Electronics

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Module No. # 04

Feedback in Amplifiers, Feedback Configurations and Multi Stage Amplifiers

Lecture No. # 03

Input / Output Impedances in Negative Feedback Amplifiers (Contd.)

We were discussing the input and output impedances in a amplifier, which has incorporated negative feedback. And as an example we took a voltage series feedback circuit and we calculated the input and output impedances. How they are modified by the incorporation of the negative feedback. Now, instead of driving for all the configurations once I have taken one example at input and the other example in output; one was shunt, the other was series connection. Then I think it should not be difficult to drive other relations, instead of a devoting time in these further derivations we will keep it reserved for other parts of the module. Now, just to give a summary of the modifications in the input, and output impedances, which are brought about by the negative feedback, I can give a summary of these results.

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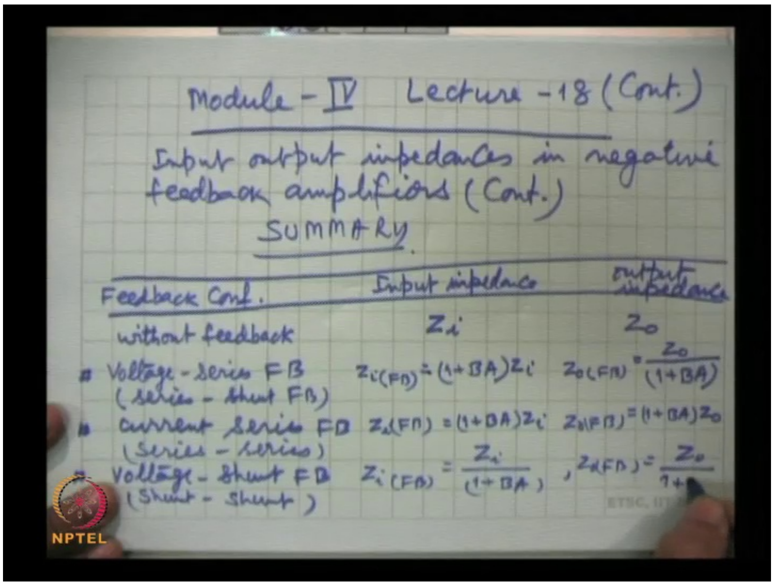

So, this is the summary for all the four configurations, this is the feedback configuration, this is input impedance, and this is the output impedance, input impedance and output impedance. Now without feedback this is input impedance is taken as Z i and the output impedance is taken as Z 0.

Now, so how this Zi and Z0 are modified in the four configurations first we take voltage series feedback which is also called Series Shunt Feedback and this is the circuit for which we have derived and we show that the input impedance Zi with feedback is increased to 1 plus BA Zi it increases and the output impedance false and this becomes equal to Z0 with feedback is equal to Z0 that means output impedance without feedback plus 1 by BA.

I remind that this parameter 1 plus BA this is a positive number for negative Feedback and the value may be for this factor 10 12 100 so, that means that input impedance just by the incorporation of the voltage series feedback the input impedance will rise if we take this factor as say 10 than this will be 10 times, if Zi is 1k it becomes 10k and here if the output is again 1k and if this factor is taken as 10 than that will reduce to 100 ohms so, this is the modification.

Now in the Current Series Feedback which is also known as series series. The input impedance and output impedance both are increased by feedback so, Zi FB is equal to 1 plus BA into Zi and Z0 FB is 1 plus BA Z0 both are increased in the third voltage shunt feedback which is also known as shunt shunt feedback. Both input and output impedances are reduced from they are no feedback values and these are Zi FB Zi 1 plus BA and Zo FB is equal to Z0 1 plus BA.

