GENERAL CERTIFICATE OF EDUCATION BOARD

Technical and Vocational Education Examination

JUNE 2021	**ADVANCED LEVEL**
Specialty Name / Code	**Electrical Power Systems – EPS(F2)**
Subject Title	**Power Electronics**
Subject Code N°	7235
Paper N°	**2**

Three hours

The Paper has Two Sections (A and B) and constitutes 35% of the whole subject.

Section A has ONE COMPULSORY Question that carries **40 marks**
Section B has FOUR Questions, each carrying 30 marks. ANSWER ANY TWO.

All sketches must be neat and clear.

You are allowed the use of Electronic calculators and mathematical sets.

No programmable calculators are allowed

You are 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.

Turn Over

SECTION A: COMPULSORY

1. **Control of a TRIAC by an R-C circuit and a DIAC:**

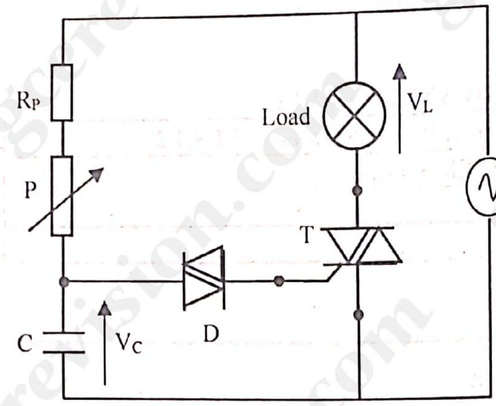


Figure 1.a

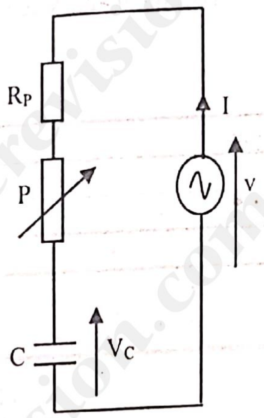


Figure 1.b

Figure 1.a shows an electronic circuit used to control a TRIAC by an R-C circuit and a DIAC. The supply voltage $v(t) = V_{\max} \sin \omega t$

a. In the circuit of figure 1a, identify and give the function of the following elements: T, D, R_P and P **(8 marks)**
b. List the components that constitute the control circuit of figure 1.a **(6 marks)**
c. Let φ be the angle of phase difference between v_c and the supply voltage v; with the help of figure 1.b prove that:
$\varphi = \tan^{-1}(RC\omega)$ with $R = R_p + P$ **(6 marks)**
d. The break- over voltage of the element D lie between +32V and -32V; give the functioning analysis of the circuit of figure 1a. **(4 marks)**
e. Draw the wave form of the voltage across the load **(4 marks)**
f. Prove that the expression of the effective load voltage V_{Leff} is

$$V_{Leff} = \frac{V_{\max}}{\sqrt{2}}\sqrt{1-\frac{\alpha}{\pi}+\frac{\sin 2\alpha}{2\pi}} \text{ or } V_{Leff} = V\sqrt{1-\frac{\alpha}{\pi}+\frac{\sin 2\alpha}{2\pi}}$$ where α is the firing angle of T

(6 marks)

g. Calculate the load active power **(6 marks)**

SECTION B:

2. SINGLE PHASE HALF WAVE RECTIFICATION

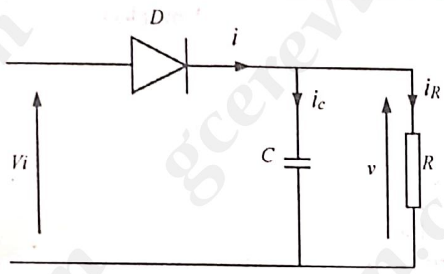


Figure 2.a

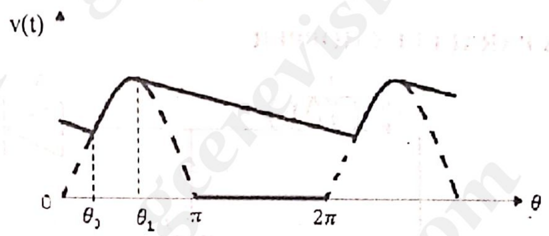


Figure 2.b

We intend to study the functioning of a half wave rectifier supplying a purely resistive load R with a capacitive filter C as shown in figure 2a.
The wave form of the voltage V is given in the figure 2b

Given that; $R = 200\Omega$; $C = 100pF$; $v_i(\theta) = 220\sqrt{2}\sin\theta$ (in volts) with $\theta = 2\pi ft = 314t$.

