※ 考生請注意：本試題不可使用計算機。 請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. (15%) Assume the operating cost function of the generating unit is $C_i = \alpha_i + \beta_i P_i + \gamma_i P_i^2$

   For the control area contains *n* generators to provide total load demand P_T,

   I. specify the **objective function** of minimal operating cost C_t and its **constraint** without considering the loss.

   II. Use the Lagrange method $L = C_t + \lambda\left(P_T - \sum_{i=1}^{n} P_i\right)$

Prove that the analytical solution for optimal λ is:

$$\lambda = \beta_i + 2\gamma_i P_i = \frac{P_T + \sum_{i=1}^{n} \frac{\beta_i}{2\gamma_i}}{\sum_{i=1}^{n} \frac{1}{2\gamma_i}}$$

2. (15%) Consider a system with the one-line diagram shown in the figure below, the per-unit ratings of the generator, transformers, transmission line, and motor are listed as follows:

   Generator: 20MVA, 13.8kV, X''_d=j0.1pu, X^2=j0.1pu, X^0=j0.05pu

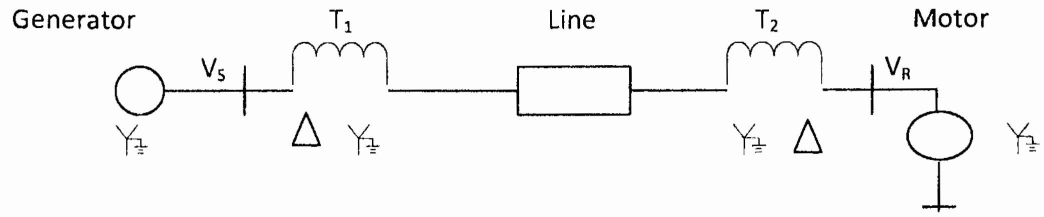
   Transformer T_1: 20MVA, 13.8kV-69kV, X_l=j0.1pu

   Transformer T_2: 20MVA, 69kV-13.8kV, X_l=j0.1pu

   Transmission line : X^1_{line}= X^2_{line}=j0.1pu, X^0_{line}=j0.3pu with 20MVA, 13.8kV base

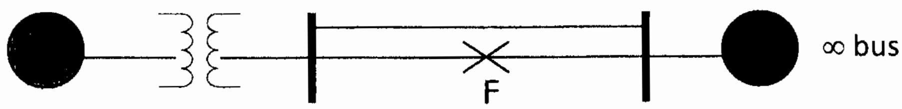
   Motor: 20MVA, 13.8kV, X''=j0.2pu, X^2=j0.2pu, X^0=j0.1pu

   The neutrals of the generator, motor, and Δ-Y transformers are solidly grounded.



   Assume the pre-fault voltage is $1\angle 0^\circ$ pu, please **derive** the **Thevenin equivalents** of the **zero-, positive-, and negative-** sequence networks in per-unit **as viewed from bus V_S**. Label all the per-unit voltages and impedances for the network diagram.

3. (10%) A temporary three phase fault occurs away from sending end of bus as shown below:



Prove that the **critical clearing angle** δ_c has the following relationship with the variables shown in the figure below

$$\cos\delta_c = \frac{P_m(\delta_{max} - \delta_0) + P_{3max}\cos\delta_{max} - P_{2max}\cos\delta_0}{P_{3max} - P_{2max}}$$

