

GENERAL CERTIFICATE OF EDUCATION BOARD
Technical and Vocational Education Examination

JUNE 2021

ADVANCED LEVEL

Specialty Name (Specialty Code)	Electrical Power Systems (EPS)
Subject Title	Automatic Control of Electrical Machines
Paper No.	2
Subject Code No.	7240

Three hours

This is a WRITTEN PAPER and has a weight of 35% of the subject.

INSTRUCTIONS TO CANDIDATES

This Paper has Two Sections (A and B).

Section A has Three Questions and each Question carries 10 marks. **ANSWER ANY TWO QUESTIONS.**

Section B has Three Questions and each Question carries 40 marks. **ANSWER QUESTIONS 4 and any other one.**

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

All sketches must be neat and clear.

Calculators and mathematical sets are allowed.

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

Turn Over

SECTION A: ELECTRICAL MACHINES

1. DC MACHINE

- a) Explain and prove using formula, the condition for maximum efficiency in a dc generator. (2 marks)
- b) The following Table 1 gives the open circuit characteristics of a d.c. shunt generator running at 300rev/min

Field current i_f (A)	0	2	3	4	5	6	7
Generated e.m.f. E (V)	0	92	132	162	183	190	212

Table 1

- i. Plot the open circuit characteristics $E = f(i_f)$ for a speed of 300rev/min. and determine the voltage to which the machine will excite if the field circuit resistance is 40Ω . (3 marks)
- ii. What additional resistance would have to be inserted in the field circuit to reduce the voltage to 200 volts at a speed of 300 rev/min? (2.5 marks)
- iii. Without this additional resistance, determine the load current supplied by the generator when its terminal voltage is 200 V. Neglect armature reaction and assume the speed to be constant. Armature resistance is 0.4Ω . (2.5 marks)
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2. A 2MVA, 33/6.6kV, Delta/Star three phase transformer has a primary resistance of 8Ω per phase and 0.08Ω resistance per phase at its secondary. The referred impedance is obtain at 7% of its rated voltage. Calculate:
- a) Transformation ratio (K) of this transformer (1 mark)
- b) The impedance per phase referred to the secondary (Z_{eq2}) (2.5 marks)
- c) The resistance and reactance per phase referred to the secondary (R_{eq2} and X_{eq2}) (2.5 marks)
- d) The secondary voltage per phase at a load of power factor of 0.75lag (2 marks)
- e) The secondary line voltage (1 mark)
- f) The percentage regulation (1 mark)
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3. A 22kVA, 415V three phase star connected Alternator delivers the rated power (kVA) at rated voltage and at 0.8 power factor lagging. The per phase effective resistance and synchronous reactance per phase are 0.5Ω and 4.2Ω respectively. The field winding is supplied with 3.2A at 230V d.c. The friction and winding loss is estimated at 310W. The iron loss is 480W. Calculate:
- a) Full load efficiency (5 marks)
- b) The terminal voltage when the load is thrown off (5 marks)

SECTION B: CONTROL SYSTEMS

4. WASHING AND EVACUATION OF PALM NUTS.

A small automatic system is designed to wash palm nuts. It comprises a collection tank (T_1), a washing tank (T_2), an evacuation tank (T_3), two conveyors (M_1, M_2) and an elevator (E), as shown in figure 1.

