GENERAL CERTIFICATE OF EDUCATION BOARD

Technical and Vocational Education Examination

Automatic Control of Electrical Machines 2
7240

JUNE 2022 **ADVANCED LEVEL**

Specialty Name and Acronym	**Electrical Power Systems – EPS (F3)**
Subject Title	**Automatic Control of Electrical Machines**
Subject Code N°	**7240**
Paper N°	**2**

Duration: 3 Hours

INSTRUCTIONS TO CANDIDATES

This is a **WRITTEN PAPER** and has a Weighting of **35%** of the whole subject marks.

The Paper has Two Sections (A and B).

Section A has THREE QUESTIONS each carrying **10 marks. ANSWER ANY TWO QUESTIONS.**

Section B has THREE QUESTIONS each carrying **40 marks. ANSWER Question 4** and **ANY OTHER.**

All sketches must be neat and clear.

You are allowed the use of Electronic Calculators and Mathematical Sets.

You are also reminded of the necessity for good English and orderly presentation in your answers.

You are advised to read carefully through the question paper, before you begin your answers.

SECTION A: ELECTRICAL MACHINES

1. A 4-pole separately excited dc generator has 310 armature conductors and runs at 1200 rpm. The machine is excited by a 220V d.c. source and the emf generated is 400V. The armature and field resistances are 0.5Ω and 200Ω respectively. The machine is used to supply a load of 50A. Calculate:

a) The flux per pole **(2 marks)**

b) The terminal voltage **(2 marks)**

c) The power delivered to the load **(2marks)**

d) The excitation current **(2marks)**

e) The excitation power **(2marks)**

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2. A single –phase transformer is supplied by a sinusoidal voltage whose effective value is V_1= 2200V at a frequency of 50Hz.

- A no load test carried out on this transformer gave the following results:-

  V_{10}= 2200V, I_{10}= 1A; P_{10}= 550W; V_{20} = 220V.

- A short circuit test gave the following results:

  V_{1sc} =150V; I_{2sc}= 100A; P_{1sc} = 750W.

- A load test gave the following results:-

  V_{1N} = 2200V, I_{2N}= 100A, $Cos\theta_2$ = 0.8 lagging.

a) Calculate the no load power factor. **(1 mark)**

b) Calculate the equivalent resistance of the transformer referred to the secondary. **(1mark)**

c) Calculate the equivalent impedance referred to the secondary (Zeq) and the equivalent Reactance referred to the secondary. **(3marks)**

d) For a nominal load:-

i) Calculate the voltage drop at the secondary using KAPP approximation. **(1 mark)**

ii) Construct the KAPP diagram. **(1 mark)**

iii) Using the approximate formula, calculate the secondary voltage drop. **(1 mark)**

iv) Calculate the active power at the secondary and deduce the efficiency of the transformer. **(2 marks)**

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3. A 6 pole, 3-phase induction motor develops a power of 22.38KW, including mechanical losses which total 1.492kW at a speed of 950rpm on 380V-50Hz mains. The power factor is 0.88. Calculate for this load:

a) Give two comparative differences between rotating and non-rotating machines **(1mark)**

b) Calculate the

i) slip (s) **(1mark)**

ii) The rotor copper losses (2 marks)

iii) The Electrical input power to the motor (2 marks)

iv) The efficiency of the motor (3 marks)

v) The line current (1 mark)

SECTION B CONTROL SYSTEMS

4.

A- DESCRIPTION

A pharmaceutical product factory wants to install a device for weighing and mixing products to constitute tablets as shown in figure 1 below.

