Cork Institute of Technology

Higher Certificate in Engineering in Electrical Engineering – Award

(NFQ Level 6)

Autumn 2006

Electrical Power Systems & Equipment

(Time: 3 Hours)

Instructions
Answer FIVE questions.
All questions carry equal marks

Examiners: Mr. J. C. Duggan
Mr. M. Hennessy
Prof. E. McQuade

Q1. The start-up sequence for an industrial plant is specified below. Control is by single stop and start push buttons. Motors M_1, M_2 and M_3 are to be started in sequence with 10s intervals between each start.
After M_3 has started a solenoid value, SV_1, is to operate for 1 minute and then turn off.
An O/L on any motor stops all. An emergency stop is required. Develop a suitable control circuit. (20 marks)

Q2. (a) A 400V. 50Hz industrial supply has an impedance of 0.0013 + j 0.0061Ω. Cables from transformer to L.T bus-bars have a resistance of 0.15mΩ. A balanced three phase short-circuit occurs on the bus-bars.
Using the information supplied in appendix A and diagrams 3 or 4 determine
(i) The steady state RMS symmetrical current.
(ii) The initial peak asymmetrical current.
Take the value of E as 410 and F as 1.1 (10 marks)

(b) A H.T supply has a capacity of 20 MVA and a Z_{pu} of 0.25. Two transformers T_1 and T_2 are supplied from this source. T_1 and T_2 are identical and have values of 6 MVA and Z_{pu} of 0.05.
Determine the maximum fault level when the transformers are connected in parallel.
(10 marks)

Q3. (a) Equipment for use in potentially explosive gas atmospheres is classified in terms of suitability for

(i) Gas Groups.

(ii) Hazardous Areas.

(iii) Temperature Class.

Explain the significance of each. (9 marks)

(b) A squirrel cage induction motor intended for use in a potentially explosive gas atmosphere has part of its marking labelled as EEx 'd,e'.

Explain the principle of the protection method(s) provided by this motor. (6 marks)

(c) Write a brief note on the ATEX directives. (5 marks)

Q4. (a) Describe a moulded case circuit breaker (MCCB). (5 marks)

(b) State the advantages of using solid state (electronic) trip units in MCCBs. (5 marks)

(c) Outline the arrangements of switch contacts in an MCCB to facilitate

(i) Conduction of current.

(ii) Making and breaking of current. (5 marks)

(d) A *reverse loop* magnetic blow-apart contact system is often used in MCCBs. Briefly describe how this system works. (5 marks)

Q5. (a) Describe the construction of

(i) A standard rotor of a squirrel cage induction motor (SCIM)

(ii) The rotor of a double cage or high torque SCIM. (8 marks)

(b) Sketch and explain the speed / torque characteristic of the motors in (a) above. (6 marks)

(c) Describe the arrangements for starting a wound rotor induction motor (WRIM). Explain how the rotor of such a motor produces an increased torque during starting conditions.

(8 marks)

Q6. (a) Write a concise note to explain why reduced voltage starting methods may sometimes be required for SCIM. (6 marks)

(b) List *four* such starting methods. (4 marks)

(c) Sketch the power (mains) circuit for a star-delta starter. (6 marks)

(d) Explain a delta-loop star-delta starter and state its advantage. (4 marks)

Q7. (a) Describe how an inductor motor may be protected against

(i) Short Circuit.

(ii) Overload. (6 marks)

(b) A SCIM requires a long run-up time when starting against a load known to have a high inertia. Describe a method of overload protection which may be applied to such a starting condition. (8 marks)

(c) What is meant by the term "single phasing" as applied to a three phase motor? What arrangements are made against this condition causing stator burn-out? (6 marks)

Q8. (a) For an ACB or MCCB what is meant by the following

(i) Rated current, I_N

(ii) Frame size rating.