a) Give the state of the diode in the intervals $\theta \in [\theta_0 ; \theta_1]$ and $\theta \in [\theta_1 ; 2\pi]$ **(3 marks)**

b) express in function of θ the following quantities in the interval $[\theta_0 ; \theta_1]$
   i. The voltage V **(3 marks)**
   ii. The currents i_R; i_c; and i **(8 marks)**

c) Calculate the blocking angle θ_1 of the diode **(4 marks)**

d) Express in function of θ the voltage V in the interval$[\theta_1 ; 2\pi]$. The discharging equation of a capacitor in the resistance R; $V = V_0 e^{-t/RC}$ will be used. V_0 is a constant **(8 marks)**

e) Calculate the voltage V at the instants 95° and 360° **(4 marks)**

3. THREE PHASE HALF-WAVE CONTROLLED RECTIFICATION

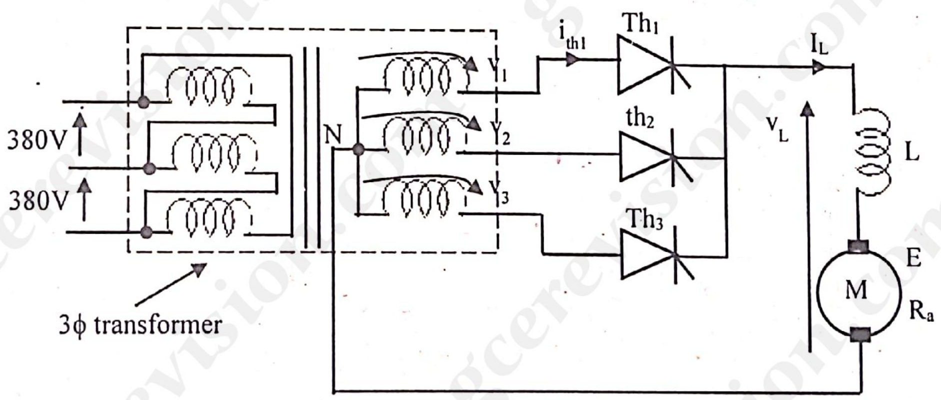


Figure 3

In the three phase half-wave controlled rectification circuit of figure 3, the thyristors are assumed to be perfect. The secondary voltages of the Delta- Star connected transformer are: $v_1(t) = 200\sqrt{2}\sin\omega t$, $v_2(t) = 200\sqrt{2}\sin(\omega t - 2\pi/3)$ and $v_3(t) = 200\sqrt{2}\sin(\omega t - 4\pi/3)$. The inductance L is high enough such that the motor current $i_L = I_d =$ constant. The motor has a back e.m.f. $E = 110V$ and an armature resistance $Ra = 1.235\Omega$. The firing angle of the thyristors is α.

a) Determine the transformation ratio of the transformer. **(2 marks)**

b) Draw on the same axis the following waveforms of the voltages and current using **appendix 1.**
   i. $v_1(t)$, $v_2(t)$, $v_3(t)$ and $v_L(t)$ if the firing angle is $\alpha = \pi/6$ **(6 marks)**
   ii. $i_L(t)$ and $i_{th1}(t)$ **(3 marks)**

c) Determine the minimum, the average and the maximum values of the voltage $v_L(t)$. **(6 marks)**

d) Determine the effective value of the current i_L **(3 marks)**

e) Calculate the useful power supplied to the motor. **(3 marks)** f)

i. Calculate the effective value of the current $i_{th1}(t)$. **(2 marks)**

ii. Determine the apparent power across the secondary winding of the transformer **(3 marks)**

iii. Deduce the power factor. **(2 marks)**

4. STUDY OF A PARALLEL CHOPPER

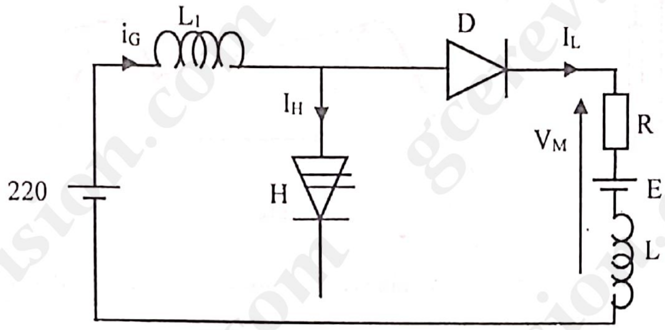


Figure 4

Figure 4 shows how the speed of a series excited dc motor is controlled using a chopper switch H. The cycle starts when the switch (H) is closed. The inductance of the armature winding is high enough to maintain the current constant in the armature.

a) Sketch the waveform of the voltage Vm. **(6 marks)**

b) Sketch the waveform of the currents I_H, I_G,I_a **(6 marks)**

c) Express the average value of Vm in terms of the duty cycle ratio α . **(6 marks)**

d) Give the average value of Vm for the following values of α : $\alpha = 0.5$; $\alpha = 0.75$ and $\alpha = 1$. **(6 marks)**

a) Establish a relation linking the speed of the motor n (rev/sec) and α given that $R=1\Omega$, Ia= 30A and E=7.61n. **(6 marks)**

5. SINGLE PHASE INVERTER

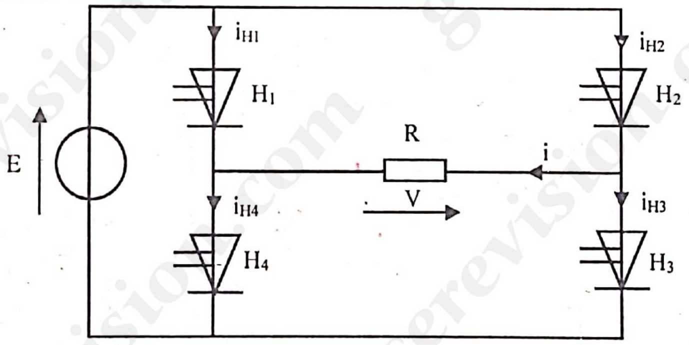


Figure 5

The circuit of figure 5 is an inverter with 4 electronics switches supplied through a generator of e.m.f. E=24V and a load resistance of value $R=100\Omega$.