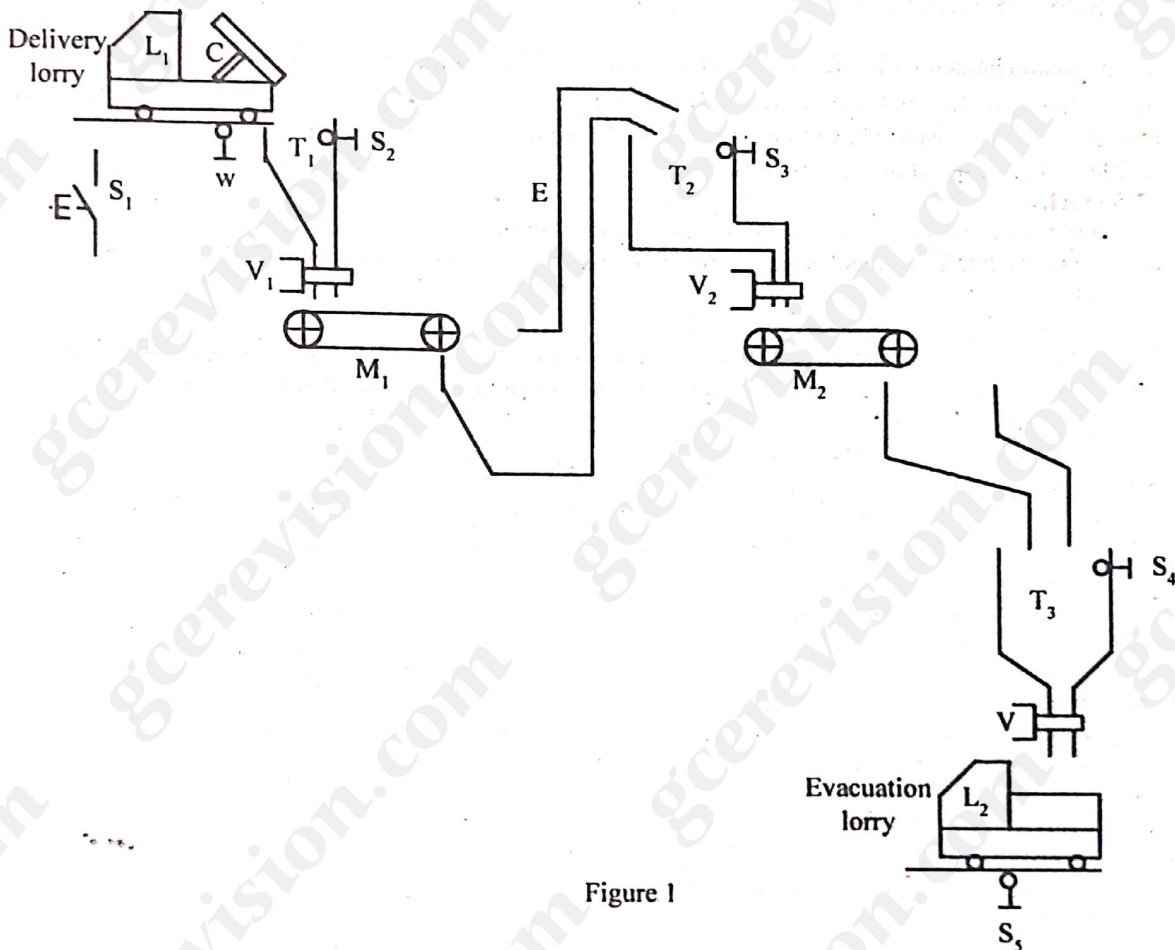


Figure 1

DESCRIPTION.

A delivery lorry (L_1), deposits the nuts into the collection tank T_1 and once this tank is full, a valve V_1 opens to pour the nuts on the conveyor. The conveyor then deposits these nuts for elevation into a washing tank T_2 . Once the washing tank is full, washing starts and ends after five minutes for another valve V_2 to open into a second conveyor. The nuts are conveyed into an evacuation tank T_3 until it is full for a third valve V_3 to open into an evacuation lorry (L_2). The GRAFCET level one of figure 2 illustrates this functioning.

