Network Analysis
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Lecture # 29
Concept Analysis and Reaction
Power in A.C Circuit - I

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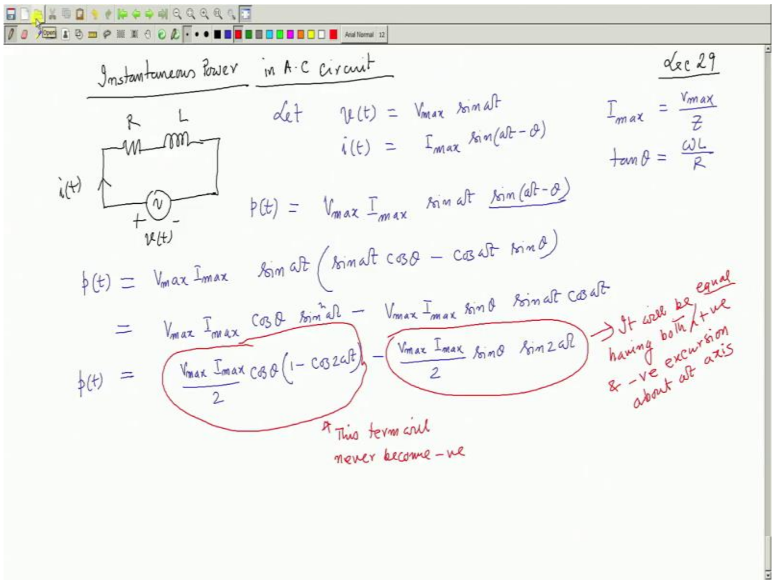

So, welcome to lecture number 29 and we have been discussing about instantaneous power in an A.C circuit it may do A.C means sinusoidal excited circuit.

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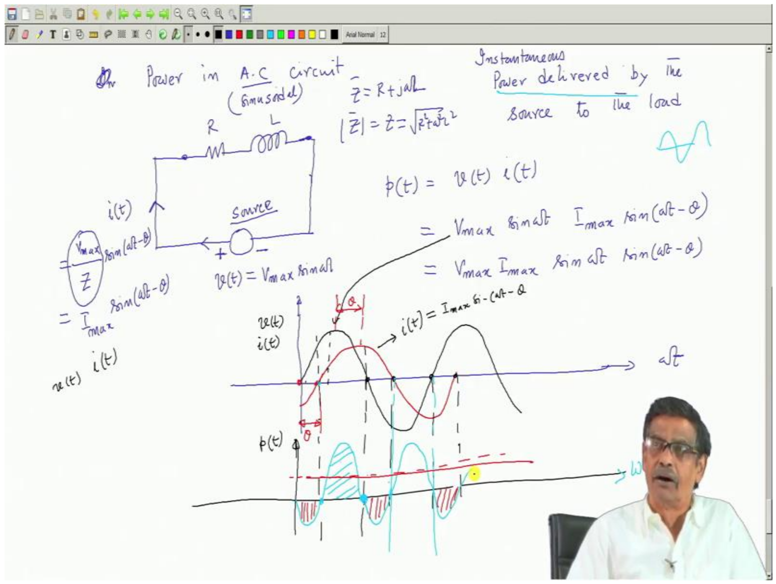

And we have seen that if it is an unreal circuit that is voltage waveform black 1 current will be lagging this, then you divide several intervals following this rule wherever 0 crossing has occurred both for voltage and current, you mark them with bullets drop article lines and say during this period voltage is + current is - So, negative power but I am calculating power delivered by the source because this is how I have assumed this as it looks like it always it delivers power.

So, Vt into it mind you gives you power delivered, but in a scenario like this, I also know this one this product will sometimes you cannot + some things will become -. So, if somebody writes in language power delivered to the load is 50, 51. So, 51 correct, but if somebody calculates as some other in stands that power delivered to the load is - 10 what is indicating - 10 telling that at that time, sources observing power and load is delivering power can load delivered power yes because there is energy storing elements inductance sometimes we will come back power to the supply anyway.

So, we plotted then the instantaneous expression of calculated the instantaneous expression and got this power and we found that there is a positive power average can be found out we can do right now, and we say this circuit observe so much what have power on average. But another way of looking at this one that this is much more, nicer way that is what I want to share with you. So, your thing was like this will play with those equation a little more.

