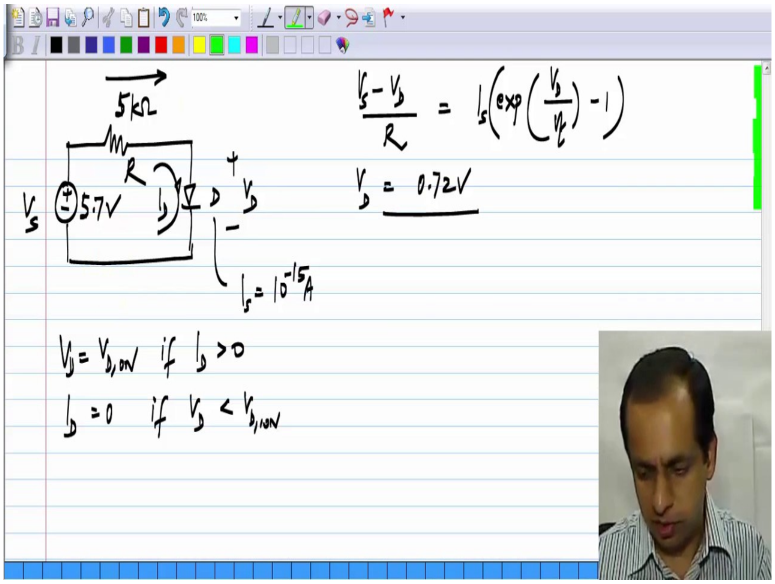
Analog Circuits
Prof. Nagendra Krishnapura
Department of Electrical Engineering
Indian Institute of Technology, Madras

Module - 01
Lecture – 10

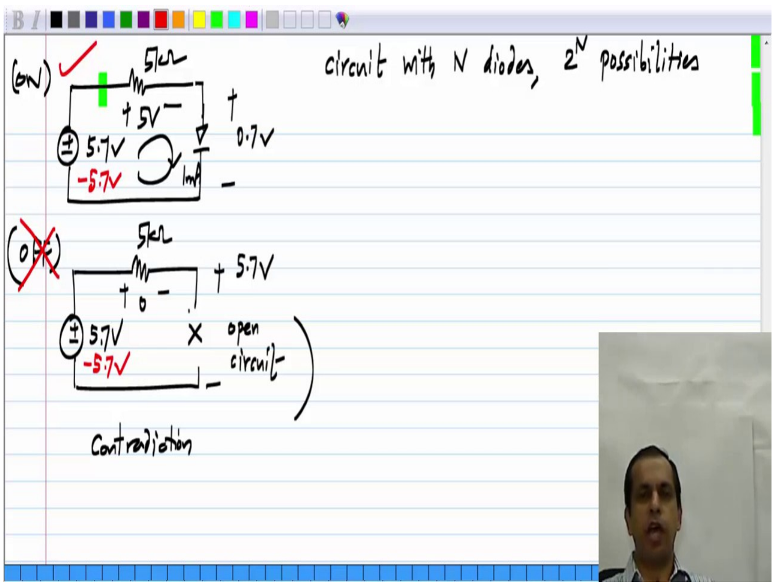
(Refer Slide Time: 00:17)



Now we will look at a couple of examples of circuit analysis when the circuit has Diodes. Of course, I will take a very simple circuit, but the principles are the same for more complicated circuits. Let us take this circuit, I have a 5.7 V voltage source, let me call that V_S. I will call this resistor – R, which I will say 5 KΩ, and there is a Diode-D with a voltage V_D across it. And I will say that this Diode has a saturation current of 10^{-15} A. Now first of all, we can write down the nonlinear equation, which is to equate the current in the resistor; $(V_S - V_D)/R$ to be equal to the current in the Diode in terms of its voltage which is $I_S \left(e^{\frac{Vd}{Vt}} - 1\right)$. And if you solve this equation using Newton-Raphson iteration or any other technique, you will find that V_D is 0.72 V or so, and you can also find the current here I_D by substituting that into$(V_S - V_D)/R$, R into the right hand side of this. Of course, our interest is not in numerically solving this nonlinear equation, but to use suitable approximations.

Now, the approximation we said we will use or we can use is that if there is a substantial forward current then this V_D will be fixed to some value, which is V_D ON. Of course, $V_D = V_D$ ON, if I_D is greater than zero; and I_D equals zero, if V_D is smaller than V_D ON. Now, because the characteristic is given as this conditional, there are two possibilities. You have to evaluate both, and this is the general principle, so any Diode in the circuit can be in ON state or the OFF state. You have to assume the two cases; you have to check the two cases and see which one leads to contradiction, obviously that is the wrong one, the other one is the correct one and for this circuit, it is very easy.

(Refer Slide Time: 02:59)



But I will just still show you to illustrate the principle. First, I will assume an ON Diode, this is where I assumed the Diode to be ON, so which means that the Diode voltage is 0.7 V. And if you make the other assumption that the Diode is OFF, in that case the current through the Diode is zero, and I can replace the Diode with an open circuit. And let me evaluate the two cases; first of all, if I assume the Diode to be ON then I have 0.7 V across this, and 5.7 V here, so the voltage across this resistor is 5 V. So the current in this is 1 mA. And clearly in this case, there is no contradiction, because the Diode voltage is 0.7 V, if there is a forward current flowing and with that assumption we calculated this and found that the forward current is 1 mA. So what we calculate is consistent that.

But let see if we had started off from the other assumption that the Diode is OFF then the Diode is OFF this is an open circuit, no current is flowing through this. So the voltage across this is zero and the voltage between these two terminals which is the voltage across the Diode will be 5.7 V. Now we know from the Diode characteristic that the Diode voltage cannot be more than 0.7 V, I am referring to the approximated characteristic. So there is a horizontal line up to 0.7 V and a vertical line after that so we can easily see that 5.7 V is not part of the Diode characteristic at all. So this tells you that there is a contradiction, so this is the incorrect assumption, and this is the correct one.

And you can just go through the same exercise by making this -5.7 volt instead 5.7, and see where you are arrive at a contradiction. Now this circuit is extremely simple. The point of doing this exercise is to go through all logical steps and make sure that you understand every step. Now when you have multiple Diodes, if you have a circuit with n Diodes then there are 2^n possibilities, that is every Diode can be ON or OFF, and if you take all those combinations there will be 2^n possibilities. And in principle, you have to check for all of these that is if you have 5 Diodes in a circuit, you have to check for 32 possibilities. But of course, frequently you can very quickly dismiss some of the possibilities, you will able to very easily see the contradiction without having to analyze them in detail. In this circuit with even a very little bit of experience circuit analysis, you should be able to see that current can only go in this direction and the Diode has to be ON. So although in principle there are there are many possibilities to check, in practice you have to check only a few of them.

But the point is to understand the systematic method, so that if you if you have to do it, you have to be able to go through all the possibilities systematically, you have to consider all the possibilities systematically and eliminate all the wrong ones.