# Microwave Integrated Circuits

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**Lecture No 31**

**DC Bias**

Hello, welcome to another model of this course microwave integrated circuits. We are in week eight and in the previous module when we were discussing active circuits we have discussed the various aspects of amplifier design like gain noise then matching yet another important aspect of amplifier design is the DC bias in amplifiers. Both the input and output of amplifiers have to be supplied with a certain biased voltage bias voltage means if you take average of the inputs.

If you compute that average then the voltage value that you get is the bias value it is like the DC value or the average value and the reason why these voltages are necessary at the input and output is because unless you provide sufficient DC bias voltage, the transistor, the internal action, the internal physics of the transistor would not work. It is not just enough that you input a signal that you want to be amplified through an amplifier it is also necessary that you provide the proper biased voltage.

How do we achieve this? The purpose of this module is to expose the various biased topologies and how to provide the required biased also. Later in this module we will be covering the frequency compensation part of amplifier design that is, we saw that the gain of an amplifier is dependent on its S parameters, but then S parameters themselves are specific for a particular frequency that is, if you change the frequency, the S parameters also will change.

So how to keep the gain constant even when the frequency is changing? So that is what we will expose in the later parts of this module, but first the bias network.

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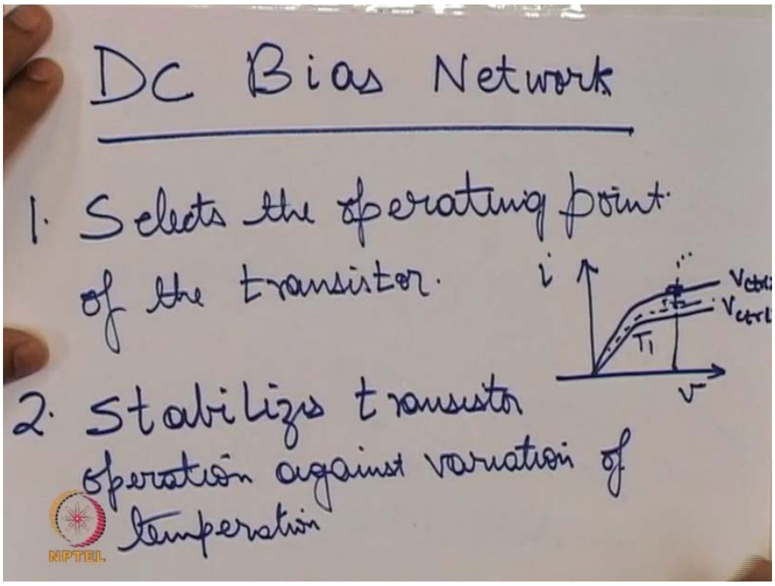


So the purpose of DC bias network is first of all its select the operating point, so operating point means if suppose our transistor has characteristics without specifying what kind of... you know characteristics this is suppose the characteristics is like this like this for various in control variation, say this is V control 1 this is we control 2 and so on.

Now setting the operating point means if you, it means you fix the point of the basic voltage input and any further voltage input would be over and above this particular point. So the variation will be above this point okay so that is quite setting the operating point then the other purpose is stabilises the DC bias network also stabilises transistor operation against variation of “temp tempers”.

So what happens is, these if you go back to the same curve if suppose the temperature T 1, this is the characteristic when the temperature changes the characteristic itself might shift, so in that case if you want to give the same kind of response then the DC bias point also has to shift if had you not had any DC bias network. And if you are only dependent on the AC input then the shift could not have been done, so DC bias if the temperature changes to compensate for the changed characteristics.

You might want to change the DC bias point then there is yet another purpose of the bias network, it is that we do not want mixing between RF and DC signals, so DC bias network the third application is separate DC and RF.

