier configuration, this was called.

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So, we said, input terminals correspond to base emitter; output correspond to collector emitter; emitter being common. It is called common emitter amplifier.

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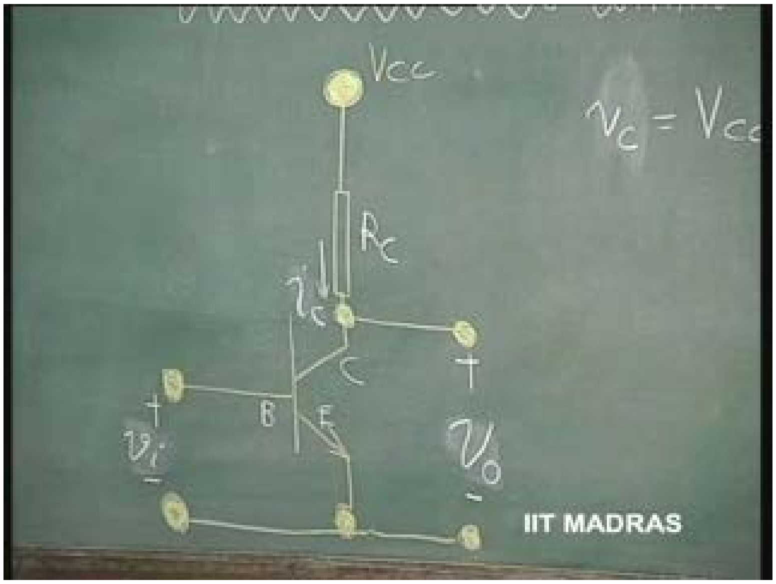

And now, the relationship between the output voltage and input voltage can be derived. That is called Transfer function. To derive the transfer function of this; V naught as a function of V i.

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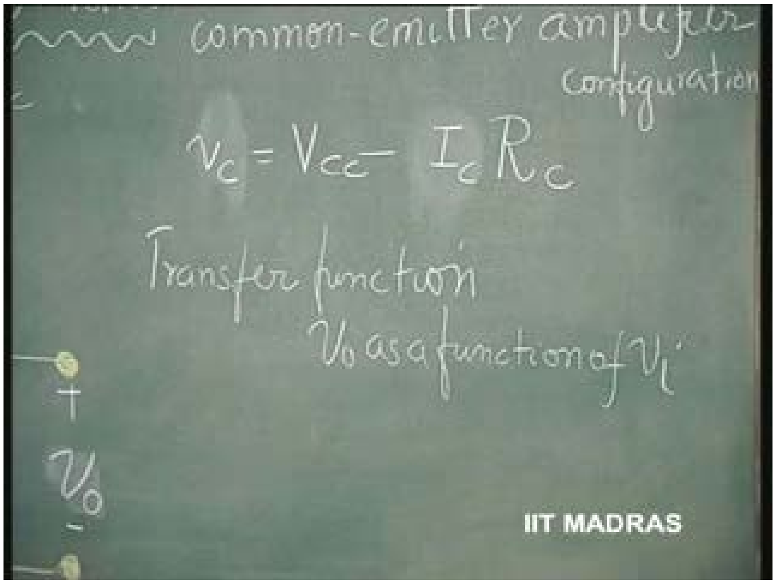

So, we got this equation, V C is going to be same as our V naught. Collector voltage V CE, actually, is going to be same as V naught, which is nothing but V CC, if I C is the current in this, minus the drop in this, i c R C, so that I C... these are different conventions adopted.

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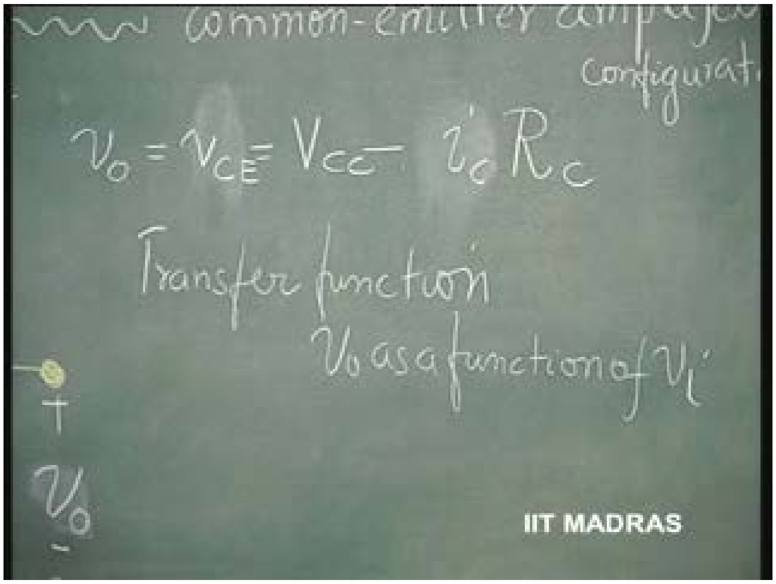

If it is capital I capital I and suffix also in capital letters, it is called DC, DC voltage. Capital letters and suffix also capital - that is the convention for DC. Capital letters with suffix being small letters - it is rms value of the AC ((.... Refer Slide Time: 3:58)) Small letters with suffix indicate instantaneous values. At any given time, it may be indicating the instantaneous value of the voltage or current depending upon the letter that is used, I or V.

So, we are now considering the instantaneous value of these voltages with respect to instantaneous value of the currents. Now, V naught therefore is equal to, at any instant of time, is equal to, V c c minus i c R c. That is always valid. So, we know that i C is equal to Alpha times i E. We are ignoring the i C naught. So, i C is equal to Alpha times i E at every instant of time. This is valid.

As long as transistor base emitter junction is forward biased and collector base junction is reverse biased, this transistor action takes place. And, other relationship is between i E and V BE. We know, that is equal to i E naught, reverse saturation current exponent, V BE by V T. V T is the thermal voltage which is nothing but K T over q, which is about 26 millivolts at room temperature.

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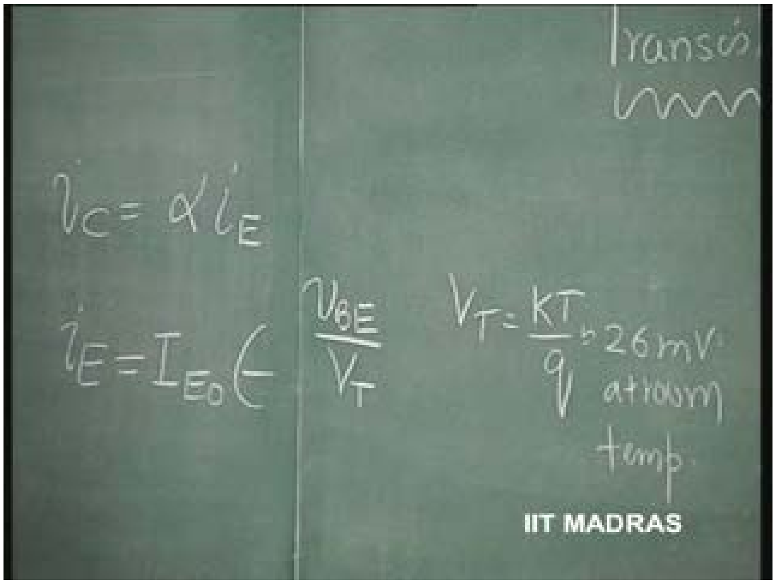

This relationship, we have already derived in the earlier situation; and i E is equal to I E naught exponent V BE by V T, which is same as I E naught exponent V i in this case because, V BE is the same as V i at every instant of time.

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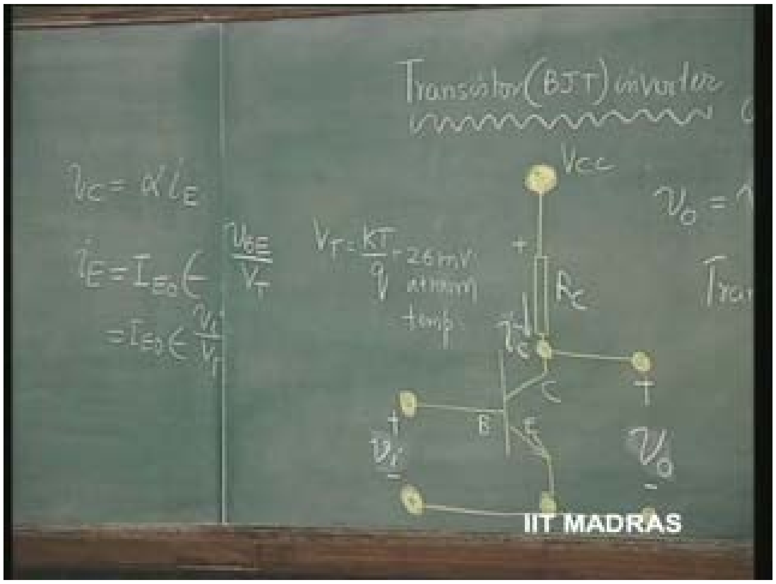

So now, substituting all these things together, we get V naught equals V CC, constant voltage, minus i C times R C; i C is equal to Alpha i E times R C, which is equal to V CC minus Alpha, i E is equal to I E naught, R C exponent V i by V T. This is where we had sort of stopped. This is the non-linear relationship between input voltage at any instant of time and output voltage at that particular instant of time.

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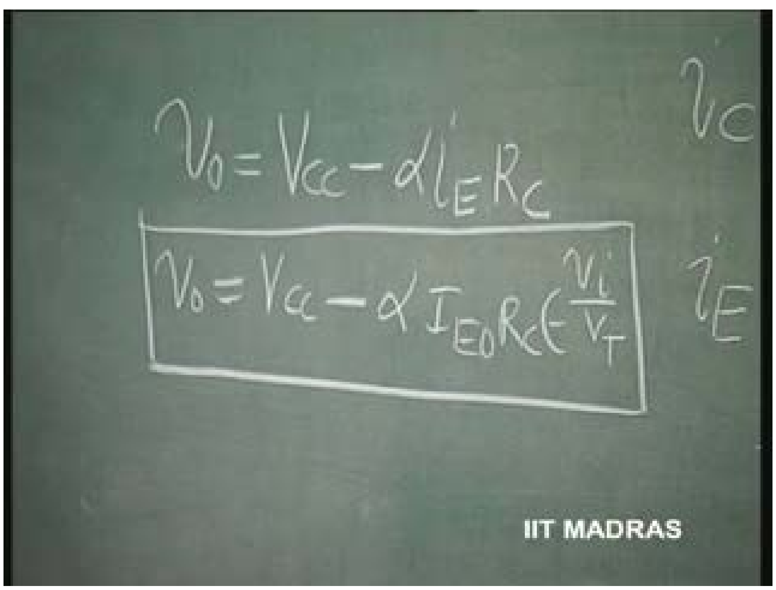

So, this is all the time, valid. And we said, a plot of this, if you plot, initially there will be almost V CC; and thereafter, at about V i equal to point 5 to point 7, this effect of current increase rapidly will occur. Then, it will go to saturation. In fact, it is not going to come to zero. It will slowly come to zero. That is, this point is going to occur between about point 5 to point 6. So, this is, let us say, point 6 volts. So, this is the nature of variation of output voltage versus input voltage.

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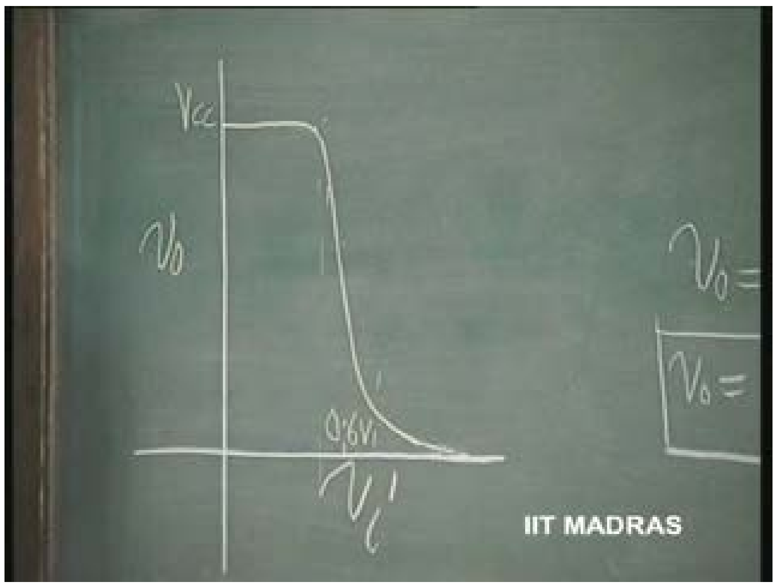

We just said, this is the region; this region is the region where the amplifier goes to saturation. Here, it is cutoff; and this is the active region. So, this region is of interest to us, where Delta V naught by Delta V i, in this case, nothing but this slope... For a change in input voltage, what is the change in output voltage? - which is called gain, voltage gain. This is called voltage gain, for the amplifier.

Had this been linear, this would be constant; whereas here, it is non-linear, so this will change depending upon the operating point. If I operate at this point, it will have some value; if I operate at this point, it will have some other value. So, Delta V naught by Delta V i, this is a small signal voltage gain; this is called small signal.

Now, because it is non-linear, this is valid. If this is linear, assumption is valid only for a small change in voltage. So, this slope is negative.

