CAMEROON GENERAL CERTIFICATE OF EDUCATION BOARD

Technical and Vocational Education Examination

JUNE 2020 **ADVANCED LEVEL**

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

Three hours

This Paper has **Two** Sections (A and B) to Answer **FOUR** Questions.

Section A: Answer Any TWO Questions.

Section B: Answer Question FOUR and Any Other One.

You are advised to read carefully through the question paper, before commencing your work.

All sketches must be neat and clear.

Calculators and Mathematical Sets are allowed.

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

SECTION A: ELECTRICAL MACHINES

1. D.C Machines

a) Give two conditions for a shunt generator to build up and produce electrical energy **(1 mark)**

b) Explain and prove using formulae why a d.c series motor must not operate at No-Load **(2 marks)**

c) A 60KW, long shunt, compound-wound generator delivers its rated current of 150A at its rated voltage.

(i) Draw and label a circuit diagram of this machine and calculate **(2 marks)**

(ii) Calculate:-

a) the rated voltage of the generator **(1 mark)**

b) the resistance of the generated load **(1 mark)**

(iii) If the resistance of the series field, shunt field and armature are 0.075, 220 and 0.15Ω, respectively, calculate the current in the shunt and series field **(1 mark)**

(iv) Calculate:-

a) the voltage across the armature **(1 mark)**

b) the generated e.m.f. **(1 mark)**

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2. A single phase 15kVA, 2300/230V transformer has $R_1 = 3.1\Omega$, $X_1 = 9.2\Omega$, $R_2 = 0.029\Omega$ and $X_2 = 0.088\Omega$. At no load it draws a current of 0.18A at a power factor of 0.3 lagging.

a) Draw the equivalent diagram of the transformer referred to the primary **(2 marks)**

b) Draw the equivalent diagram of the transformer referred to the secondary **(2 marks)**

c) Calculate the equivalent reactance (X_{eq}), equivalent resistance (R_{eq}) and the fictive elements (resistance R_C and magnetising reactance X_m) all referred to both primary and secondary **(2 marks)**

d) If the transformer supplies a full load current at a power factor of 0.8 leading, calculate:

i. The voltage across the load **(2 marks)**

ii. The voltage regulation in percentage **(2 marks)**

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3. A squirrel cage, 4 pole asynchronous motor carries the following indication on its name plate: 3-phase, 50Hz, 230/400V

The resistance of one stator winding is R = 0.7 Ω. The motor is fed by a network of 400V between phases.

a) Determine :

i) The type of windings connection for normal operation? **(0.5 mark)**

ii) The synchronous speed? **(0.5 mark)**

b) On no-load, the motor runs at a speed closed to synchronous speed, absorbs a current of 5.5A and a power of 845W. Determine :

i) The stator copper loss on no-load **(1mark)**

ii) The iron loss if mechanical losses are equal to 500W **(1mark)**

c) At full-load operation, the stator current is 16.5A, power factor $\cos\phi = 0.83$ and rotor speed is 1400rev/min. Calculate :

i. The stator copper loss on load **(1mark)**

ii. The absorbed power **(1mark)**

iii. The rotor input power **(1 mark)**

iv. The slip **(1 mark)**

v. The rotor copper loss **(1 mark)**

vi. The useful power at the shaft **(1 mark)**

vii. The shaft torque **(0.5 mark)**

viii. The motor efficiency **(0.5 mark)**

SECTION B: CONTROL SYSTEMS

4. **Automated Packing Process:** Table 1 gives the activation, deactivation and output equations of a GRAFCET Level 2 of the system not describe.

a) **Table 1: Activation and Deactivation Equations**

Stage	Activation	De-activation	Output										
			A+	B+	C+	E+	A-	B-	C-	E-	KM1	X	T=5sec
0	$A9.c_0$	1											
1	$A0.S_0.a_1.b_1.S_i.S_1.c_0.e_0 + A3.S_1.S_c^-$	2				1							
2	$A1.e_1$	3								1			
3	$A2.e_0$	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) **Use TSX-21 PLCof Telemechnique to program this system with the following Addresses.**

