CHITTAGONG UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Level-3, Term-II, EEE '20 Batch, Examination 2022 - '23, Date: 6 May 2025
Course Code: **EEE 363/ EEE421 (O)**, Title: **Microprocessor and Interfacing**

**Full Marks 210** **Time 3 Hours**

*The figures in the margin indicates marks. Answer any 3 questions from each section. Use separate script for each section.*

## Section A

Q.1(a) What do you mean by a microprocessor and microcontroller? Explain the main tasks of the microprocessor. 10

Q.1(b) How do you define a register? Discuss different types of multipurpose registers. 12

Q.1(c) What is the significance of the flag register? Explain active and status flags of the flag register with relevant examples. 13

Q.2(a) What are the functions of assembler directives? Explain with examples. 5

Q.2(b) Find out the correct and incorrect instructions from the following instructions Correct the incorrect instructions showing appropriate causes. 15

(i) XLAT AX
(ii) POP 1234 H
(iii) IN AL, BX
(iv) MOV 75H, AL
(v) MOV [AX], [BX]

Q.2(c) A Program and memory maps are shown Fig. 2(c). Determine - 15

i) All the register values after the final instruction,
ii) The final change in associated memory map.

```
MOV AX, 5566H
MOV IP, 2003H
MOV SP, 2009H
MOV SI, 2003H
MOV DI, 2004H
DEC BYTE
PTR[SI+2]
CLD
LODS B
STOS W
MOVS B
```

| CS map | | SS map | | DS map | | ES map | |
|---|---|---|---|---|---|---|---|
| 10 | 2009 | A0 | 2009 | 11 | 2000 | AA | 2000 |
| 20 | 2008 | A1 | 2008 | 12 | 2001 | AB | 2001 |
| 30 | 2007 | A2 | 2007 | 13 | 2002 | AC | 2002 |
| 40 | 2006 | A3 | 2006 | 14 | 2003 ← | AD | 2003 |
| 50 | 2005 | A4 | 2005 | 15 | 2004 ← 14 | ~~AE~~ | 2004 ← |
| 60 | 2004 | A5 | 2004 | 15 16 | 2005 55 | 0A | 2005 |
| 70 | 2003 | A6 | 2003 | 17 | 2006 | 1A | 2006 ← |
| 80 | 2002 | | | 18 | 2007 | 2A | 2007 |

Ax = 5

Fig. 2(c)

Q.3(a) Write an assembly language program to clear rightmost 2-bits, to set bit number 7, 8, and to invert the 14 and 15th bit position of a given value FFOEH. 10

Q.3(b) Using jump instruction, write an assembly language program for the following series: 15
1+2+3+4+5+ ... + 100

Q.3(c) Mention three names of relational operators. Differentiate between "While-. ENDW" and "REPEAT – UNTIL" instructions. 10

Q.4(a) Determine the resultant hex code for the following instructions: 20

i) MOV 43H[SI], DH
ii) IN AL, 05H.

[use the supplied table.]

Q.4(b) Write an assembly code which can calculate the sum of first N Fibonacci numbers. 15

## Section B

Q.5(a) With neat sketch, explain about the bus buffering and latching scheme of 8086 microprocessor. 15

Q.5(b) For the following instructions, write down the status of the control pins named as: $\overline{RD}$, $\overline{WR}$, DT/$\overline{R}$, ALE, $\overline{DEN}$ 15

i) IN AL, DX
ii) MOV [AX], BX
iii) MOV [AX], [BX]

Q.5(c) How maximum and minimum mode operations differ in microprocessors? 5

Q.6(a) Why address decoding is necessary? How to decode memory? 10

Q.6(b) Fig. 6(b) shows the 74LS244 tri-state octal buffer used as an interfacing device. 1

i) Determine the port address 5
ii) Write instructions to interface DIP switches.