(iii) Rated ultimate breaking capacity, I_{CU}

(iv) Rated short-time withstand current, I_{CW}

(v) Rated insulation voltage, U_i (10 marks)

(b) The supply arrangements to an industry requires that a number of circuit breakers may only be closed in a defined way.

Breakers C_1 and C_2 may be closed together.

Breaker C_3 may be closed in combination with either C_1 or C_2, *but not both*.

Describe a key interlocking system to facilitate this. (6 marks)

(c) Distinguish between a "short key" and a key exchange box system of Cartell interlocks. (4 marks)

4.3 **RELATIONSHIP BETWEEN SUPPLY SYSTEM SHORT-CIRCUIT VALUES**

The short-circuit current values I_p, I_s and I_k described in 4.1, and shown in Diagram 1 are related as follows:

$$I_k = \frac{V_r}{\sqrt{3} \times Z} \times 1.1^*$$

I_s = I_k+contribution from connected motors (See 4.2 above).

I_p = $I_s \times M$

Where V_r = rated line voltage (RMS) of the transformer.

Z = impedance to point of fault in ohms.

*1.1 is a factor to take account of high voltage value on the HV side.

M = Asymmetry factor which is a function of the $\frac{R}{X}$ ratio of the faulted circuit. (See Diagram 3).

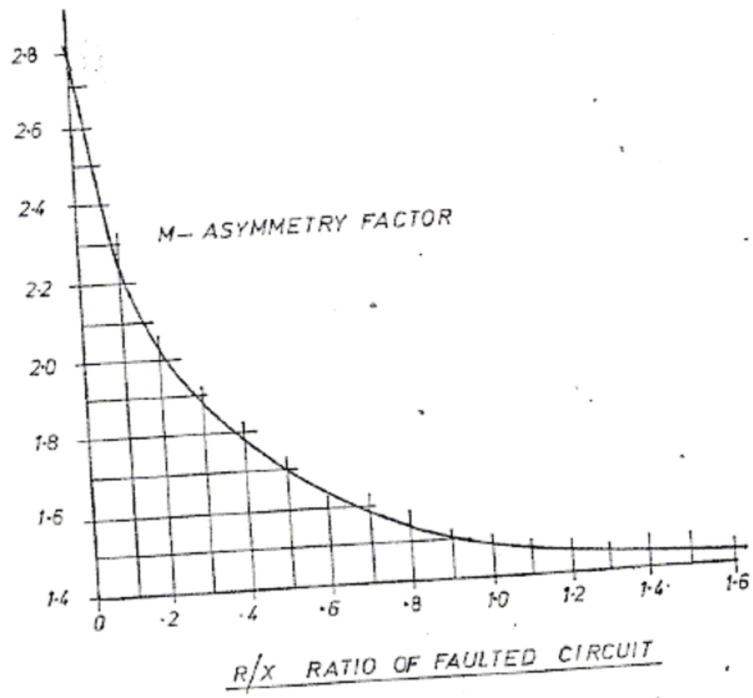

Diagram 3.

APPENDIX A

EXAMPLES OF FAULT LEVEL CALCULATIONS

A-1 **METHODS OF CALCULATING SHORT CIRCUIT VALUES**

The following formulae are applicable to the calculation of the short circuit values defined in Section 4.

(a) Steady State Symmetrical Short Circuit Current.

$I_k = \frac{E \times F}{\sqrt{3} \times Z} (A+jB)$ in RMS Amps

I_k = Absolute value of I_k in RMS Amps.

(b) Initial Symmetrical Short Circuit Current.

$I_s = I_k + I_m$ (RMS Amps.)

I_s = Absolute Value of I_s in RMS Amps.

(c) Peak Asymmetrical Short Circuit Current.

$I_p = I_s \times M$ (Instantaneous Amps.)

Where

E = Circuit EMF in Volts.
= Rated 10 kV/LV transformer open-circuit voltage.

F = Factor to allow for tap ratio, and H.V. system voltage variations.

Z = Absolute Value of total circuit impedance in ohms.