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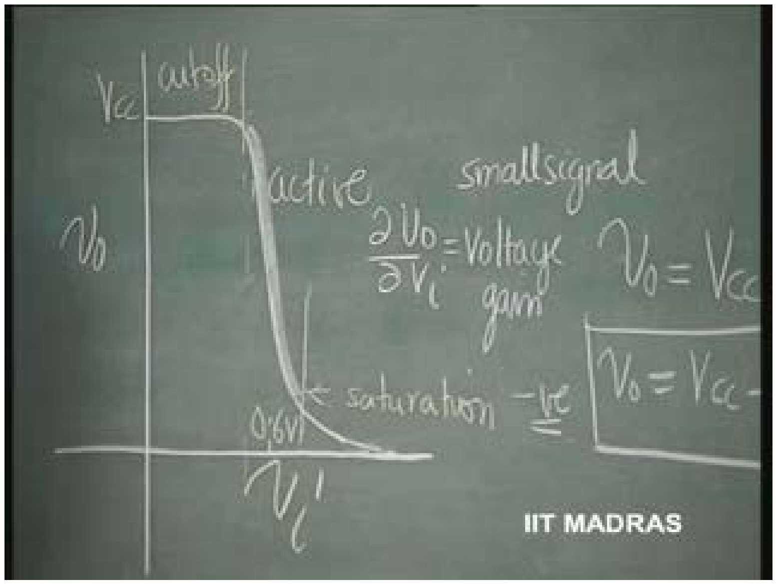

What it means is, when the... What is negative slope indicating? When the input voltage is increasing, output voltage is decreasing. When input voltage is increasing, V naught will be decreasing. This is indicated by this - V i increasing means, this arrow; output voltage is decreasing. That is why there is an inversion. So, this means, let us say, this is an inverter.

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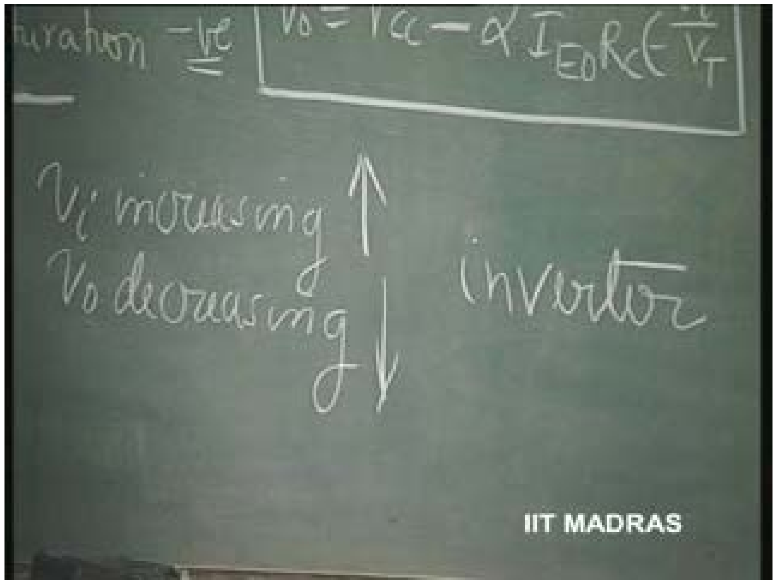

When the V i is increasing, output voltage is decreasing; that is what is meant by inversion. So, now again, if the input voltage is high, if the input voltage is high, output is low. So, if the input is high, output is low. If the input voltage is low, somewhere here, output is high.

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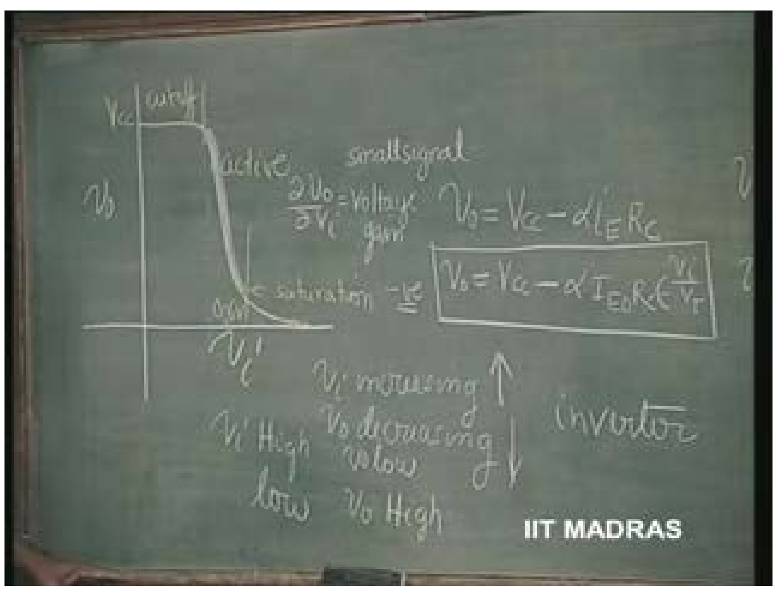

This is a very interesting thing. If input voltage and output voltage are ((put Refer Slide Time: 10:45)), if I denote high as 1 and low as zero, this is called the binary bit level.

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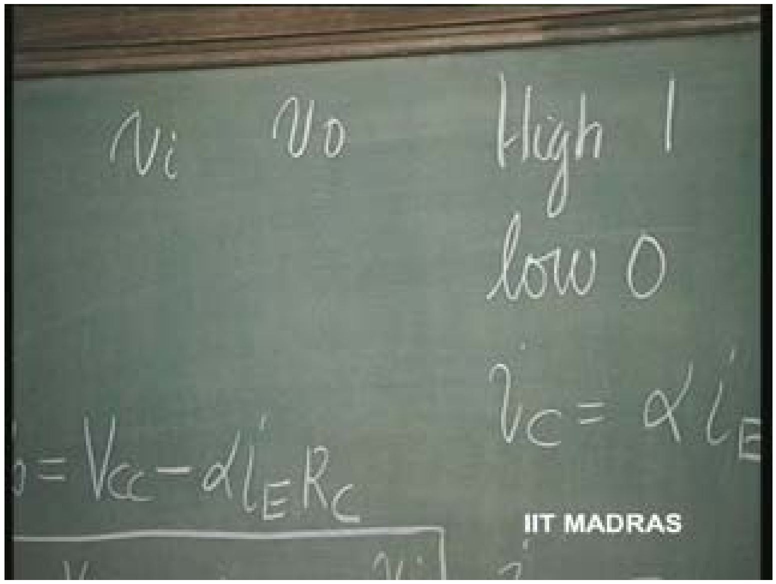

1 and zero, high and low, positive logic. Then, V i if it is 1, V naught is zero; if V i is zero, V naught is 1.

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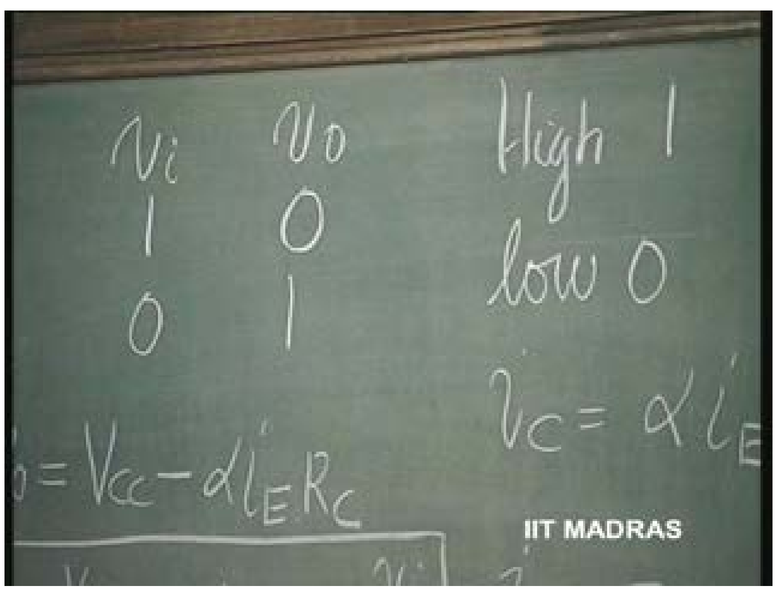

Or, if V i is A, V naught is A bar. This is the logical operation; so, this is also called a digital inverter.

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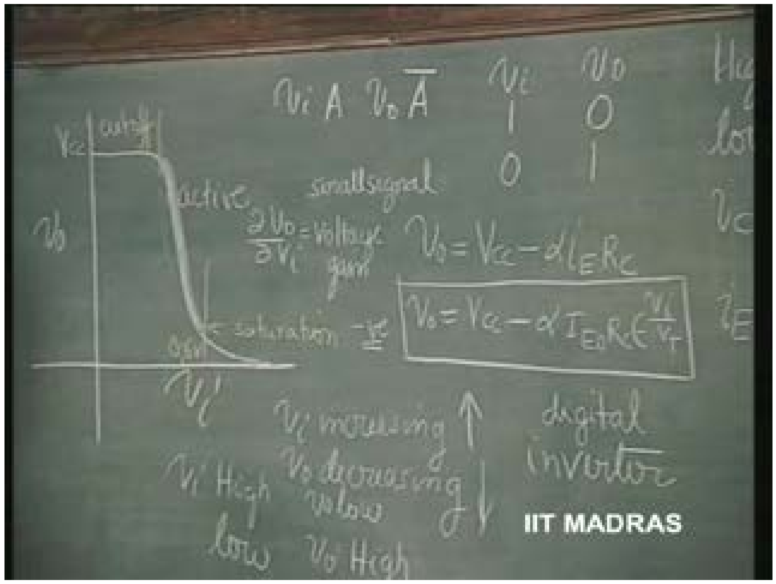

As long as we are operating in the cut-off and saturation regions; the V naught and V i should be such that the operation should be in the cut-off and saturation; not in the active region. So, operation is in the cut-off or saturation region; then it is called a digital inverter.

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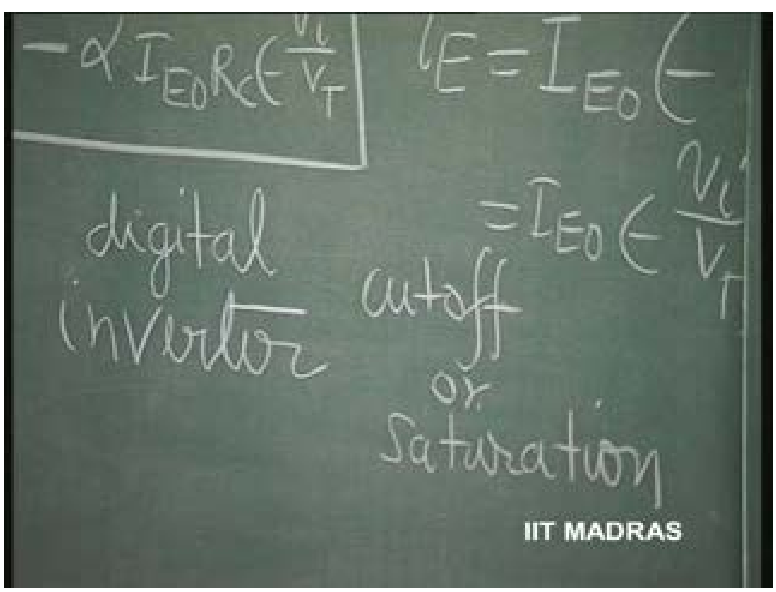

So, if the input is high, output is low. If the input is low, output is high. If V i is 1, V naught is zero; and V i is zero, V naught is 1. This is an important basic building block of digital system. Without this, no digital system can be fully designed. That means, what we have learned with diodes, the diode gate; we discussed AND gate and OR gate. By using just diodes, we can build AND gate and OR gate. This is the logic. We had seen this when we discussed applications of that.

Now, adding this operation, this operation is called... A is input, A bar is the output. This is a NOT operation. NOT operation. So, with this NOT operation added, we can have AND gate cascaded to NOT operation, forming NAND gate; OR gate cascaded to NOT operation, giving NOR gate. NAND and NOR gates by themselves can give you design of any digital system. Just using only NAND gates and NOR gates, you can build any logic system that you desire.

So, if we incorporate this inverter as one of the basic building blocks along with the other gates that we had discussed, we can build any digital system, logic system that we desire. And, if we operate in this region and if the bias is such that the operating point is in this region, which is the active region, it is then used for inverting; it is also an inverter, but inverting amplifier. This is called the inverting amplifier.

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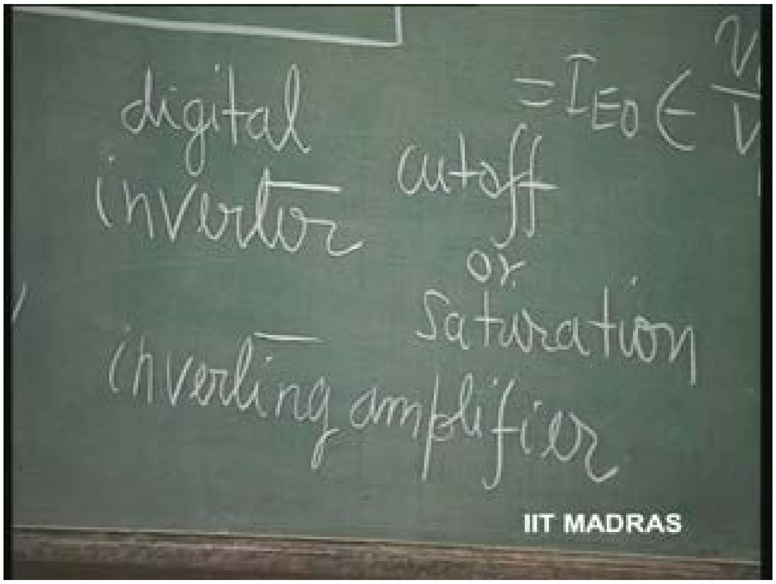

The gain is negative; or, the slope here, Delta V naught by Delta V i is negative. That is what is meant by inversion. If the voltage is incremented, output will be decremented. So this is what is meant by inverting amplifier. For amplification to really exist, Delta V naught by Delta V i should be greater than 1; voltage amplification for example, in this case.

If it is a voltage amplifier, the voltage gain has to be greater than 1. That is the border line defining what? - where exactly we are entering. So, if you plot these characteristics and draw a line with slope equal to minus 1 on the characteristic, that particular point where the slope is equal to minus 1, it is separating the active region from the cut-off and saturation.

