科目：電力系統(300C)　　　校系所組：清華大學電機工程學系（甲組）

一、(10%) Two impedance loads are connected in parallel to a 2400 volt 3ϕ voltage source with load 1: 300 kVA, pf=0.8 lagging; load 2: 240 kVA, pf=0.6 lagging. Assume a-phase voltage is $\overline{V}_{an}=2400/\sqrt{3}\angle 0°$ V rms and the phase sequence is abc.

(一)、(5%) Draw a single phase equivalent circuit;

(二)、(5%) Find all three source line currents.

二、(5%) Solve the previous problem in per unit on bases of $V_{base}=2400/\sqrt{3}$ V, and S_{base}=300/3 kVA. The per unit impedances should be marked in the equivalent circuit.

三、(10%)

(一)、(5%) What are basic assumptions made in power (or load) flow analysis?

(二)、(5%) What information can be obtained through power flow analysis?

四、(10%) For the schematic given in Fig. 1.

(一)、(5%)

1. (2.5%) Explain what is inrush current with proper derivations for the resulted flux $\phi(t)$;
2. (2.5%) How to yield the minimum inrush currents, why?

(二)、(5%) As the switch SW is turned off, describe the transient voltage problems and causes at $v_2(t)$, and describe the protection remedies.

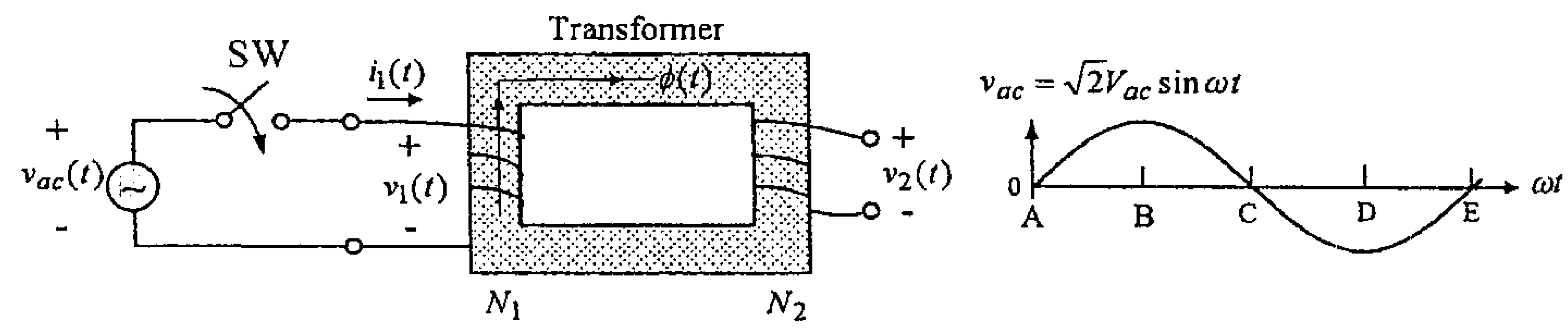

Fig. 1

五、(9%)

(一)、(5%) Draw the equivalent circuit of an induction machine.

(二)、(4%) For the induction machine operated in the generating mode:

1. (2%) label power flows on its equivalent circuit;
2. (2%) describe how to calculate its energy conversion efficiency?

六、(6%) A single-phase line possesses the following line constants at 60Hz: $z=0.02+j0.2$ (Ω/km), $y=0.08\times10^{-6}+j1.25\times10^{-6}$ (S/km) . Sketch the magnitude frequency response of characteristic impedance $|z_C(\omega)|$. $|z_C(0)|=?$ $|z_C(\infty)|=?$