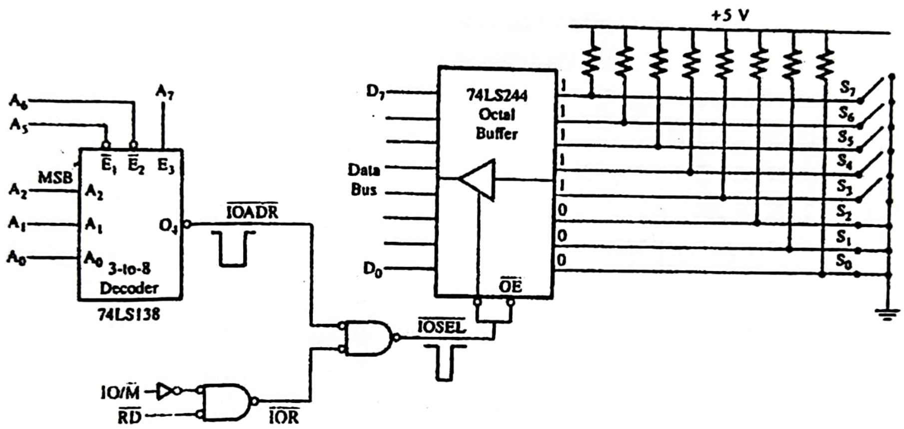



Fig. 6(b)

Q.6(c) How 8284A clock generation produces CLK and PCLK? Explain 10

Q.7(a) Explain the control word format of BSR mode. 10

Q.7(b) Write an assembly code for sending control word in 8255 PPI. Control word is 10001111 and address is FFEFH 10

Q.7(c) illustrates the I/O device interfacing with 8255 PPI. Write an assembly language program to display digit 8 using 7 segment display. (Note that other applications must have to turned off.) 15

Q.8(a) With neat sketch briefly explain the subsystem that handles all the interrupt request in 8259 PIC. 10

Q.8(b) Represents a counter. Write a subroutine to initialize counter 2 in mode 0 with a count of $60,000_{10}$. 10

Q.8(c) Write an assembly code reading data to 8251 USART using potted basis. 15

The End

**Table A2. Instruction Set Summary**

| 1 Mnemonic and Description | Instruction Code | | | |
|---|---|---|---|---|
| **DATA TRANSFER** | | | | |
| **MOV = Move:** | 76543210 | 78543210 | 76543210 | 76543210 |
| Register/Memory to/from Register | 100010dw | mod reg r/m | | |
| Immediate to Register/Memory | 1100011w | mod 000 r/m | data | data if w = 1 |
| Immediate to Register | 1011 w reg | data | data if w = 1 | |
| Memory to Accumulator | 1010000w | addr-low | addr-high | |
| Accumulator to Memory | 1010001w | addr-low | addr-high | |
| Register/Memory to Segment Register | 10001110 | mod 0 reg r/m | | |
| Segment Register to Register/Memory | 10001100 | mod 0 reg r/m | | |
| PUSH = Push: | | | | |
| Register/Memory | 11111111 | mod 1 1 0 r/m | | |
| Register | 01010 reg | | | |
| Segment Register | 000 reg 1 1 0 | | | |
| POP = Pop: | | | | |
| Register/Memory | 10001111 | mod 000 r/m | | |
| Register | 01011 reg | | | |
| Segment Register | 000 reg 1 1 1 | | | |
| XCHG = Exchange: | | | | |
| Register/Memory with Register | 1000011w | mod reg r/m | | |
| Register with Accumulator | 10010 reg | | | |
| IN = Input from: | | | | |
| Fixed Port | 1110010w | port | | |
| Variable Port | 1110110w | | | |
| OUT = Output to: | | | | |
| Fixed Port | 1110011w | port | | |
| Variable Port | 1110111w | | | |
| XLAT = Translate Byte to AL | 11010111 | | | |
| LEA = Load EA to Register | 10001101 | mod reg r/m | | |
| LDS = Load Pointer to DS | 11000101 | mod reg r/m | | |
| LES = Load Pointer to ES | 11000100 | mod reg r/m | | |
| LAHF = Load AH with Flags | 10011111 | | | |
| SAHF = Store AH into Flags | 10011110 | | | |
| PUSHF = Push Flags | 10011100 | | | |
| POPF = