國　立　清　華　大　學　命　題　紙

九十二學年度 電機工程學 系（所） 甲 組碩士班研究生招生考試

科目 電力系統 科號 2302 共 5 頁第 1 頁 *請在試卷【答案卷】內作答

Fundamental to 3-Φ Circuit

1. (a) The total harmonic distortion of the input current of a nonlinear load is 65%. What is the maximum power factor that this nonlinear load can possibly reach? Please show your calculation.

   (b) Does $v(t) = e^{-t} + 100\cos(377t), 0 < t < \infty$ have a phasor representation (Yes/No)? Why?

   (c) Assume the voltages of a three-phase three-wire distribution system are unbalanced, and the Y-connected loads are also unbalanced. Among the positive sequence component, negative sequence component, and the zero sequence component, which one is least likely to appear in the line current? Why?

20%: (a)題 10 分，(b), (c)每題 5 分

2. A battery-powered inverter-fed motor drive is as shown. Assume that $V_B = 300V$, $T_e = 12N-m, \omega_r = 200rad/\sec.$, the efficiency of inverter is $\eta_i = 0.8$, the inverter output phase voltage is $v_{an} = \sqrt{2}(200)\sin 377t(V)$. If the switch is closed, the motor line current is

$$i_a = \sqrt{2}(10)\sin(377t - 60^\circ) + \sqrt{2}(8)\sin(3\times 377t - 30^\circ)(Amp.)$$

(a)Find the motor output power P_m, the inverter output power P_i and the efficiency of motor η_m;

(b)Find the current in neutral line $i_{n,N}$.

(c)Find the battery output power P_B and current I_B.

(d)If the switch SW is opened, find i_a and I_B.

20%: 每題 5 分

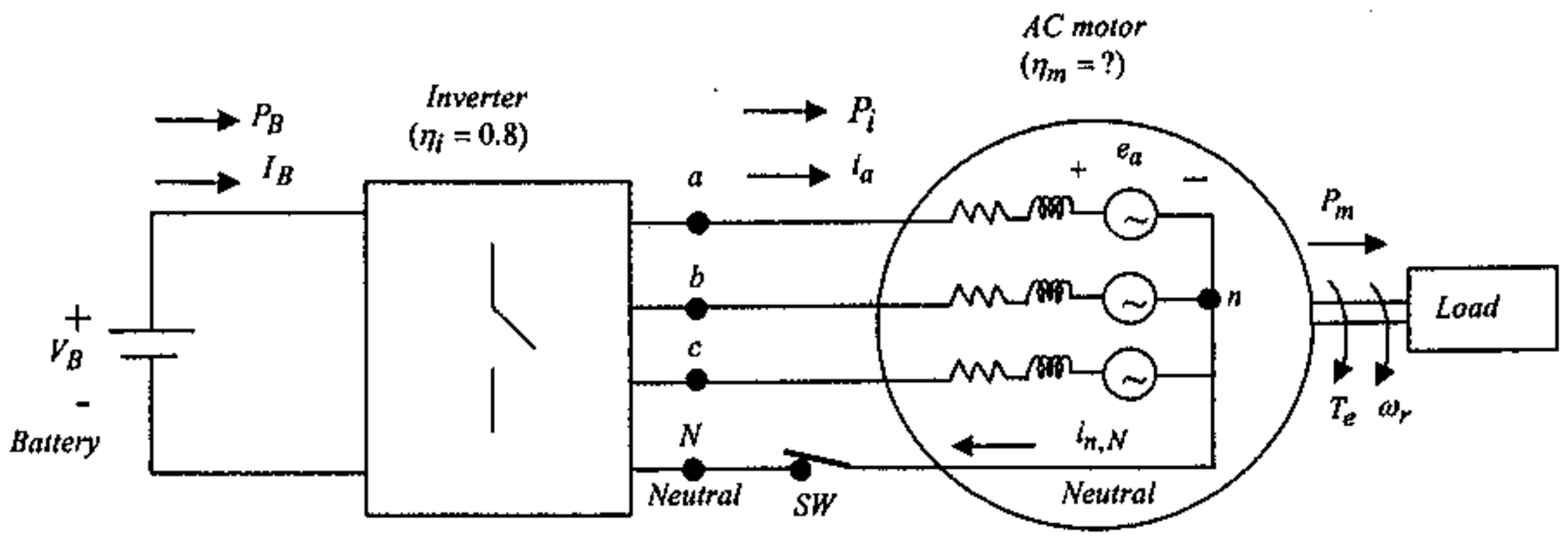

Figure 1

Voltage Control and Power Flow

3. (a) Give two voltage control schemes commonly applies to the power system.

