ETL - Power Electronics

T078

Thursday, 31/10/2013

8:30 –11:30 AM

WORKFORCE DEVELOPMENT AUTHORITY

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ADVANCED LEVEL NATIONAL EXAMINATIONS, 2013;

TECHNICAL AND PROFESSIONAL TRADES

EXAM TITLE: Power Electronics

OPTION: Electronics and Telecommunication (ETL)

DURATION: 3hours

INSTRUCTIONS:

The paper is contains Three **(2)** Sections:

Section **I**: Sixteen **(16)** questions, all **Compulsory**. **55marks**

Section **II**: Five **(5)** questions, **Choose any Three (3)**. **30marks**

Section **III**: Two **(2)** questions, **Choose any One (1)**. **15marks**

Section I: All the 16 questions are Compulsory 55marks

01. Explain why is IGBT a voltage controlled device. **1mark**

02. A voltmeter shoes 230 VAC. What does it mean? **1mark**

03. What are the different types of power MOSFET? **2marks**

04. Differentiate latching current from holding current in case of a thyristor. **2marks**

05. What are the main components used for isolating the Power Circuits, Power Semiconductor from the low-power circuit? **2marks**

06. Describe a snubber circuit and precise its function. **2marks**

07. What are the different types of chopper with respect to commutation process? **3marks**

08. Differentiate the structure of a DIAC from that of a bipolar Transistor. **3marks**

09. What are the different methods of firing circuits for line commutated converter? **3marks**

10. How is the inverter circuit classified based on commutation circuitry? **4marks**

11. Identify different losses that occur in a thyristor during working conditions. **4marks**

12. Identify five (5) among different applications of controlled rectifier. **5marks**

13. Describe a dc chopper and identify its main characteristics. **5marks**

14. What is the difference between power diode and signal diode? **6marks**

15. Identify in the following components which are current driven and those which are voltage driven: SCR; GTO; GTR; MCT; IGCT; SIT. **6marks**

16. Explain why GTOs are more used in power converters compared to SCRs. **6marks**

Section II. Choose and Answer any three questions. 30marks

17. A UJT has 10V between its bases and is characterized by intrinsic stand-off ratio of 0.6; inter-base resistance of 10kΩ. The forward voltage drop in the pn junction is 0.7V. Determine the value of R_{B1} and R_{B2}; the standoff voltage and the peak-point voltage. **10marks**

18. An operational amplifier has feedback resistor Rf = 12K Ω and the resistances in the input sides are R1=12K Ω, R2=2K Ω and R3=3K Ω with the corresponding inputs voltages applied on inverting terminal Vi_1 = +9V, Vi_2 = –3V and Vi_3 = –1V. Non-inverting terminal is grounded. Calculate the output voltage. **10marks**

19. Identify different types of filters commonly used in power supply circuits and give corresponding schematics. **10marks**

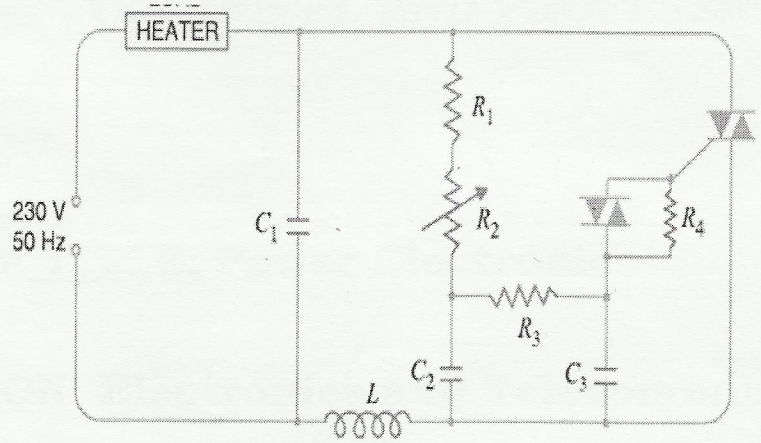
20. **a)** Draw the circuit diagram of Four-diode Full-wave Bridge Rectifier and show the direction of the current through different diodes. **4marks**