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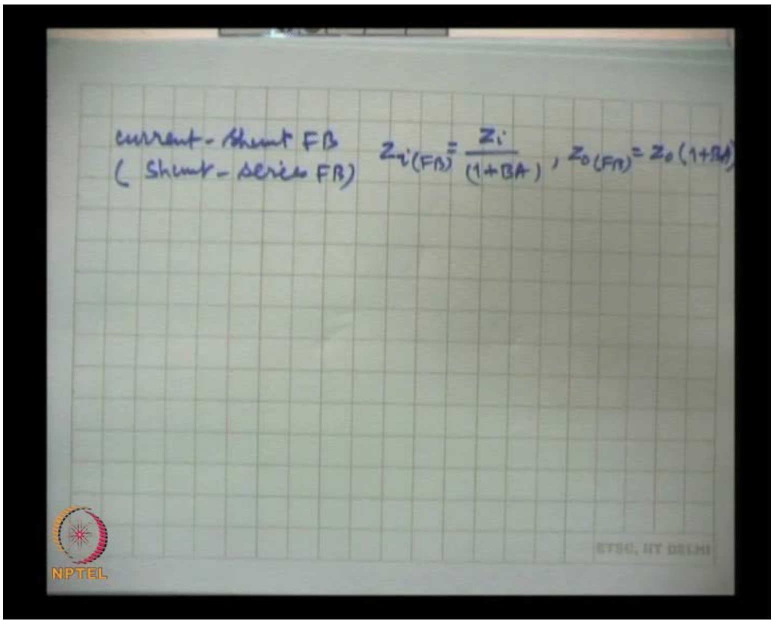

And finally, in the last configuration Current Shunt feedback which is also known as shunt series feedback the input impedance is reduced and this is a Zi FB equals to Zi 1 plus BA and the output impedance increases so, Z out FB is equal to Z0 1 plus BA so, this are the expression for the impedances the modified impedances for a amplifier circuit which incorporates negative feedback.

Now, depending on the requirement sometimes the mean objective of incorporating of negative feedback besides a stability is to change the input and output impedances so, of course, in all this four configurations the common factors of negative feedback common characteristics are always there, that means you choose out of these four any configuration in the circuit will show a stability the circuit will reduce the distortions and so on.

So, you have to choose a proper circuit depending on your impedance requirements and one in another thing you should notice which we said also in the beginning that when the connection of the input for the feedback network is in series than the resistance will increase, and when the connection feedback network is connected in parallel than the effect will be the reduced impedance either at input or at output. And all these modifications are of the of the value 1 plus BA, A is the gain of the amplifier without feedback and it is known as open loop gain, and B is the feedback factor or the gain of the feedback network and this can be so in any feedback circuit. What we want to know is what is the value of A? What is the value of B? Then all parameters concerning the negative feedback we can a find out so, this was about the impedances.

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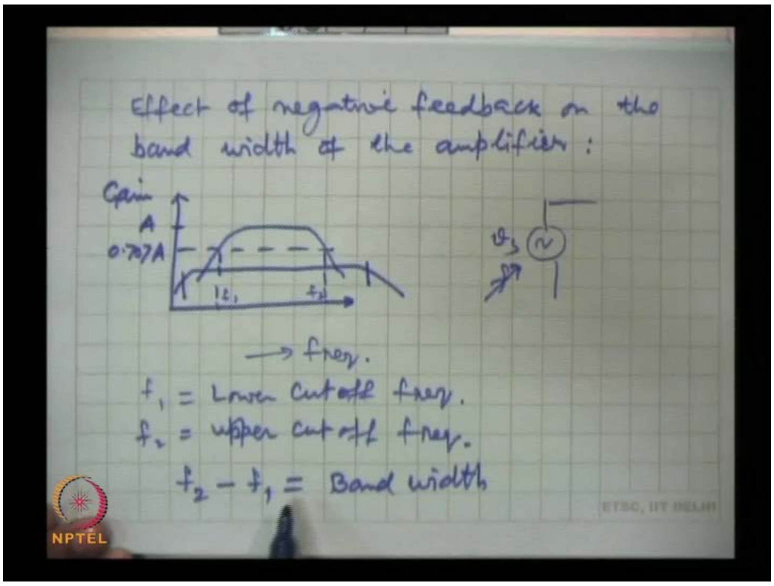

Now, we continue this a feedback a studies and we take the effect of a negative feedback and the band width of the amplifier, effect of negative feedback on the band width band width of the amplifier we study these thing yes, negative feedback enhances the band width first let us see what is band width. In general for any amplifier if we plot the game versus frequency response meaning that here this is the input signal and

suppose, for this type of experiment we keep the frequency variable frequency is varying we start from very low frequencies and go to high frequencies and measure the gain of the amplifier for example, it may be a simply a voltage gain then, what is the kind of when we plot gain versus the signal frequency than what kind of plot we get this is this here this in the gain, and this is the frequency; frequency of input signal frequency of the signal to be amplified frequency.

