Part 1A Paper 3: Electrical and Information Engineering,

Analysis of Circuits EXAMPLES PAPER 2

This examples paper is based on material from lectures 5 onwards. Questions containing material of tripos standard are marked *.

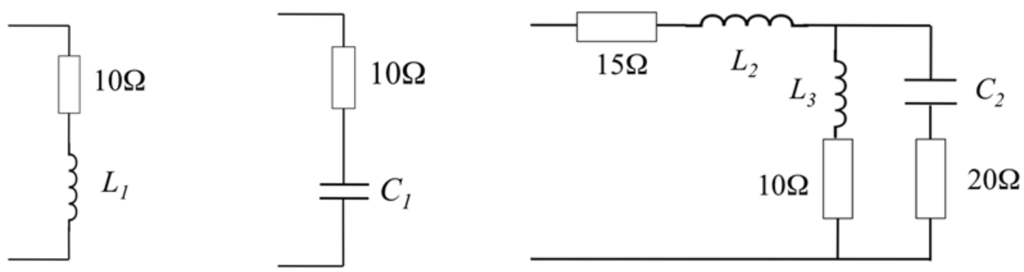
AC Circuit Theory

1. Sketch the following voltage waveform: $V(t) = 10 - 2\cos(314t)$. Determine the value of the following quantities:

(a)	The amplitude	(b)	The peak-peak amplitude
(c)	The time-averaged value	(d)	The rms amplitude
(e)	The frequency	(f)	The angular frequency

(Discuss with your supervisor why the rms amplitude is more relevant than the average amplitude in practical small signal circuits.)

2. For each of the circuits shown in Fig. 1, find the equivalent complex impedance in both Cartesian and polar forms, i.e. $(x + jy)$ and R angle(θ). at a frequency of 1 kHz. The values of the inductors and capacitors are $L_1 = 10$ mH, $L_2 = 850$ μH, $L_3 = 10$ mH, $C_1 = 10$ μF, $C_2 = 10$ μF.



(a) (b) (c)

Fig. 1

3. For each of the bridge circuits shown in Fig. 2, derive conditions for balance of the bridge (i.e. when no current flows through the current meter, labeled ' det'). Express the unknown component values R_X, L_X, C_X in terms of the other known components R_2, R_3, R_4, C_3 and C_4.

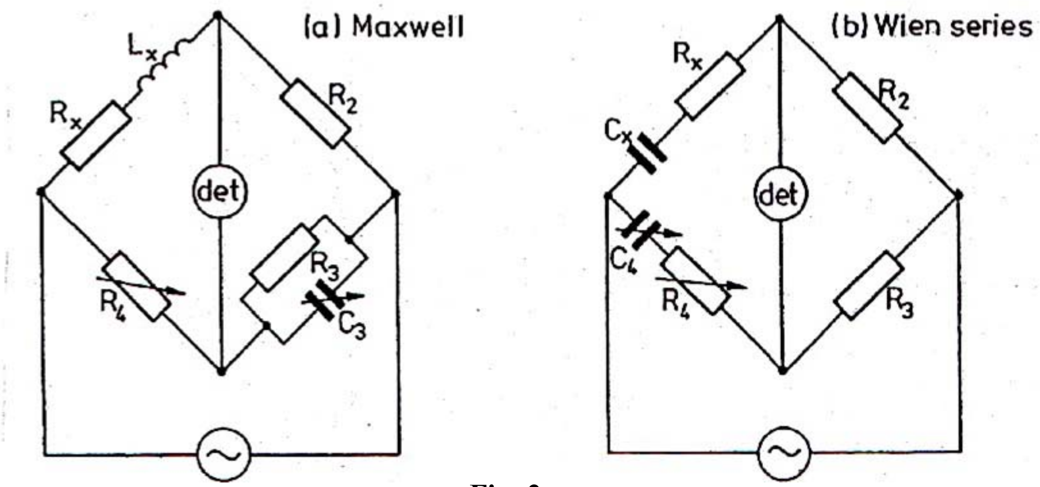


Fig. 2

4. Fig. 3(a) shows an AC source, v_1, whose voltage is given as a complex quantity in Cartesian form.

(a) Determine v_1 in polar form

(b) At the frequency at which the source operates, the impedances Z_1 and Z_2 are shown in Ohms. Find the amplitude and phase of the current i_2, and hence determine the voltage v_2 in rectangular and polar form. Determine the phase difference between v_2 and v_1, and the overall gain of the circuit.

(c) In order to predict what will happen when further loads are connected across AB, it is desirable to reduce the circuit to its Thévenin equivalent as shown in Fig. 3(b). Determine V_T and Z_T in rectangular and polar form.