So, this was my circuit. This was the voltage AC voltage, sinusoidal voltage and this was current while solving this current for this current, I have taken help of the phasor. Now I am trying to interpret about the power. So, I have come back to time and trying to indicate the things. So, what did they do? I told you let Vt = V max sin omega t, i t = I max RL circuit sin omega t - theta. What is I max? Did not forget I max is a call to be V max by this Z, is it a phasor? No, it is magnitude without the bar I am writing get his proof over r squared + omega squared L square.

What is theta and theta from this exploration I can calculate theta is standing yet, so, I have solved this circuit I have this results before me, then I calculated the instantaneous power, which if you calculate this I wrote last time V max I max sin omega t - theta, this is the thing I can now you see what I am doing this power instantaneous power Vt will be equal to V max I max it is there and this is sin omega t I will write it like this.

And this sin omega t - theta i can write it as Sin omega t Cos theta - Cos omega t Sin theta mind you this is a fixed angle already changing with time sin theta tan theta is fixed for a given circuit by L/R. So, this is how you right then also this one you break up in this excursion V max I max cos theta faster into sin squared omega t this faster - V max I max sin theta and then sin omega t cos omega t this way can right.

Now, this can be written as V max I max by 2 cos theta. So, by 2 and 1 sin squared omega T 1 sin squared omega t can be written as 1 - cost to omega t is the thing -, this 1 also can be written as V max I max by 1 sin theta and these 1 into sin omega t cos omega t is signed to a magnitude these what have done rejuvenate now, this instantaneous power it is cleverly broken up into 1 components just by simple trigonometric manipulations.

Now, look at the faster very carefully this term. This term if you look at it will remain always positive, it cannot be negative. I will escape and show you and these ones in sin omega t sin t is constant and this term. So, this term will never become negative. This term sin omega t both + - is excursion it will be having both positive and negative excursion about omega axis equal having both equal positive and negative x. Choose any value of omega to you put it will be always positive, or at best it can be 0 but it will never become negative now.

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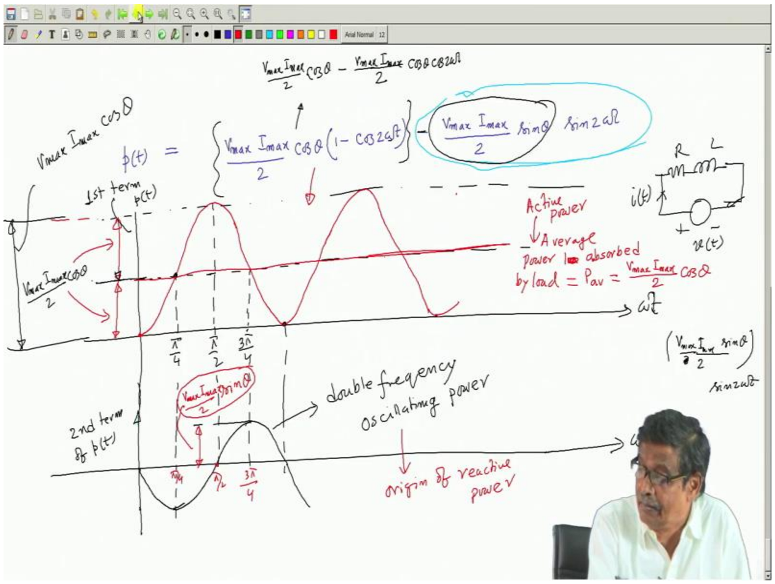

This equation helps us to understand much better copy and I will paste it here. So, this is the thing we have written there and I will lead is this. So, this is the instantaneous expression of the path. Now, this one I would like to sketch this term, I will sketch then this term and it will be easily understood what I am trying to say so, this is support the thing is, now, this term is nothing but V max I max by 2 into cos theta, this bracket I am opening got the point this term only am writing the V max I max by 2 cos theta - V max I max by 2 cos theta cos omega. So, it will be a DC value.

This 1 is constant V max I max by 2 cos theta is constant so I have to add to this component, this is the DC component. Suppose, this level is V max I max by 2 cos theta, this constant, this is a constant number, then to this I have to add a sin to omega t term with a negative peak values. So, it will be just like this the sum of these negative sin value which will then go like this what is at this level this will be also these 0 are equal this will be to V max I max cos theta this whole thing got the point these the only the faster I have sketched.

So this is the first term which has been sketched here, this term I have not sketched, clear and you see this quantity will never ground 0 and come negative. At best it can become 0 at some times. So this term will basically tell you that power absorbed by dissertate always positive then I sketched this time sketched including this negative this term had sketched how we do look like it is simple signed to omega t.