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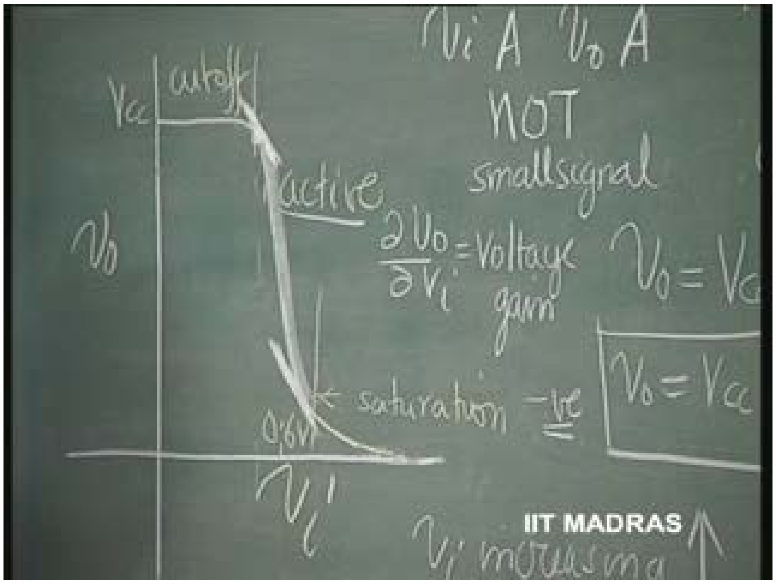

And that defines in digital system design; we can discuss this as noise margin for digital 1 or digital zero. What is the noise margin? Because, if the output lies anywhere in this region, we are not sure whether it is a 1 or a zero. Only when it is in this region or this region, we are clear that it is either a 1 or a zero. So, this transition region is very important in digital inverters.

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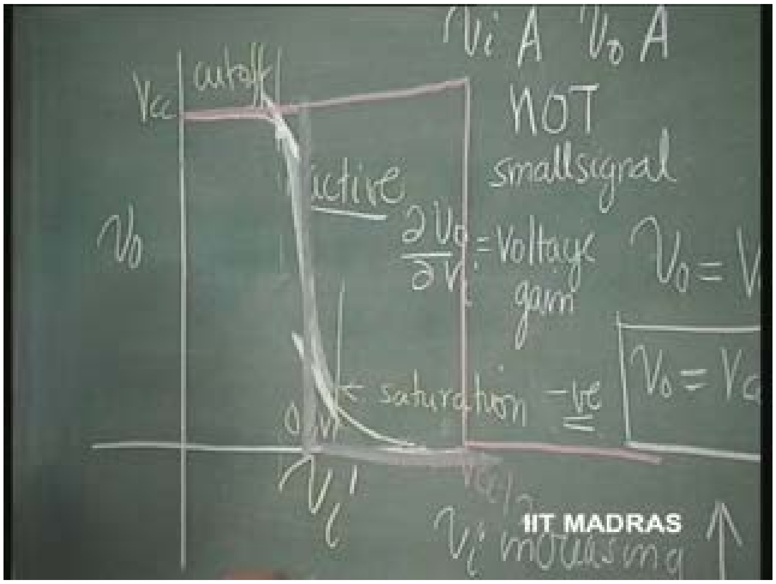

The ideal inverter, let us now compare it with ideal inverter, will have a characteristic like... if this is V cc, at exactly, let us say V cc by 2, it will not take place at point 6; it will have equal noise margin for both 1 and zero. So, at exactly V cc by 2, this transition should take place and this should be abrupt. So, this transition should not take place at point 6. It should take place somewhere much beyond this point and this should be... this is an ideal inverter. This should occur at V cc by 2 and this slope should be infinity.

That means gain should be infinity. So, ideal inverter has characteristics like this. This is nowhere near ideal. The transistor inverter is nowhere near ideal. The transition is taking place at about point 6 or so; and that also is gradual.

So, we have now discussed about prominent characteristics of this inverter in terms of transition from high to low. That should be, strictly speaking, as abrupt as possible so as to give the maximum dynamic range for the noise margin, etcetera; and this slope here should be infinity for the ideal inverter.

In practice, you can compare it with bipolar junction transistor inverter where the transition takes place at point 6. This can be shifted suitably by adding additional diodes in series with this. So, we can just put additional diodes and shift the transition to may be even at a point equal to V cc by 2. But the transition character remains similar to this, exactly like this; it is not abrupt.

Now, if it is operated at a certain operating point for using it as an amplifier, then at that particular operating point, bias point, or operating point, or Q point, we have a voltage which is a DC voltage, over and above which we can superimpose our varying, time varying signal.

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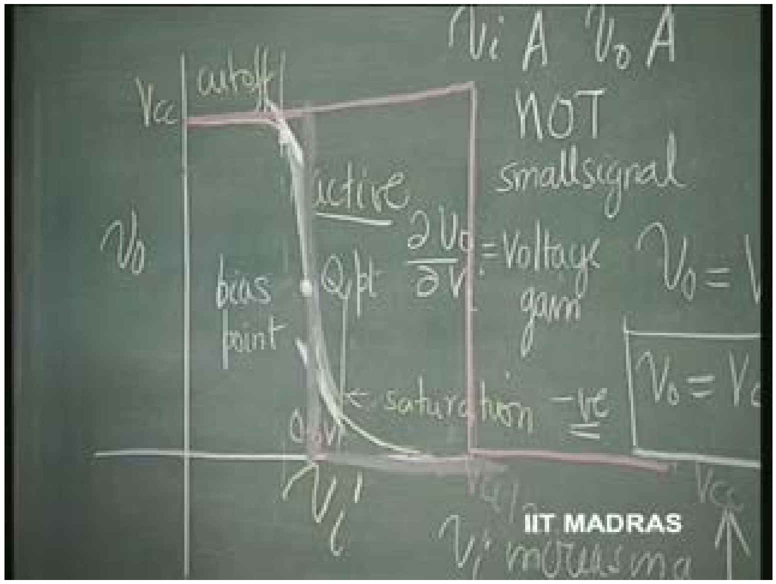

So, this has a constant voltage. This voltage, we will call it as V i Q, which is nothing but V BE quiescent.

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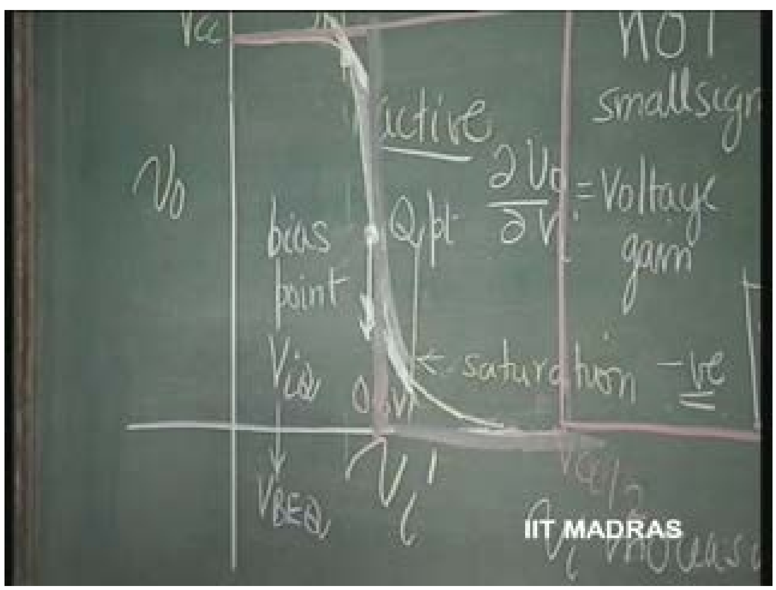

So, if you do that, then we saw that this equation can be rewritten as V cc minus Alpha I E naught into exponent V i Q by V T into exponent Delta V i by V T.

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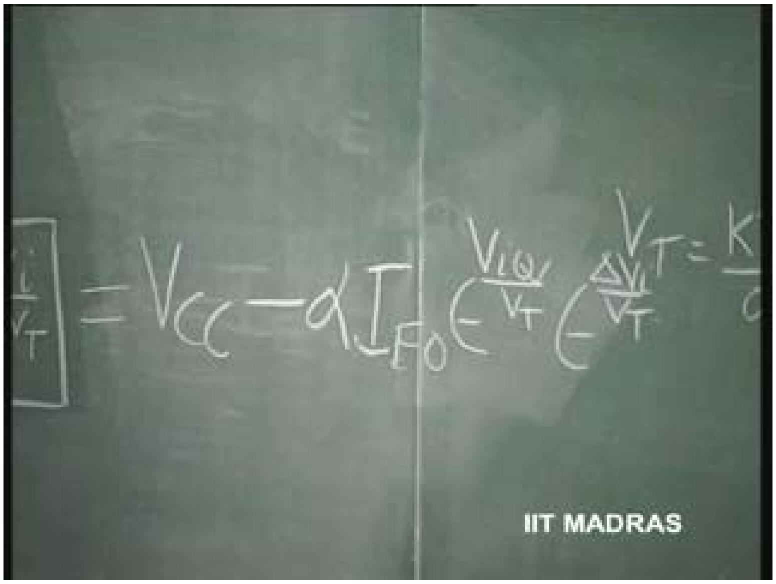

So, V i is given as V i Q plus Delta V i. We just say, the varying signal is superimposed over a quiescent voltage of V i Q.

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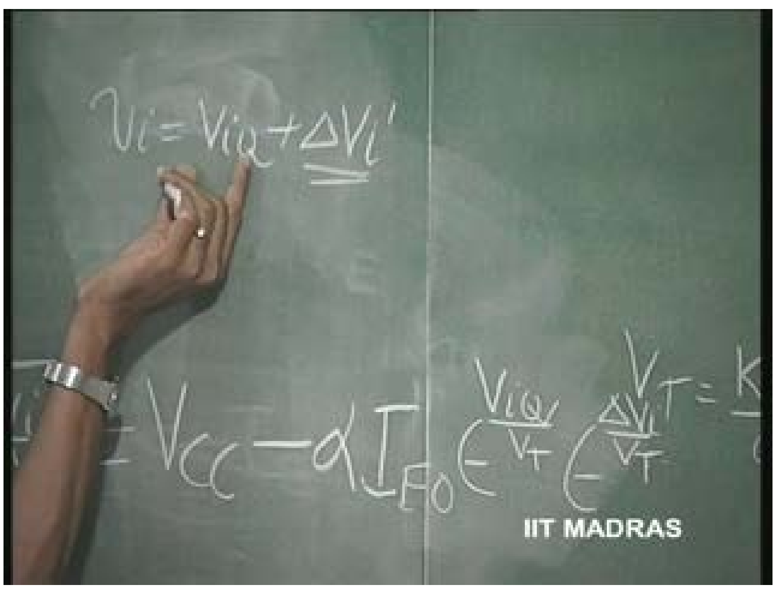

Then, we can put V i as V i Q plus Delta V i here and split this as exponent V i Q by V T into exponent Delta V i by V T into R c. So, this is equal to V cc minus Alpha I E naught exponent V i Q by V T. What is this? This can be called as I E naught exponent V i Q by

V T, is same as I E naught exponent V BEQ by V T. This is nothing but I EQ. So, this is nothing but quiescent emitter current. This into R c into exponent Delta V i by V T.

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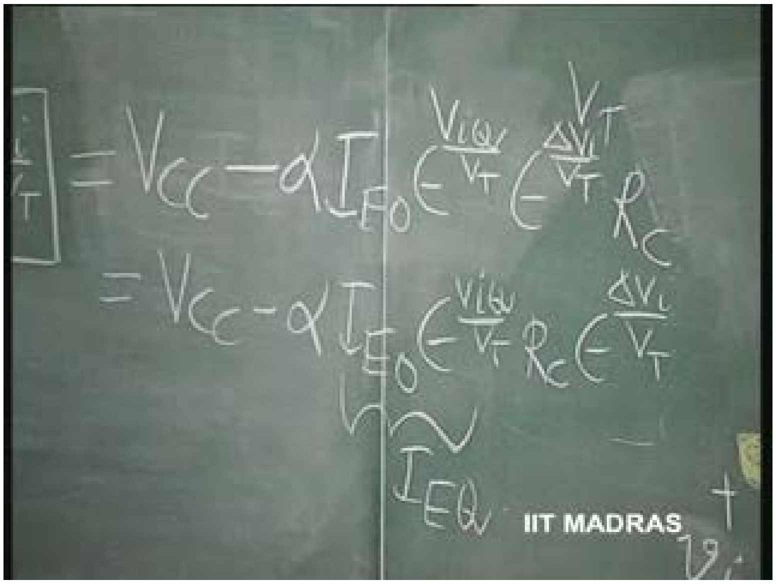

So, this whole thing - Alpha times I E naught into exponent V i Q by V T is nothing but I EQ. So, V cc minus Alpha I EQ into R c. This exponent Delta V i by V T, we are now going to expand it as, 1 plus Delta V i by V T plus Delta V i square by V T square, so on...

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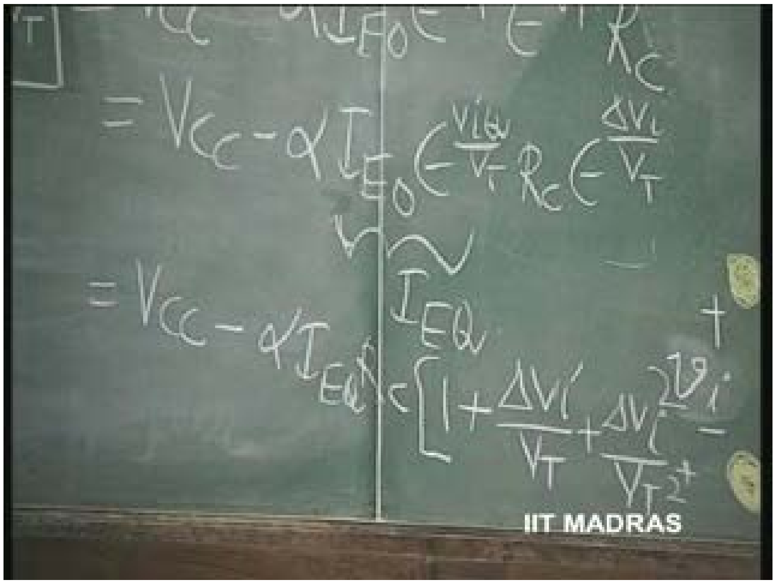

So, this is the output voltage V naught, is now equal to V cc minus Alpha I EQ R c.

