Network Analysis
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Lecture # 01
Introduction: KVL, KCL and Power Balance

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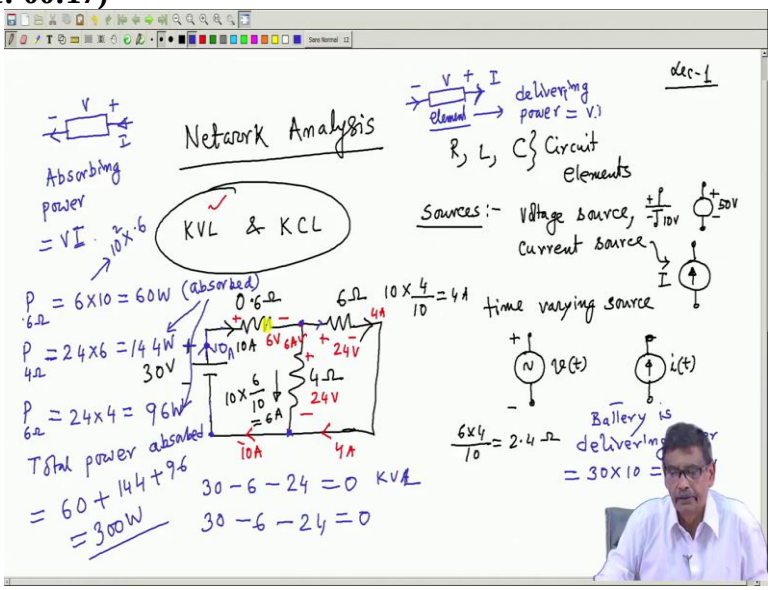

So, we are in the first lecture of this course network analysis and the network analysis is an important course in the sense that though those who are studying electrical or electronics or for that matter in engineering discipline, it is a sort of fundamental course. And there will be about 60 lectures in which I will be covering this course, maybe a bit more and I will start from the rather very initial stage of static analysis review those things which you perhaps already learned in your basic electrical technology course.

But will add some new flavors to those problems that you have already solved. In general network analysis problem is essentially is that there will be a given network a network will consist of several circuit elements like R resistance inductance cell and capacitance C, and there will be a number of sources connected to that network. The problem at hand will be to find out the current scene various branches or power in this arcade things like that.

Therefore, very loosely speaking and network essentially consists of elements like resistance, inductance and capacitance these are circuit elements and there will be sources which will energize the subject and these sources could be a voltage source or a current source or both or current source. So, a circuit will essentially consist of these circuit elements and sources like voltage source and current source.

They a volt source is usually denoted by if it is this it will be denoted by battery like this or if it is a large DC voltage it will be noted by polarities mentioned like this, this is our DC voltage are mentioned. Similarly current source will be mentioned like a circle within an arrow and besides it the magnitude of the current these are the 2 terminals of the current source, these are the 2 terminals of the voltage source like that.

And similarly here the voltage source could be a 10 volt battery or say 50 volt DC source sources could be also time dependent it may change with as time passes, so, in that case it is safe to be a time varying voltage. In case of DC sources of course, with time the magnitude of the voltage or magnitude of the current source will not change, but still we can have a time varying sources like this time varying sources can be for example, a semisolid varying time varying voltage source could be represented by this semisolid symbol

And it will be indicated like this Vt similarly, you can have a time varying current source exciting circuit and circuit consists of R, L, C. So, this in general, we would expect these are the various components to be present in a circuit. And if the sources are known, if the parameters of these circuit elements are known, then I should be in a position to find out the currents. The essential team to solve any circuit problem centers around 2 laws.

One is called KVL laws, cut jobs voltage laws and KCL laws.. And this is at the center stage to solve any circuit problem. KVL law says that in any circuit the sum of the voltages will add up to 0. Similarly KCL means ketchups current laws, which states that some of the current at a particular junction of a given circuit will add up to 0 will come in detail what do I mean by this, but, this KVL and KCL if you know and you if you do not know anything.

No new circuit theorems, interesting circuit properties. Suppose I do not, I now all the KVL and KCL what I am trying to tell is that, with this knowledge KVL and KCL any circuit can be solved maybe it will become lengthy it is not a very efficient method but none the less these are the two laws which is used to solve any circuit problem. To give you an example, what I am trying to tell is that suppose you have a simple circuit like this DC circuit surface.