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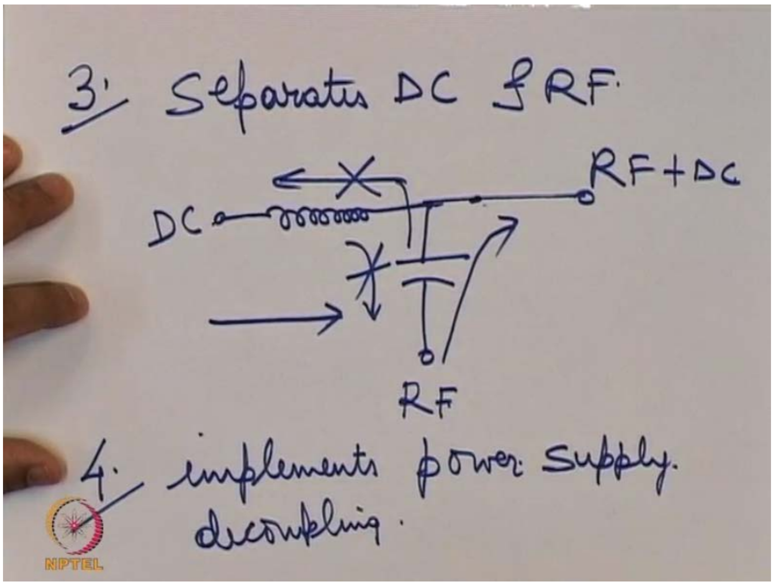


Okay, so DC and RF separation means that see ideally you know that bias network that you should use should be something like this.

This is a very high inductance value and this is a very high capacitance value, so that it will allow only high-frequency to pass through this, it will not allow any DC to pass through it. Similarly, because of the high inductance value it will not allow any RF to pass through it and it will allow only DC to pass through it, so that is the basic so at the output here only DC is coming and here only DC is coming from the side and RF is coming from this side and 2 are mixed.

So separation means that you have a different you know you have a separate DC supply, you have a separate RF supply and they are the both the two networks are not interfering with each other and that is achieved by this bias network. Then it also and finally you know one final use of this DC bias network could be it implements power supply decoupling what it means is that any you know.

Suppose you have a DC supply here and you connect it to this is see the terminal which supplies power to our transistors in our amplifier. Any surge in the DC input voltage without DC bias network or without this decoupling inductor will create problems for this amplifier, so it also kind of isolates any surge in the input DC to the output so how do, so this is our basic DC, so ideally any DC biased circuit should be like this. If I if I can draw it again

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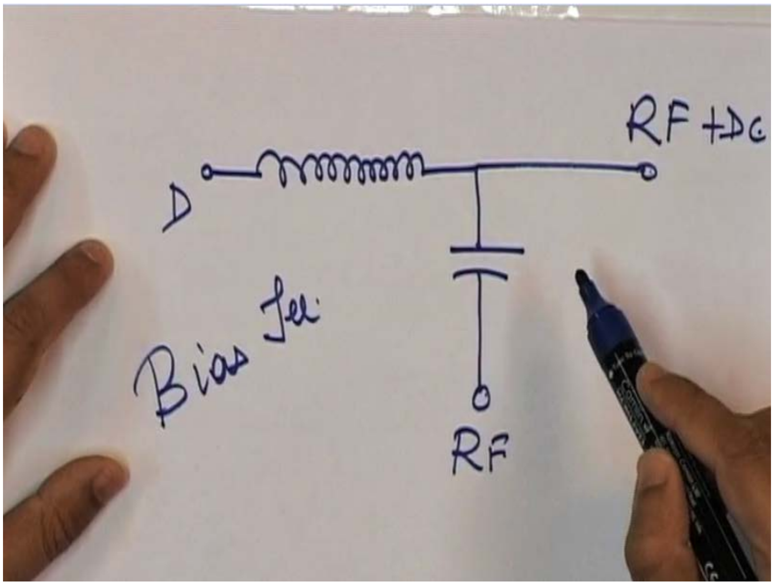


There is a very high inductance value and there is a very high capacitance value. Output will be RF + DC. This configuration by the way is known as a biased T. The question is that we do not get such an ideal high-value inductance or an ideal high-value capacitance, so easily let us see how using micro strip lines we can implement this. So if we go through the slides on the monitor.