Turn Over

GRAFCET LEVEL 1

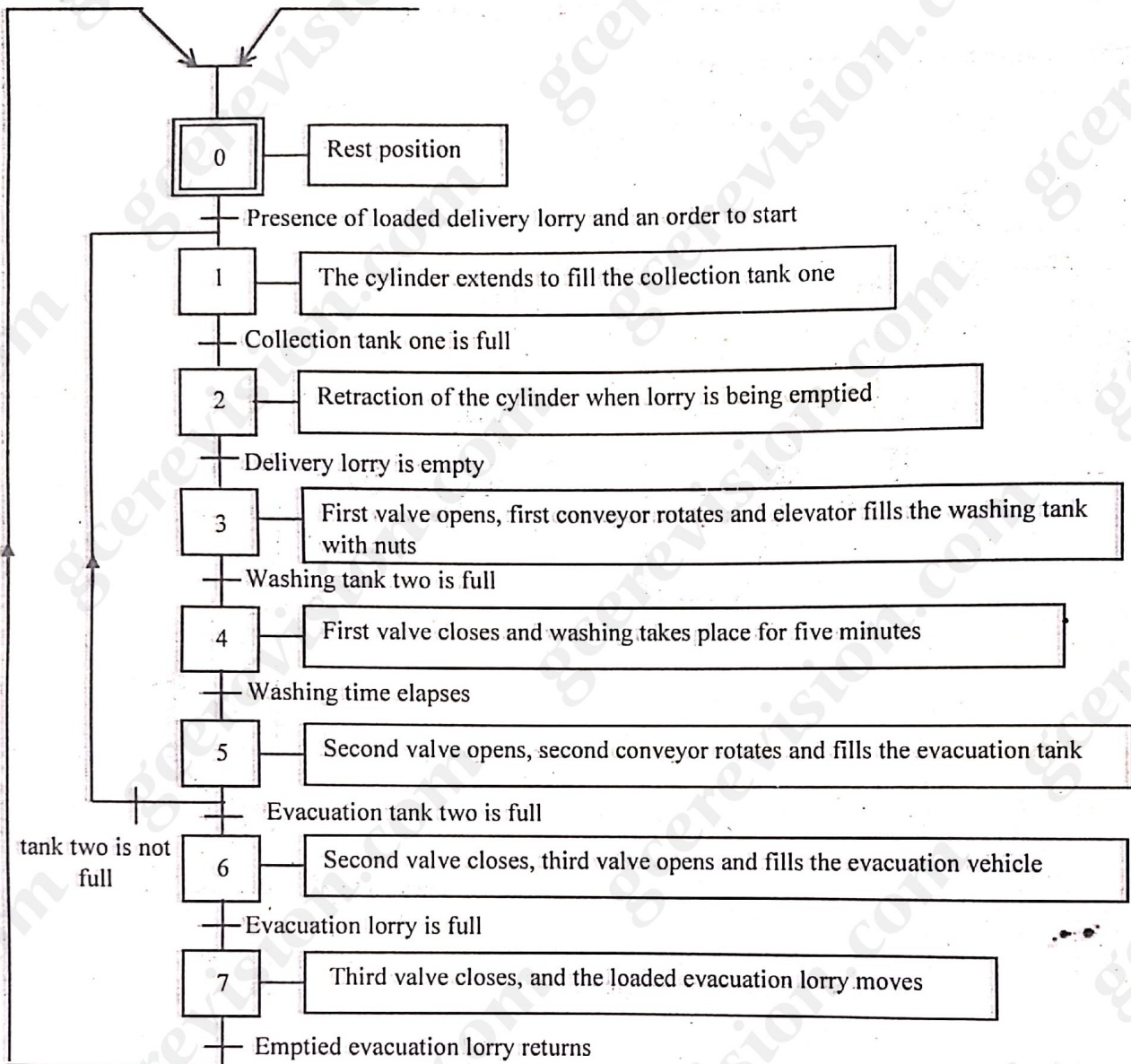


Figure 2

KEY

- Extension of a cylinder (C+)
- Retraction of a cylinder (C-)
- Opening of a valve (V+)
- Closing of a valve (V-)
- Delivery lorry empty ($\overline{w}$)
- Delivery lorry full (w)
- Evacuation lorry empty ($\overline{S_5}$)
- Evacuation lorry full (S_5)
- Rotation of conveyor one (KM1)
- Elevation of nuts (KME)
- Washing of nuts (KM3)
- Rotation of conveyor two (KM2)
- Movement of evacuation lorry (KMA)

III - WORK REQUIRED

Establish the corresponding GRAFCET level II

(40 marks)

5. The GRAFCET level two represented in figure 3 is that of an **AUTOMATIC DISTRIBUTION SYSTEM**, whose description and functioning are not given.