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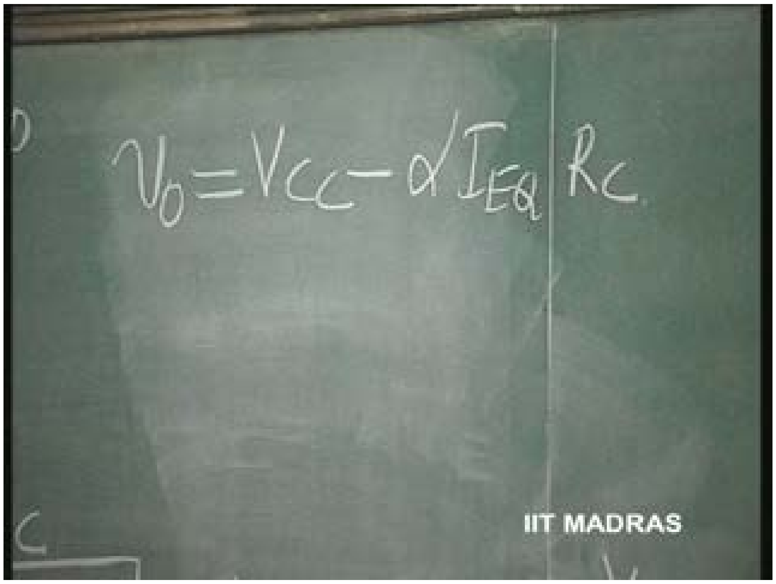

What is Alpha I EQ? I CQ. Alpha times I EQ is nothing but I CQ, quiescent collector current. So, I CQ. Because, Alpha times I EQ is equal to I CQ into... so, V cc minus Alpha I EQ R c is I CQ R c; plus, I CQ R c by V T. I am taking it inside, into Delta V i. This is minus now.

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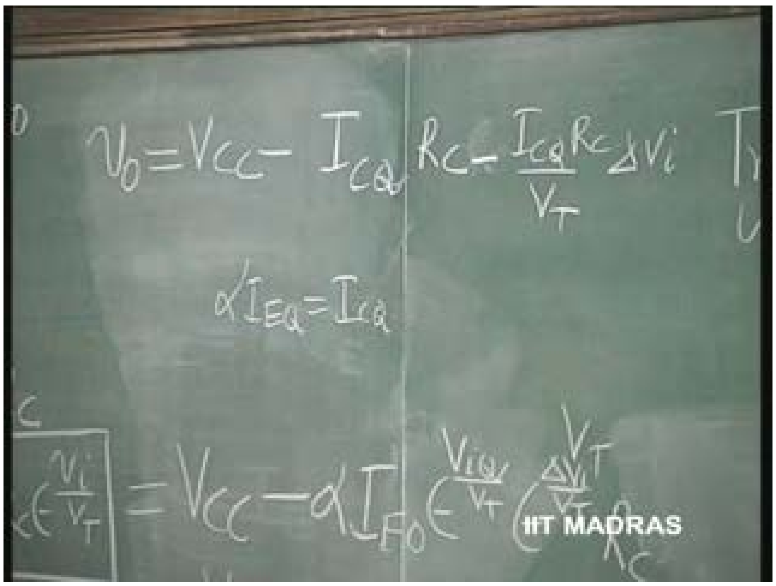

I am taking everything inside the bracket; minus, I CQ Delta V i square by V T square by factorial 2. Then, Delta V i cubed by V T cubed by factorial 3, which is 6. So on...

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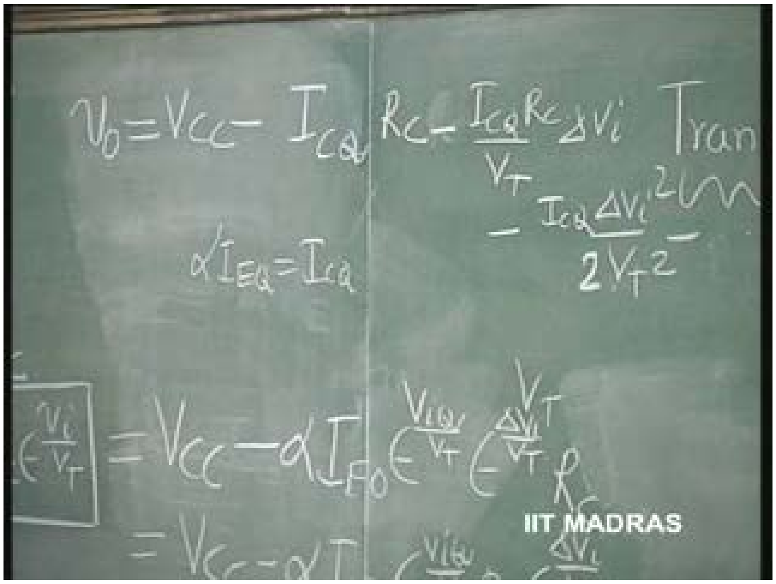

So now, you can see here. V cc minus I CQ R c, V cc minus I CQ R c; we can call it as V naught Q, quiescent output voltage. So, this whole thing is going to be represented as V naught Q, quiescent output voltage, minus I CQ R c divided by V T times Delta V i.

This is an important parameter. What is it? This is some constant. I CQ R c is voltage. V T is voltage. So, this is a constant. This is called the amplification factor or gain, into Delta V I.

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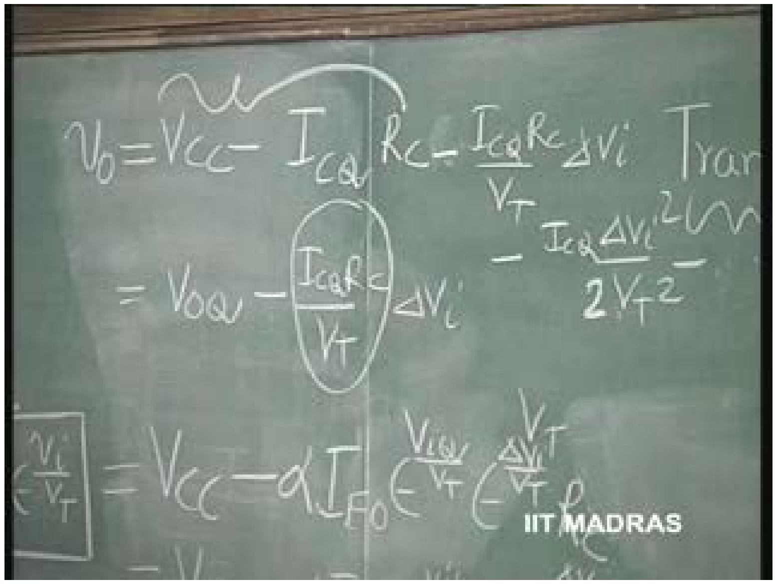

This is going to be therefore V naught cubed plus Delta V naught. Because of applying Delta V i, there is a Delta V naught at the output. That Delta V naught will correspond to minus I CQ R c by V T into Delta V i. That is the linear term. Then, the non-linear term corresponds to I CQ into Delta V i by this square.

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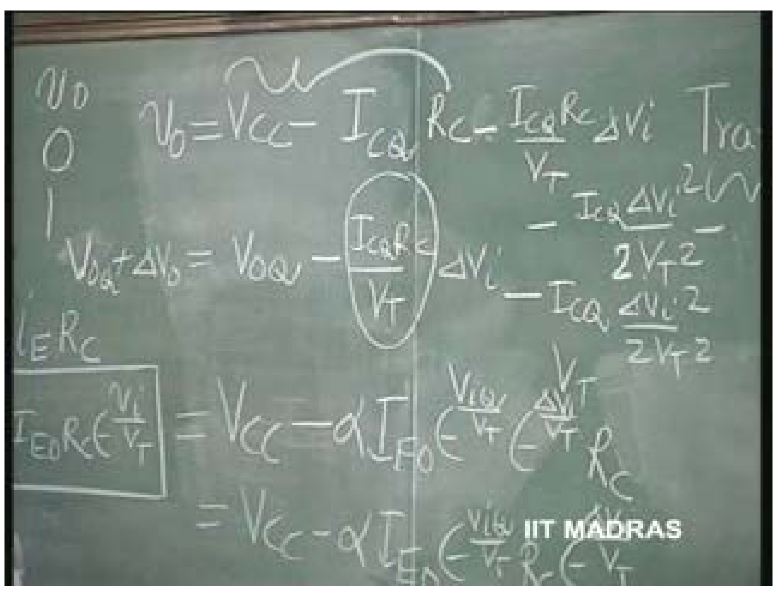

So, those should remain very small. For that to happen, we have to have, this particular thing, Delta V i by V T should be much less than 1. This is the assumption for small signal.

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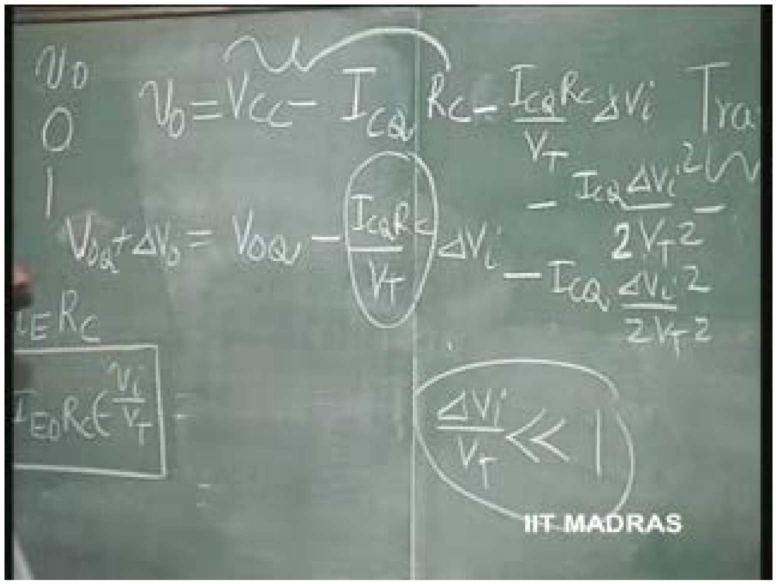

This is because, that exponent Delta V i by V T, we have expanded as 1 plus Delta V i by V T plus Delta V i by V T squared by factorial 2, etcetera. So, Delta V i by V T factor should be much less than 1. This is called small signal. In which case, the non-linearity can be neglected and I can consider that, for a Delta V naught, there is a Delta V i; or, Delta V naught by Delta V i is equal to, how much is it? - minus I CQ by VT into R c, which is indicating, there is a inversion; and the slope corresponds to I CQ by V T into R c.

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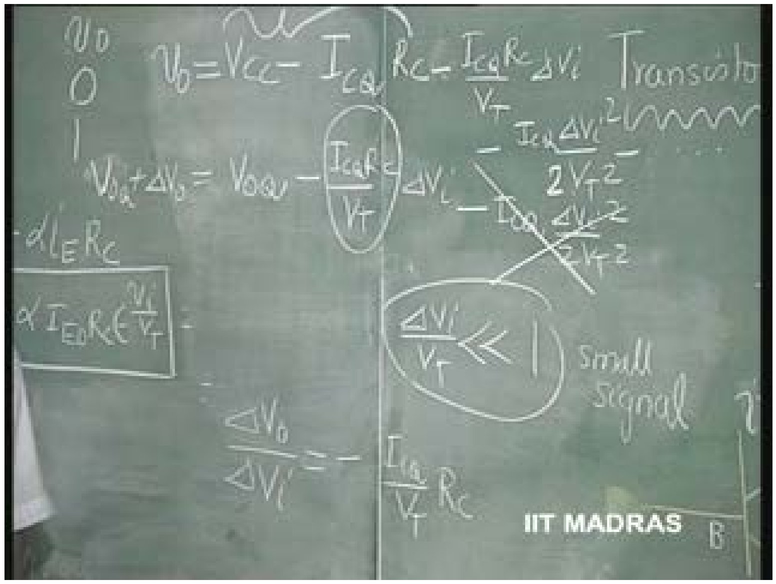

This factor, I CQ by V T is characteristic of the transistor amplifier and that I by V is called a transconductance of the amplifier. So, this I CQ by V T, which is characteristic of the amplifier, R c is the load that you are connecting, is nothing but g m or transconductance; transconductance of the bipolar transistor amplifier, which is g m.