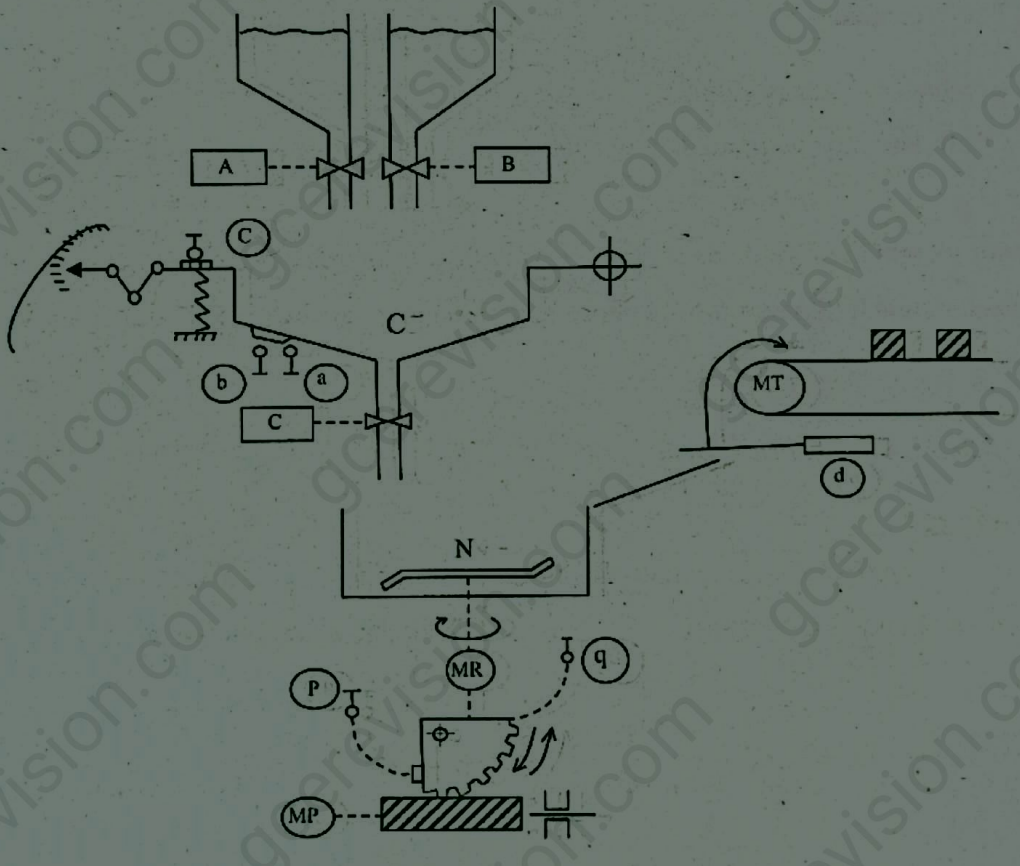

Figure 1

B- FUNCTIONNING

The mixer N receives the products A and B weighed by the weighing machine C and the soluble brick which can became powder, the bricks are brought one after another by a carpet MT. The automatic

system permits to realise a mixture of the three products. The motor MP permits the emptying of the mixed products.

B-1 Cycle of Functioning

The cycle starts only if the weighing machine C is empty.

An action on the push button D_{cy} provokes simultaneously the weighing and the releasing of the products according to the following procedure:

- Weighing of the product A (action on a); then weighing of the product B (action on b); emptying of the weighing machine C (action on c) in the mixer N.
- Arrival of two brick separately (action on d).
- Rotation of the mixer for 2 min (transition from star to delta takes 10sec).
- The motor MP rotates forward to empty the solution and is stopped by p, and then it returns and is stopped by q. The cycle ends

NB: - The system has emergency stop S_0

-The sequence of mixing must be immediately after the previous sequences of weighing and arrival of brick.

-The sequences of weighing of products and the arrival of the brick must be simultaneous

-A two-way selector switch (S_3) permits to choose a functioning cycle by cycle (C/C) or automatic cycle (CA).

C- TECHNOLOGICAL SPECIFICATIONS

C1- Operative Part

The installation is equipped with threesimple effect jacks A, B, C associated to distributors 3/2 controlled electrically and return by spring. The other actuators have the following characteristics as shown in table 1.

Table 1

Designation	Characteristics	Pre- actuators
Jack A	Simple effect	A
Jack B	Simple effect	B
Jack C	Simple effect	C
MT	3-phase squirrel cage induction motor 220/380V: direct online starting	KM1
MR	3-phase squirrel cage induction motor 220/380V; star-delta starting	KA2; KM3; KA4
MP	3-phase squirrel cage induction motor 220/380V: direct online starting, forward and reverse	KM5; KM6

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C2- Control Part

The sensors a, b, c, d, and p are limit switches of Tele mechanic.

- **Safety and protection**

The general protection of the installation is assured by a 4 -Poles fuse isolator. The motors are protected by a thermal relay.

- **Supply**

The supply is 3 x 380 + N + T.

- **Functional chart**

The GRAFCET level 1 in ***figure 2*** describes the functioning of the system.