So, once again I sketched it here mind you I am skating against omega t always whenever, whatever you are sketched show the axis very clearly. So, this is omega t you can identify the value of this omega t how much is the value of this omega t there it has to be phi by 4 at phi by 4 if you put it is phi by is 0 and at this point the value is the V max I max cos theta only. This 1 if you put phi by 4 in this expression cos phi by 0 cos phi by 2 is 0 and you will be left with V max I max cos theta by 2 and this 1 will be how much cost phi by 2 this should be why, because at phi by 2 this is cos phi - 1 - + 2 to cancel out and this whole length is the V max I max cos theta.

Because these are this so, this whole team whole thing is V max I Max cos theta that it is doing then once again from symmetry it we can easily so, pi by 2 + pi by 4 it will be ordered 3 pi by 2 and so on and it will be 0. Here you can find now, I have to scale this 1 this is z, it has got a peak value and signed to omega t so, it will have a both + and - excursion. So, I will also stage that the second term and its value is V max I max by 2 sin theta.

Now, the question is, if it is possible for at this point, it will have peak value is not so, I am now skating this term V max I max by 2 into sin theta is the peak value of that sin wave into sin omega t descent skating. So, at omega equal to pi by 4 for if you put sin pi by 2, so, it will it must have that big value occurring at pi by 4. So, it is a sin term with this big value but anyway I have to add to this app to once again subtract.

So, - of that will be like this. So, it has to start from 0 and it will reach maximum here to magnetically. So, it will be late this then at pi by 2 then if you put pi by 2 sin phi is 0. So, it must 0 here and then once again it will reach maximum and once again it will reach you and go to negative, but this is a sin to omega t term it will have both positive and negative excursion. So, second term of pt and this is this 1 is first term of the pT that is what pt therefore instantaneous absorbed by the RL circuit.

We are now going much deeper into it and trying to understand what is happening here. So, this is your vt, this is your i t and this first term that is this term, I understand that , it always delivers power to the circuit because this raid 1 is always positive, sometimes it is becoming 0, but never coming negative. And this 1 is the power which is oscillating between source and the load. So, a double frequency oscillating power, got the point.

And what is the peak value of this 1 is V max I Max by 2 V max I max by 2 that all and it is omega t on skating. So, this is pi by 4, this is pi by 2 and so on 3 by 4. Therefore, it is this power which is which is flowing to and flow between the source and these load sometimes parties absorbed by these because inductances there are some things parties returned back to the source but this is the average power.

Which load is absorbing these the average power this all against time this much power is absorbed by the source, but on an average the load is absorbing average power absorbed by load is this this line and what is that value I will write it as p average is equal to V max into I max by 2 sin theta. And this turn, which represents the power oscillating between source and load has a peak value whose value is V max I max by 2 inches into sin theta a forgot another term sin theta this is big value. It will be this.

Now, therefore, we say that power which you will be oscillating between source and the load will be called reactive power it is never consumed by the circuit. So, this is the origin of origin of reactive power and this power which is about absorbed by the load or consumed by the load is called the active power. Therefore, in A.C. circuit when things are sinusoidal excited circuit doing things are getting both voltage and current are changing with time.

No point in talking about instantaneous power, it is better you tell me how much average power I am consuming is not that A to B much more meaningful than to calculate instantaneous board at this is 10 time consuming this much power these know your electricity bill should be prepared based on the average power you are consuming. After all, it is only 20 millisecond 1 cycle of the supply is not in the previous survey. This is the this is 20 millisecond in 20 millisecond, how much energy we are consuming what is powering through that time based on that your how much power you are consuming should be calculated based on the average power clear.

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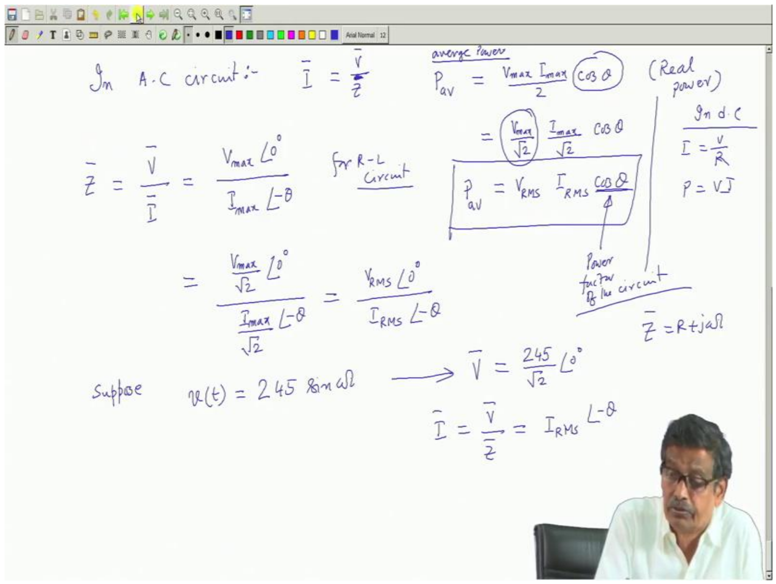