b) Identify its advantages and disadvantages. **6marks**

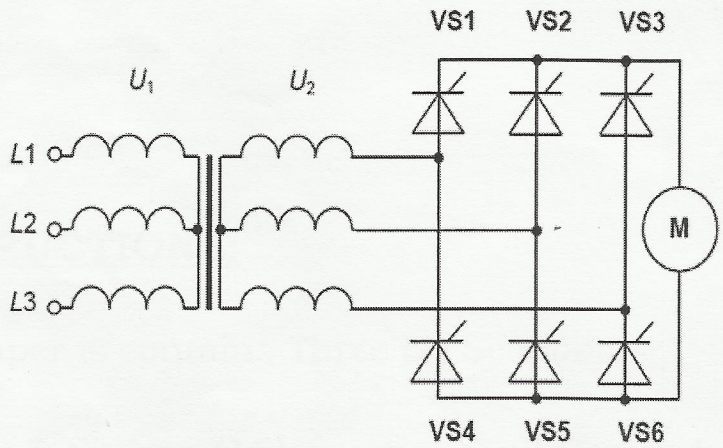
21. Draw the circuit of an OPAMP non-inverting voltage feedback amplifier and deduce the equation for its closed-loop gain. **10marks**

Section III. Choose and answer any One (1) question 15marks

22. Describe the behavior the following circuit : **15marks**



23. Analyze the circuit represented bellow and answer to the questions :



a) What is the type of that circuit? **1mark**

b) Identify its main characteristics. **6marks**

c) Determine the switching order of the elements represented by VS1,VS2,...., VS6. **6marks**

d) What will happen if the element M possesses high inductance? **2marks**

SECTION I.

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01. IGBT is voltage controlled because:
- the controlling parameter is gate-emitter voltage. 1
- the gate terminal is insulated. 1
- the output current is controlled by input voltage. 1

1mark

Consider one only

02. 230 VAC shown by voltmeter means that:
- It is the rms (root mean square) value 1
or - It is the effective value of AC voltage. 1

Consider one only. 1marks

03. Types of power MOSFET
- Enhancement Only MOSFET 1 < N-channel MOSFET 1 / P-channel MOSFET 1
- Depletion-Enhancement only MOSFET 1 < N-channel MOSFET 1 / P-channel MOSFET 1

Consider two. 2marks.

04. - Latching current is the minimum value of anode current which it must attain during turn on process to maintain conduction when gate signal is removed. 1
- The Holding current is defined as the minimum value of anode current below which it must fall to for turning off the thyristor. 1
- Holding current is the maximum anode current, gate being open, at which SCR is turned-off from ON condition 1

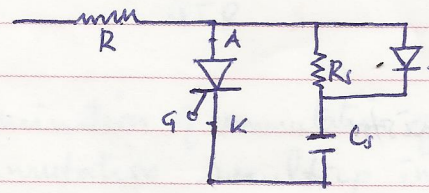
2marks.

Consider two only.

05. Components used isolating power circuits:
- opto-couplers (like opto-triac, opto-thyristor, Relays) 1
- transformers 1
- Solid state relay 1

Consider two only. 2marks.

06. Snubber circuit and its application:

* 

0.5

2marks.

* It consists of a series combination of a resistor and a capacitor in parallel with the thyristors. 0.5
* It is mainly used for $\frac{dv}{dt}$ protection. 1

07. Types of chopper wrt. to commutation process.

- Voltage commutated chopper 1
- current commutated chopper 1
- Load commutated chopper 1 Consider three only — 3 marks
- Line commutated chopper 1
- Forced commutated chopper 1

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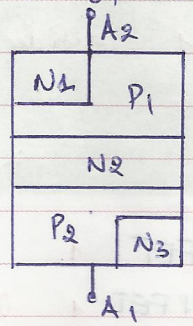
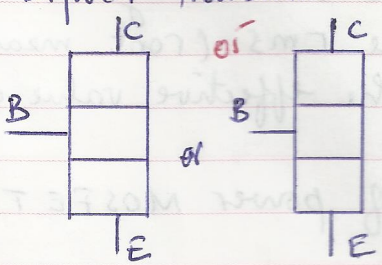
08. DIAC structure



01

- It has four junctions 01
- It has two terminals 01
- There is no terminal attached to base 01
- Three regions are identical nearly layer insite 01
- The doping concentration are identical 01 to give the device symmetrical propertis.

