國 立 清 華 大 學 命 題 紙

96 學年度 電機領域聯合招生 系（所）＿＿＿＿＿組碩士班入學考試

科目 電力系統 科目代碼 9905 共 3 頁第 1 頁 *請在【答案卷卡】內作答

1. The power flow calculation is a basic and useful tool of the power system engineers. (a) Explain how to formulate the load flow equations of an n bus system. (b) What information can be obtained from the solution of (a). (10%)

2. A three-phase 750hp, 60Hz, 4800V Y-connected induction motor is operated at rated load with 0.85 efficiency and 0.8 lagging power factor. It is desired to add a Y-connected capacitor bank to raise the power factor to 0.95 lagging. Please derive a formula of ΔQ, namely the required var of the capacitor bank for the desired power factor correction. (10%)

3. Fig. 1 shows a one-machine-infinite-bus (OMIB) power system model. Two transmission lines are with identical admittance $Y=jB$. Let $|V|$ and δ be the magnitude and the phase angle of the synchronous generator. $|V_\infty|$ is the voltage magnitude of the infinite bus. The generator has a round rotor and zero resistance. A fault occurs on one of the lines. Assume that the fault is removed instantaneously by opening the breakers of the faulted line. The fault is not transitory and the breakers "lock out" in the open position. Suppose the faulted line is repaired and we close the breaker at $t=T$ and remain closed to restore the line to service. (10 %)

   (1) Express the active power and the reactive power delivered by the synchronous generator when the system is operated at the pre-fault system and at the post-fault system.
   (2) Illustrate how to apply the Equal-Area Stability Criterion to calculate the critical clearing time (CCT) $C_{ritical}$.

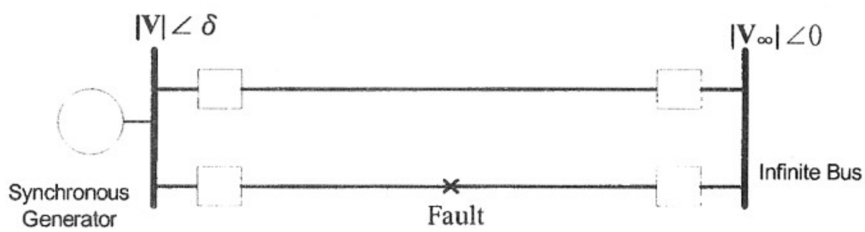


Fig. 1.

4. An isolated power station has the following parameters: Turbine time constant T_T=0.5 sec. Governor time constant T_G=0.2 sec. Generator inertia constant H=5 sec. Governor speed regulation R=0.1 per unit. The load varies by 0.5 percent for a 1 percent change in frequency. (10 %)

   (1) Draw the load frequency control (LFC) block diagram of this isolated power system.
   (2) The turbine rated output is 250 MW at the nominal frequency of 60 Hz. A sudden load drop of 50 MW occurs. Find the steady-state system frequency in Hz.

5. Consider the transmission line in the sinusoidal steady state. Let $z=r+j\omega l$ be the series impedance per meter and $y=g+j\omega c$ be shunt admittance per meter to neutral. The receiving end is located at $x=0$ and the sending end is at $x=l$. The per phase terminal voltage and currents are V_1 and I_1 at the receiving end and V_2 and I_2 at the sending end. A typical differential section of line length dx is shown in Fig. 2. The series impedance of the differential section is zdx. The shunt admittance is ydx. (10 %)

(1) Applying Kirchhoff's voltage law (KVL) and Kirchhoff's current law (KCL) to this section, find the corresponding two first-order differential equations.
(2) Express the propagation constant γ and the characteristic impedance Z_c in terms of z and y if the transmission line is lossless.
(3) Find the general solution $V(x)$ and $I(x)$ of the transmission line at any x located between $x=0$ and $x=l$.
(4) Let $V_1=AV_2+BI_2$ and $I_1=CV_2+DI_2$. Find the transmission parameters A, B, C, and D.

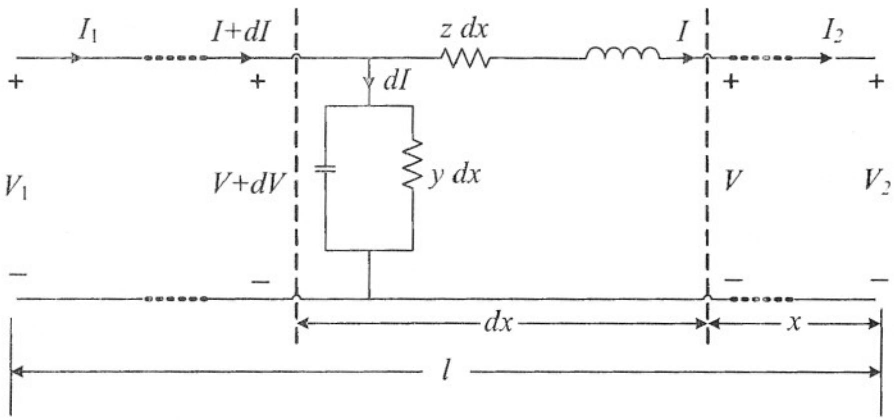


Fig. 2.

