Cork Institute of Technology

Higher Certificate in Engineering in Electrical Engineering – Award

(NFQ Level 6)

Summer 2007

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. (a) With the aid of neat labelled sketches, explain the following types of short circuit faults.

(i) three-phase balanced fault

(ii) ungrounded phase to phase fault

(iii) phase to ground fault (6 marks)

(b) A low voltage supply has a source impedance of 0.0013 + j 0.0061 Ω.
The feed from transformer to LV bus-bars has a cable resistance of 0.15 m Ω.
A symmetrical (balanced) three-phase short circuit occurs across the bus-bars.
Assuming values for voltage of 410 V and voltage variation of 1.1 and using tables supplied, calculate:

(i) the final steady state symmetrical fault current

(ii) the initial asymmetrical peak fault current (10 marks)

(c) Discuss the possible effects large motors installed close to the intake may have on the initial fault current cycles. (4 marks)

Q2. (a) Outline the conditions necessary to allow two power transformers to operate in parallel. (5 marks)

(b) The supply to an industry is obtained from two transformers connected in parallel.
The load delivered is 500 kW at a power factor of 0.82, lag.
Transformer T_1 has resistance and inductive reactance values of 3.0 and 4.5 Ω respectively. The corresponding values for T_2 are 2.8 and 5.2 Ω.
Determine:

(i) the power share in kW of each transformer

(ii) the power factor at which each transformer operates (15 marks)

Q3. (a) Identify the conditions necessary to cause an atmospheric explosion of a flammable substance. (3 marks)

(b) The nameplate on an apparatus intended for installation in a potentially explosive atmosphere includes the following markings:

EEx "1_a" IIc T_6

Explain the meaning of the codes used on this nameplate. (4 marks)

(c) Potentially Explosive Gas Atmospheres are defined by three terms:

(i) Gas Groups
(ii) Hazardous Zones
(iii) Temperature Classes

Explain the significance of each of these terms. (6 marks)

(d) Outline the principle of operation and give a practical application of one of the following protection methods:

(i) EEx, d
(ii) EEx, e
(iii) EEx, p (7 marks)

Q4. (a) Explain the concept of an intrinsically safe system. (4 marks)

(b) In relation to an intrinsically safe *associated apparatus*, explain:

(i) a non-countable fault
(ii) a countable fault
(iii) an infallible component (6 marks)

(c) For an intrinsically safe system, distinguish between:

(i) the ratings "1_a" and "1_b"
(ii) an IS *apparatus* and an IS *associated apparatus* (10 marks)

Q5. (a) In relation to circuit breakers to IEC 947-2 (EN 60947-2), explain what is meant by:

(i) I_{cm} , rated s/c making current

(ii) I_{cu} , rated ultimate breaking current

(iii) I_{cw} , rated short-time withstand current

(iv) Category A

(v) Category B (10 marks)

(b) Briefly discuss *discrimination* and *cascading* for series connected (major and minor) LV circuit breakers. (5 marks)

(c) Sketch the *general shape* of the trip characteristic of a LV circuit breaker. Explain the advantages of an electronic trip unit of a circuit breaker. (5 marks)

Q6. (a) State concisely why squirrel cage induction motors (SCIM) are favoured as industrial drives. (5 marks)

(b) With the aid of neat labelled sketches, show that you understand the concept, construction and application of:

(i) a standard SCIM

(ii) a double cage SCIM

(iii) a wound rotor induction motor (15 marks)

Q7. (a) For a typical induction motor, sketch:

(i) the torque/speed curve

(ii) the current/speed curve (4 marks)

(b) Explain whey a reduced voltage starting method may sometimes be required for a squirrel cage induction motor (SCIM). (6 marks)

(c) With the aid of a power (line) diagram, explain the operation of <u>one</u> method of reduced voltage starting of a SCIM. (10 marks)

<u>OR</u>

(c) Briefly discuss the concept of soft starting for SCIM. (10 marks)

Q8. (a) The LV supply to an industry is delivered from a supply company source which has a capacity of 15 MVA at a per unit impedance of 0.30.

Two on-site transformers are fed from this supply.

The rating of T_1 is 5.5 MVA at 2 p.u. of 0.06, while T_2 has a rating of 6 MVA at Z pu. of 0.05.

Determine the fault level in MVA if the installation is fed from:

(i) T_1 only

(ii) T_2 only

(iii) T_1 and T_2 connected in parallel (12 marks)

(b) The supply arrangements for a factory requires that a number of circuit breakers may only be closed in a defined manner.

CB_1 and CB_2 may be closed together.

CB_3 may be closed if CB_1, or CB_2, is closed but not with both CB_1 and CB_2 closed.