Bipolar transistor.



01

- It has three junctions 01
- It has three terminals 01
- All terminals are attached to base 01
- The regions are not identical 01

Choose consider only three

3 marks

09. Methods of firing circuits for line commutated converter :

- UJT firing circuit 1
- The cosine wave crossing pulse timing contrd 1
- digital firing schemes. 1

3 marks

10. Classificatin of inverters based on commutation circuitry :

- Line commutated inverters 1
- load commutated inverters 1
- Self- commutated inverters 1
- Forced commutated inverters 1

4 marks

11. Different losses occuring in thyristor :

- Forward conduction losses 1
- loss due to leakage current during forward and reverse blocking 1
- Switching losses at turn-on and turn-off 1
- Gate triggering loss. 1

4 marks

12. Five applications of controlled Rectifier.
- Steel rolling mills, printing process, textile mills (different machines) employing Dc motor drives 1
- Dc traction 1
- Electro-chemical and electro-metallurgical process 1
- Portable hand tool drives 1
- Magnet power supplies 1
- HVDc transmission system. 1
- Rectification 1

5 marks. Consider five only.

13. * A Dc chopper is a high speed static switch used to obtain variable Dc voltage from a constant Dc voltage. 1

Dc chopper characteristics:
* High efficiency 1
* Smooth acceleration 1
* Fast dynamic response 1
* Regeneration 1

5 marks.

14. Difference between power diode and signal diode.

Power Diode	Signal Diode.
- Constructed with n-layer, called drift region between p^+ layer and n^+ layer 1	- Drift region is not present 1
- The voltage, current and power ratings are higher 1	- Voltage, current, and power are lower 1
- Power diodes operate at high speeds 1	- Operates at higher switching speed 1
- lower switching speed	- Operate at low speed

6 marks.

15.

Current driven devices	Voltage controlled devices.
SCR 1	MCT 1
GTO 1	IGCT 1
GTR 1	SIT 1

6 marks.

16. a) Elimination of commutation of commutating components in forced 1 commutation resulting in reduction in cost, weight and volume 1

b) Reduction in accoustic noise and electromagnetic noise 1 due to elimination of commutation chokes 1

c) Faster turn-off, permitting high switchings frequencis 1

d) Improved efficiency of the converters 1

6 marks.

SECTION II.

17. a) Determine the value of R_{B1} and R_{B2}.

$V_{BB} = 10V$, $\eta = 0.6$, $R_{BB} = 10K\Omega$, $V_D = 0.7V$

$R_{BB} = R_{B1} + R_{B2}$ 1

$10 = R_{B1} + R_{B2}$ 1

$\eta = \frac{R_{B1}}{R_{B1} + R_{B2}}$ 1

$0.6 = \frac{R_{B1}}{10}$ 1

6 marks

10 marks.

$R_{B1} = 0.6 \times 10K\Omega = 6K\Omega$ 1

$R_{B2} = 10 - R_{B1} = 10 - 6 = 4K\Omega$ 1

b) Standoff voltage

$V_{standoff} = \eta \times V_{BB}$ 1

$= 0.6 \times 10 = 6V$ 1

2 marks

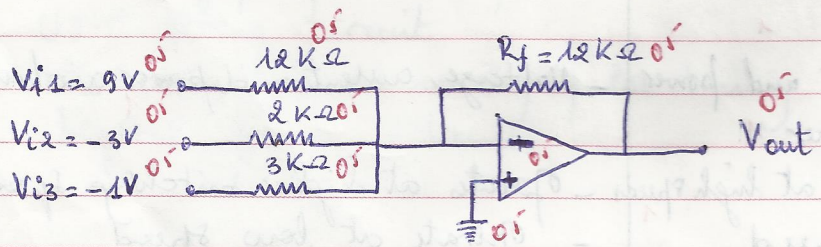
c) Peak-point voltage

$V_{peak-point} = \eta \times V_{BB} + V_D$ 1

$= 6 + 0.7 = 6.7V$ 1

2 marks

18.



