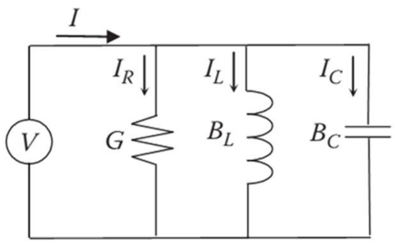
ELEC-E8422 An Introduction to Electric Energy

Exercise Session 1: AC Circuits

EX 1 AC Circuits

The 230 V voltage source in the figure is connected in parallel with a resistance, inductance and capacitance. The frequency of the source is 50 Hz, the resistance is 5 Ω, the reactance of the inductance is 10 Ω, and the reactance of the capacitance is 2 Ω.

1. Calculate the load total impedance
2. Calculate the frequency at which the load is seen as a resistance of 5 Ω.



EX 2 Phasors and Power

The voltage over a load and the current through are:

$$v = 150\sin(314.14t + 0.2)\ \text{V}$$
$$i = 25\sin(314.14t - 0.5)\ \text{A}$$

Calculate:

1. The frequency of the source
2. The source voltage phasor
3. The load current phasor
4. The active power drawn by the load
5. The reactive power drawn by the load

EX 3 Power and Energy

An electric load is connected to a 230 V voltage source. The load impedance changes durring a 24 hours period according to the table below. Calculate the electric energy consumed by the load during the 24 hours period. You can use a spreadsheet calculation program.

Time period	Impedance Ω	Power angle (°)
8.00 – 10. 30	10	30
11.00 – 13.00	20	0
15.00 – 17.00	15	60
17.00 – 20.00	5	45

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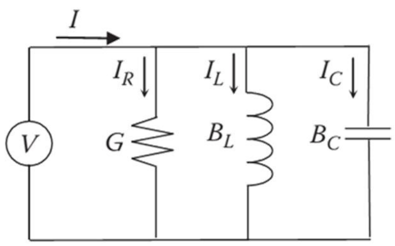
EX 1 AC Circuits



1. The load admittance:

$$\overline{Y} = G + (B_C + B_L)j$$
$$= \frac{1}{5} + (\frac{1}{2} - \frac{1}{10})j$$
$$= 0.2 + 0.4j$$

Fromwhich we calculate the impedance:

$$\overline{Z} = \frac{1}{\overline{Y}}$$
$$= \frac{1}{0.2 + 0.4j} = 1.0 - 2.0j\ \Omega$$

2. The reactance depends on the frequency but the inductance and the capacitance do not. Let's first calculate these quantities:

Inductance:

$$L = \frac{X_L}{2\pi f}$$
$$= \frac{10}{2\pi * 50} = 31.8\,\text{mH}$$

Capacitance:

$$C = \frac{1}{2\pi f X_C}$$
$$= \frac{1}{2\pi * 50 * 2} = 1.6\,\text{mF}$$

If the load is seen as a resistance, then $B_L = B_C$ (absolute values), i.e.

$$\frac{1}{2\pi f_0 L} = 2\pi f_0 C$$

i.e.

$$f_0 = \frac{1}{2\pi\sqrt{CL}}$$
$$= \frac{10^3}{2\pi\sqrt{31.8*1.6}} = 22.31 \text{ Hz}$$

EX 2: Phasors and Power

1. Frequency (read from the wave form)

$$\omega = 2\pi f = 314.14$$

$$f = \frac{314.14}{2\pi} = 50 \text{ Hz}$$

2. Voltage phasor

$$\bar{V} = \frac{V_{\max}}{\sqrt{2}} \angle \theta_v$$
$$= \frac{150}{\sqrt{2}} \angle (0.2 \frac{180}{\pi})$$
$$= 106.07 \angle 11.46° \text{ V}$$

3. Current phasor

$$\bar{I} = \frac{I_{\max}}{\sqrt{2}} \angle \theta_i$$
$$= \frac{25}{\sqrt{2}} \angle (-0.5 \frac{180}{\pi})$$
$$= 17.68 \angle -28.65° \text{ A}$$

4. Active power

The phase angle between the current and the voltage is

$$\theta = \theta_v - \theta_i = 0.2 + 0.5 = 0.7 \text{ rad}$$

The active power is calculated as:

$$P = VI\cos(\theta)$$
$$= 106.07 * 17.68 * \cos(0.7)$$
$$= 1.434 \text{ kW}$$

5. Reactive power

$$P = VI\sin(\theta)$$
$$= 106.07 * 17.68 * \sin(0.7)$$
$$= 1.208 \text{ kVAr}$$

EX 3 Power and Energy

The energy is computed as:

$$E = \int_0^T P dt$$

Because the power is constant over some periods, we can we can calculate it as:

$$E = \sum_i T_i P_i$$

For this purpose, we can make the following spreadsheet (Excel)

Period		Impedance	Power angle	Current	Power	Period	Energy
start	End	Ω	deg.	V/Z A	VIcos(Θ)	t:min	Wh
8:00	10:30	10	30	23,0	4581,27	2:30	11453
11:00	13:00	20	0	11,5	2645,00	2:00	5290
15:00	17:00	15	60	15,3	1763,33	2:00	3527
17:00	20:00	5	45	46,0	7481,19	3:00	22444
							42713