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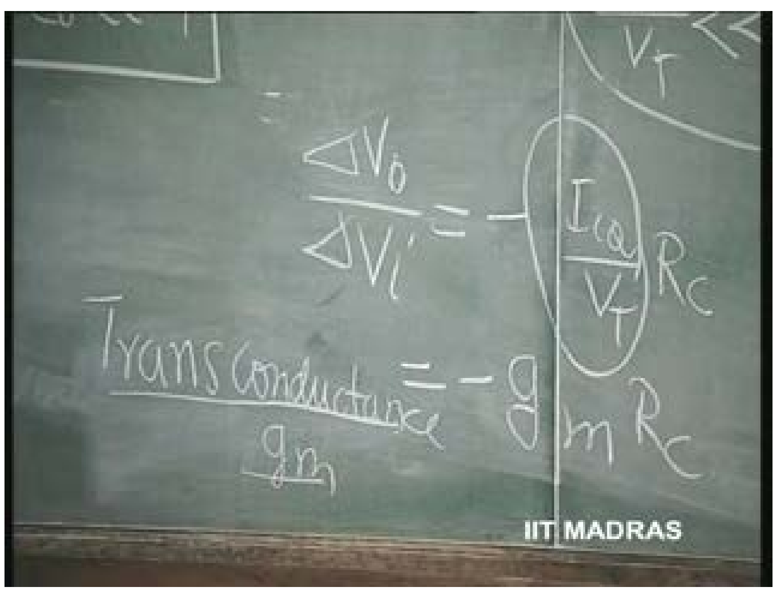

The definition for g m therefore is... g m is nothing but Delta I C divided by Delta V BE. Delta I C by Delta V BE, because Delta I naught, I c is same as I naught, Delta I naught by Delta V i it was. So, Delta I c by Delta V BE at the given operating point.

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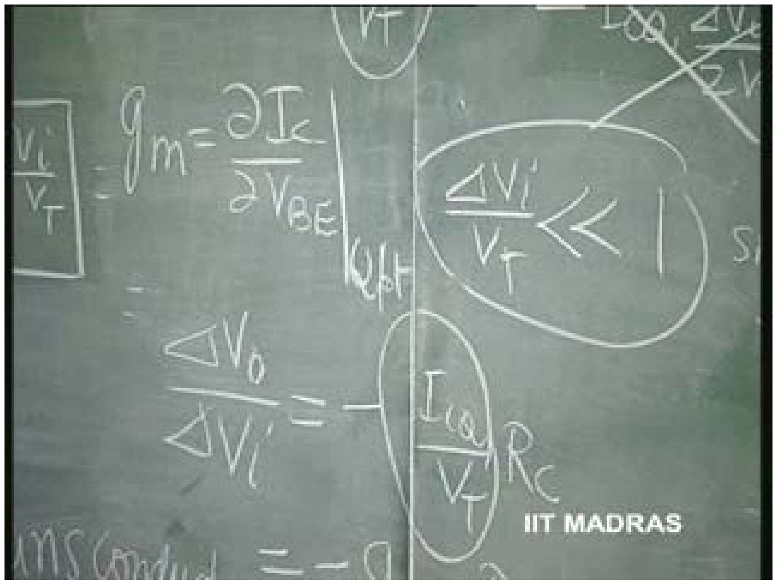

So, please remember. This is an important derivation which tells a lot about amplifier; that, it is an amplifier only for small signal; and what is small signal? The change occurring at the input should be much less than V T. What is V T? About 26 millivolts; which means, much less than 26 millivolts means, it should be of the order of millivolts, less than millivolts.

So, if that is the case, then we can say that it is linear and the value of the gain is minus g m into R c; and what is this g m? Transconductance. What is transconductance? It is nothing but Delta I c which is now Delta I naught divided by Delta V BE which is Delta V i here. Change in collector current for a change in base to emitter voltage, which is nothing but I CQ by V T.

If you remember, this is exactly same as 1 over V T divided by I EQ roughly; V T by I EQ is called r e in the diode. Small r e. Diode small signal resistance is nothing but r e which is Delta V diode by Delta I diode. So, g m of a transistor is same as almost nearly 1 over r e; strictly speaking, it is Alpha over r e; slightly less than 1 over r e because of the factor Alpha. So, g m of a transistor is Alpha divided by r e, where r e is Delta V diode by Delta I diode. In this case, Delta V BE divided by Delta I E. This is same as Delta V BE divided by Delta I E.

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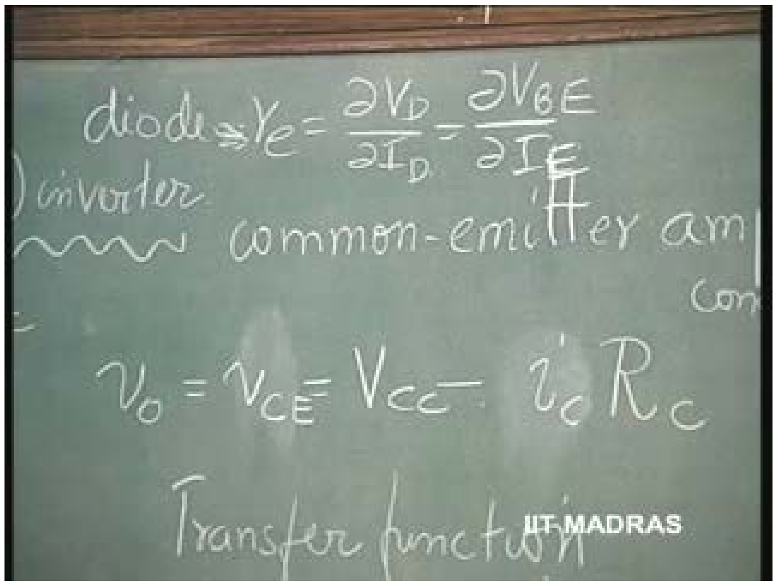

So, since the input characteristic is between emitter current, and emitter base voltage is that of a diode, this r e is the diode resistance that is occurring in the emitter, equivalent resistance; that is, Delta V diode by Delta I diode, which is same as Delta V BE by Delta I E, which is defined as V T by I E. So, this is got as V T divided by I EQ.

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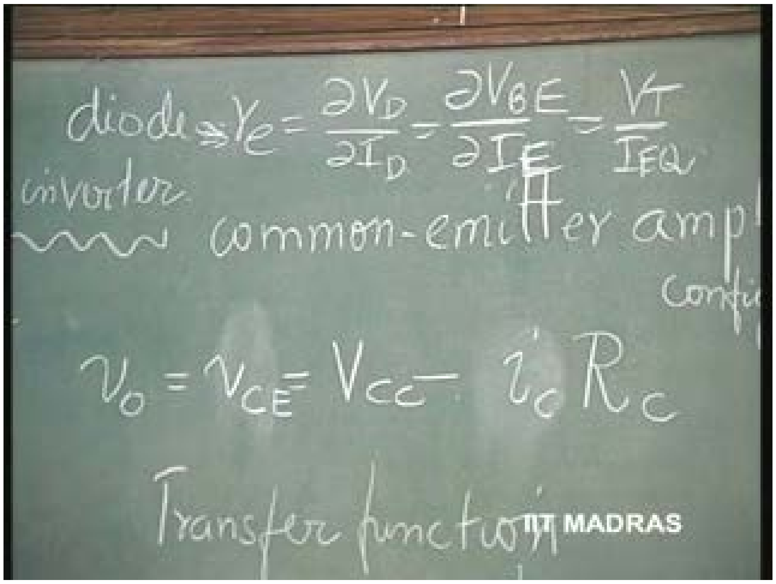

So here, it is nothing but g m, which is Alpha times I EQ divided by V T. That means Alpha times... divided by r e. So, this is an important definition. Minus g m into R c is the gain.

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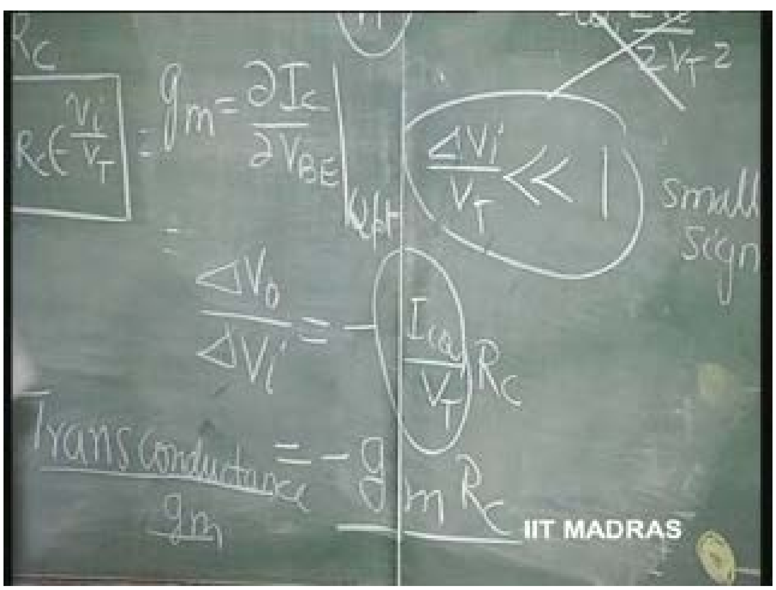

Now, we will consider this transistor as a switch, control switch, which is an important function. We want a switch to be closed at our command. This is a switch. Given a command, I want to close this switch; and given another command, I want to open this switch.

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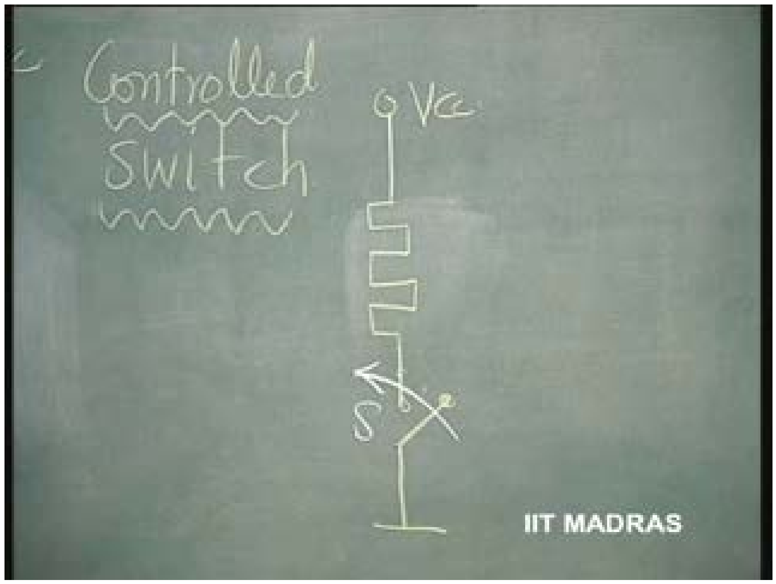

So, a switch is either an open circuit or a short circuit. This is a heater element; which is nothing but a resistive element, heater. I want to heat this. Then I want the power to be connected. So, V cc is the DC voltage which will get connected when this switch is closed and disconnected when this switch is open. So, this is how our soldering irons and all those things can function.

I want to heat the heater element by connecting the power and I want to sort of, as soon as I reach the temperature, I want to disconnect the power; and again, I will connect it; again disconnect it. Or, I might, control manner; connect it and disconnect it, so that the temperature rises up to a point and keeps on remaining around that point. So, this is an ON OFF controlling system, like our fridge.

Our fridge is nothing but an ON OFF controller where the moment we switch it ON, the temperature is reached, certain temperature is reached; and as soon as it falls below a certain point, set point, again switch compressor is switched ON. And, it again, it will get cooled and it will go to that particular temperature at which we want it. Again, there will be power switched off.

Like that, this will be normally remaining at a sort of constant temperature, around a constant temperature, so that it is OFF ON, OFF ON, OFF ON... so that controller is called an ON OFF controller. Very simple controller. Therefore, it is never going to reach this set point temperature ever. It will always fluctuate around the set point by a certain set magnitude. This can be adjusted.

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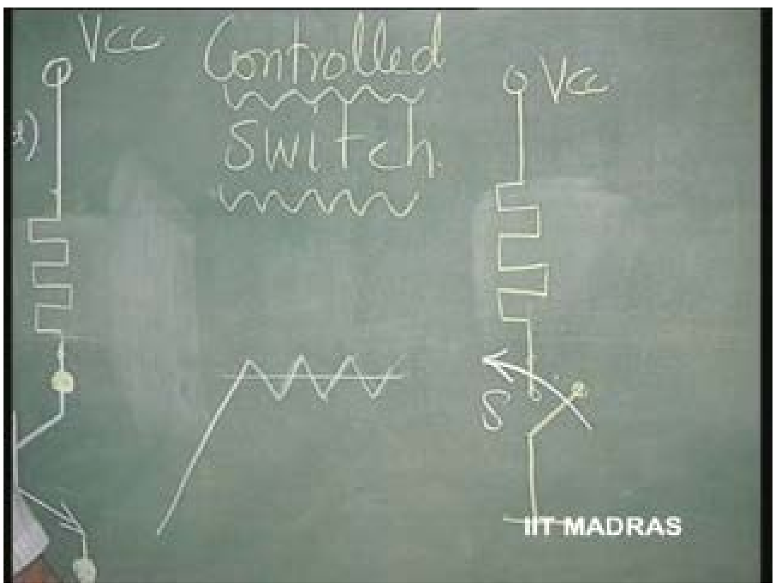

Now, such controllers require a control switch. A transistor can be used as a switch. Let us see how. We have just now discussed that a transistor can be brought into active region. From active region, it can be brought into saturation. What is saturation? We will see this. Saturation, we will now define as a point at which it is violating the transistor action, in the sense, no longer I C is equal to Alpha times I E. When does it happen? When base to collector junction starts getting forward biased. It should be, strictly speaking, reverse biased, when we have transistor action. We do not want this switch, which is now the transistor acting as a switch, to remain in the active region. So, this is the difference between amplifier and a switch.

This transistor should not remain in the active region. Either, it should be off... switching it off is easy; I can simply make this zero. So, this is not forward biased. So, if V i is zero, transistor T is off. This is the simplest way to switch it off. So, I E is zero when V i is zero; and therefore, there is no I c. So, this is off. The switch S is open.