A simple circuit like that, suppose, the voltage is this one and this is supposed 6 ohm this is supposed 4 ohm and it has also got some simple circuit with that I will try to explain what do I mean by this. So, the equivalent resistance 6 ohm and 4 ohm they are in parallel it will be 6 into 4 by 10 that is 2.4 ohm and this is supposed this resistance is supposed .6 ohm and here is 30 volt resources. So, I have been asked to find out the currents.

Now, in this circuit it is 2.4 + 0.6 that is 3 ohm so, and then this current will be 10 ohm these will know from school days. That is these varying in parallel, then this is in 3. So, 2.4 + 0.6 is 3 ohm. So, this current will be 10 ampere and then this current will be these 2 are in parallel. So, the total current into 4 divided by some of these 2 resistance 10 is not total current. If you want to find out this current.

Then that other resistance divided by some of these 2. So, this will become equal to 4 ampere. Similarly, this current will be the total current into the other resistance 6 divided by 10 that is to be 6 ampere is not if I solve this circuit from the knowledge of series parallel resistance and so on. Therefore, after we have solved this circuit, I know the currents in all the blanks and all the parameter values are known of course.

Here are considered only resistance it does not matter we will see later. Now, the question is what is the voltage drop across this, 0.6 ohm resistance i into R, L, C voltage drop. So, I will write down the voltage drop as this is plus this is minus because current is flowing from left to right and the magnitude of this voltage will be 0.6 into 10 that is 6 volt is not this will be resist. Similarly, voltage drop across this resistance will be 4 into 6 that is + -. This + - is put knowing the direction of the current here and this will be 24 volt.

Similarly, the voltage drop in this brand will be 4 ohm and 6 ampere is flowing, this is also 24 volt this will be the secret. So, I have solved the circuit. Now, first of all cut off current law, let me see whether it is satisfied. This is 10 ampere coming and 6 ampere is flowing here and 4 ampere is flowing there. So, this is 4 ampere and this is 6 ampere so, cut off current law is satisfied at this junction.

Similarly, at this junction it is 4 ampere there, this is 6 ampere their so 6 + 4, 10 ampere there. So, it can be found out in a very simple manner. So, KCL with the help of this simple example we know what does it mean that is whatever total current coming in that must be equal to the sum of the currents leaving the junction. Now, what about KVL says that considered any closed path in the network and the sum of the voltages, if you add up that will sum up to 0.

For example, considered this look this closed path. Now, after identifying the closed path, what I will do is this I decide to start my journey from this point and I will traverse this closed path. In this direction does not matter suppose, I decide I will go this way. So, from these 2 these, if you go there is a 30 volt voltage value so, I suppose as decide to assign a plus sign to this.

So, I reached from this point to this point, then I will go from this point to this point in this part there is no voltage drop, no voltage exists. So, only 30 volt we have encountered then from this to this if you go there is a 6 volt appearing across this .6 ohm resistance and this 6 voltage from + to -. So, I will put a -6 here is it not? So, -2+ have assigned + then +2- have assigned -6 then I will I bring this point here there was no drops.

So, from this to this if you come, it will be once again from + to -, so, - and this was voltage drop is 24. Now, if you sum it up it is equal to 0. So, this is KVL in this closed loop similarly, in this loop it is so simple you from start from this point from these 2 these if you go - to + is +24 volt, then + to – is -24 volt and that is 0 and you reach this point. So, after you sum up this voltage from this to this we have to come back to the same point that is essential.

So, here there is no voltage drop. That is right no other terms existed here. It is also true for this loop also supposed to be closed part is chosen here. This bigger outer loop any closed path KVL

law says that all brick some of the voltage is appearing across the source waves or circuit elements must add up to 0. So, suppose in this outer loop, if you start from this to this point, it is 30 volt, then from this to this + to - is -6 volt, then I have decided I will not go this way, but this way, then from this to this if you go it is -24.

So, you have resist point and you have decided to come back here forming the closed part and that also amongst regent. So, this is KVL therefore, this is a nutshell KVL and KCL is all about that is, however complex the circuit is it will consists of several closed paths and the voltage drop across all the elements including the sources, if you add up that will add up to 0. Similarly, whatever junction you take.

They whatever current is coming in will be equal to whatever current is living out that particular junction and knowing this any circuit can be solved KVL and KCL (FL: 16:35) because I have drawn the circuit. I will also tell you another important things with a reference to this simple circuit which consists of only desistance and a fixed DC voltage, we have explained KVL KCL.

