Analog Circuits
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Module - 05
Lecture – 01

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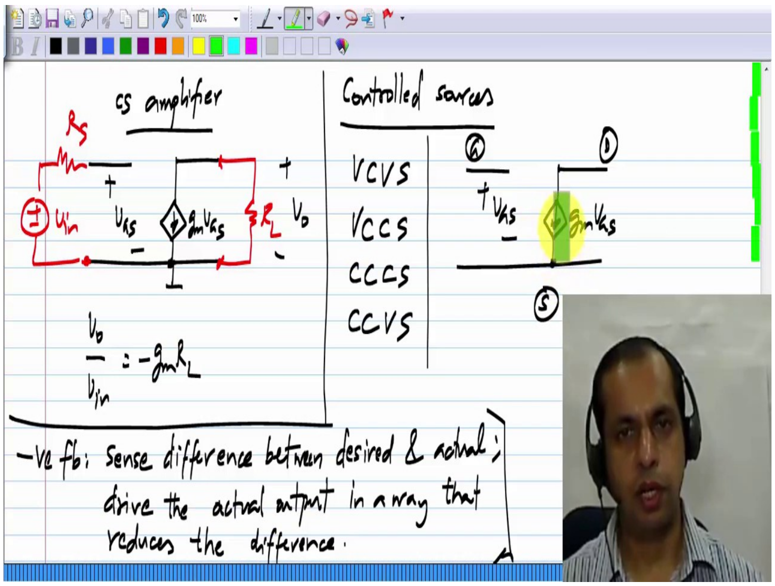

We have discussed the common source amplifier and many different ways of biasing it. The common source amplifier is a native use of the MOS transistor that is the incremental picture of a MOS transistor is this; omitting the output conductance g_{ds}; it is by itself a voltage controlled current source. In a common source amplifier, what we do is simply connect a source to one side – signal source and load to the other side. And of course, there can be extra components, because of the way we choose to bias the transistor, but this is the basic common source amplifier. And this gives a gain which is $-g_mR_L$, this is the output voltage.

Now, there are many occasions when you need a different type of functionality, that is this gives you a certain gain, but the gain is dependent on the load resistance, and it of course dependent on the g m of the transistor and so on. So, you may want the voltage gain that is independent of the load resistance, so regardless of what load you connect, you will get the same gain so that is one possibility or you may want a voltage controlled current source just like the MOS transistor but it should not depend on g_m. Like I said before these characteristics of semiconductor devices like g_m and so on that trans conductance and other parameters depends strongly on temperature and they also vary quite lot from device to device. So, it is useful to have something where you could still have a voltage controlled current source like the MOS transistor, but it is characteristics do not depend on the trans conductance which makes it more accurate.

So in short, we would like to realize other types of controlled sources. And the four types of controlled sources are voltage controlled voltage source, voltage controlled current source, current controlled current source and a current controlled voltage source. So, all these can be realized using a MOS transistor, although the MOS by itself looks like a voltage controlled current source whose trans conductance depends on its operating point. So, we will realize all these things. And in order to realize any of these things, we have to use the concept of negative feedback. Now, we already familiar with it, because we use negative feedback to bias the transistor at given current instead of at a constant gate source voltage. We will use the same principle to realize these controlled sources.

Now, before we go into the details of implementation in a MOS transistor, we have three terminals, gate, drain and source. And there is a controlled source between drain and source; and the value of the controlled source depends on the gate source voltage v_{gs}. When we use negative feedback, what we have to do is let say we have to sense the difference between certain quantities, and drive the output in a way such that the difference is reduced. Negative feedback means that you sense the difference between some quantities, I will say desired and actual, and you drive the output, that is the actual output, in a way that reduces the difference, so that is negative feedback that is you drive the output in a way that reduces the difference between the desired and actual output.

When we use a MOS transistor to do this, we have to drive let say current into some load or increase or decrease the voltage at some node that is we have to either increase or decrease the current going into some branch or increase or decrease the node voltage. How do we do that the MOS transistor by itself is the current source that is the controlled current source. We can still control voltages with it.

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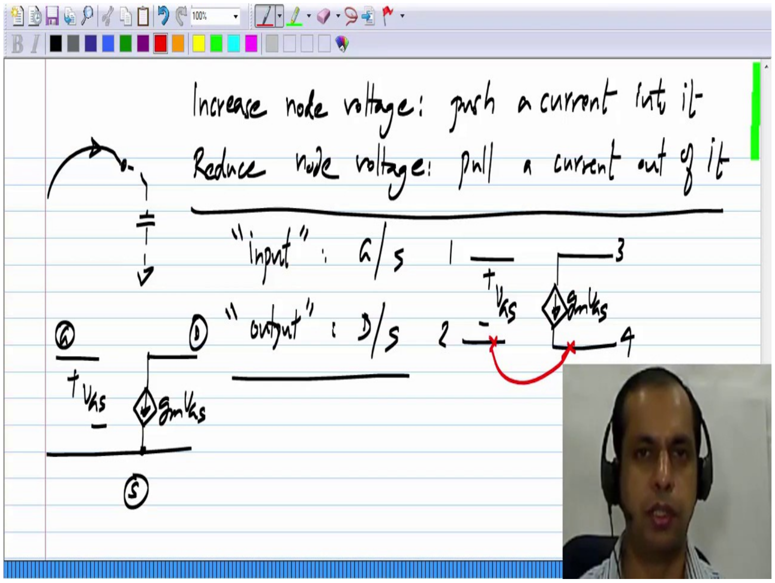

So, if you want to increase the node voltage, you have to push a current into it. This we have seen earlier, you can always imagine a parasitic capacitance and the current flowing into that parasitic capacitance and eventually the voltage will rise. And similarly, if you have to reduce the node voltage, you pull a current out of it. And of course, if you want to change the current in branch, you simply drive the current from the controlled current source through that branch. So, we can either control voltage or current while we still have a controlled current source, it is possible. And also we have to sense the difference between certain quantities. What is the MOS transistor sense the difference between, it senses the gate source voltage. This we have talked about earlier, it is unilateral device. If you want to change the value of the current source, you have to change the gate source voltage that is the only way to do it.

So, somehow whatever it is that you want to sense it has to be translated into gate source voltage in the appropriate direction. So when gate source voltage changes, these current changes that is the only way to change it. When you sense the difference between desired and actual value somehow that has to be converted into a corresponding v_{gs} so, that the drain current is changed. So you have to apply feedback controlled to the gate source part of it, and you will get the output from the drain source. So I hope that part is clear.

Also you can see that in a MOS transistor the cause is applied between gate and source and the effect appears from drain to source. So, the input can go to either gate or source, and the output can come from either drain or source. We will see examples of both and of course, drain can only be an output; you cannot apply something to the drain and expect something to happen. And gate is only an input, you cannot expect anything out of the gate, no signal comes out of it. The source can be either. So the source is part of both the controlling side and the control side and it can be either input or output. And again we will say examples of both of them.

Now, because of the way the MOS transistor is, there are some restrictions, what I mean by that is, let say we had some hypothetical device with four terminals and the controlling and control sides were completely separate. So, let us say this happened to be v_{gs}, and this was $g_m v_{gs}$. I will just call this terminal one, two, three and four. In this, it is very clear that one and two belong only to the input, and three and four only to the output. And this picture also is very symmetrical. Whereas, the actual MOS transistor we have, it does not look like this. These two are together, there is a common terminal, so that also introduced some constraint into some of the circuit that we will realize, and I will point them out as we go along. So, our goal in the next several lessons would be to realize controlled sources using a MOS transistor and we will use negative feedback in order to do that.