Analog Circuits
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Module - 02
Lecture – 12

We now have some form of an amplifier using a MOS transistor, which sets up the correct operating point as we want and also sets up the correct small signal incremental equivalent circuit that is with the signal source connected to gate and source and the load resistance appearing across drain and source. The circuit we came up with was, the signal source here in series with the source to setup the operating point voltage between gate and source. In our numerical example, it was three volts. And this appears across the gate and source of the MOS transistor. And on the drain side, we have the load resistance in series with the drain and we have to have a bias voltage which is V D S zero plus the operating point current times R L. This set up the operating point of V D S zero between the drain and source of the MOS transistor, and a dc voltage drop of I D zero R L across the R L.

And in our numerical example, V G S zero was three volts, and V D S zero was three volts which gave an I D zero - the operating point current of two hundred microamperes. So, the operating point conditions are known. And we, in fact came up with this operating point to get g m of two hundred micro Siemens, which was in turn to get a gain of twenty. For this, the voltage source in the drain side must be twenty three volts. Now we know that the operating point picture of this in which we simply set V S to zero will be, we have three volts, R S of hundred kilo ohms, and twenty three volts, R L of hundred kilo ohms. Even if I just gave you the circuit, you did not know that it was connected to this. You could evaluate the operating point and see that the operating point current here is two hundred microamperes.

In fact, I would encourage you to try this out, just think of this is a new circuit, which you are seeing for the first time and evaluate the operating point. Now, remember one thing about MOS transistors, it could be in triode region or saturation region or cut off, so you have to try to all of them. Now of course, this is not something new, in case of diodes also, the diode could be on or off. So, when you are analyzing the operating point of a circuit with diodes, you have to assume that each diode was either in saturation or linear; and work out the calculations and see which is consistent. Exactly the same thing happens here, so you can try assuming that this is in triode, calculating the operating point; and assuming that this is in saturation, calculating the operating points, and see which is inconsistent. And you can also try what happens if it is in cut off. So, that will also obviously come out to be inconsistent.

Then the incremental picture of this, which is with only the incremental source being non-zero; these sources which are fixed will be zero. I will show R L like this, but it is exactly the same as what did we have here. Now this works, it gives a gain of minus 20 that is the incremental voltage across R L will be minus twenty times the incremental voltage V S, and it has the right operating point and so on. But there are some other problems with this. So, let us go through them.

First of all the input source is represented like this. Now, this is just the representation of the input source. It does not mean that the input sources are actually a voltage source with a resistance, and you can connect its two terminals anywhere you want. Very frequently what happens is that one of the terminals of this, this terminal has to be connected to ground. And ground here means whatever is the common reference node of the circuit. And why does this happen, because one easy example is to consider where this source is really the output of another amplifier. An amplifier is usually represented by a triangle like this with an input between this point and the common point which is ground and an output, which is also between this point and a common point which is ground.

This is very frequently encountered case, because I mean you connect amplifiers together, so your input source is really another amplifier. This representation is still valid, it will be represented by V S in series with R S. The only problem is that it is not a floating voltage source, that is these two terminals cannot be independently connected somewhere. This terminal has to be ground; whereas in our case, this is not. Similarly, the load R L this is also just a representation of whatever comes after this amplifier that is the load. It does not have to be a physical resistor whose two terminals can be connected to anything. So, the obvious example is it could be the input of the amplifier. So, this could be the load; I mean between these two terminals, you will see a resistance of R L, but clearly this is not a resistance whose two terminals can be connected to any two nodes in the circuit, because this node is already the common reference node of the circuit.

So, the same example holds the input of an amplifier could represent the R L; and the output of an amplifier could represent the input source V S R S. Either of this can be connected in the configuration that I have shown; R L cannot be connected in series with this voltage, this cannot be connected in series with that and so on. And the additional problem is that we have two dc sources 23 volts and 3 volts. This is just to setup the operating point. This is also cumbersome; I mean you are familiar with gadgets; you know that there is a single source or a battery I mean if for a single amplifier, we need two dc sources. Imagine when you have hundreds of amplifiers, you cannot connect that two hundred batteries for hundred amplifiers. You have to obtain all these dc voltages from a single source. And for convenience you can make that the highest source that is we can say that we have a single source of 23 volts available, and it is up to you to generate 3 volts from the 23 volts and do what do you want with that.

The two problems are that the source and load are not ground referenced. That means that in reality the load resistance R L must have one of its terminal connected to ground, and the source voltage has to have one of its terminal connected to ground. And in our topology, this is not the case. And secondly, it is also needs a multiple dc bias sources, and this is again highly undesirable. You would like to have a single supply voltage source from which you derive all of the dc bias values that you want. So, we will see how to solve these problems in following lessons.