Therefore, this is the thing now, so, this p average now we make an important statement in AC circuit therefore, in AC circuit we have seen what i bar current in the circuit is V bar by this circuit but we have seen just like your DC circuit, only thing this time the numbers are complex and p average this V max I max by 2 into cos theta that is the real power which real power that I have explained just right now.

So, this is the thing. So only being in DC circuit current in DC I just got down here in DC current is V/R power is V into I, now here is in the expression of the average forward we find peak value of that sinusoidal voltage into peak. Well the current, but there is a factor to appearing it is nothing wrong one can leave with this apart from this this turn of course cos theta will be always there. So, this expression is written like this V max by root 2 into I max by root 2 into cos theta and you know V max by root 2 is nothing but RMS value of the supply sinusoidal pairing quantity with time be V max sin omega t.

What is the value V max sin omega t, similarly current is also sinusoidal what will be sinusoidal value, it is I RMS into cos theta sometimes people just did not understanding, once you write the average power consumed by the circuit is Vi cos theta, it means these elements i s and r s got the point. Now, after knowing this, so, it is quite then similar to that of DC circuit only thing 1 factor comes sin theta that you of course, you cannot have it cannot be productive voltage and current RMS value of voltage and current except for this case when theta = 0.

But anyway then we will leave with this average is voltage and current and last one thing I will add, why dividing the phasor I told you suppose I told you that Z bar is a equal to voltage bar for that divided by current for that and this voltage phasors I defined in terms of maximum values they be executed and current failure also I wrote like this I max some - theta for RL circuit is not this is what I wrote. But that is phasor represented by the peak values there will be absolutely nothing will be wrong.

If you divide these by root 2, and I max by root 2 to both numerator and denominator you divide by root 2 and rightly this and say that while you presenting phasors, I will represent in terms of RMS quantities, that is I will write be V RMS 0 degree RMS theta. So, you get burn, demand sank age. Therefore, at the end what we will be doing what people will do is that if any sinusoidal quantities they are suppose I say that the vt is equal to some voltage sin omega t.

Then while telling in terms of phasor what I will do V bar I will hence take these values that 245 divided by root 2 angled 0. It does not change Z bar it is equal to r + j omega t. So, I will calculate Z bar but then if you calculate I bar from these V bar by Z bar, e will get obviously I RMS - theta. Therefore, representing in phasor rotations because, to get similar expression for power as indices are similar, not identical cos theta is there, these cos theta it is called the power factor of the circuit.

So, how nice it is therefore, in a circuit, sinusoidal current and they will have in general some face displacement between them. So, sometimes the instantaneous product of voltage and current will become + sometimes -. If you are using some power in this circuit there must be some average value, so this thing to summarize, once again I am telling this is the expression of the average power just from this is the expression of the instantaneous power.

Then we intelligently broke up this 2 into 2 terms, 1 term is always positive, it will never have negative this term never becomes negative it may come to 0 that is there and there is another term which is an also a double frequency term and this will have identical positive and negative excursion. So average value of this quantity is 0. No doubt about it from these, if you sketched this way form, as expected, there was no negative value of this faster it will be oscillating.

So, it will have an average value and that average value will V max I max by 2 cos theta, because average of sin 2 omega t is 0 all the time. If you calculate average over a cycle, sin cos in terms average value is 0. So this will give you 0 value. So this is the average be V max I max by 2 cos theta. And the second term which is only I have been signed to omega t know DC term as they added to it.

So, it will have identical + - excursion and it will continue like that. So, sometimes the circuit will absorb power from the suits and sometimes some other interval, it will return back the same power to the source that power will never be consumed by the circuit. Here electricity bill is consumed on the basis of this average power you are consuming who will in the next class tell you something more about this power factor and its implication. Thank you.