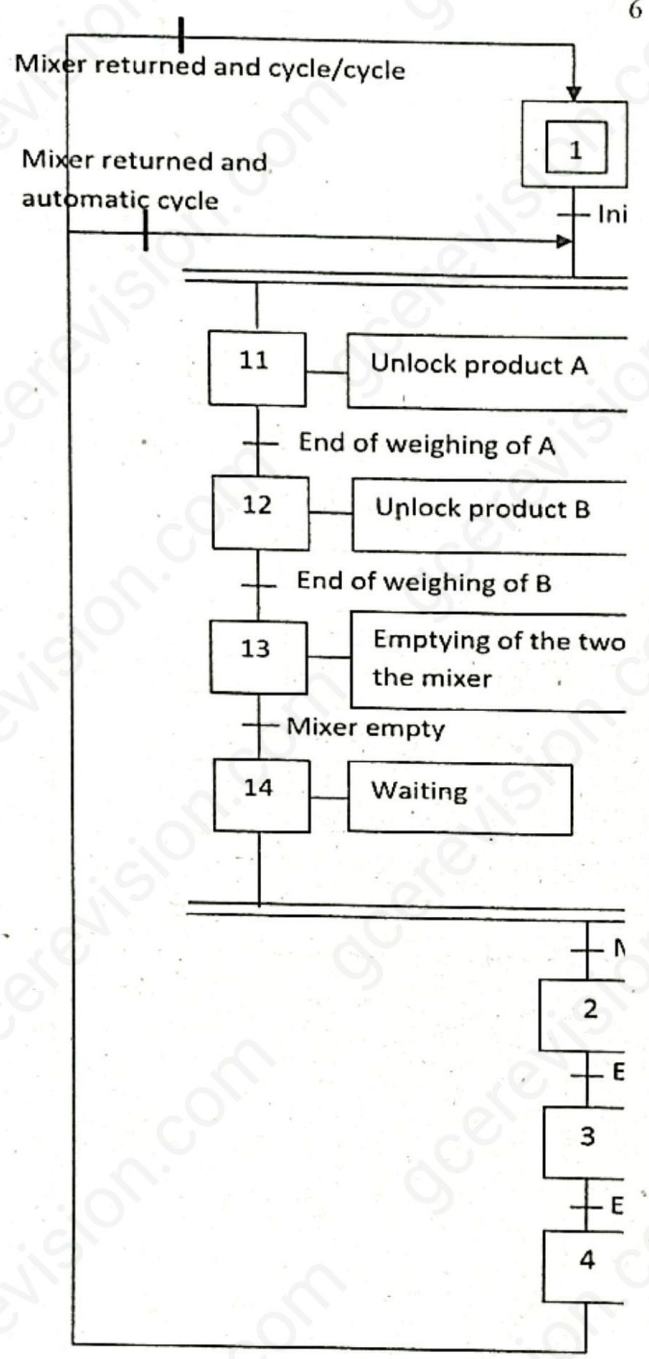

Figure 2: GRAFCET Level I

D- WORK REQUIRED

i) Establish the complete diagram of the power circuit of the installation. **(20 marks)**

ii) From the GRAFCET level 1 given, establish the GRAFCET level 2 corresponding to the functioning of the system **(20marks)**

5. **Automated Packing Process:** Table 2 gives the activation, deactivation and output equation of a GRAFCET Level 2 of a system not describe.

a) Activation and Deactivation Equations

Table 2

Stage	Activation	De-activation	Output										
			A +	B +	C +	E +	A-	B-	C-	E-	KM 1	X	T=5S
0	$A9.c_0$	1											
1	$A_0.S_0.\ a_1.\ b_1.\ S_i.\ S_1.\ c_0.\ c_0 + A3.S_1.\ S_c^-$	2				1							
2	$A1.e_1$	3								1			
3	$A2.c_0$	1 + 4									1		
4	$A3.\ S_1.\ S_c + A7.\ a_1.\ S_1.\ S_t^-$	5						1				1	
5	$A4.b_0.\ x_0$	6		1									
6	$A5.\ b_1.\ x_1$	7					1						1
7	$A6.a_0.t/6/5sec$	8 + 4	1								1		
8	$A7.a_1.\ S_1.\ S_t$	9			1								
9	$A8.c_1$	0							1				

b TSX- 21 PLC of Telemecanique is used to program this system with the following Addresses of table 3.

Inputs Addresses Outputs Addresses Addresses of Stages

Inputs	Code/Address
S_0	200
S_1	201
S_i	202
S_c	203
S_t	204
a_0	205
b_0	206
c_0	207
e_0	210
x_0	211
a_1	212
b_1	213
c_1	214
e_1	215
x_1	216
t	217

(a)

Output	Code/Address
A^+	230
B^-	231
C^+	232
E^+	233
KM1	234
T	235
A^-	236
B^-	237
C^-	240
E^-	241
X	242

(b)

Stage	Code/Address
0	000
1	001
2	002
3	003
4	004
5	005
6	006
7	007
8	010
9	011

(c)

Table 3

WORK REQUIRED

Program the system using TSX 21 respecting the Addresses of table 3 **(40 marks)**

