EE2111A Activity Sheet - Week 5 Studio 2

Start	Duration	Activity
0:10	30 mins	Briefing
0:40	100 mins	Activity #1: KVL in AC circuit
		Activity #2: KCL in AC circuit
2:10	15 mins	Debriefing

Group size: Individual activity

Learning Objectives

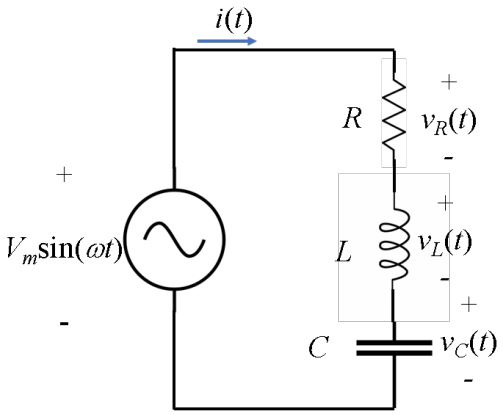
To be able

- to measure voltage and current in AC circuits using oscilloscope
- to find phasor representation of sinusoidal signals
- to verify KVL using voltage phasors
- to apply KCL to the measured current phasors

Equipment and components required

- Oscilloscope
- Signal Generator
- Bread-board
- Resistor 100 Ω (three)
- Inductor 1 mH
- Capacitors: 0.1 μF

Background knowledge



KVL and KCL hold in AC circuits just like they do in DC circuits. However, as the voltages and currents are time varying, these laws hold at every instant of time. For the circuit shown above, the KVL is

$$v_S(t) = v_R(t) + v_L(t) + v_C(t).$$

You know that voltmeter or ammeter measures the magnitude of voltage or current, and not as a function of time. The magnitudes alone do not satisfy KVL or KCL in AC circuit. If the amplitudes of the voltages in the circuit shown above are $V_{m,S}$, $V_{m,R}$, $V_{m,L}$, $V_{m,C}$, respectively, then

$$V_{m,S} \neq V_{m,R} + V_{m,L} + V_{m,C}.$$

However, in an AC circuit driven by sinusoidal source, the KVL or the KCL holds if the voltages or currents are expressed as phasors.

What is a phasor?

Phasor is an abstraction of a sinusoidal waveform that keeps the information of its amplitude and phase but discards frequency term. In an ac circuit driven by a source of frequency ω rad/s, all voltages and currents will be sinusoidal with the same frequency. So, the frequency is known for all voltages and currents.

There are a few conventions for defining the phasor. The EPP2 notes used the following:

$$x(t) = A\sin(\omega t + \phi) \quad \Rightarrow \quad Ae^{j\phi} = A\angle\phi = \bar{X}.$$

To express a sinusoidal function using phasor, one must know its amplitude A and its phase ϕ.

Activity #1: Verify KVL in a series RLC circuit

- Patch up a series RLC circuit on the breadboard using R = 100 Ω, L = 1 mH, C = 0.1 μF.
- Use a 10 V, 10 kHz sinusoidal voltage generated by the signal (function) generator as the source.
- Observe the input voltage $v_S(t)$ in CH1 and measure its amplitude.
- While keeping $v_S(t)$ connected to CH1, observe the voltages $v_C(t)$, $v_L(t)$, and $v_R(t)$, **one at a time** in CH2, and measure the amplitude of the waveform and its phase-shift with respect to $v_S(t)$. (**Be mindful** of the internal connection between GND of two channels of the scope.)
- Write phasor expressions of all four voltages and verify KVL,

$$\bar{V}_s = \bar{V}_R + \bar{V}_L + \bar{V}_C.$$

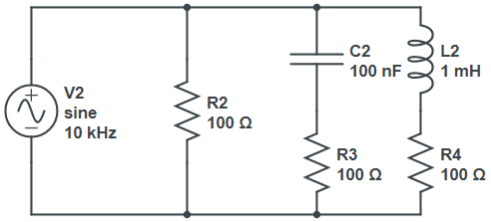
E-logbook:

Record the following:

- images of the oscilloscope screens while measuring different voltages,
- Time domain expressions of $v_S(t)$, $v_R(t)$, $v_L(t)$, and $v_C(t)$
- Their phasor expressions, and
- The KVL equation.

Activity #2:

KCL in an ac circuit



1. Patch up the circuit shown above on the breadboard.
2. Source: 10 V, 10 kHz sine wave
3. Measure
   (a) the amplitude and

(b) the phase with respect to the source

of the currents in the three parallel branches.

4. Determine, applying KCL, the amplitude of the current supplied by the source.

E-logbook:

Record the following:

- images of the oscilloscope screens while measuring the currents,
- Phasor expressions of the three branch currents,
- KCL equation, and
- The amplitude of the source current.