Cork Institute of Technology

Higher Certificate in Engineering in Electrical Engineering – Award

(National Certificate in Engineering in Electrical Engineering – Award)

(NFQ – Level 6)

Autumn 2005

Electrical Power Systems and Equipment

(Time: 3 Hours)

Answer FIVE questions.

All questions carry equal marks.

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Q1. (a) With the aid of neat, labelled diagrams explain the following types of short circuit faults

(i) Three phase symmetrical (balanced) fault (2 Marks)

(ii) Phase to phase (ungrounded) fault (2 Marks)

(iii) Phase to ground fault (2 Marks)

(b) An industrial consumer has a supply impedance of $0.00125 + j\,0.006\Omega$. A balanced three-phase short circuit occurs at the intake. Using the information provided in appendix A and diagram 3, determine,

(i) the steady state rms symmetrical current

(ii) the initial peak asymmetrical current

Assume the supply voltage, E, to be 400V and factor F is 1.1. (14 Marks)

Q2. An industrial control system has the following specification:

Motor M_1 may be run in either forward or reverse direction. Starting is by means of forward or reverse push buttons.

If M_1 is started in the forward direction, after 10 seconds motor M_2 will start and continue to run.

If M_1 is started to reverse, motor M_3 will start immediately and run for 30 seconds only.

The stop button stops all motors. An overload on M_1 stops all motors. An overload on M_2 or M_3 stops only that motor. Develop a suitable control circuit. (20 Marks)

Q3. (a) A H.T. supply has a capacity of 12 MVA and a 25% impedance. It supplies two transformers in parallel. Transformer T_1 has a capacity of 6MVA and a 5% impedance, corresponding values for T_2 are 5MVA and 4.5%. A fault develops on the secondary side of the transformers.

Determine the maximum level of the fault if it is supplied by

(i) Transformer T_1 only

(ii) Transformer T_2 only

(iii) Both transformers in parallel. (16 Marks)

(b) Briefly explain a simple, H.T. ring distribution system. (4 Marks)

Q4. (a) A number of circuit breakers in a supply arrangement may only be closed in a defined way.

CB_1 or CB_2 may be closed alone.

CB_1 and CB_2 may be closed together.

CB_3 may only be closed provided either CB_1 or CB_2 is open.

Describe a key interlocking system to facilitate this arrangement. (10 Marks)

(b) For circuit breakers to IEC 947-2 explain the difference between I_{cu}, rated ultimate breaking current and I_{cw} rated short time withstand current. (5 Marks)

(c) Briefly discuss *discrimination* and *cascading* as applied to series connected circuit breakers. (5 Marks)

Q5. (a) State why three phase, squirrel cage induction motors are favoured as industrial drives. (6 Marks)

(b) What is meant by the term "fail to safe" (fail-safe) in engineering and give an example of its application. (4 Marks)

(c) Give <u>three</u> examples of braking of electric motors and explain the operation of any <u>two</u> of these. (10 Marks)

Q6. (a) Reduced voltage starting methods may sometimes be required for SCIM. State <u>four</u> such starting methods and discuss any <u>two</u> under the following headings:

current, voltage, torque, application and limitations. (12 Marks)

(b) Name the protective features incorporated in an induction motor circuit. State the function of each of these features. (4 Marks)

(c) Explain, with the aid of a diagram, one application of a Current Transformer (CT). (4 Marks)

Q7. (a) Discuss why a P.L.C. may be chosen over a hard-wired / electromechanical control system for a modest industrial manufacturing plant. (8 Marks)

(b) Name the main parts of a P.L.C. and state their function. (6 Marks)

(c) List five distinct control functions which are available on a P.L.C. Show in list or ladder format how any two of these are applied in practice. (6 Marks)

Q8. (a) Hazardous places / potentially explosive atmospheres are classified in terms of zones. Name and define these zones. (6 Marks)

(b) Identify the conditions necessary to cause an atmospheric explosion of a flammable substance. (4 Marks)

(c) List three protection concepts for electrical apparatus for use in potentially explosive atmospheres. Describe the basic techniques for any one protection method.

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.

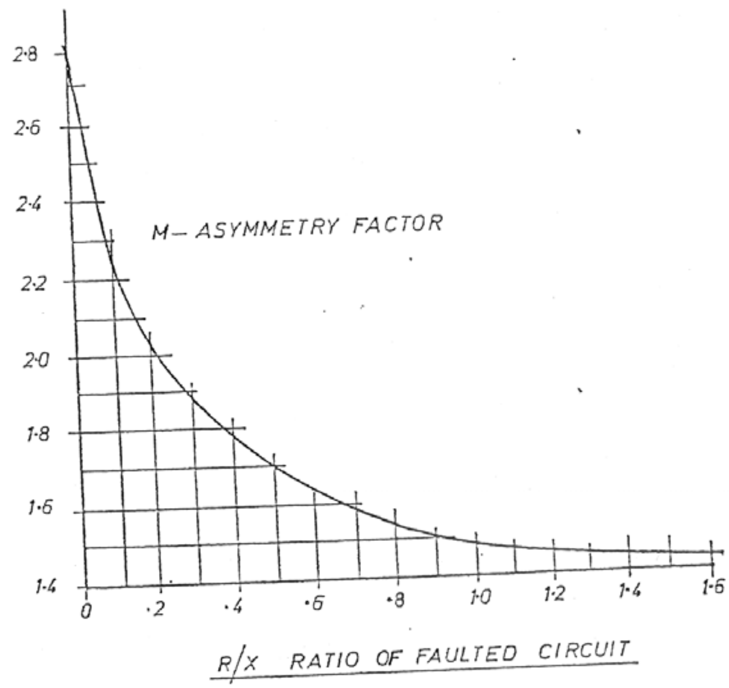
2·8
2·6
2·4
2·2
2·0
1·8
1·6
1·4
M— ASYMMETRY FACTOR
0
·2
·4
·6
·8
1·0
1·2
1·4
1·6
R/X RATIO OF FAULTED CIRCUIT

Diagram 3.