6. The GRAFCET LEVEL TWO represented in figure 3 is that of a packing unit in a soap factory.

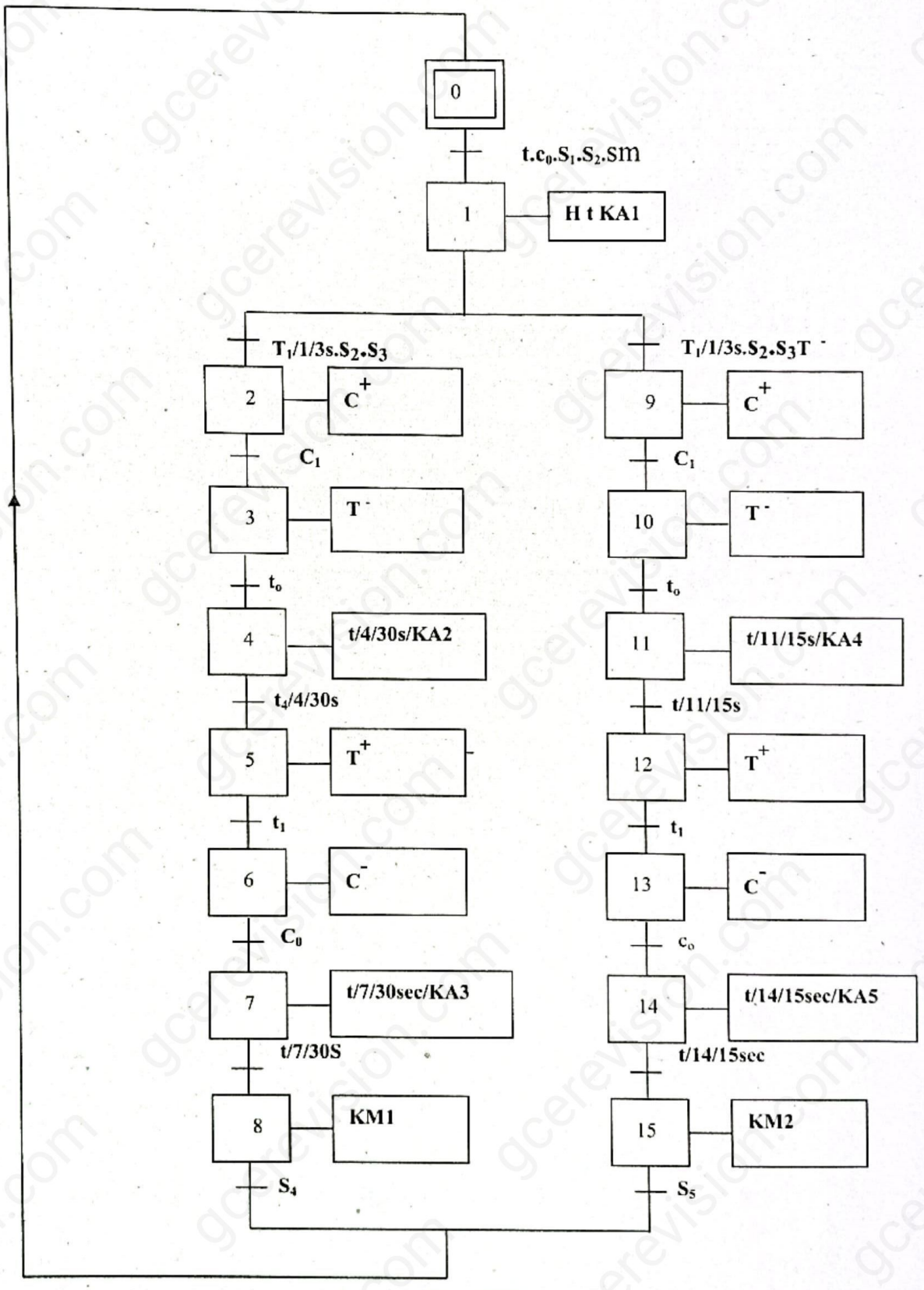

Figure 3: GRAFCET level II

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Tables 4, 5 and 6 give the addresses inputs, output and addresses of stages respectively.

Table 4: Inputs Addresses

Inputs	Code/Address
S_1	200
S_2	201
S_3	202
S_4	203
S_5	204
t_0	205
t_1	206
c_0	207
c_1	210
Sm	211
T_4	771
T_7	772
T_{11}	773
T_{14}	774
T_1	775

Table 5: Output Addresses

Output	Code/Address
H	230
C^-	231
C^-	232
T^+	233
T^-	234
KM1	235
KM2	236

Table 6: Addressesof stages

Stage	Code/Address
0	000
1	001
2	002
3	003
4	004
5	005
6	006
7	007
8	010
9	011
10	012
11	013
12	014
13	015
14	016
15	017

WORK REQUIRED

Wire the pneumatic sequencer from the GRAFCET of figure 3 **(40 marks)**