Now, we are seeing that this plot can be divided easily into three regions of frequency one is, I will come to this in greater details later but, at the moment our objective is to a study the impact of negative feedback on the band width. So, if here the gain is taken as a we take 70.7 percent that is 0.7 over 7 of the gain we draw a line and this line cuts a two points here and here this is f1 and this is f2 these are two cut off frequencies lower f1 is called lower cut off lower cut off frequency and f2 is upper cut of frequency. Now, the difference of this two frequencies f 2 minus f1, this is called bandwidth band width of the amplifier depending on our application how much this bandwidth should be we have to design the amplifier accordingly it may be very large it may be a small requirement may be of not very high bandwidth and requirement may be very high bandwidth.

So, accordingly that circuit has to be a designed and negative feedback enhances this is one of the techniques incorporation of negative feedback enhances the bandwidth that means. If this is the bandwidth with the with without feedback than with feedback for example, this may be like that so ,here f1 also increases f2 also increases f1 increases means it becomes further lower so, it false actually f1 false and f2 rises so the band width increases.

Now, how does it happen let us briefly explain, you have seen in the feedback systems that the effect of negative feedback is to resist any change in the circuit. I repeat that the effect of negative feedback is to resist any change in the circuit performance. Now, this is the change in circuit performance when we change the signal frequency the gain is falling here also the when we increase we gone increasing the frequency there is a region where the gain is almost constant, and this is known as a mid frequency region. mid frequency region and so there is a mid frequency and than again it falls because, we are going to study this things soon in details so at the moment, I just a talk about the bandwidth so remembering the fundamental that negative feedback resists the change. When the frequency is further lowered the gain will change and that gain will be resisted by the negative feedback that will it will not change that fast.

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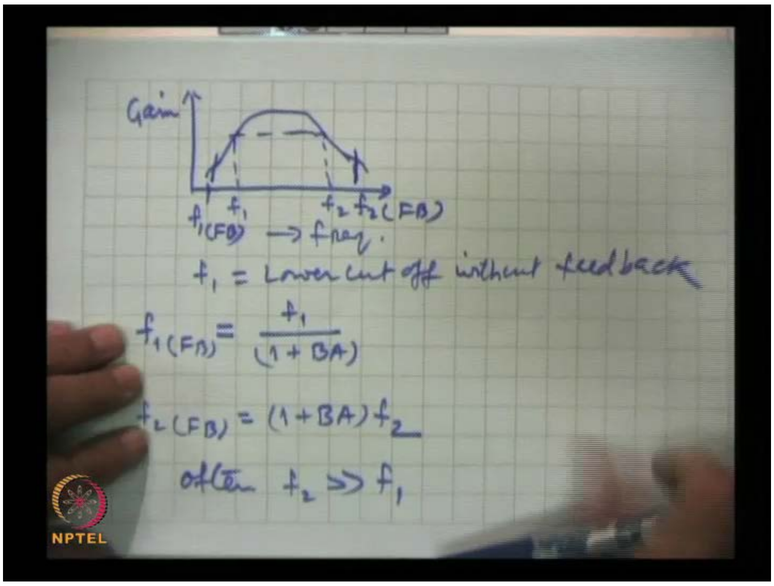

So, in a way that means that if this is f1 when signal frequency is further reduced this change of gain will be resisted by the negative feedback and if f1 is the lower cut off without feed back with feedback that means f1 with feedback is reduced and as we have seen that all changes are of the magnitude of 1 plus BA. So, f1 is reduced by the factor 1 plus BA so, it becomes here for example f1 FB in the same way the f2 FB that means upper cut off with feedback is increased that means it moves in this direction here f2 FB and this is 1 plus BA into f2 so, lower cut off is reduced and upper cut of is increased and hence the bandwidth of the amplifier increases. Now, often f 2 is very large in comparison to f1 f2 this upper cut off is very large in comparison to f1.