(b) For each scheme you gave in (a), explain how the scheme is modeled in the power flow analysis.

(c) One of the voltage control schemes can also react when the system encounters transient instability problem. What is the scheme?

(d) For a 345kV power system, if the 345kV overhead lines were all replaced with underground cables (as such the power system had excess reactive power), what phenomena do you expect for the system if the power flow computation still converges? Answer by giving multiple choices among the following:

(1) Some load bus voltages are higher than the rated.

(2) Some system generators are operating in the under-excitation mode.

(3) The generator at swing bus could be tripped by loss-of-field protective relay.

(4) The surge impedance loading increases for this 345kV network.

(5) None is correct.

In you answer to (a) and (d), you are not requested to explain; as for (b) and (c), you are requested to give one sentence only for each scheme.

20%:每題 5 分

Transformer Modeling and Fault Analysis

4. Figure 2 depicts an artificial industrial power system. As shown, a 3-winding transformer feeds power from the 161kV system outside the plant to the inplant motors. The inplant motors at 2 voltage grades are grouped into two equivalent motors respectively.

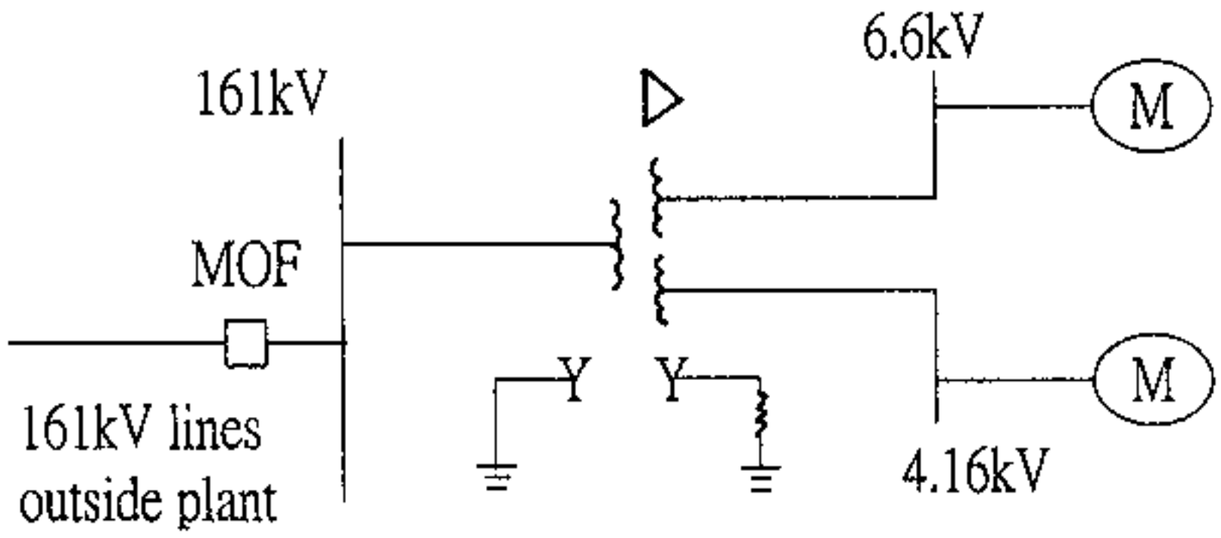

Figure 2

System data in per unit on system base (75MVA, 161kV) are given below (As shown, the given below are only notations for these system data.):

3-winding transformer

- Voltage rating for p. s. t windings: 161kV/6.6kV/4.16kV,
- MVA rating for p. s. t winding: 75MVA/ 20MVA/ 15MVA
- P. U. impedance of star-connected equivalent circuit: Z_{pt}, Z_{st}, Z_{tt}
- Grounding resistance at neutral of t-winding: R_g

161kV system impedance

- Positive and zero-sequence impedances: Z_{1s}, Z_{0s}.

6.6kV system equivalent motor

- positive, negative and zero sequence impedances: Z_{1M}, Z_{2M}, Z_{3M}

4.16kV system equivalent motor

- positive-, negative- and zero-sequence impedances: Z_{1m}, Z_{2m}, Z_{0m}

161kV, 6.6kV and 4.16kV inplant feeders: Negligible.