Another thing I will explain that is these are circuit elements sources can be also considered to be circuit elements, but capable of delivering power into the circuit. So, this is 1 element source element these are elements fine. Now, in this circuit, let us do some power balancing. What does it mean? Remember any circuit elements therefore, we have learned that any general circuit elements it may be desistance inductance or capacitance.

Let me put it in a box and suppose, you calculate the voltage drop existing across that particular element if you find a situation exists like this voltage drop polarities like this and it is its current direction is like that then I will say that this particular element is delivering power that is what happens in a battery in general. So, this box could be a battery could be any resistance could be inductance capacitance.

We will go into detail for that detail into that but in general if there is an element, if you managed to calculate the voltage existing across that element with the polarity, correct polarity, and you have also managed to solve the current flowing through this particular element, and you

find the current direction is like this, then I will say that this element. This element is delivering power could magnitude is Vi that is what I will tell.

If it so happens that there is a circuit element which could be anything either R, L, C or a back source. If you find that the voltage across the element is like this, this polarity is important and current is entering through the positive terminal of that particular element, then I will say this element is absorbing power and the value of these observing part will be this voltage with this polarity into i that is the thing got the point.

So, in a circuit there will be elements there will be sources connected. Suppose I have solved the circuit for example, with the reference to this simple network, I know all the currents I know all the voltages existing across each elements including sources then I will be able to identify which of these how many elements are there 1, 2, 3 and 4, these are source another than element in the circuit. So, what the battery is doing is it absorbing power or delivering power.

Suppose I want to accept me. So I come to this battery has got these 2 terminals these are the two terminals of the battery and what is the current? Current is flowing like this, how much is the value 10 ampere. So, what the battery is doing? It is delivering power because this is the element voltage across this + - and through the + terminal 10 ampere is coming out. So battery is delivering power and what is the value of this power 30 into 10 voltage into current.

This situation it is delivering power 30 so it is delivering power 300 watt got the point. Now where this power is going, this power whatever the battery is delivering he is absorbed by expected to be absorbed by this 3 resistances. So, let us see power in this point 6 ohm resistance what it is absorbing or delivering power voltage drop across is this is + this is -. This is 6 volt and current is entered in 10 ampere.

Through the + terminal like this and therefore, this must be absorbing power. So, what is the value of this port voltage across the element 6 into 10 is not that is 60 watt which happens to be equal to this is also equal to i square into 0.6, i square are is some as Vi because V=iR so on. So, power absorbed by this point 6 ohm resistance is this power absorbed by the 4 ohms resistance.

So, this is observed mind it observed 4 ohm resistance also absorbs power why because the voltage across it is 24 volt with this is + this is - and 6 ampere is entering through the plus terminal. Therefore, through this 4 ohm resistance power observed these 24 voltage across this into 6 ohm 6 ampere and it will be equal to 144 watts is it This will be the power absorbed by 4 ohm. And what about power 6 ohm this resistance.

Does this 6 ohm delivers or observes power it observes power because voltage across it is this is plus this is minus and current is entering 4 ampere through this therefore, this also absorbs power and the value of that power is this into 4 and this is equal to 96 watt therefore, this also absorbs power and this element also observes power So, total power absorbed will be equal to 60 + 144 + 96. And if you sum this up this is going to be equal to 300 watt so 300 watt.

So, the point to be noted these days in any network, however complex it is with time varying voltage source with RLC all things are present KVL and KCL rule has to prevent, they must be satisfied at all times and also the power balance Must be also true at all times. This is the one of the very fundamental thing I must tell you, no matter how complex these activities whether the sources are time varying.

Whether are RLC are present with sources time varying at any given time T. If you know the instantaneous voltage drop across all the elements and instantaneous value of the currency in all the elements, this power balance must prevail along with the fact that KVL and KCL will be satisfied. So, with this simple example, I have explained to you various important things which will take up in detail in next few lectures that for a given network.

The conclusion of today is lecture is for a given network no matter whether it is only contenting are RLC or whether it is an electronic circuit with transistors of present there will be sources and all the circuit elements if you know and suppose, somehow we have managed to find out currents in all the branches, then, be rest assured that KVL in any closed path is satisfied at all times that is very important. KCL at any junctions will be satisfied.

At all times and power balance must be satisfied that is, there will be some fellows in the circuit primarily the sources which will deliver power into the circuit and that power will be absorbed by different other elements in the circuit will see in the next class also that there will be circuits where it is not true that sources will always deliver power there may be situations, when sources to will observe power. Those things will take up in the next class. Thank you.