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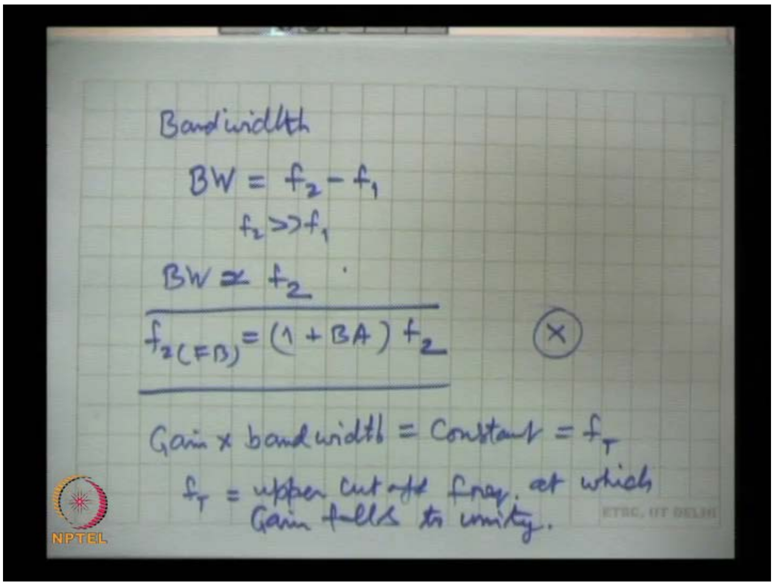

In that case f 2 instead of as we said the band width we can write BW this is the actually f 2 minus f 1 but, an that the condition the f 2 is very large in f1 band width is often taken as is almost equal to f2 so that the band width with the negative feedback becomes f 2 FB is equal to 1 plus BA into f 2. This is the change in bandwidth if this factor is 100 than bandwidth is raised by two orders of magnitude just by incorporation of the negative feedback. We can this we have just an logical grounds we have come to this expression let us call this expression x we can come to this expression again by another consideration.

One fundamental we should remember that the gain band width product, gain into band product is a constant for any amplifier, and this comes out to be equal to when gain look here ,when gain is unity that means gain false to 1 than that is a known as a upper cut of frequency and fT what is fT? fT is upper cut off frequency at which Gain false to 1 that is unity. Gain band width product is constant for any device and for the circuit which is using the device and this product is equal to fT. If gain is taken as one here and than this is the bandwidth so, fT fundamentally becomes equal to band width so, upper frequency which we are taken as the band width so upper cut off frequency at which gain false to unity. Now this expression gain into band width is equal to fT let us call this equation y this is true for every all frequencies.

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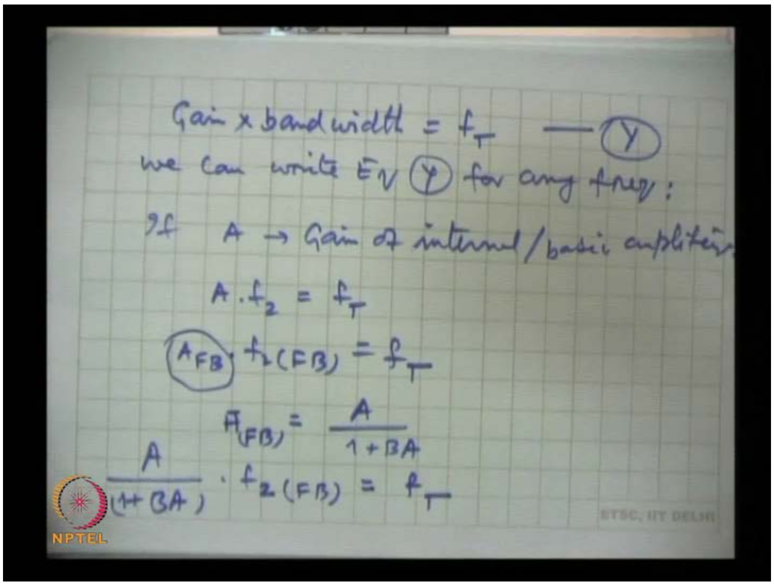

If gain increases band width false and the product will is still be equal to fT and if the gain of the this we can write for any frequency, we can write equation y for any frequency and for any frequency that gain will change and hence, the band width will also change making this constant.

So, if A is the gain of internal amplifying basic amplifier that means amplifier with out feedback than we can write this equation like this a f 2 equal to fT gain band width in which equal to fT and in the same way for the feedback circuit A FB into f2 FB is equal to fT. What I am doing you should follow me that band width we defined for any in general for the amplifier between these two cut off frequencies f 2 and f1. so, band width is equal to f2 f1 but, f1 in general is very small as compared to f2 so, we can drop f1 band width becomes f2 and so, that the we have said that f2 with feedback it increases and it becomes f2 with feedback 1 plus beta A into f2. Now, this is expression we can arrive at from different angle gain band width product for any amplifier is constant if we attempt to raise the gain than band width will fall.