(a) For a 3-Φ fault at 4.16kV bus, draw the sequence network for the faulted system, and indicate the fault point, system neutral and notations for the system data on the network diagram.

(b) Assume the faulted is a direct ground fault (1-Φ-G) at phase A of the same bus. Draw the sequence network for the faulted system, and indicate in the same way as problem (a).

(c) Assume the grounding resistance for R_g is 2.4Ω, give a formula to calculate R_g in pu on the system base selected above.

(d) To evaluate the circuit breaker rating at 4.16kV bus, one must calculate the possible maximum fault current. What are the fundamental factors necessarily evaluated in the calculation? Answer by giving multiple choices among the following:

(1) 3-Φ fault current at 4.16kV bus,

(2) 1-Φ –G fault current at 4.16kV bus,

(3) X_1/R_1 ratio where R_1+jX_1 is the equivalent impedance derived from the positive sequence network of (a) and the 3-Φ fault current: $I_{f3\phi}=1.0/(R_1+jX_1)$.

(4) X_0/R_0 ratio where $R_0 + j X_0$ is the equivalent impedance derived from the zero sequence network of (b) in the same way as in statement (3).

(5) R_0/X_1 ratio where R_0 and X_1 have been defined in statements (3) and (4).

(6) X_0/X_1 ratio where X_0 and X_1 have been defined in statements (3) and (4).

(e) To evaluate the arrester rating at 4.16kV bus, one must calculate the possible highest system voltage (which is an overvoltage) under the bus fault condition. What are the fundamental factors necessarily evaluated in the calculation? Answer also by giving multiple choices among (1)~(6) of problem (d).

For problem (c), you need not calculate numerically; for (a)~(e), you need not give any explanation.

30%: (b)每題 10 分，其餘每題 5 分

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Protection Relay

5. (a) Figure 3 depicts the equivalent circuit of a CT connected to an overcurrent relay. Assume during the fault of protected feeder, CT saturates. What actions will you take to solve the saturation problem? Answer by giving multiple choices among the following:
(1) Increase the CT ratio;
(2) Increase relay's CTS (Current tap setting);
(3) Decrease relay's TDS (Time dial setting);
(4) Add harmonic restraint function to the relay;
(5) Decrease the current tap setting of relay's restraint winding;
(6) None is correct.

(b) For a differential relay to protect substation's main transformer, what actions will you take to prevent the relay from maloperation due to current inrush? Answer by also giving multiple choices among (1)~(6) of problem (a).

For problem (a) and (b), you need not give any explanation.

10%: 每題 5 分

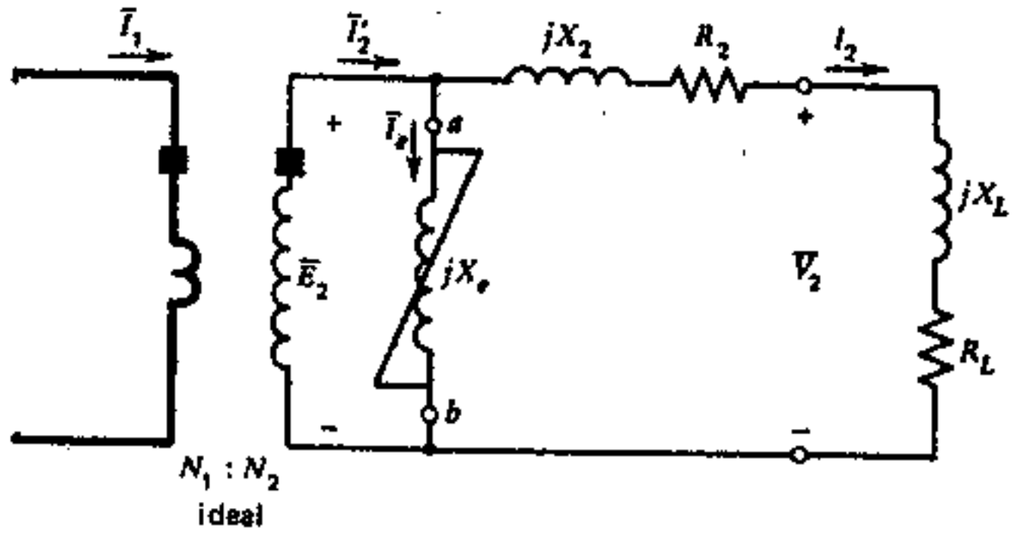

Figure 3