Analog Circuits
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Module - 02
Lecture – 03

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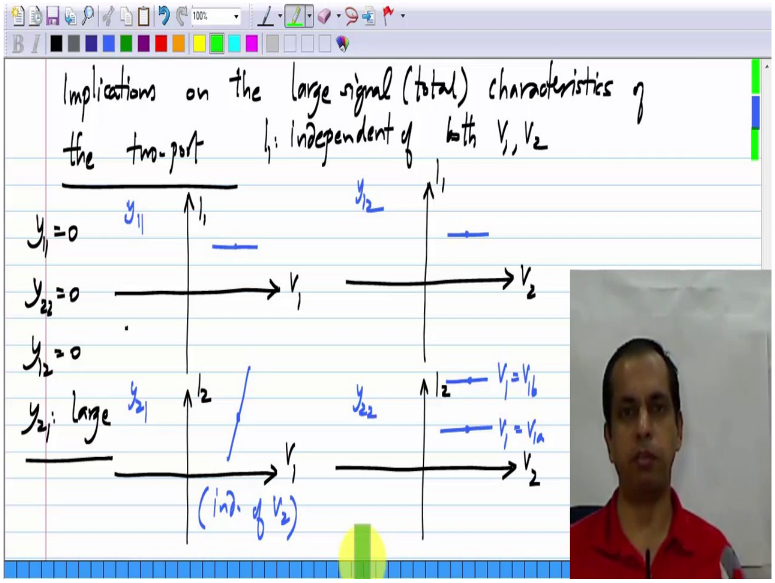

Now let us see what the implications are on the large signal that is total characteristics of the two-port. What do we have now, we have y_{11} equal zero, y_{22} equal zero, y_{12} equal zero and y_{21} should as large as possible. Now the large signal characteristic can be described by these four graphs, where one of the variable is on the x axis and the other variable is fixed or it's varied as parameter. Now, these small signals parameters are the slopes of these characteristics. For instance, the slope of I_1 versus V_1 is y_{11}; slope of I_1 versus V_2 is y_{12}; slope of I_2 versus V_1 is y_{21}, and slope of I_2 versus V_2 is y_{22}.

Now what does it mean to have y_{11} equals zero, by the way these are only around some operating point. You have to choose the operating point correctly, because the total characteristic of the nonlinear ah device can be anything, it is around some operating point that we need to have these constraints. So what does it mean to have y_{11} equal to zero, it means that these characteristics I_1 versus V_1 are flat around some operating point. So let say this is the operating point here, then that means that the slope of I_1 versus V_1 is zero. And similarly because y_{12} is zero, slope of I_1

versus V_2 is also zero. Now V_1 and V_2 are the only variables, so what does it mean here around some operating point y_{11} is zero that is the variation of I 1 with V 1 is negligible, it is zero. The variation of I_1 versus V_2 is also zero, because y_{12} is zero, so this means that this current I_1 is constant that is it is independent of V_1 and V_2 around some operating points, so that's what it is implied by these two small signal parameters.

Again it has to be remembered that this needs to be true only around at certain operating point, it does not have to be true everywhere. If it is true around at certain operating point, we have to choose that operating point. And similarly y_{21} is very large, so what does it mean the variation of I_2 versus V_1, the slope of I_2 versus V_1 has to be very large around some operating point. It has to be as steep as possible. And y_{22} is also zero, so that means that I_2 versus V_2 that has a characteristic like that around the operating point. So what it says is that I_2 versus V_1 has to be very steep, whereas I_2 versus V_2 has to be very shallow that is I_2 should not dependent on V_2 at all around some operating point.

I also said that basically these graphs are ah drawn for instance I_2 versus V_1 is drawn with V_2 as a parameter ,because I_2 does not change with V_2, so essentially this characteristic I_2 versus V_1 should be independent of V 2.Because clearly around this operating point we know that I_2 is not changing with V_2. On the other hand, for this graph I_2 versus V_2, V_1 is the parameter; and we know that I_2 changes very sharply with V_1, in order to have a very large y_{21}.So if you draw a parametric plot here, so for a particular value of V_1, you will have this. For another value of V_1, we will have a very different current, but it will still be flat that is it is independent of V_2. So if V_1 is V_1, the current will be different but the variation of I_2 versus V_2 will be flat, that is this slope will be zero.

So what we have done is to evaluate the constraints on small signal parameters, and from that infer what the large signal parameters have to be. And these are good characteristic of amplifiers, regardless of what device you build. For instance, if you are trying to invent a new device, you have to invent a device which follows these things in order to maximize the gain. Of course, instead of choosing y parameters, you can choose some other parameters and try to maximize the gain according to that parameters, but the qualitative characteristic will be the same; meaning these characteristic these parameters 11, 12, and 22 will be nearly zero, and the characteristic two one will be very sharply varying. So all it means is that the second port must respond strongly to the first port and all other responses must be very small. I hope this part is clear, you will actually see later that the real devices that we have like the MOS transistor or the bipolar transistor do conform to this in their idealized form, so that is why we choose to go like this, but it also gives you sort of generalization, you do not have to stick to bipolar transistors or MOS transistors, any other device comes along just by looking at the characteristic, you should be able to say if it will make a good amplifier device or not.