Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (Second Year)

Subject: Physics

Paper Code: PYS101

Paper Title: Network Analysis

Unit: 3 Transient Response of RL and RC circuits and RLC circuit to DC and AC signals

Module Name: Sinusoidal response of RLC circuit.

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Transcript

Welcome students. The program is Bachelor of Science, second year
Subject Physics Semester three.
Paper code PYS 101
Paper title Network analysis
Unit Three Response of RL, RC and RLC Circuit to DC and AC
Module name. Sinusoidal response of RLC circuit.
Module number 18

I'm Efrem D'Sa from Camel College of Art, Science and Commerce for women.
The outline is AC analysis of RLC circuit.
Voltage equations for RLC circuit,
Solution for RLC circuit and its interpretation.

Learning outcomes
Apply Kirchoff's Voltage law to series RLC circuit.
Determine impedance phase relationship between voltage and current in a series RLC circuit.
Understand the variation in impedance, phase angle with frequency.

First The sinusoidal response of RLC circuit.
If the voltage V(t) and current I(t) be the instantaneous values of voltage and current. And writing Kirchoff's voltage law for the close circuit,
we have V(t) is equal to the current into the resistance plus the voltage across inductance plus the voltage across capacitance.

As VL, the voltage across inductance is equal to LdI by dt.
And the voltage across the capacitance is equal to 1 by C integral of I(t)dt.
We, if it take the current AC current I(t) to be Im sin omega t
Then the voltage as a function of time is given by substituting the current I(t) in this expression, which gives us on differentiating and integrating gives us R Im sin omega t plusomega L I M cos omega t minus Im divided by omega C cos omega t.
Now this is a trignometric method of the solution, now this method becomes complex and tedious. So we use other simpler methods.

Like Phasor method, j operator method and complex method.

Using j operator method, that is complex number method.
Here we define j operator which operates on a vector to effectively rotate it by 90 degrees and minus j operator by minus 90 degrees without any change in magnitude to the vector. So if you consider the current i(t) to be a complex corresponding to a complex voltage V(t)
Since the voltage across inductor leads the current by 90 degrees,
and j that will be multiplied by j to indicate this 90 degrees
and the voltage across the capacitor lags current by minus 90 degrees.
so multiplied by minus j OK to represent the lag of current.

So using the j operator method. we simply write the voltage at anytime t is equal to the current (t) into the resistance plus j times omega L into the current minus j times the current divided by omega C
Here we can easily write voltage as a function of time is equal to the current as a function in bracket R plus j omega L minus j into one by omega C where if I right for the Z vector impedance, Z is equal to V(t)/I(t), then the impedance vector is given by R + j in bracket omega L minus one by omega C.

The magnitude of Z is the square root of the vector impedance
square root of R square plus omega L minus1 by omega C the whole square.

The magnitude of circuit current is It is given by the voltage divided by the magnitude of the vector impedance alpha the phase angle by which the applied voltage leads or lags the current or the phase difference between the applied voltage and current is given by the relation.
alpha is tan inverse in bracket omega l minus one by omega C the whole divided by R.

The magnitude of Z, phase angle alpha and the magnitude of current It vary with frequency of applied voltage.

We can consider 3 cases.
One is when omega L minus1 by omega C is greater than 0.
When omega L minus one by omega C is less than zero and
3rd when omega L minus one by omega C is equal to 0.

The case one omega L minus one by omega C is greater than zero.
The net reactance is positive that is inductive, alpha is positive and the applied voltage vt leads the circuit current It by a phase angle alpha.
That is voltage lags the current by a phase angle alpha is equal to tan inverse one by omega CR.

So I have again the case one here
The net reactance is positive that is inductive alpha is positive applied voltage vt leads the circuit current It by a phase angle alpha. The impedances Z here is greater than equal to R.

In case of omega L being greater very much greater than one by omega C that is at high frequency.
The RLC circuit acts like an RLC circuit acts like an RL circuit with
Z is equal to omega L an alpha is 90 degrees.

Case 2 omega L less than one by omega C,
the net reactance is capacitive, alpha is negative, applied voltage Vt lags the circuit current It by a phase angle alpha.
The impedance here Z is again greater than R.
If omega L is very much smaller compared to 1 by omega C that is for very low frequencies.
The RLC circuit acts like an RC circuit and that is equal to 1 by omega C and alpha is minus 90 degrees.

Case 3. omega L minus 1 by omega C is equal to 0.
That is, omega L is equal to 1 by omega C, here the net reactance is 0, alpha is negative, applied voltage that is in is in phase with the circuit current It with alpha equal to 0.
The impedance is purely resistive Z minimum is equal to R.
The maximum current flows through the circuit, phase difference 0,
omega L is equal to 1 by omega C indicates a series resonant

with resonance frequency omega naught square equal to 1 by LC
or frequency f naught is equal to 1 by 2π root LC

The notations used as shown in the slide.
References as shown in this slide.

Thank you.