University of Glasgow

Degrees of BEng in Engineering

POWER ENGINEERING 3 (UESTC3005)

2017

Attempt all questions. The total number of possible marks is 100.

The numbers in square brackets in the right-hand margin indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.

An electronic calculator may be used provided that it does not have a facility for either textual storage or display, or for graphical display.
If a calculator is used, intermediate steps in the calculation should be indicated.

Continued Overleaf

Q1 Consider the single-phase AC circuit shown in Figure Q1.

(i) The current $i(t)$ can be written in the form $i(t) = I_m \cos(\omega t + \varphi)$ A, determine the values of I_m and φ . [4]

(ii) Calculate the average power dissipation P_{avg} in the circuit, and explain where the power is dissipated. [4]

(iii) Construct a phasor diagram showing input voltage $v(t)$ and current $i(t)$ [2].

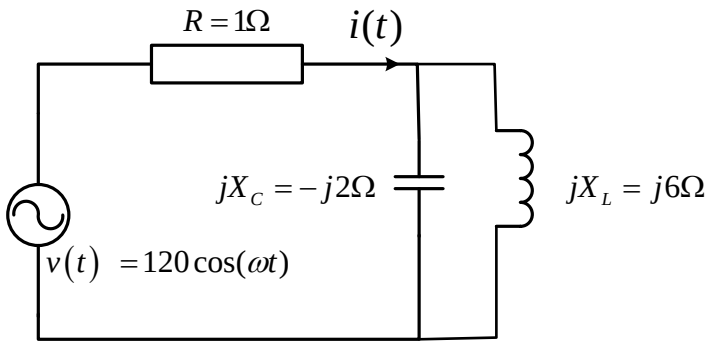

Figure Q1

Continued Overleaf

Q2 (a) A balanced delta connected load of $(20+j20)\ \Omega$ is connected to a 3-phase 220V/50Hz (RMS phase voltages) power supply shown in Figure Q2.

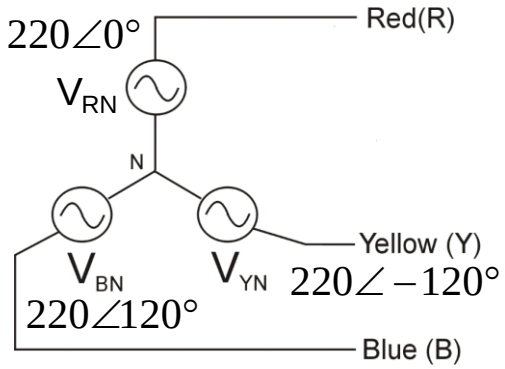

Figure Q2 Balanced 3-phase power supply

Draw the circuit diagram and from this:

(i) Draw the circuit diagram including the implementation of a two-wattmeter power measurement [2]

(ii) Calculate the magnitude of the line voltages. [1]

(iii) Calculate the three line currents (I_R, I_Y and I_B). [3]

(iv) Construct a phasor diagram showing all line voltages (V_{RY}, V_{YB} and V_{BR}) and phase voltages (V_{RN}, V_{YN} and V_{BN}). [6]

(v) Determine the total output supply power (W) using two-wattmeter measurements. [3]

(b) An unbalanced delta connected load consisting of Z_{RY} (10+j10)Ω, Z_{YB} (10+j0)Ω and Z_{BR} (0+j10)Ω is connected to the power supply shown in Figure Q2. Draw the circuit diagram and from this:

(i) Calculate the three load phase currents (I_{RY}, I_{YB} and I_{BR}). [3]

(ii) Calculate the three line currents (I_R, I_Y and I_B). [3]

(iii) Calculate the three load phase power consumptions (W) [3]

(iv) Construct a phasor diagram showing three line voltages (V_{RY}, V_{YB} and V_{BR}), three load phase currents (I_{RY}, I_{YB} and I_{BR}). [6]

Continued Overleaf

Q3 (a) Given the equivalent circuit parameters shown on Table Q3 for a 110V/10V single phase transformer, determine the following for a 2Ω resistive load connected to the secondary terminals:

(i) Draw the equivalent circuit labelling all circuit parameters [2]
(ii) Output load voltage (V) [2]
(iii) Output load current (A) [2]
(iv) Output load power (W) [2]
(v) Transformer losses (W) [2]
(vi) Efficiency (%) [3]
(vii) Voltage Regulation (%) [3]

Parameter	Value
R_c	5kΩ
X_M	600Ω
R_{1eq}	15 Ω
X_{1eq}	3 Ω

Table Q3

(b) A three-phase Δ/Y transformer bank is rated 110kV/22kV and delivers 3300kVA to a balanced delta connected load at rated voltage. Assuming an ideal transformer, calculate the following:

(i) Construct a phasor diagram showing all primary phase voltages and secondary line voltages for the three-phase transformer in the question. [6]
(ii) Bank Ratio and Phase Ratio. [2]
(iii) The magnitudes of the secondary line currents [2]
(iv) The magnitudes of the primary line current [2]
(v) The magnitudes of the currents in the primary coils [2]

Continued Overleaf

Q4 (a) A 2-pole star connected three-phase induction motor has the per-phase equivalent circuit shown in Fig. Q4

(i) If the locked rotor test produces a per phase input power of 2000 W with a phase current of 100 A at a phase voltage of 40V, and the phase resistance of the motor windings is measured at 0.1 Ω using a multimeter, calculate the rotor resistance R_r and stator resistances R_s, and total leakage reactance X_{eq}

[6]

(ii) If the slip at a given load is s = 0.03, calculate the motor speed n_r (rpm), motor output power P_o (W), motor output torque T_o (N.m) and efficiency when operating with a 220V 50Hz supply where 220V is the phase voltage V_{ph}.

[12]

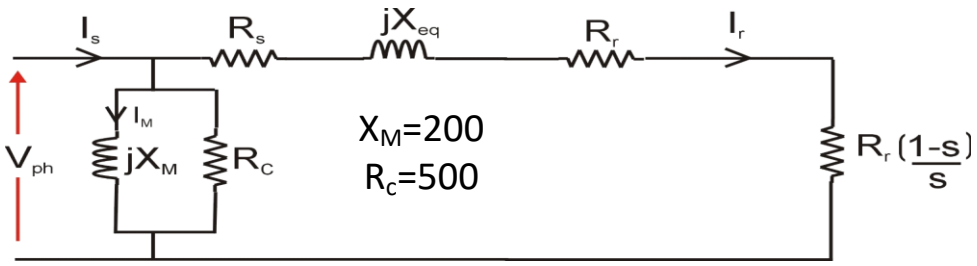

Fig Q4

(b) A star connected 3-phase wound field synchronous generator with a synchronous reactance X_s of 3Ω is connected to a 690V (line) grid and supplies 2MW at 0.9 lagging power factor at its terminals. Calculate the phase current and resultant voltage V_{XS} across the synchronous reactance, and determine the required excitation voltage (E_{ph}) and load angle (δ).

[12]

End of Question Paper