5 marks

10 marks

$V_{out} = -\left(\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2 + \frac{R_f}{R_3} V_3\right)$ 1

$= -\left(\frac{12}{12}(9) + \frac{12}{6}(-3) + \frac{12}{3}(-1)\right)$ 1

5 marks.

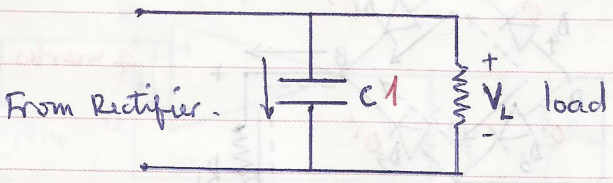
$= -(9 - 18 - 4)$ 1

$= -9 + 18 + 4$ 1

$= 13V$ 1

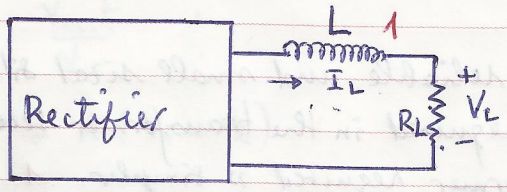
19. Types of filters.

(i) Capacitor : C filter 1



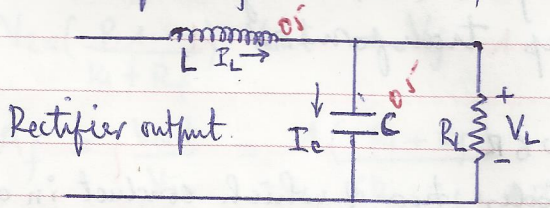
2 marks

(ii) Series inductor filter : L filter 1



2 marks

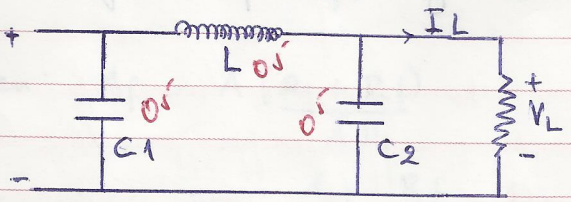
(iii) choke input filter : LC filter 1



2 marks

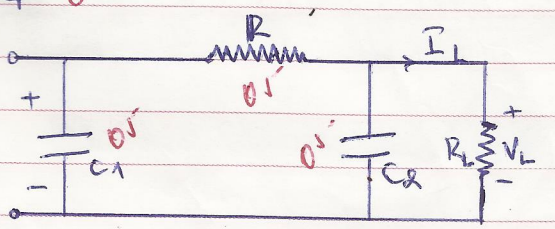
10 marks

(iv) π Filter : CLC filter 0½



2 marks

(v). RC filter 0½



2 marks

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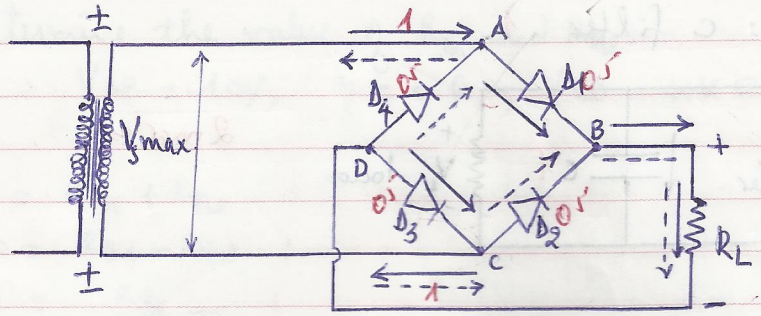
2a. a) Four diode full wave bridge rectifier. (FWBR)



4 marks

b) * Advantages of FWBR.

1. Low cost, highly reliable and small sized silicon diodes 1
2. No centre tap is required in the transformer secondary; the transformer required is simpler. 1
3. The PIV is one half that of centre-tap rectifier 1
4. Transformer Utilization factor (TUF) is higher than that of centre tap transformer. 1

10 marks

4 marks

* Disadvantages of FWBR.