On the other hand if the gain falls the band width will increase and this product is constant and from this equation gain band width is equal to fT if gain is unity, than fT is equal to band width. so, we can define fT fT is the band the upper cut of frequency which is band width upper cut off frequency at which gain falls to unity. Now, this equation gain band width product is constant and equal to fT can be written for any frequency so, first is A when A is the gain of the internal amplifier, the amplifier which is not yet using the feedback than we can write A into f2, f2 is the upper cut off frequency of the an without feedback amplifier is equal to fT and with feedback the same similar equation can be written A FB into f2.

This is the band width of the amplifier with feedback and the product is equal to fT. Now, substituting here for this AFB we remember AFB feedback is equal to A 1 plus BA so, here we substitute this so that it becomes A 1 plus BA into f2 FB is equal to fT. Since, fT is equal to Af2 this equation becomes A 1 plus BA f2 FB equal to Af2 and this A is cancelled with this and so, that f 2 FB becomes equal to 1 plus BA into f2. This is the same equation as we head earlier equation x f upper cut off which is band width for a feedback amplifier equals 1 plus BA into f2 same we get here from a different angle

So, always remember that negative feedback is going to enhance the band width. but, what is the price which we will pay for this advantage that the gain will false so, if for example, if this factor is say 50 you know that if gain is gain earlier is say 10000 and than with feedback it will be reduced by this factor so, with feedback AFB this will be 10000 divided by 50 so, this becomes only 200.This is the price but, with this the bandwidth will go up and this band width if this factor is 50.

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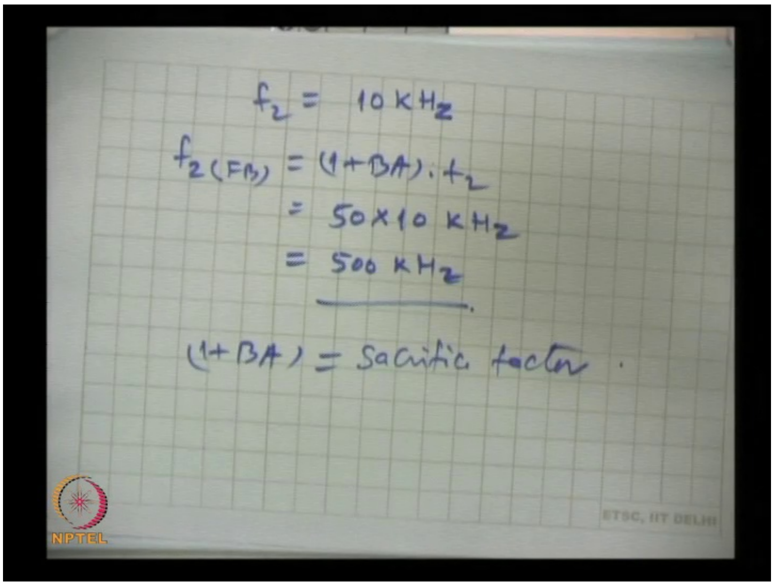

And let us see that f2 that is the band width of the amplifier without feedback. Suppose, it was 10 kilohertz with feedback the band width will be FB 1 plus BA into f2 and this factor we have taken as 50 so, 50 into 10 kilohertz so, 500 kilohertz instead of 10 kilohertz it will become 500 kilohertz band width increases by the same amount by which the gain falls. So, these are various advantages of negative feedback which we talked, and the only thing which is which we sacrifice is the gain and some times 1 plus BA is called is sacrificing factor sacrifice factor and, in any feedback configuration all quantities are always modified by the factor 1 plus BA. So, this factor for feedback analysis for feedback design for feedback performance the value of 1 plus BA .This is a very important so this was about feed backs.

