Analog Circuits
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Module – 02
Lecture – 17

This is the small signal equivalent of the common source amplifier. It has these two capacitor C 1 and C 2. Earlier we did all our analysis assuming that C 1 and C two are large, if there is infinitely large they do behave like short circuits. Now, we will see exactly how large they have to be. In order to analyze the circuit which has capacitors and inductors we need to do sinusoidal steady state analysis. We will assume that the input V s is the sinusoid at a frequency omega, some omega. And we know that while doing sinusoidal analysis, we represent all voltages and currents by phasor that is what I do here. This is the phasor correspond to the input voltage.

And we have R s, C 1 will be an impedance one by j omega C 1. And this voltage here V G S again I will represent as a phasor that is V G S; and the output voltage here is V o. And we will also need this voltage later, and I will call that V D, so that is the incremental drain voltage phasor or the voltage between drain and source. Now, I will assume that you are all familiar with sinusoidal steady state analysis, if not please go back to basic electrical circuits and brush up your basics. Now, this current source of course, is g m times V G S, which is the phasor. Now V s gets divided between these impedances and R 1 parallel R 2 to give you V G S; and V G S gives you V naught.

So, I will evaluate these two expressions separately. Essentially V G S by V s and V o by V G S; and I could combine the whole thing to give me V o by V s. If I multiply the two, I will get V o by V s, I do not want to write lengthy expressions so that is why I stick to this.

So, if you do the analysis correctly, you will see that V G S by V s, basically the fraction of V s that appears as V G S, this is equal to R 1 parallel R 2 divided by R 1 parallel R 2 plus R s plus one by j omega C 1, which can be written as j omega C 1 R 1 parallel R 2 divided by 1 plus j omega C 1 R 1 parallel R 2 plus R s. Now what do we mean by C 1 is very large, basically it should behave like a short circuit. We know that if it did behave like a short circuit, V G S by V s will simply be the ratio of these resistors R 1 parallel R 2 divided by R 1 parallel R 2 plus R s.

And here we can very easily see that if this part here, if omega C 1 times R 1 parallel R 2 plus R s is much more than one then we can simply neglect this one in the denominator, and this j omega C 1 will cancel out and this expression will reduce to, this, R 1 parallel R 2 divided by R 1 parallel R 2 plus R s, which is the resistive divider expression. So, this is the criterion for choosing the capacitor or C 1 must be much greater than one by omega R 1 parallel R 2 plus R s and so on. Or in other words, if I write in terms of the reactance of the capacitor, I will have the reactance of the capacitor one by omega C 1 much smaller than R 1 parallel R 2 plus R s. This is the criterion for C 1.

And what does it mean in terms of the circuit, if I reduce this V s to zero, that is when the input to the circuit is nulled, this is the circuit we have. And you simply see that R s plus R 2 parallel R 1, which you see in this expression, is the resistance that appears across C 1. Now, again if you recall basic electrical circuits, the way you evaluate time constants in a first order system is by looking at the resistance that appears across a capacitor so that is exactly what we are doing here. Now, one more point I have to quickly mention is that this is the second order system, but there are two separate first order systems which are decoupled, so it is correct to treat this as two separate first order systems. So, this is the first order system.

And all you have to do is to find out the resistance that appears across the capacitor and make sure that the capacitive reactance is much smaller than that resistance. Or in other words, another way of saying that is to make sure that the time constant is much more than the reciprocal of the frequency. And when I say frequency here, this omega is in radians per second, so please keep that in mind. So, all these criteria mean the same thing. So, you should be to relate this to what we learnt in basic electrical circuits, so that is how you choose C 1, you just have to make sure that the reactance of the capacitor C 1 is much smaller than R s plus R 1 parallel R 2. Then it behaves like a short circuit that is what we mean by a large enough capacitor.

In practice, what is done is we have inequality that is C 1 much greater than one by omega times R 1 parallel R 2 plus R s. So, what is the actual value that you choose for C 1. So, let us say you evaluate this expression and this comes out to ten nano farad. Now what should be C 1; if it is one micro farad, it is more than this; if it is one milli farad, it is also much more than this. But of course, you do not go crazy like that typically if you take C 1 to be let say ten times this constraints, ten times 10 nano farad equals 100 nano farad that is good enough, or you can make it a little more, but you do not have to make it like thousand times or something like that.