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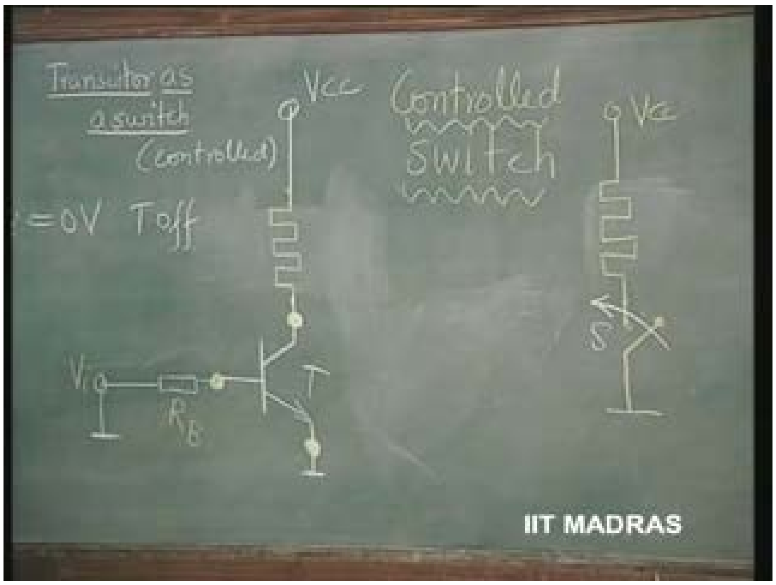

The only current that will now flow in this whole circuit will be I c naught, strictly speaking, because the collector base junction is reverse biased to an extent equal to V cc. Because there is no I c, this voltage is same as very nearly equal to V cc; and therefore, only the reverse bias saturation current flows; that is I c naught, which is very small. So, you can for all practical purposes ignore the current flowing in the circuit. Therefore the switch S is off.

Even in a practical switch, only when it is open, we can say that it is very high resistance; it is not strictly infinite resistance. So, there may be some leakage current flowing. Like that, our transistor also has certain amount of leakage current flowing; which means, it is not an ideal switch. So, with V i is equal to zero, T is off or switch is off; and V i equal to, let us say V cc. So, V i equal to zero may correspond to digital zero; and V i equal to V cc may correspond to digital 1.

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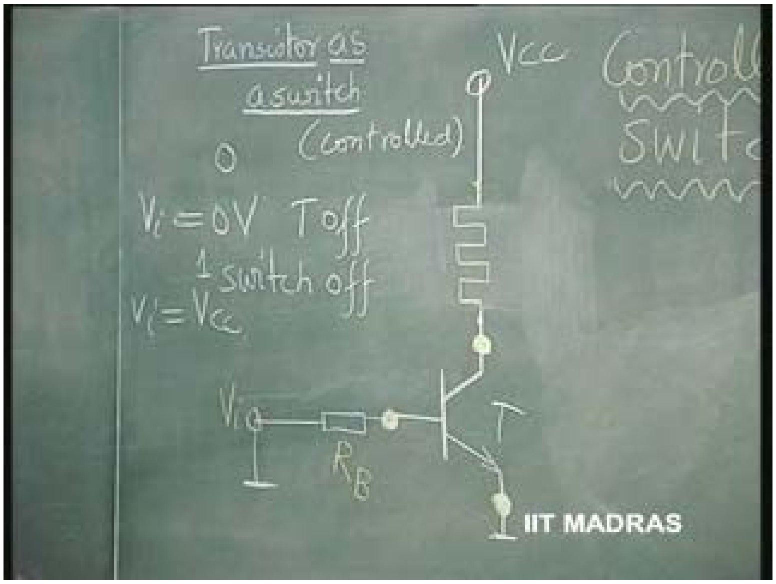

So, actual command signal comes from a digital inverter, may be. So, it is either high or low; there is no intermediate value it is going to take. And therefore, when V i is equal to V cc, we want this switch to be ON. Now you will understand the reason for putting R B. If I do not have this R B at all, then this when it goes to V cc, when it goes to V cc, if it is not there at all, this V cc will come across base to emitter junction, and there will be enormous current; because, even for point 5 to point 6 volts, there will be very high current. So, you cannot sustain this much amount of forward voltage; and therefore, this junction will collapse. It will get destroyed because there is no current limiting.

So, R B is the current limiting resistance put in the base. So, this is an important resistance to be put in the base of a switch. This, you must remember. When the transistor is being used as a switch, this will be limiting the current. What is the current now? So, V i is equal to, when V i is equal to V cc, the current is going to be V cc minus V gamma; this is nothing but V BE divided by R B; that is the base current.

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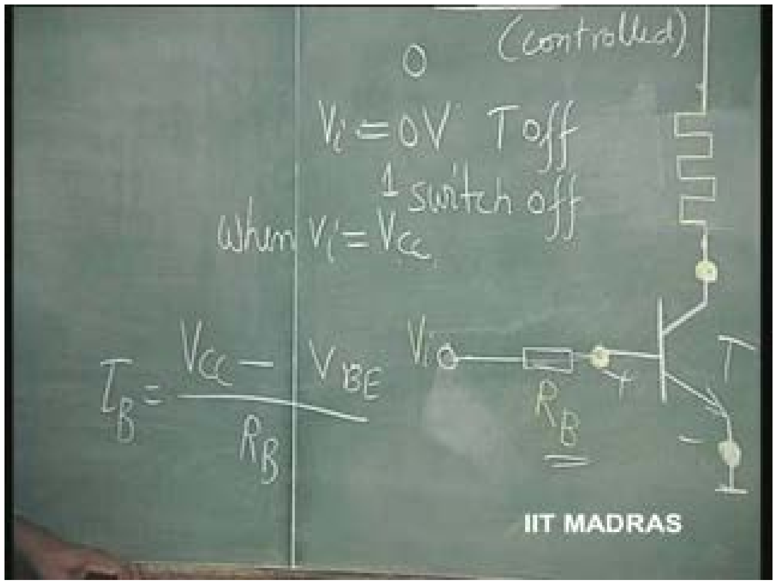

When V i is equal to V cc, V cc minus V BE, V BE is of the order of point 5 to point 6, so V gamma. This is nothing but V gamma. So, V cc minus V BE by R B is the current. So, you can fix the current at any satisfactory value. What is the current which you will select? When such a current flows through this transistor, the transistor should go to saturation. It should not remain in the active region.

Let us assume that this resistance is R c. So, if the transistor is going to saturation, then the current in the circuit, both will have to be forward biased. Let us say, this is point 6, this is point 6. That means, this voltage is going to be zero volts. This is forward biased; this is also forward biased. This will be zero volts. Then the current in this is going to be V cc by R c. So, the maximum current that can flow through this is V cc by R c.

So, I c max corresponds to V cc divided by R c. If the transistor at that point of time has gone to saturation, then the base current should be such that it is in saturation. What does it mean? That means the relationship, that is, I C is equal to Alpha times I E is no longer valid.

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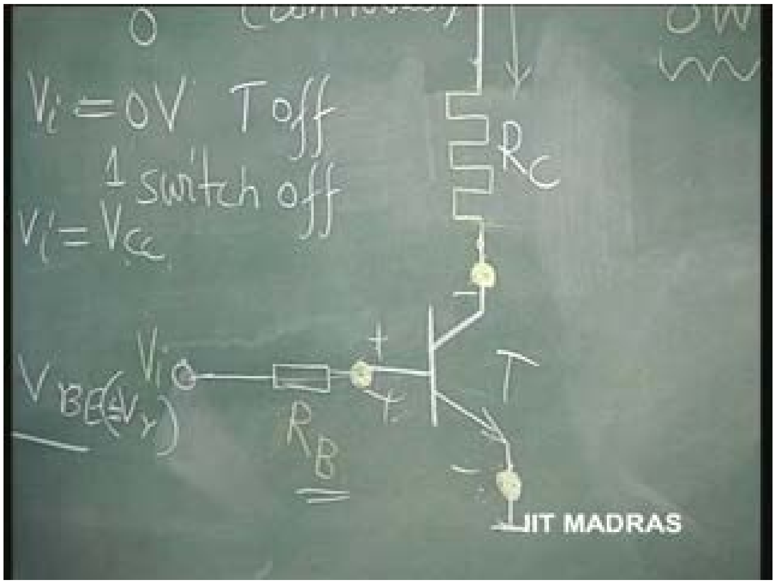

What it means is I c equal to Alpha times I E is no longer valid. I c... here we know I B. What is I B? I B is equal to... we know that I c plus I B is equal to I E. This is always valid.

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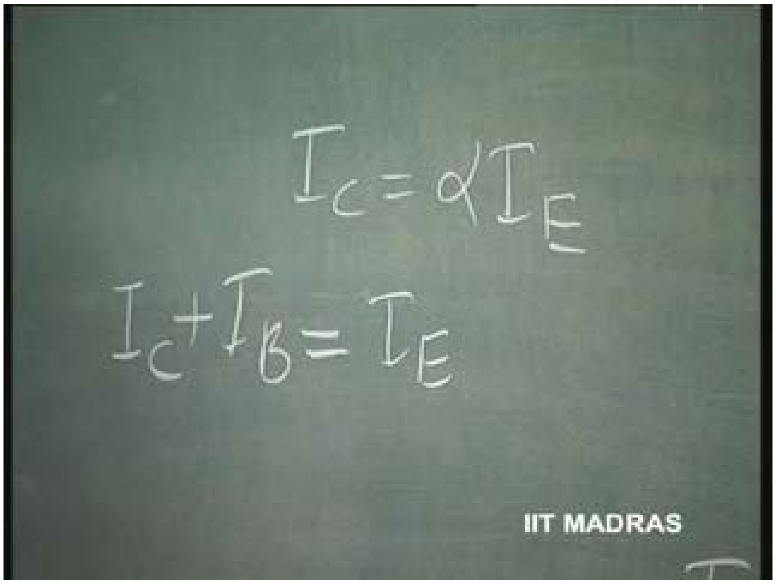

This is I B, this is I c and this is I E.

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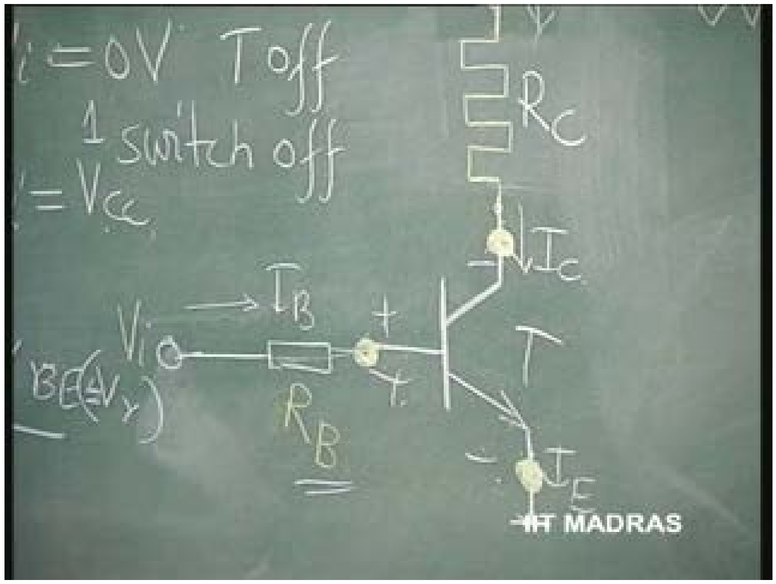

I E is equal to I c plus I B by Kirchhoff’s law; and this, if it is satisfied, I c is equal to Alpha times I E. So, I E is equal to I c by Alpha. I will replace I E because we want to find out the relationship between I c and I B. So, I will eliminate I E from this. I E is equal to I c by Alpha. So, we have now I B equal to I c minus, in fact, I c by Alpha minus I c, from this.

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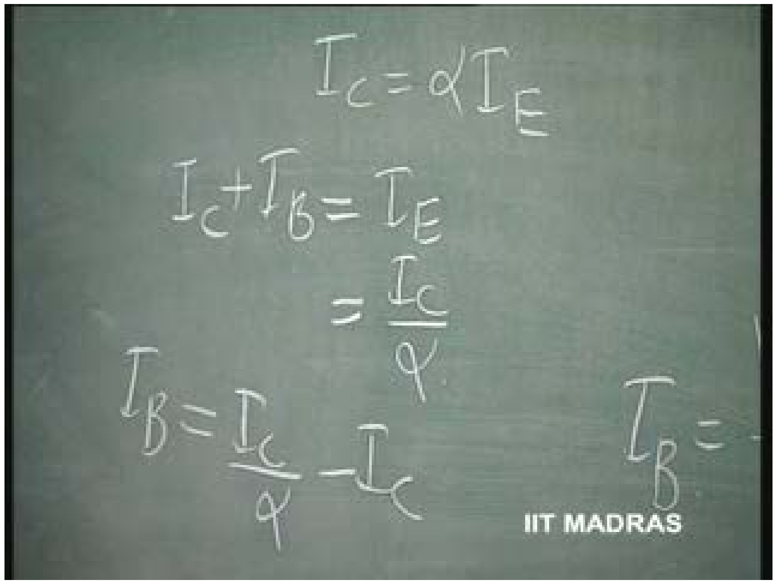

Or, I B equal to 1 minus Alpha by Alpha into I c. Is it clear? Or, I c is equal to Alpha by 1 minus Alpha times I B. This factor is popularly called Beta. So, Beta is equal to, always, Alpha by 1 minus Alpha, for the transistor; so, that into I B.