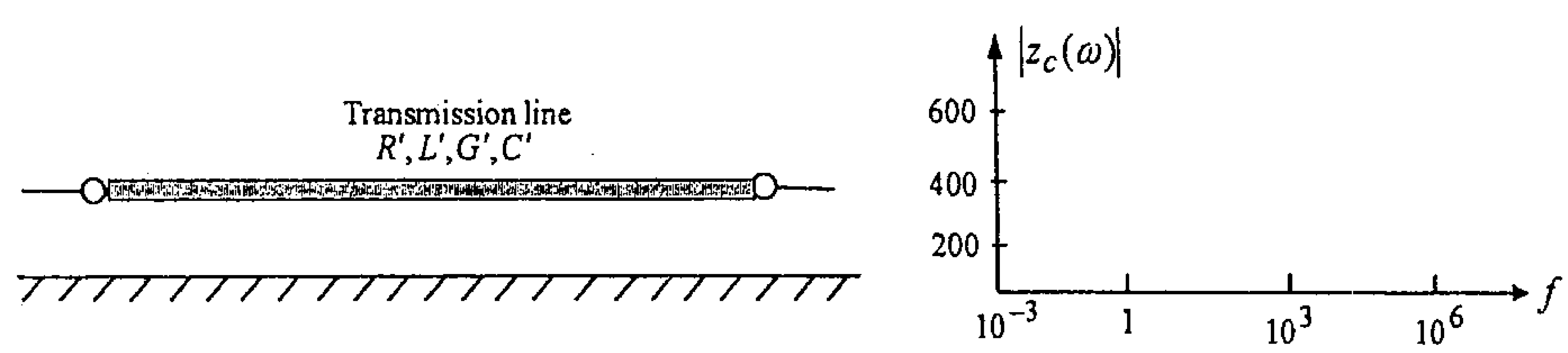

Fig. 2

七、(15%) A generator rated at 400MW, 0.8 power factor, 20 kV has a star-connected stator winding which is earthed at its star point through a resistor of 1.0 ohm. The generator reactances, in per unit on rating, are X_1=0.2, X_2=0.16, and X_0=0.14. The generator feeds a delta star-connected generator transformer rated at 550MVA which steps the voltage up to a 275kV busbar. The transformer star-point is solidly earthed and the transformer reactance is 0.15 p.u. on its rating. The 275kV busbar is connected only to the transformer. Assume that for the transformer $X_1=X_2=X_0$. Using a base of 500MVA calculate the base current and impedance of each voltage level. Calculate the fault current in amperes for:

(一)、(5%) a 275kV busbar three-line fault;

(二)、(5%) a 275kV single-line-to earth fault on the busbar;

(三)、(5%) a 20kV single-line-to-earth fault on the generator terminals.

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八、(10%) For a H bridge converter as given in Fig. 3, the DC bus voltage Vd=100V. Its PWM carrier is a triangle wave with the frequency of 6Hz.

(一)、(5%) The desired output voltage is v_0 = 75V (DC). If the uni-polar PWM is used to control this H-bridge converter, please draw the modulation voltage command alongside the PWM carrier, the waveforms of v_{Ao} and v_{Bo} respectively. Note that the duty ratio of these waveforms must be marked clearly.

(二)、(5%) The desired output voltage is $v_0(t)$= 75 sin(377*t). If the bi-polar PWM is used to control this H bridge converter, please draw the modulation voltage command alongside the PWM carrier.

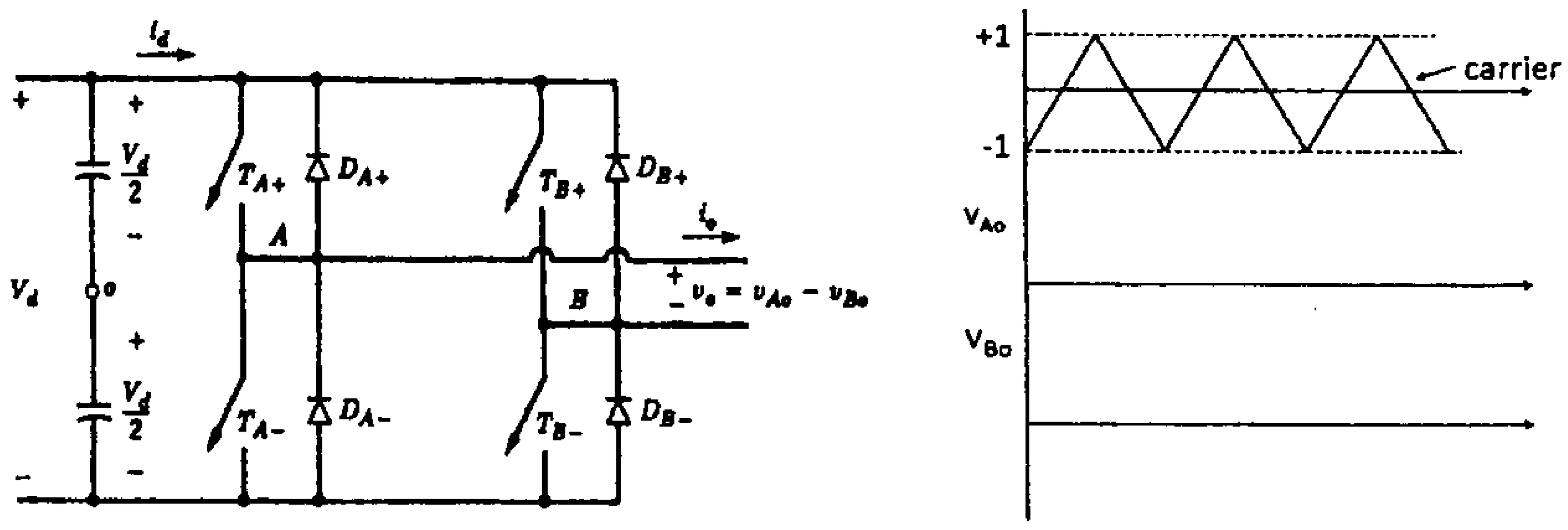

Fig. 3

九、(5%) Consider three synchronous generators in parallel operating at 60 Hz and having widely different speed regulations, with R_1=5%, R_2=10%, and R_3=16.7%. A load increase of 0.1pu occurs. Compute the initial decrease in frequency and how the change in load is shared by these three machines initially.