Describe a suitable key interlocking system for this arrangement. (5 marks)

(c) Discuss the advantages of a key-exchange box interlocking (Costell) system. (3 marks)

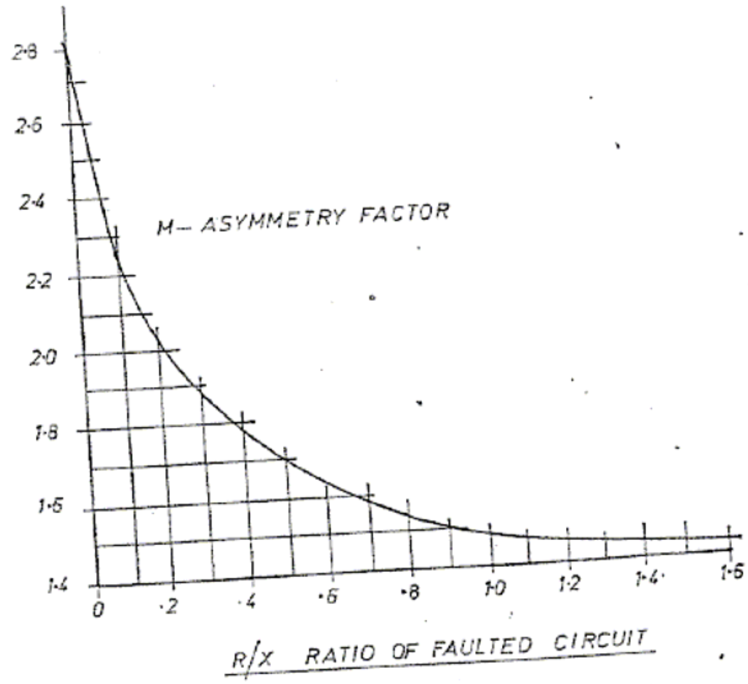
2·8
2·6
2·4
2·2
2·0
1·8
1·6
1·4
M— ASYMMETRY FACTOR
0
·2
·4
·6
·8
1·0
1·2
1·4
1·6
R/X RATIO OF FAULTED CIRCUIT

Diagram 3.

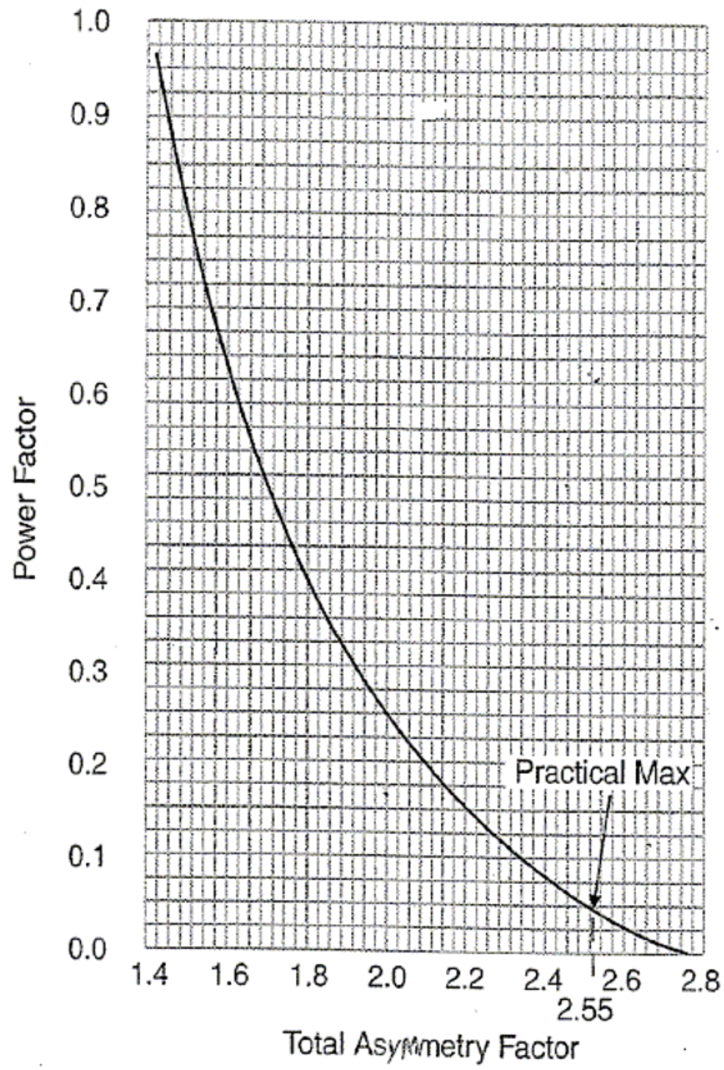

Figure 4
Asymmetry Factor Chart

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.
		(Noté: These circuits are generally inductive, and in such cases B is negative).
I_m	=	Motor short circuit current.
	=	6×(Motor Rated Current)×(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.