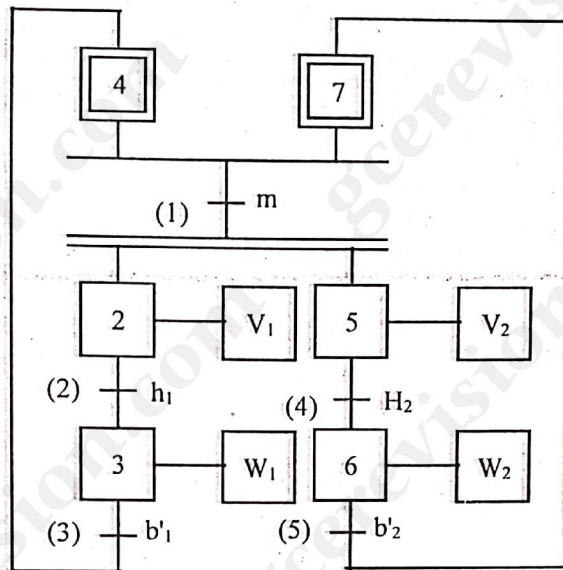


Figure 3

WORK REQUIRED

- a) Establish the activation, deactivation and output equations of this system by reproducing and completing table 2

(15 marks)

STEPS	ACTIVATION	DEACTIVATION	OUTPUT			
			V ₁	W ₁	V ₂	W ₂
4	A3.b1	5.2				
7						
2						
3						
5						
6						

Table 2

- b) Draw the complete equivalent electronic sequencer of system above

(25 marks)

6. The equations of activation, deactivation and action of an automatic system not represented are as in table 3. The system is to be piloted by a PB100 PLC.

STEPS	ACTIVATION	DEACTIVATION	ACTION
0	10.T ₀ . S ₁	1	KM ₁
1	0.S ₀ .n ₀ .f ₀ .t ₀ + 10.t ₀ .S ₁	2	KM ₁ ..KM ₃ .T=3s
2	1.t/1/3s	3	KM ₁ .KM ₂ .KM ₄ .KM ₅
3	2.Pb.C	4	KM ₁ .V ₁ ⁺
4	3.t ₁ + 9.n ₀ .C	5	KM ₁ .V ₂ ⁺
5	4.f ₁	6	KM ₁ .KM ₂ .KM ₃ .T=3s
6	5.t/5/3s	7	KM ₁ .KM ₂ .KM ₄ .KM ₅ . V ₁ ⁻ . V ₃ ⁻
7	6. n ₁ . t ₀ . Pb	8	KM ₁ .V ₂ ⁺
8	7.t ₁	9	KM ₁ .V ₂ ⁻
9	8. f ₀	10	KM ₁ .V ₃ ⁺
10	9. n ₀ .C	0	KM ₁ .V ₁ ⁻

Table 3

Turn Over

Using the addresses of PB100 PLC for steps, captors and outputs as follows:

Steps

Steps	0	1	2	3	4	5	6	7	8	9	10
Addresses	A00	A01	A02	A03	A04	A05	A06	A07	A08	A09	A0A

Inputs

Inputs	S ₀	t ₀	t ₁	f ₀	f ₁	n ₀	n ₁	Pb	C	S ₁
Addresses	000	001	002	003	004	005	006	007	008	009

Outputs

Outputs	KM1	KM2	KM3	KM4	KM5	V ₁ ⁺	V ₁ ⁻	V ₂ ⁺	V ₂ ⁻	V ₃ ⁺	V ₃ ⁻	T
Addresses	020	021	022	023	024	025	026	027	028	029	02A	A10

WORK REQUIRED:

Write the programme using PB100.

(40 marks)