1. It needs four diodes, two of which conduct in alternate half cycles 1
2. Total voltage drop in diodes becomes double of that in case of centre tap rectifier. 1

2 mark.

21. OP-AMP non-inverting voltage feedback amplifier.

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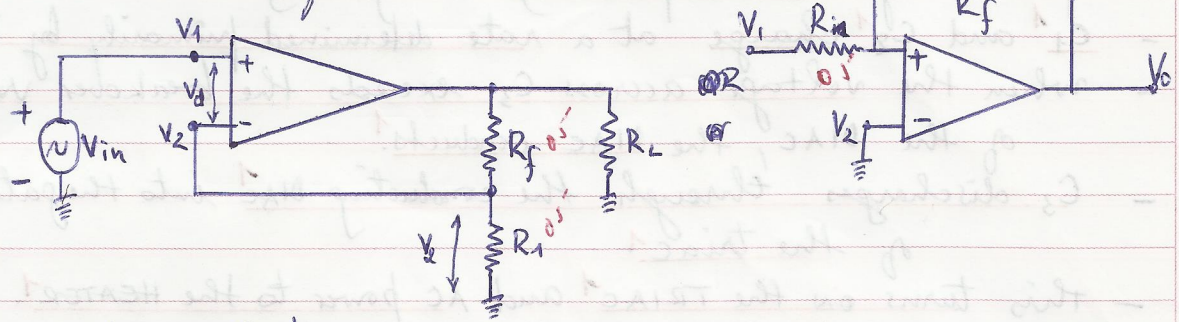
Schematic diagram.



10 marks.

$A_f = \frac{V_{out}}{V_{in}}$ 1

$V_{out} = A(V_1 - V_2)$ 1

$V_1 = V_{in}$ 1

$V_2 = \left(\frac{R_1}{R_1 + R_f}\right) \cdot V_{out} = V_f$ 1

$A_f = \frac{V_{out}}{V_{in}} = A\left(\frac{R_1 + R_f}{(R_1 + R_f + AR_1)}\right)$ 1

As $AR_1 >> (R_1 + R_f)$ and $R_1 + R_f + AR_1 \approx AR_1$ 2

Then $A_f = A\left(\frac{R_1 + R_f}{AR_1}\right)$ 1

$= 1 + \frac{R_f}{R_1}$ 1

SECTION III.

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22. - Input voltage increase positively[1] or negatively[1]
- C_1[1] and C_2[1] charge at a rate determined primarily by R_2[1]
- when the voltage across C_3 exceeds the breakover voltage[1] of the DIAC, the DIAC conducts.[1]
- C_3 discharges through the conducting DIAC[1] into the gate of the triac[1]
- This turns on the TRIAC[1] and AC power to the HEATER[1].
- By adjusting the value of R_2[1], any portion of positive or negative half cycles of ~~cycle~~ supply voltage can be passed through the heater[1].
- this permits a smooth control[1] of the heat output from heater[1].

15 mark

23. a) It is a three-phase bridge rectifier using 6 thyristors[1] or It is a 3ϕ controlled bridge rectifier.

b) 1- This circuit does not require neutral line of the 3-phase[1] source

2- It is a 2 quandrant rectifier.[1]

3- There is more than one open thyristor in cathode group or anode group.[1]

4- Voltage ripple is low because the output voltage consists of 6 pulses per period[2]

5- At least one thyristor from each group must conduct to facilitate the flow of the motor current[1]

6- ~~Determine the switching order of the elements represented~~

15 marks

c) The switching order :

1) $V_{S1} + V_{S6}$ 1
2) $V_{S6} + V_{S2}$ 1
3) $V_{S2} + V_{S4}$ 1
4) $V_{S4} + V_{S3}$ 1
5) $V_{S3} + V_{S5}$ 1
6) $V_{S5} + V_{S1}$ 1

d) If the element M (which constitutes a load to the circuit: for example a motor) possesses high inductance, the forward current continues to flow on the negative anode voltage[1] and the switching-off of the thyristor is delayed.[1]