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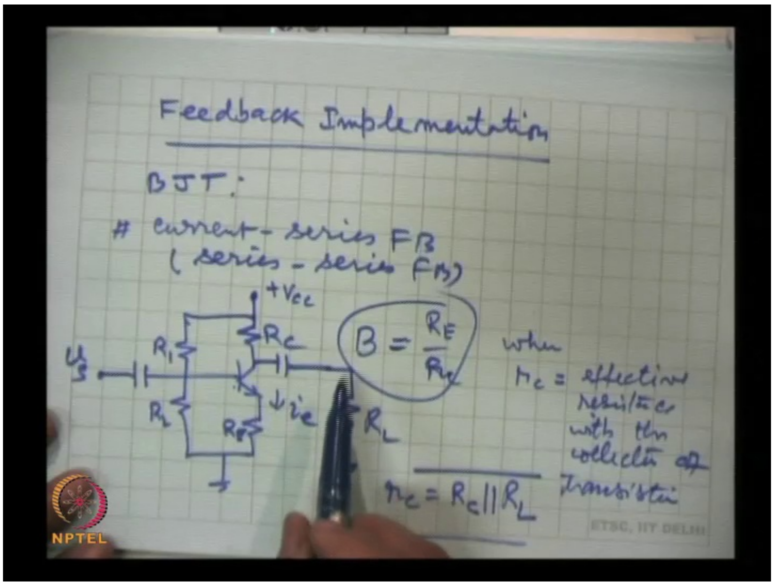

Now, the last thing about feedback is feedback implementation so far, we have been drawing the block diagrams for the feedback circuit. We isolated a amplifier we called it basic amplifier having again A than we attached to this a feedback network and we analyzed the circuit and we have seen what are the effects which the feedback brings.

Now, we talk of actual circuits in a actual circuits what is the feedback network and how the circuits are design first I take two examples from the BJT from Bipolar Transistor these two circuits we have talked earlier and I am sure you must have you must have noticed that I have used even there the word feedback one is this example this is the example of current series feedback which is series series feedback .In the circuit will look familiar to you this is the circuit this is RC R1 R2 RE, you remember this circuit we talked when we talked about the biasing methods of a transistor. In an amplifier the emitter junction has to be forward biased collector junction has to be reverse biased no matter in which configuration we are using the transistor whether in common base, or common emitter, or common collector. But this has to be remembering that we have to bias the emitter junction always forward biased and collector junction as reverse bias.

Now, so and here in corporation of this resistance RE that is a feedback resistance here because in the absence of this resistance, we have seen that the input is a no way connected to the output and circuit is highly in a stable any variations will be reflected immediately in change of the characteristics of the amplifier for example, rise in temperature will give rise will go will enhance the gain which is a note desired.

Incorporation of this resistance because now through this current series feedback the voltage developed here will be proportional to the current flowing from here so, the voltage developed becomes the part of the input now, the net input which is going to the transistor is not the signal which we are applying signal plus this voltage and this voltage will take correct measures and it is return in series that is why current series feedback that means the voltage developed here is proportional to the output current and this voltage goes with this v s with proper sign. In the sign is minus here to the net if for any reason unwanted situation that temperature changes are you change the device ie for example increases than this voltage will also increase, that means the net voltage vs minus the voltage developed here will fall and that will take the correct the measures and the current will not raised.

Here this beta B the feedback factor or the gain of the feedback can be shown to be approximately equal to RE by RC where, RC is the effective resistance with the collector of transistor. What we mean by effective actually, this is the circuit to which we will couple a load resistance with the capacitor than the effective resistance is actually, the two are in parallel because for ac analysis dc voltage sources have to be grounded this is already ground this is to be grounded capacitors are taken a short. So, the two resistance is will come in parallel so than this RC will be RC in parallel with load resistance RL. If it is 4k this is 4k it becomes 2k the parallel combination of 4 k and 4k will give you 2k so, that is the value we have to use so, this is the value of a the feedback factor. The other familiar circuit again from the bipolar transistor is voltage shunt feedback.