Table2: Inputs Addresses

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

Table3: Outputs Addresses

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

Table4: Addresses of Stages

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

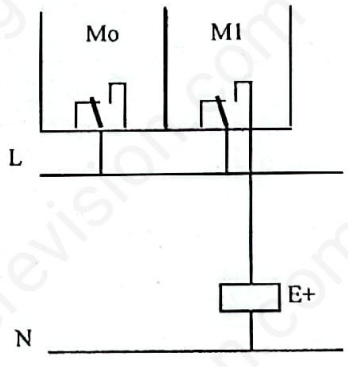

Figure 1: Uncompleted Power circuit

c) **Work required:**

i) Establish the GRAFCET level two of this system **(20 marks)**

ii) Draw its power circuit by completing figure 1 **(20marks)**

5. The GRAFCET level two represented in figure two is that of a packaging unit in a soap factory.

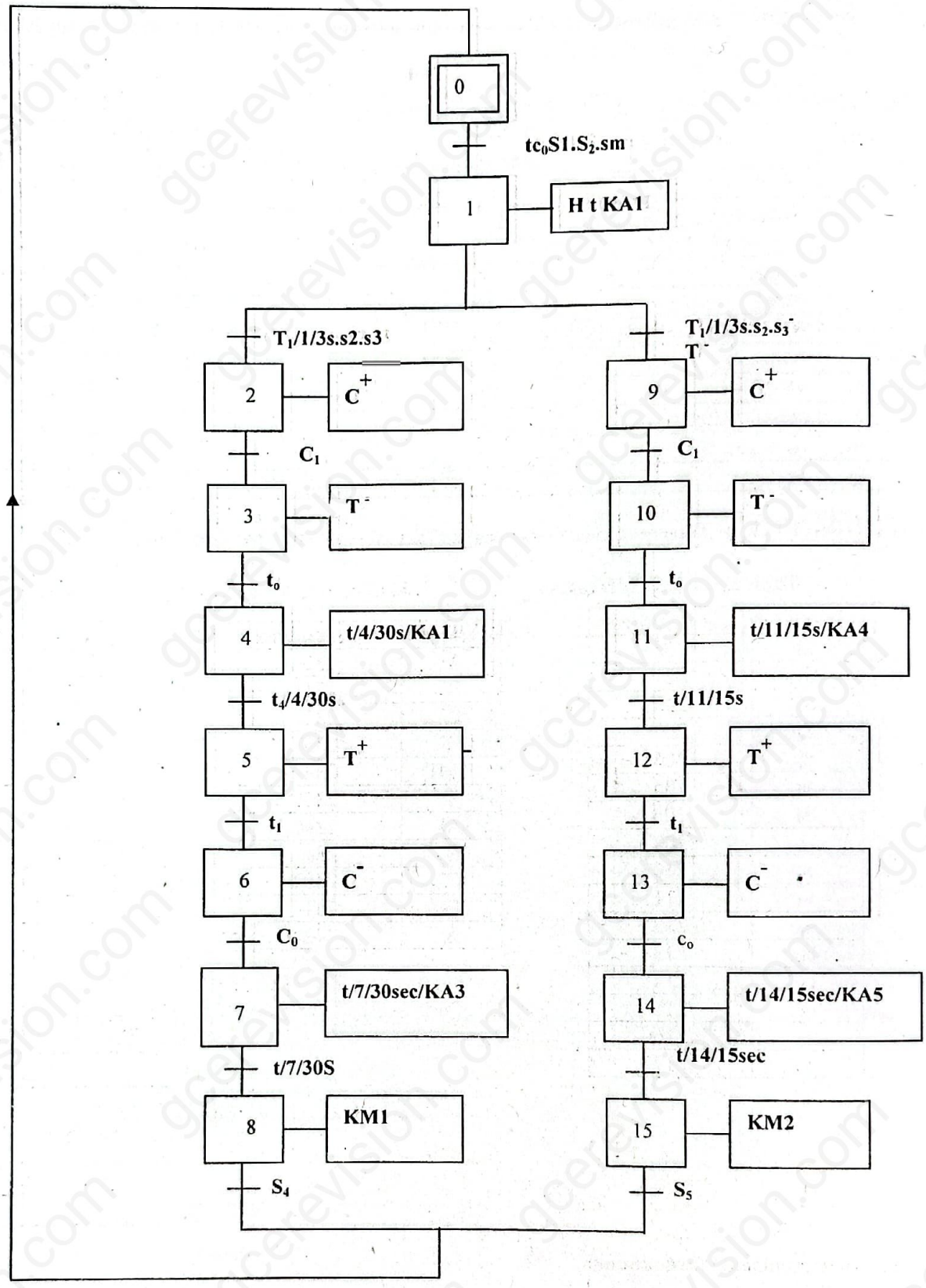

Figure 2: GRAFCET Level II of the automated system

Tables 5, 6 and 7 give the addresses inputs, addresses of stages and addresses of output respectively.