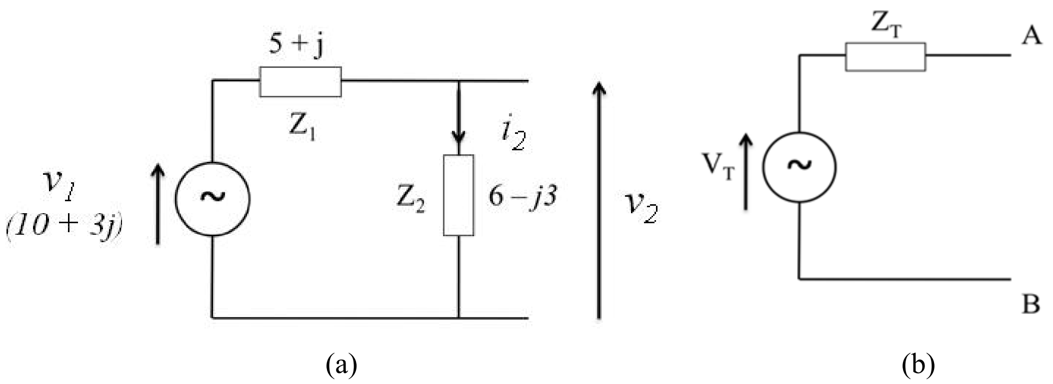


Fig 3.

5. A 50 Hz AC voltage source has a Thévenin equivalent resistance of 100 Ω and a rms voltage of 20V. It is connected to a load consisting of a 0.159 H inductor in parallel with the series combination of a 50 Ω resistor and a 63.7 μF capacitor. Sketch the circuit and calculate the current that flows through the inductor and its phase with respect to the source.

6. A simple radio receiver circuit is shown in Fig. 4. The antenna, which receives a voltage, v_1, of 100μV and has a resistance, R_{Ant} = 30 Ω. It is connected to a series resonant (LC) circuit that acts as the tuner, the output of which (v_2) is amplified before being sent to the headphone/loudspeaker drive circuitry. The inductor, L and variable capacitor, C are assumed to be ideal.

(a) What value of C is required to make the circuit resonant at 198kHz? What will the value of v_2 be at that frequency?

(b) If the inductor were to be made of copper wire wound onto a 50mm long, 15mm diameter cardboard tube, how many turns would be required to make the inductance L? *Discuss with your supervisor how many turns would be required if the inductor were to be wound on a 15mm diameter rod of ferrite.*

(c) If the radio was required to tune across the longwave band from 148 kHz to 284 kHz, calculate the range of capacitance required using a variable capacitor. How might such a variable capacitor be constructed?

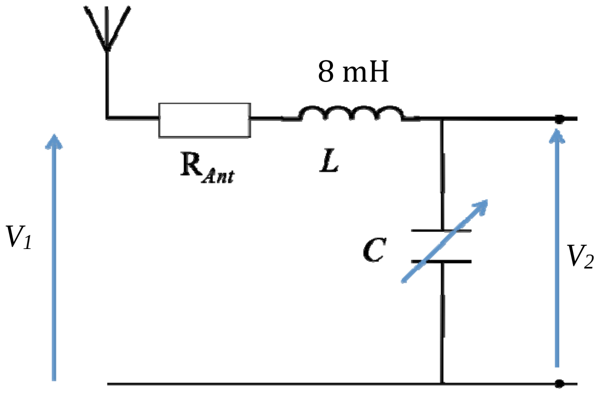


Fig. 4

7. An AC voltage generator has a voltage of 100 V, and internal resistance of 1 MΩ. It is connected to the terminals of a parallel resonant (LC) circuit. The capacitor has a value of 100pF and a Q-factor of 1000. The inductor may be represented by an inductance of 10 mH in series with a resistance of 10 Ω. Calculate:

(a) The resonant frequency of the circuit

(b) The voltage across the circuit at resonance

(c) The half-power bandwidth

Answers:

1. 2V; 4V; 10V; 10.1V; 50Hz; 314 rad/s

2. a) 10 + j62.8, 63.6 81^{o}; b) 10 – j15.9 Ω, 18.8, -57.8^{o}; c) 43.2 - j2.22 Ω, 43.3, –2.94^{o}

3. $R_X = R_2R_4/R_3$, $L_X = R_2R_4C_3$; $R_X = R_2R_4/R_3$, $C_X = R_3C_4/R_2$

4. 10.44 V 16.67^{o}; 0.832 + 0.424j A; 6.26 + j0.048 V, 6.25 0.439^{o}, -16.26^{o}, 0.6; 6.26 + 0.048j V, 3.048 – 0.264j Ω

5. 0.08 - j0.16 A, 0.179 A -63.4^{o}

6. 81 pF (81 x10^{-12} F), 33.1 mV -90^{o}; 1342 Turns; 145 pF to 39.3 pF

7. 159 kHz; 83.3V; 1.92 kHz

Tripos questions that are appropriate for revision purposes: Christmas revision 2018 on lectures 1-10, 2009 Q2 & Q3, 2008 Q4, 2007 Q1, 2006 Q2

It is recommended that you attempt these questions over the Christmas vacation, as well as any work that your College sets you. In order to optimize the learning process, study the lectures first, and then try the tripos questions. You should attempt these questions without looking at your notes – only do so afterwards to check for yourself and fill in the gaps.

TDW November 2018