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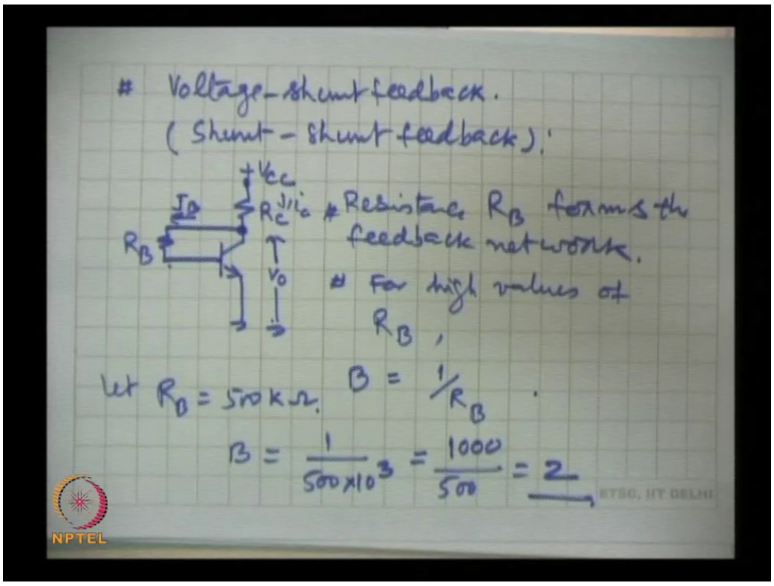

Voltage shunt feedback which is also called shunt-shunt, and this circuit again you will recall RB. I am sure you will recall this circuit this is IB here, the feedback is through this resistance RB; so, resistance RB forms the feedback network. How this feedback helps in bringing about the stability this we have already talked when we were talking about the biasing a schemes. This was the collector feedback bias which is often, used when and the simplicity of the circuit is a very iterative. so, and of course, it brings a stability so, through this now the current input current IB is a function of the output voltage and it is return in parallel that is why voltage shunt feedback we are sampling the output voltage and that will send the current. If for any reason current ic changes than drop across this resistance RC will increase and this will fall it will send laser current and that raise in current ic will be checked will be restricted.

This we have discussed and for high values of resistance RB the factor B feedback factor this is equal to 1 by RB so, suppose it is 500 kilo ohms than let RB the 500 kilo ohms than B will be 1 by 510 to power 3, which is 1000 by 5 this is 2.

Now, I take two examples from for feedback from operational amplifiers operational amplifiers we will be talking little later that is one of the modules and we will go in greater details about operational amplifiers. Operational amplifiers are very important in all kinds of electronics whether it is analog electronics or digital electronics.

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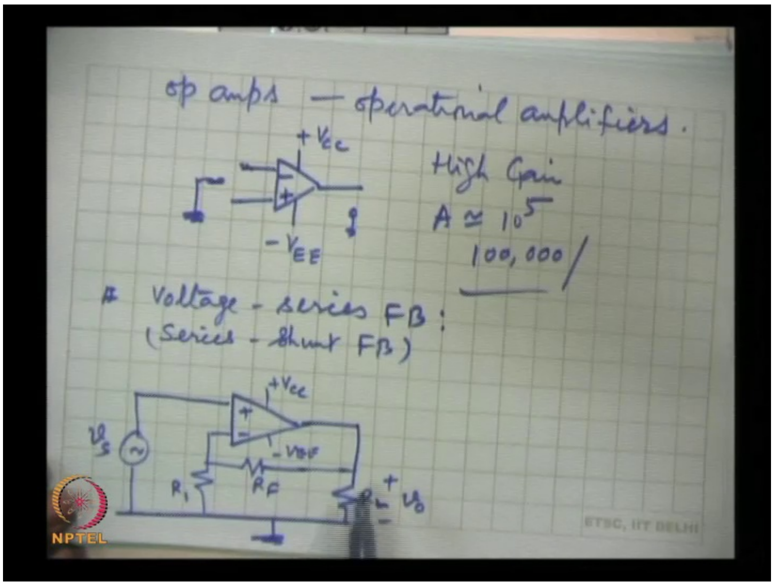

Operational amplifiers are popularly called as op amps, operational amplifiers very large role of op amps is there in the development in the advancement of the electronics. Now, op-amps is a very special amplifier why it is called operational amplifier? this we will see later that operational amplifiers can be used for summing purposes, two signals can be two or more signals can be summed up this can be used as a multiplier, as a sign changer, as a differential amplifier, as integrator amplifier and so, on there a very large applications of operational amplifiers. Details we will a study later but, for the time being few more points we have to remember the circuit symbol for operational amplifier is this.

There are two inputs one is with minus sign other is with plus sign this is called inverting input, and this is plus sign is known as non-inverting this is the output now all voltages are given with respect to ground. So, if we give here a ac signal than here the polarity if the signal is attach is given to the inverting input than at the output it will appear with phased version, that means there will be a phase change of phi. When it is it is a highest positive peak positive it will be peak negative, if we apply a dc voltage plus it will appear s minus and if we give minus it will appear s plus.