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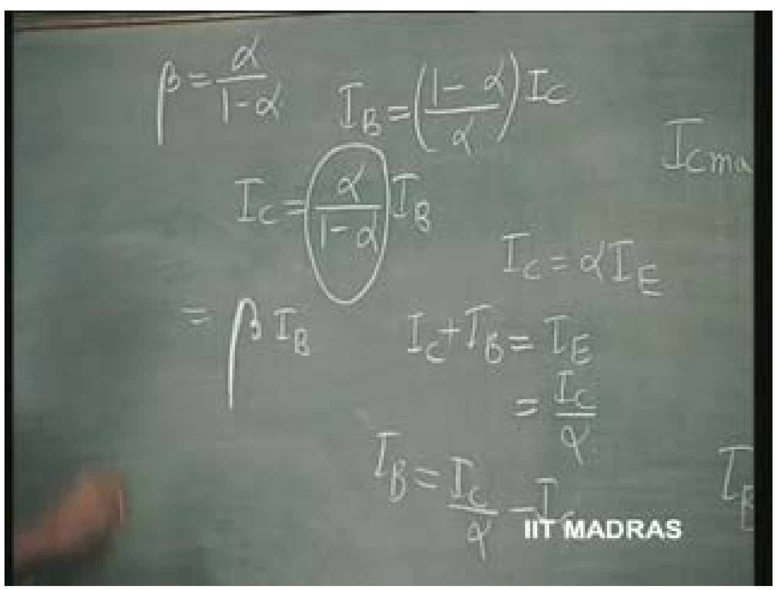

If, for example, Alpha equal to point 99, find Beta. Beta is therefore equal to Alpha by 1 minus Alpha, which is 99.

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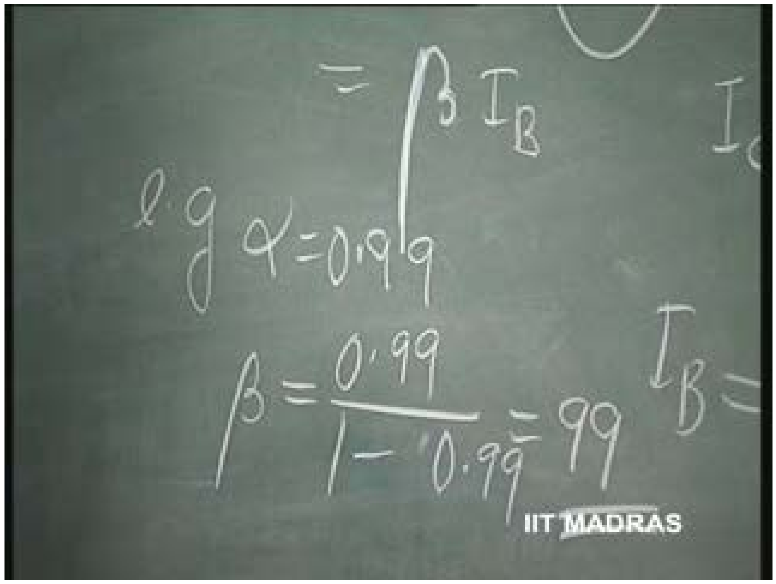

Is it clear? So, please remember. If Alpha is very close to 1, Beta is going to be very high. So, Beta is the relationship between I c and I B; and if Alpha is equal to 1, Beta is going to be equal to infinity. That means, why it is infinity for the finite collector current? - we have zero base current. So, Alpha and Beta are related by this. Please remember this. So, in turn, we can find out Alpha as, from this, Beta divided by 1 plus Beta.

So prove: Alpha is equal to Beta by 1 plus Beta.

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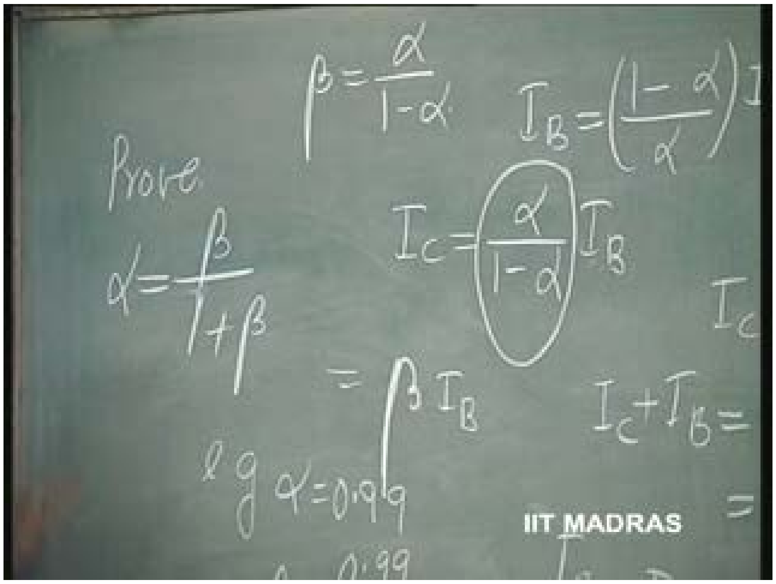

So, from this relationship, we can prove that. Now, we have this particular relationship wherein we want I c equal to Alpha I E not to be satisfied, because transistor has gone to saturation.

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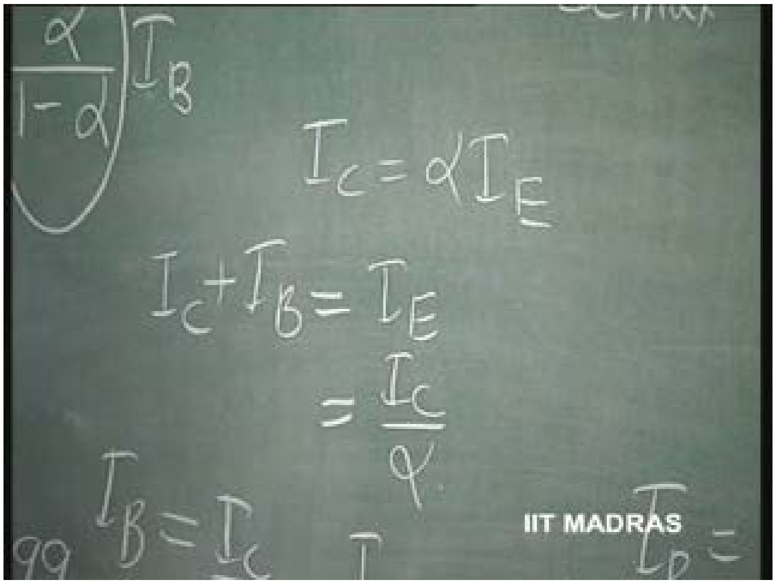

When will it happen? If I make the base current such that it is more than what is going to be determined by this; that means, if I B is equal to I c by Beta, this relationship is satisfied. Transistor action exists. If I B is equal to I c divided by Beta, then, transistor action takes place. If I B is greater or much greater than I c divided by Beta, then, the transistor is in saturation. That means, in this case, the transistor is in active region, because transistor action still takes place; but if I B is much greater than I c by Beta, transistor action does not take place.

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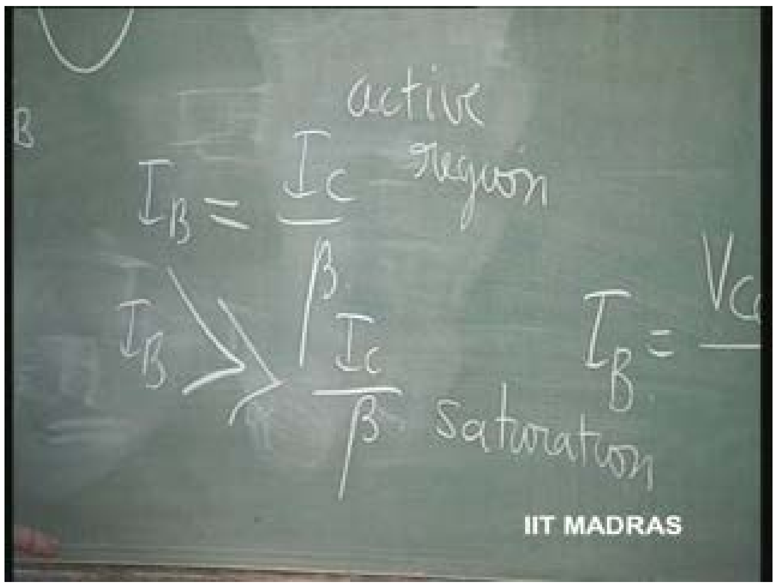

Why? That is because both junctions are getting forward biased. So, we are therefore using this information in order to force the transistor to saturation. If both the junctions are forward biased, then the whole transistor can be replaced by a single node because this is a short circuit. This is a short circuit. The entire thing is almost nearly equivalent to a short circuit. That is what a switch should be. Why should it go to saturation? Why cannot it be in the active region? That may be your question. Because, then it is not going to act as a switch. Switch, when it is closed, has zero voltage drop across it and current can be anything fixed by these resistances.

So, in order to make it look like a switch and to make the current determined by this resistance, we have to make it go to saturation. Otherwise, current will always be determined by the input voltage. The input voltage should not determine the current. The current should be only determined by R c.

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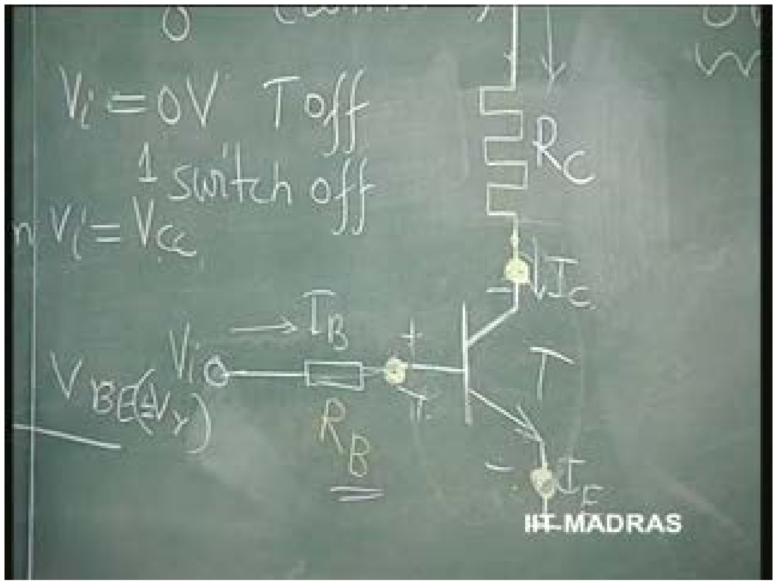

So, this is an important design requirement. That means, I B should be much greater than V cc minus... that is, I B, which is this, should be much greater than V cc divided by R c; that is the collector current, maximum collector current, divided by Beta minimum.

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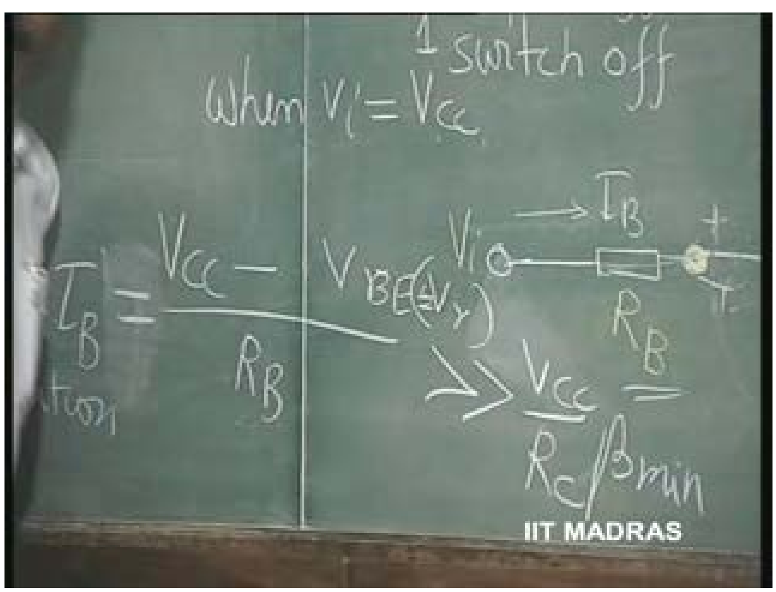

Now, what is this Beta minimum? Beta is not a factor which is going to remain constant. It may change with respect to temperature, etcetera, operating point and all. So you have to take the worst case value for Beta. This is given by the manufacturers. There is a minimum value that you can take for the Beta. So, under the worst case also, this should go to saturation. So, V cc by R c is the maximum current; that divided by Beta minimum; even that current ((drive Refer Slide Time: 46:45)) is exceeded. So, the base current should be greater than that. If you make it too large compared to that, then it might damage the junction.

So, that is why this is called a current limiting resistance. This cannot be made, R B cannot be made, too small. R B cannot be made too large. The maximum value for R B is limited by this equation; minimum value is limited by the maximum base current that it can permit through the transistor without damaging it. So, both maximum and minimum limits for the base resistances are determined by the fact that the maximum resistance is governed by this equation; minimum resistance is governed by the fact that base current cannot exceed a certain value without damaging it. So, any resistance within that range must be put here in order to design it as a switch. This may be therefore called a power switch.

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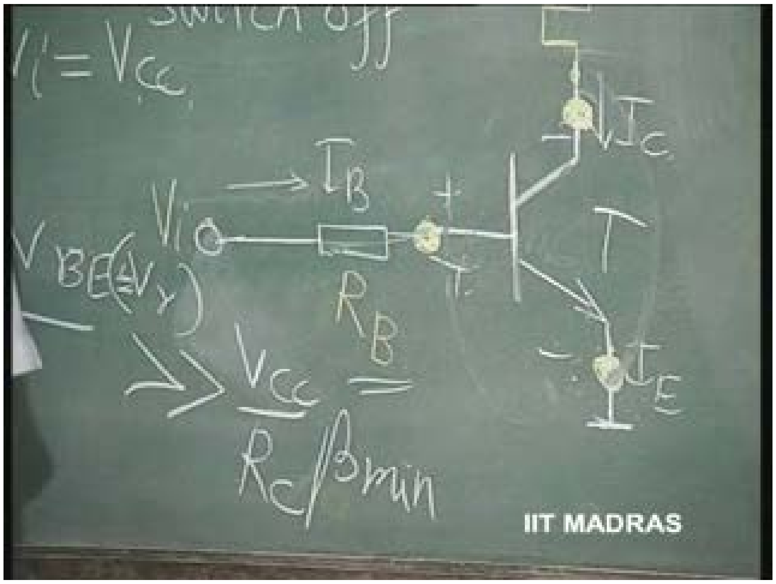

This transistor may be capable of sort of taking currents of the order of amperes and still act as a switch. This may be a relay coil, which may take hundreds of milliamperes may be, to sustain some switching action. So, these are commonly used in control circuits for controlling the relays, heater coils, etcetera. So, design of a switch is very important and you should make the transistor necessarily go to saturation.