Table5: 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

Table6: Addresses of 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

Table7: Addresses outputs

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

Work required

Carryout the programming of the automated system using TSX-21 PLC of Telemecanique using the addresses given on Tables 5, 6 and 7. **(40 marks)**

6. An automatic system whose description and functioning are not given, is represented by the functional chart in figure 2.

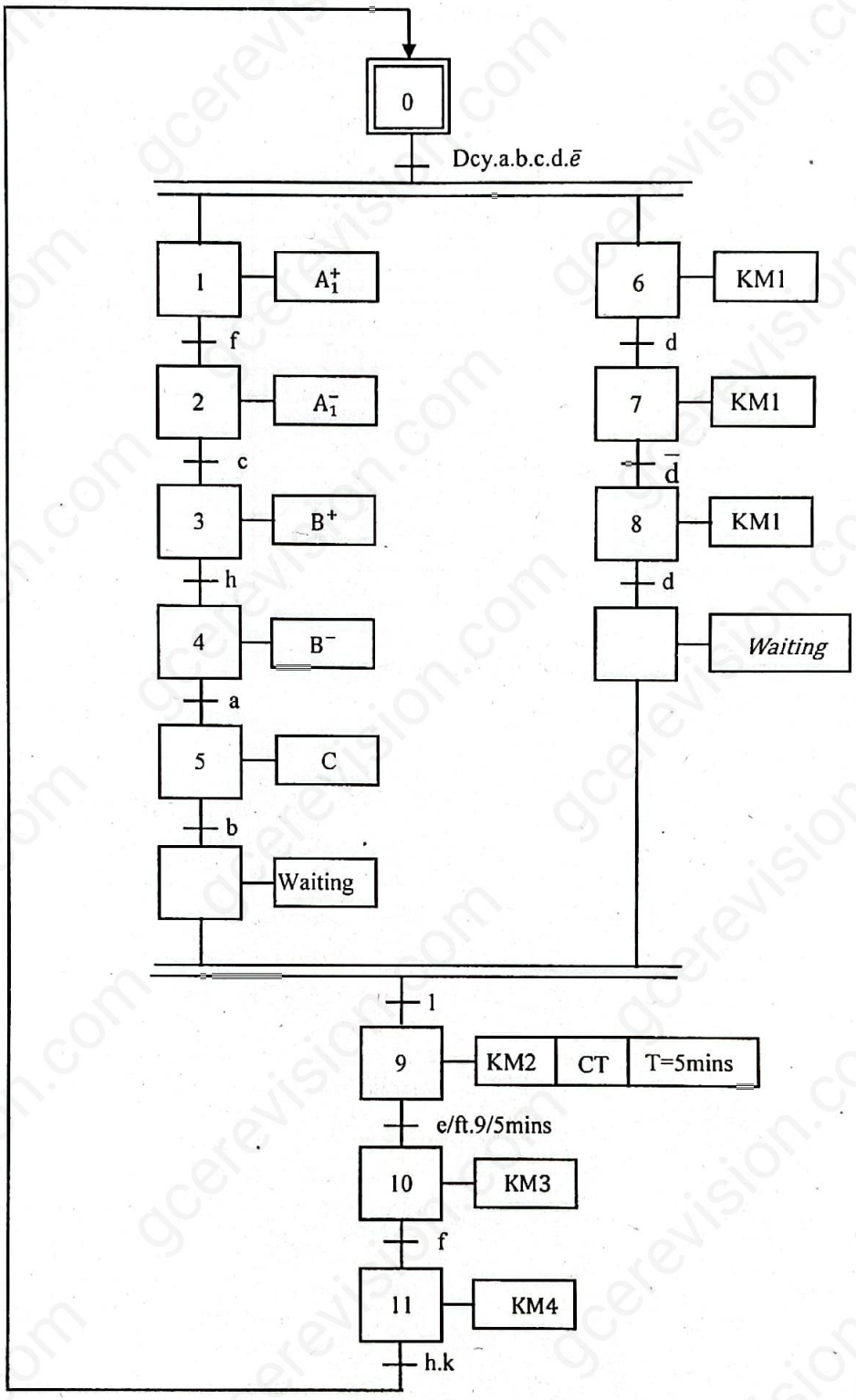

Figure 3

Work Required:

Draw the equivalent electro-magnetic sequencer of Figure 3 **(40 marks)**