十、(5%) In a control area, there are two synchronous generators, 100MW each. The marginal costs (MC) for these two machines can be expressed as follows: MC_1=1.8+0.01P_1 (in $/MWh) and MC_2=1.5+0.02P_2 (in $/MWh). If the area has to supply a total of 150 MW, calculate the area optimum marginal cost and the power supplied by each machine.

十一、(10%) Consider the system of Fig. 4 with two transmission lines. The transient reactance of line I and Line II are X_L and $2X_L$ respectively. The generator is modeled as a constant voltage source $E\angle\delta$ behind the transient reactance X_s. The reactance of the transformer is X_{TR}. The voltage of the infinite bus is $V\angle 0^\circ$. Assume a three phase solid-ground fault occurs on line I either at the near side A, or at the far side B, the faulted line is not removed instantaneously.

(一)、(6%) Find the expression of electrical power output during the pre-fault stage, the fault-on stage, and the post-fault stage.

(二)、(4%) Use the equal area criterion to identify which fault has a longer critical clearing time.

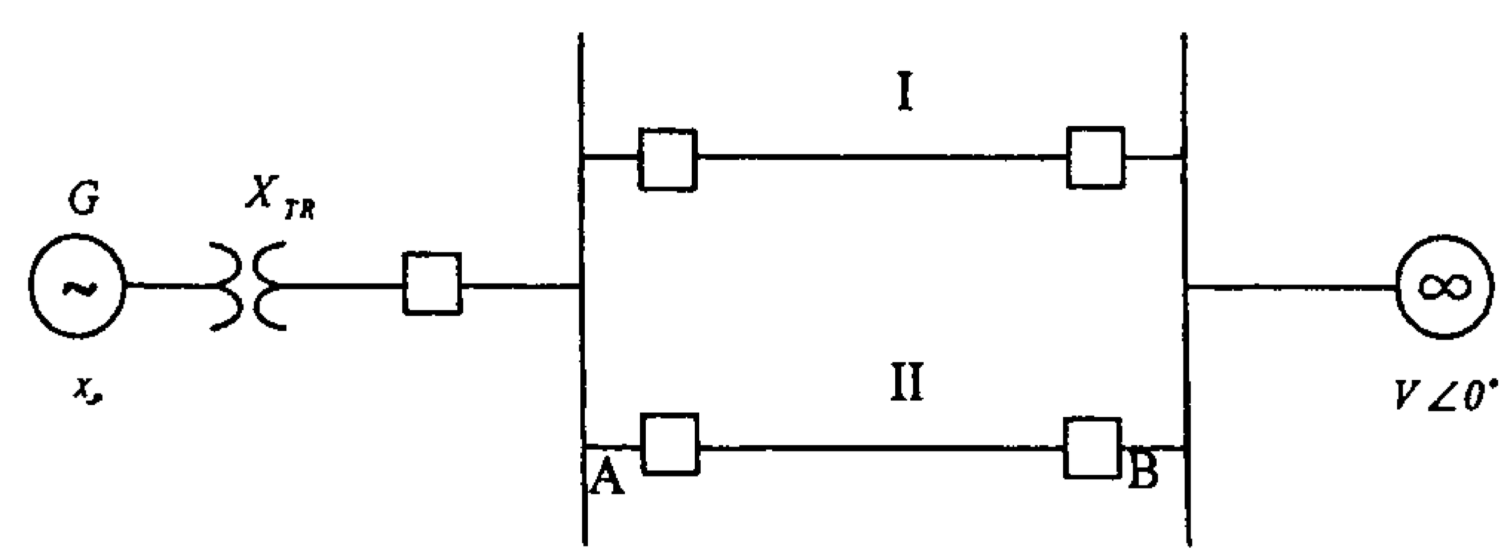

Fig. 4

十二、(5%)

(一)、(3%) Plot the schematic diagram for the differential protection of a single-phase two-winding, 10MVA, 80 KVA/20KVA transformer and illustrate its operation principle.

(二)、(2%) Select suitable current transformers (CT) ratios for the primary site and the secondary site from Table I.

Table 1 Standard CT Ratio

50:5 100:5 150:5 200:5 250:5 300:5 400:5 450:5 500:5 600:5 800:5 900:5 1000:5
1200:5 1500:5 1600:5 200:5 2400:5 2500:5 3000:5 3200:5 4000:5 5000:5 6000:5