Now, this is unlike an amplifier design where obviously I will not put any series resistance. Series resistance will cause unnecessary loss in signal. So, V i is applied directly to the base. In the case of a transistor being used as a switch; only then, I will put a current limiting resistance. If I am using the transistor as an amplifier, R B has to be as small as possible. Necessarily, you will not put a series resistance; it will be zero; because otherwise, we will lose certain amount of signal in the series resistance. Only part of the signal will appear at the input; and therefore, when it is being used as an amplifier, R B is zero. You will not put a resistance there.

So, this is to be noted in the difference in design of an amplifier as against a switch. The switch normally gets as its input; again, you have to note, either a high or a low. The low is always zero because we do not want any voltage, ((especially Refer Slide Time: 49:40)). We can simply ground it. High is always necessarily the supply voltage. So, these are the two inputs which come into existence in discussing a switch and its performance. No other input need to be considered.

Whereas, in the case of an amplifier, the input to be considered is at base directly and it can be changing depending upon the operating point and the linearity you want and the dynamic range you want. So, we will revert back to discussion about amplifier with V i being applied here; and this is not a heater element any longer. This may be the load resistance R c. So, V i is at V i Q plus Delta V i. Input is applied like that. How do you apply this?

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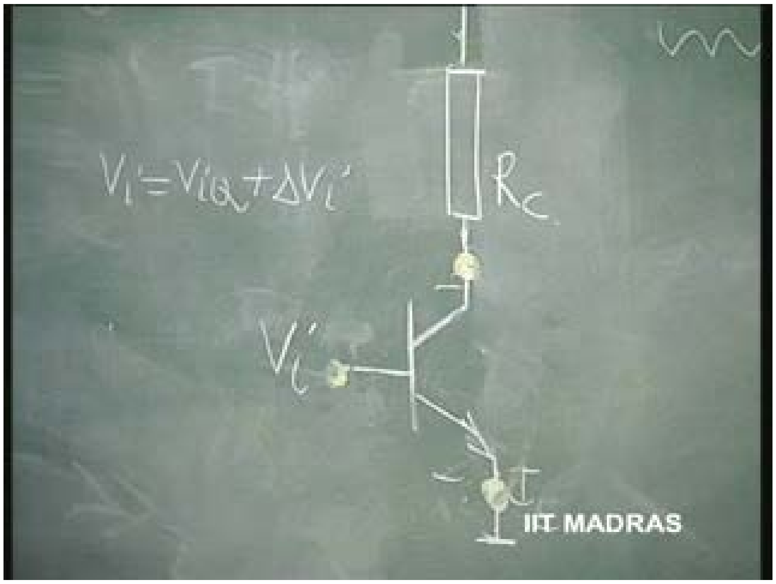

V i Q can be a battery. Now, Delta V i should be a source, which should come in series with this. So, that this is... How do I do it?

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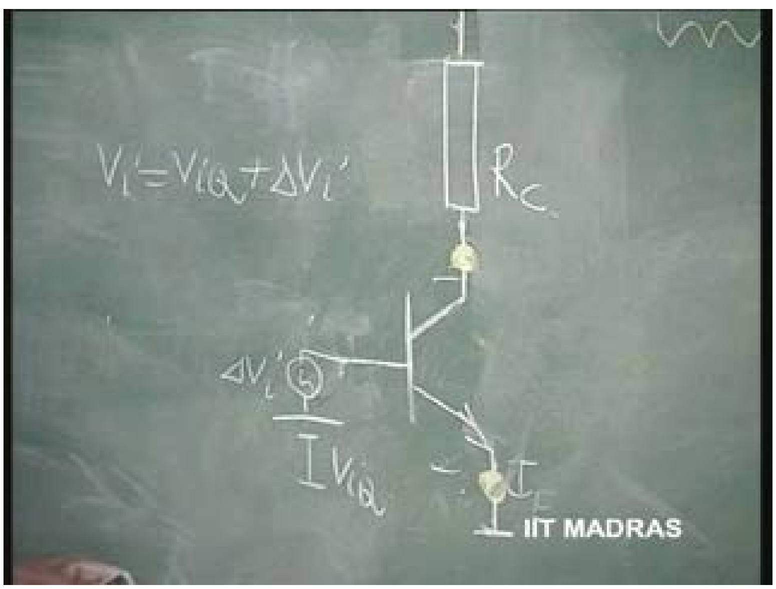

I have to put a battery which has a voltage of V i Q, in series with a small signal of Delta V i in order to sustain this kind of thing. At that point of time, I can get V naught which is, V naught Q plus Delta V O. That is what we have said. Now we will discuss how this can be done.

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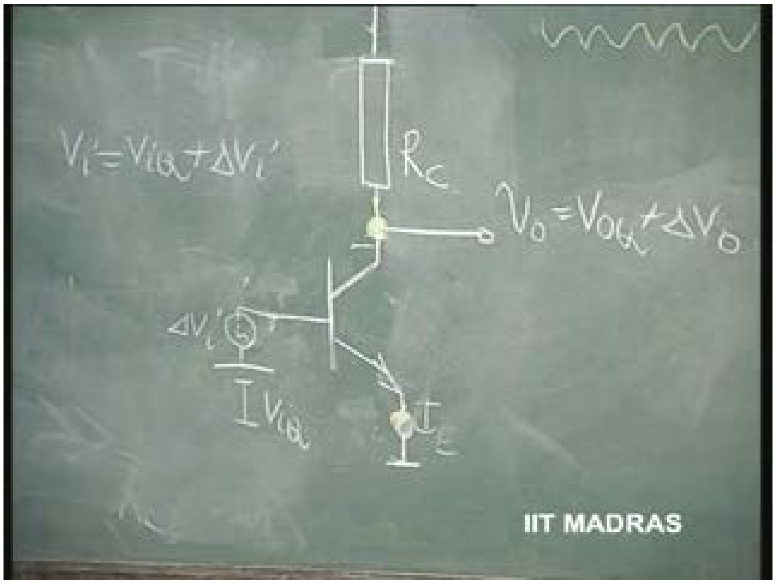

One way to do it is put a battery in series with a source. But this source has to come in series with the battery. That means there is no common ground with respect to this point, emitter. This has no common terminal. Our amplifier, design and sources, etcetera, we have been always talking of a reference common point; and if we take this as a reference point, all the voltages have to be sort of discussed with respect to this point.

So, the AC voltage should be really applied with reference to this point. So normally, the sources are independently coming. They are always giving you source voltage with respect to a common ground. If you want an arrangement like this, the only way we can have it is, you have a common AC, with a common ground; and then couple it by means of a transformer. You know about transformers; this transformer can couple this signal to this like this.

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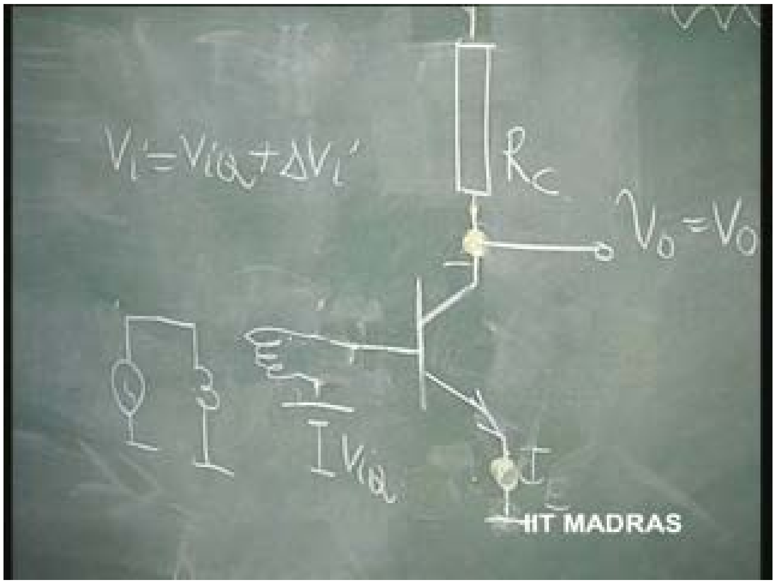

So, either a transformer coupling has to be done or, how do we do this further? One way to do this is to introduce a resistance here so that this is not biased by means of a voltage at all. So, if I add whatever some DC voltage here, let us say, we have V cc; and then you put R B here. This is now being biased by means of base current; no longer base voltage.

Earlier, I was putting a battery which was V i Q. Now, no longer a battery is put. Like that. I am having the same battery V cc and putting a series resistance there. I do not want to use another battery. I would like to use the same battery here. So, V cc in series with a resistance, if I put... Just now, while discussing switch, we know that a base current gets fixed here. What is the base current? V cc minus V gamma divided by R B. So, it is biased. This is called current biasing.

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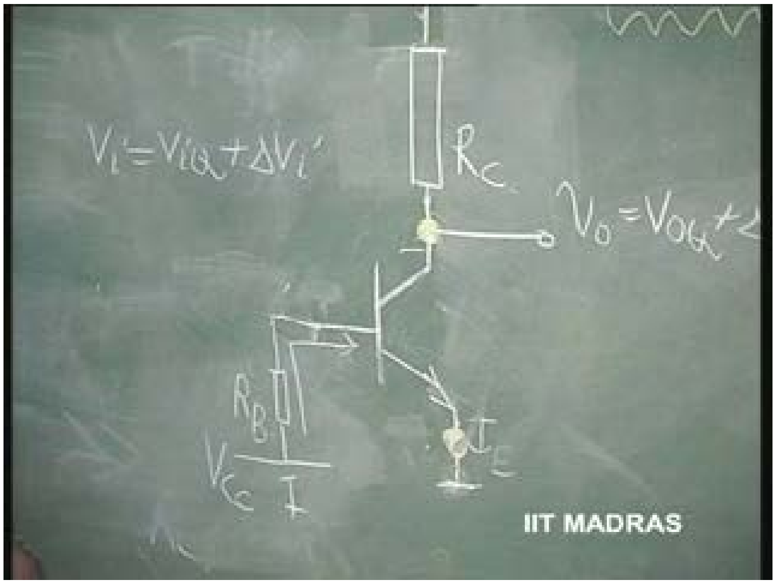

The earlier one was voltage biasing. If I do this current biasing, where the current I BQ gets fixed as V cc minus V gamma by R B, then, I can superimpose an AC by using capacitive coupling.

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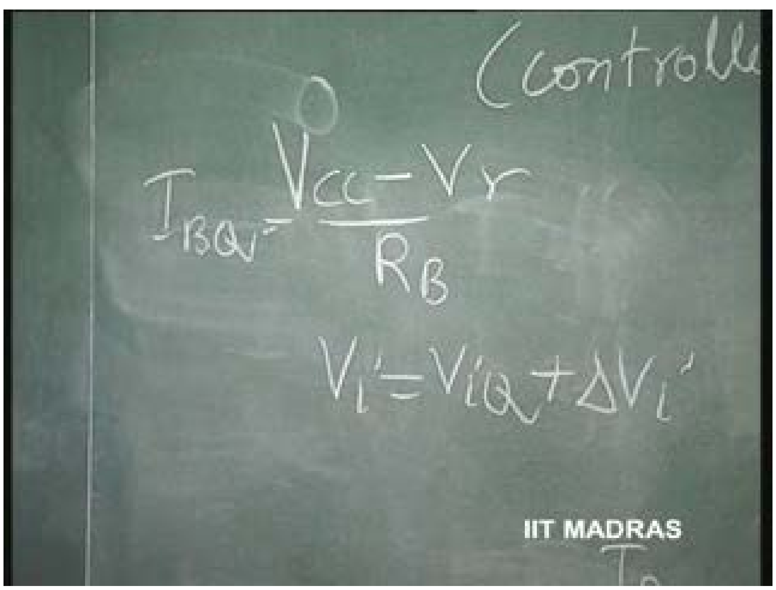

This capacitor will block the DC and will couple the AC.

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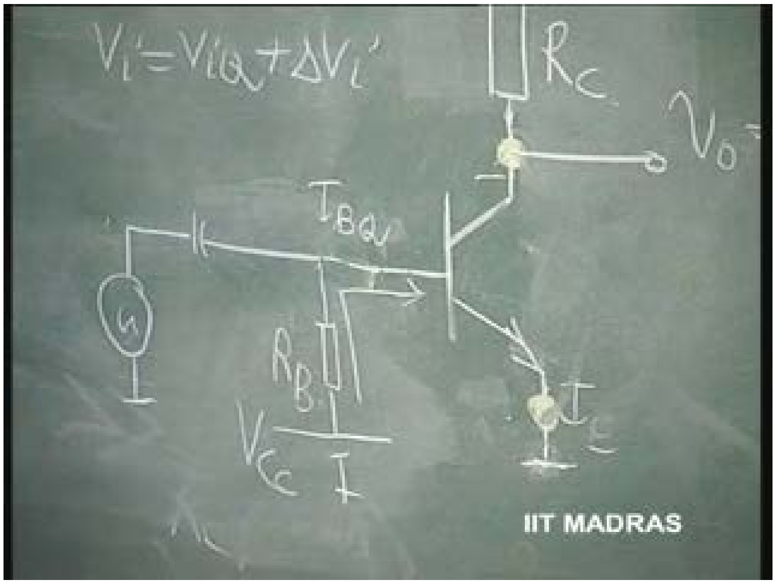

So, this is the advantage of using current biasing instead of voltage biasing. So, instead of using a battery whose value is V B EQ, and what is the order of V B EQ? - of the order of point 5 to point 6, I can use this current biasing. We will discuss further about this in the next class; biasing a transistor.

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