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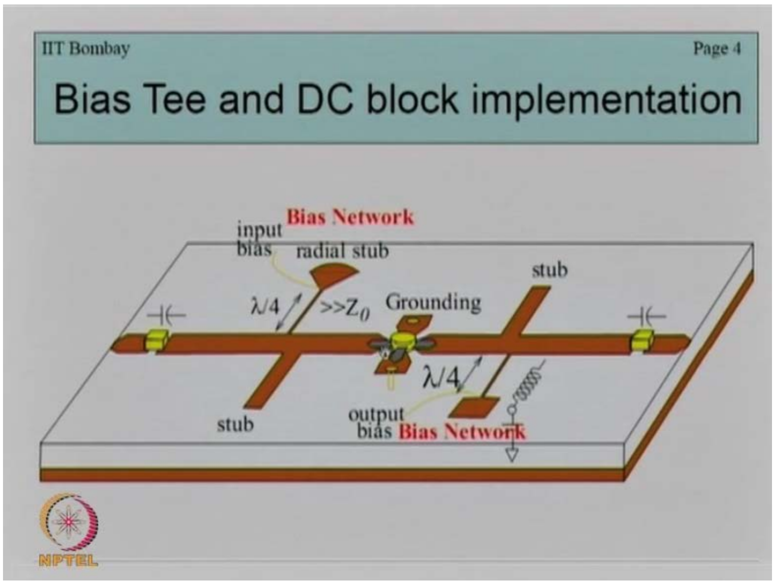


This is the diagram of a DC bias network... 2 DC bias networks. This transistor connect now how does this work... first thing note that this is my input, this is my output, this is my transistor, this is say a BJT type transistor with a base here sorry this is the this is the base, this is the emitter, and this is the collector, so it will act as an amplifier but then both the emitter and the collector need a certain value of DC voltage.

So this whole thing is our matching network or input matching network this whole thing including this stub is our output matching network, so we have already studied about input matching network. Recall in the previous module we studied about input matching network and output matching network, how to do an input and output matching using the Smith chart using the Z and Y Smith chart, so this is as you can see this is a stub and this is the length of transmission line.

This is also a stub and length of transmission line, but you also as I said you also need DC to permeate to the emitter and the collector. How to do... that but this kind of you know this particular piece of stub that you see here is called a radial stub. It is like shaped like a sector of a circle and it is at a distance of lambda by 4 or quarter wavelength from this matching network.

Now radial stub has very low input low input impedance. Okay, so my input bias voltage is connected directly to the radial stub. If a radial stub has very low input impedance here, then on quarter on adding a quarter wavelength of transmission line like this, then impedance that any RF signal will see here is very high because recall the quarter wavelength will invert the input impedance.

The other aspect about the radial stub is that it has a very broad bandwidth, so any RF signal over a very broad bandwidth will be will see a very high input impedance here. And therefore they will be attenuated they will not be allowed to pass through it. Similarly, here this is a square patch shaped stub with again lambda by 4 transmission line, so here also this square patch it has very low input impedance to not as broadband as the radial stub.

And this is connected here so that any output signal that comes here will not pass through this quarter wavelength because it sees m very high input impedance here. Another hand, the DC voltage that will have no impediment because that is simply DC and these are metal lines so any DC voltage that is spread either here or here will be transmitted to the emitter and collector respectively.

So this way we have implemented the bias network with... so that both the RF and the DC voltages are combined and when the signal reaches the emitter or the collector. Now the previous example was an example of what we called as passive bias network. In some cases we need what we called active bias circuit so what is an active bias circuit?

An active bias circuit is circuit which produces a particular bias voltage irrespective of any changes in the circuit or temperature or other voltage variation, so this this is you know an active biasing network.

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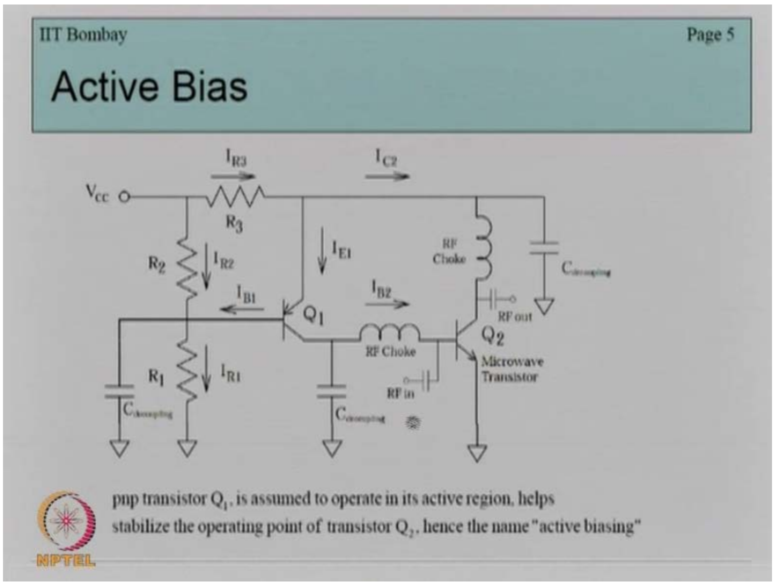


First let us see the qualitative qualitatively how does this circuit works.