6. Suppose that we wish to determine the economic operating point for two generation units when delivering P_L MW power to a load. The cost rate of each unit is described by $F_i(P_i)=0.5a_iP_i^2+b_iP_i+c_i$, $i=1$ and 2, where P_i is the electrical power generated by unit i, $P_i^{min}\leqq P_i\leqq P_i^{max}$. Suppose that we neglect the line power constraints and line losses as well.(10 %)

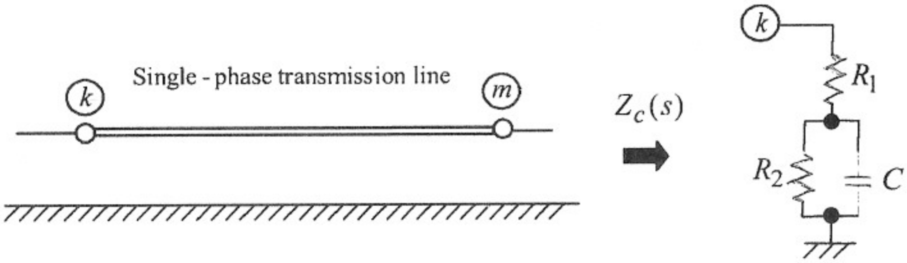
(1) Formulate this economic dispatch problem as a constrained optimization problem and define the associated the Lagrange function.
(2) Describe a possible procedure to find the optimal dispatch.
(3) If we neglect generation limits, find the optimal dispatch rule.

7. The characteristic impedance of a single-phase transmission line can be approximately expressed as: (20%)

$$Z_c(s) = \frac{5s+10}{s+10}$$

(1) It is to be represented by the electric circuit as shown, find R_1, R_2 and C.

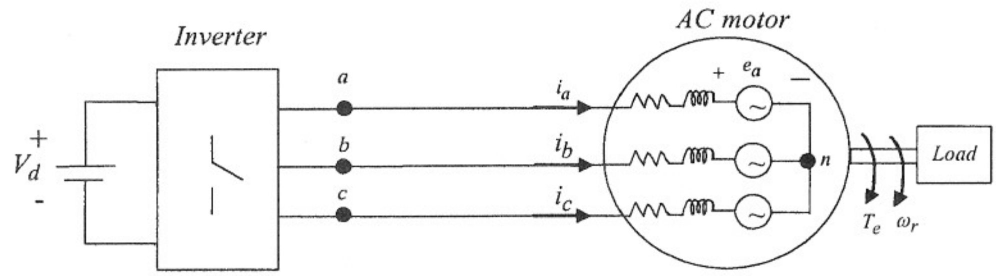
(2) Find the surge impedance of this transmission line.



(3) The line currents of an inverter-fed AC motor drive are:

$$i_a = 10\sin(377t) + 5\sin(3\times 377t)(A),$$
$$i_b = 10\sin(377t - 120^o) + 5\sin(3\times 377t)(A),$$
$$i_c = 0(A).$$

Find the zero-sequence current of this motor.



8. A single-phase converter is as given in Fig 3. The AC input voltage $v_s = V\sin(\omega t)$, and the thyristor T_1 is triggered with a delay angle of α behind the zero crossing of v_s. (20%)

(a) Sketch the waveforms of output voltage v_o.

(b) Calculate the average value of v_o.

(c) As in Fig. 4, mechanical switches are often used to connect or disconnect the AC load from the input voltage. Please design a solid-state switch using thyristors to replace the mechanical switch.

Fig. 3.

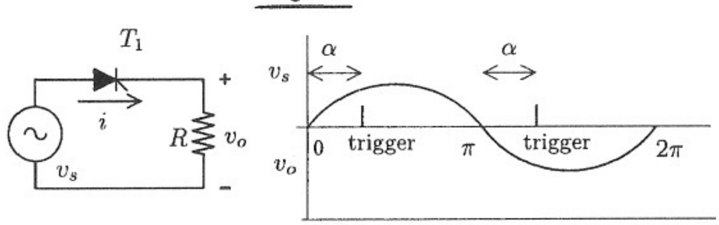


Fig. 4.