, where P_{1max}, P_{2max}, P_{3max}, are the peaks of the power curve,

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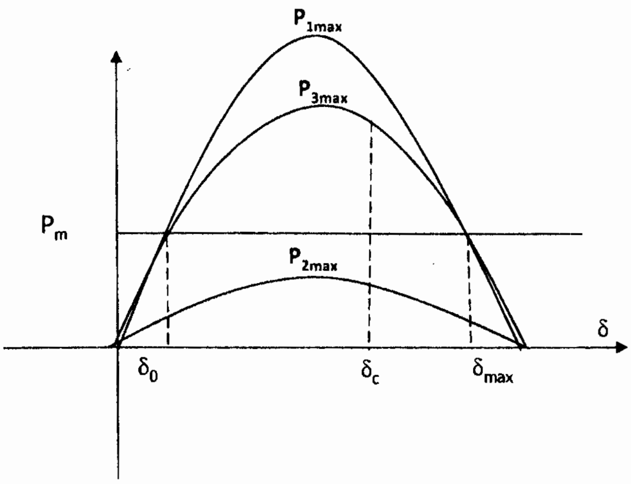
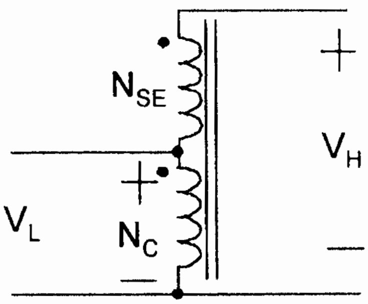
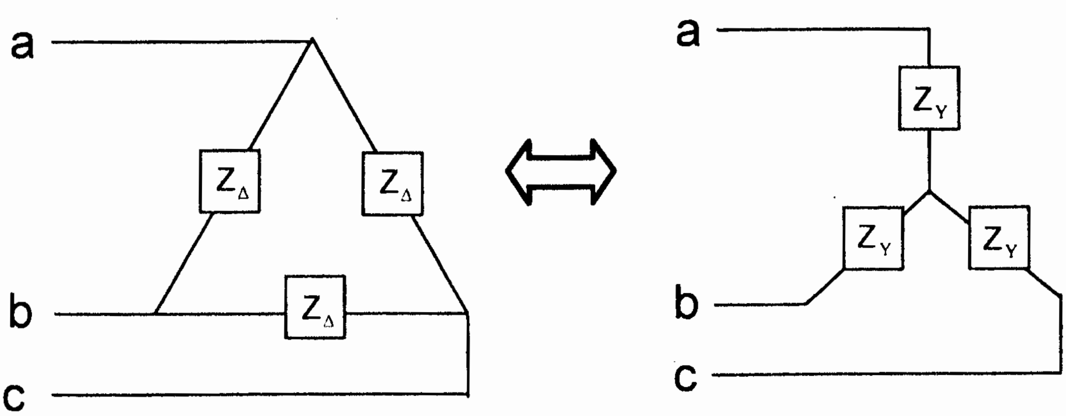
respectively.



4. (10%) **Derive** the **voltage conversion ratio** V_H/V_L for the step-up autotransformer, as shown below.



5. (10%) **Prove** $Z_\Delta=3Z_Y$ for the following two equivalent three-phase networks.



6. (10%) **Draw** the equivalent circuits of (1) **long-shunt diffentially compound DC <u>generator</u>**, (2) **long-shunt diffentially compound DC <u>motor</u>.**

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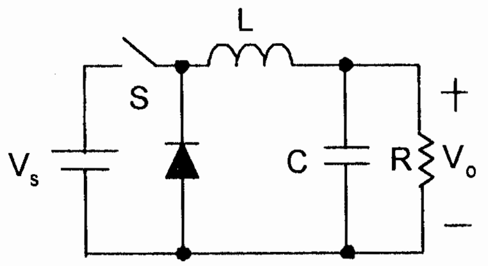
7. (10%) **Prove** the **output voltage ripple ratio** $\frac{\Delta V_o}{V_o}$ of the following **continuous-conduction mode** (CCM) buck converter equal to $\frac{\pi^2 \cdot (1-D)}{2} \cdot \frac{f_c^2}{f_s^2}$, where

D is the **duty cycle** of the main switch S,

f_s is the **switching frequency** of the main switch S,

fc is equal to $\frac{1}{2\pi\sqrt{L \cdot C}}$.

Note: ALL components used in this circuit are ideal.



8. (10%) **Derive** the **maximum** current value of the inductor L in the **above CCM buck converter**.

9. (10%) **Derive** the **minimum** current value of the inductor L in the **above CCM buck converter**.