(a) Indicate the interval of conduction of each switches over one period **(4 marks)**

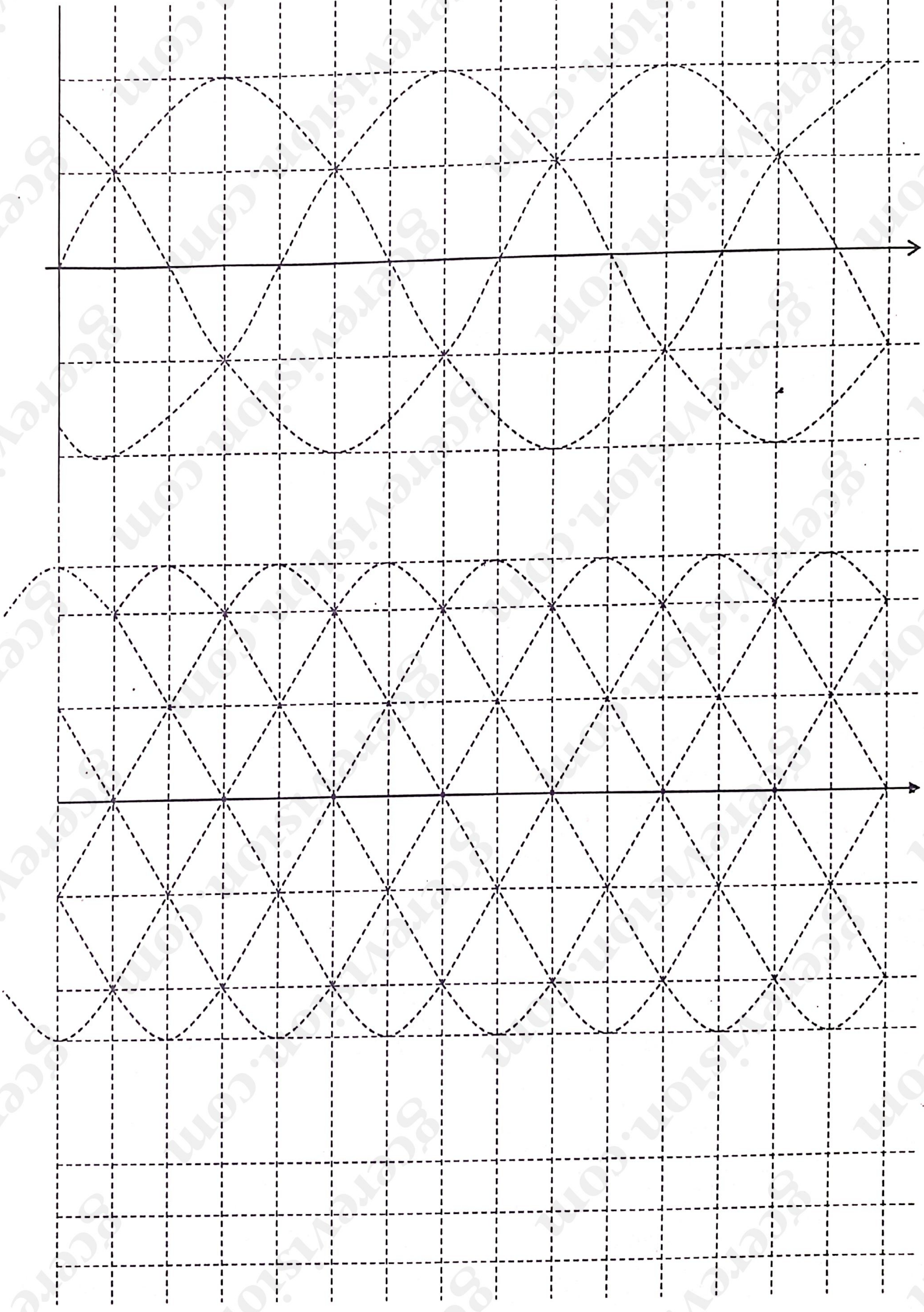
(b) Sketch the wave form of the voltage v(t) and that of the current i(t) across the load **(8 marks)**

(c) Give the value of the maximum voltage V_M of v(t) **(2 marks)**

(d) Determine the power received by the load **(6 marks)**

(e) Calculate the average value of the current through each switch (i_{H1}, i_{H2}, i_{H3}, i_{H4}, and i) **(10 marks)**

Appendix 1 (Q3b)



TO BE SUBMITTED WITH THE ANSWER BOOKLET