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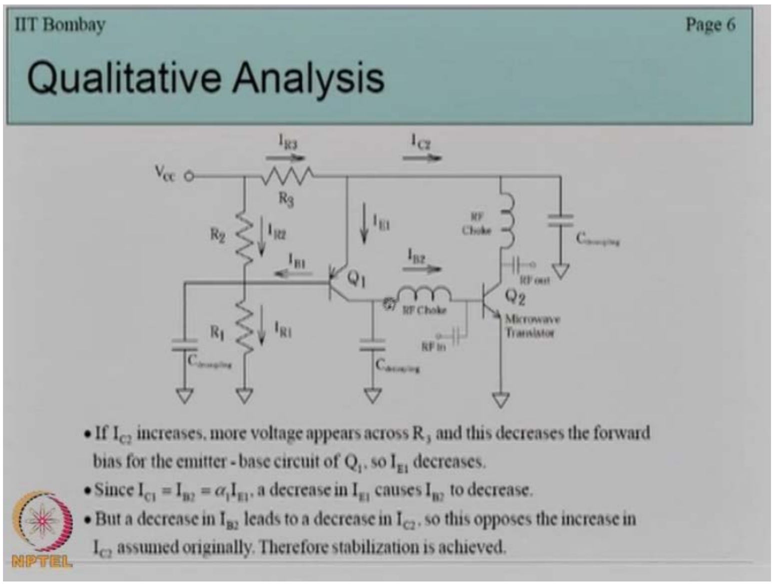


If supposed this I C 2, for some reasons say the I C 2 changes and increases, this I C 2 directly goes in to the collector current collector emitter current of this.

Pardon the emitter current of this transistor Q 2 if I C 2, increases then the voltage across R3 will increase. If the voltage across R3 increases, then the voltage drop across emitter here across the emitter collector terminal for this transistor Q 1 will reduce. If the voltage  if the if this current through the emitter and collector reduces for Q 1, then this current... note that this Q 1 output current from the collector terminal it feeds the base of Q 2.

And because now this it current is less, the total current going into the base of Q 2 will also be less and so since the base current is low, automatically the collector and emitter current of Q 2 will also reduce. So I C 2 will also be reduced, so it is like a self compensating circuit.

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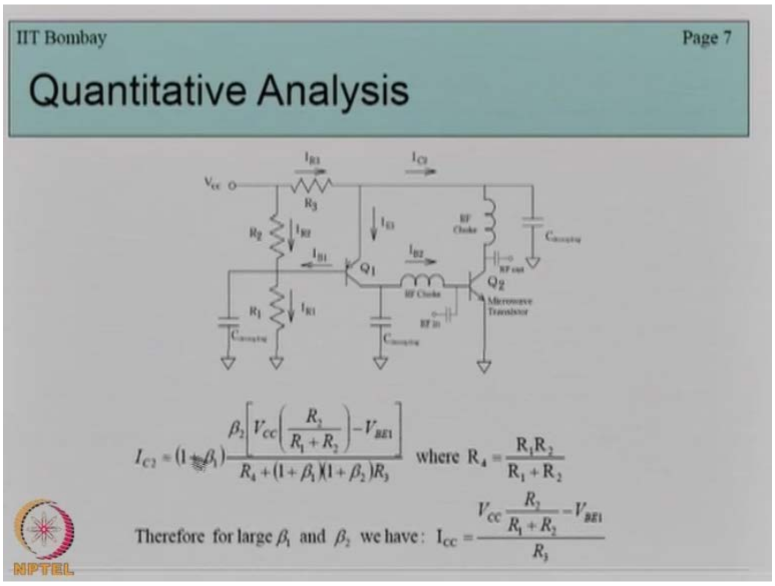


Now the collect now quantitatively if we analyse the circuit then the value of I C 2 that we get is this. Beta 1 and beta 2 are the current gains of transistor 1… transistor Q 1 and Q 2 respectively.

Now from this formula what we see is that for large is beta 1 and beta 2 that is the current gains of Q 1 and Q 2 are quite large, and then this I C 2 will reduce to this value which is independent, which is a constant value. So by this feedback mechanism we have we ensure that the total collector current flowing into Q 2 is constant Thank you.