There are two inputs and if the signals are given at both the inputs than difference of the two will be amplified this is a very important a system operational amplifiers and there is a this is not shown the batteries this makes use of a split power supply. So, plus VCC minus VEE but, as I said they are they implied that without a dc bias this the no electronic circuit works so but, this is not shown for the sake of simplicity of the circuits this may be 9 volts, 12 volts, 15 volts up to 30 volts because there is very large number of operational amplifiers in the market there more than 2000 different types of operation amplifiers to meet different requirements.

So, remembering that it is a high gain by high gain we mean that the most commonly used a op amps have he gain voltage gain to the tune of 10 to power 5 that means 100 1000 gain of 100 1000. So, it say multistage amplifier, it is a direct coupled amplifier and so on.

Now, the one beauty why this is so popular that is different but, why we are taking examples from here that, in these two circuits which we discussed this two circuits either this or this here the feedback network was the part of the mean circuit. Here in op amp we externally connect the feedback resistances and they are it is easy to understand and to draw at things so first we take just two examples the one is voltage series feedback.

Voltage series feedback which is also series shunt feedback and the circuit is this, if we want to use from out of this two input terminals if we want to use one the other is grounded. So, that way if we ground this non inverting terminal than we are using as a inverting amplifier and if we ground the inverting input then signal will be fade to the non inverting input and than we are using it as a non inverting amplifier.

And if signals are given to both none is none of the two is grounded than we have talking about differential amplifier and the difference of the two signals will be amplified. So, here this is RF R1 this is of course, plus VCC minus VEE this plus VCC gives reverse bias to the collector. So, of the transistors and this forward biases the emitter of the amplifier here this is RL and the voltage developed across RL the load resistance which is V0 a part refraction of this is a fed back is fed back through resistance.

So, these R1 and RF network forms the feedback network and the voltage drop this is also acting as a voltage divider. So, V0 is divided and the one which is a dropped across R1 is fed back in this circuit that is the feedback connection and here the voltage which are feeding is proportional to V0 this is voltage developed here is Vf and Vf varies in proportional to V0 and lastly, there is current shunt feedback.

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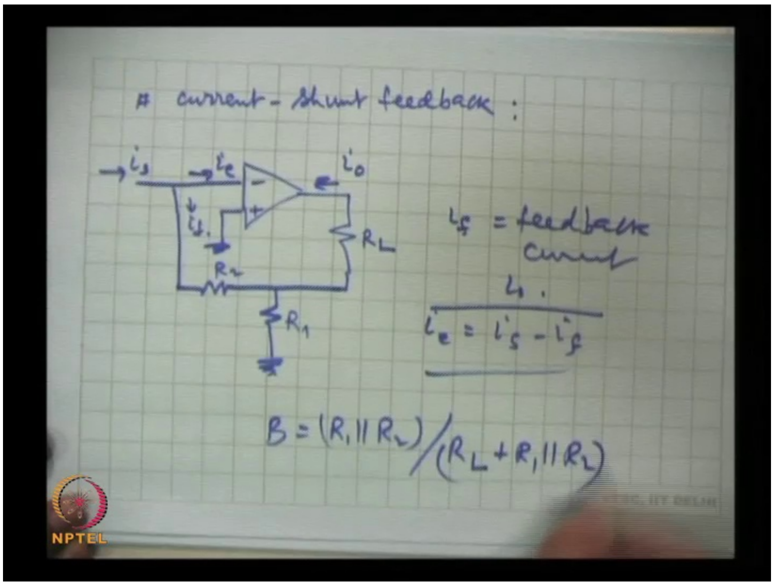

Current shunt feedback this is this (no audio from 52:09 to 52:48) basically this is the here operational amplifier is acting as a current amplifier. So, this is is which is divided into two parts ie and if. And this current if which is the feedback current it is varying in proportion to i0 and obviously here ie is is minus if. So, this is the error signal which goes here in the amplifier and B can be shown to be equal to parallel combination of R1 R2 divided by R1 R2 plus R2 this is the expression for B this is the feedback part, feedback circuits feedback analysis of the amplifier and the remaining part of this module that is the coupling methods a study of RC networks and why we get that kind of frequency response, which was shown we will be talking that.