A+jB = Cosine and Sine of phase angle of Ik with respect to E.

$A = R / \sqrt{R^2+X^2}$

$B = X / \sqrt{R^2+X^2}$

R = Total Resistance of impedance of Figure 4.2 ohms.

X = Total Reactance of impedance of Figure 4.2 ohms.

(Note: These circuits are generally inductive, and in such cases B is negative).

I_m = Motor short circuit current.
= $6 \times$(Motor Rated Current)$\times(0.3-j0.954)$

If the motor rated current is not known, it should be assumed equal to the transformer rated current.

M = The asymmetry factor which is a function of the R/X ratio of the faulted circuit. It may be read from Diagram 3.

Examples of calculations are given in Appendix A-2 and data for some frequently occurring applications are given in Appendix A-3.

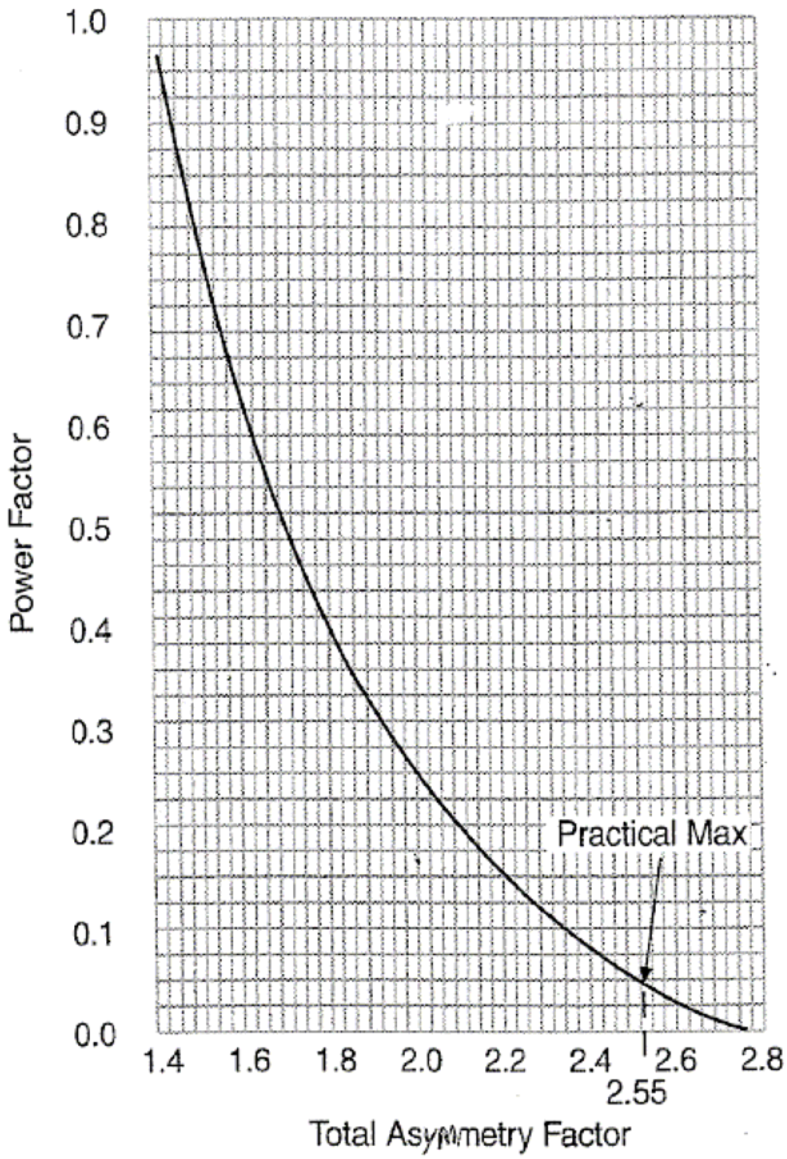

Figure 4
Asymmetry Factor Chart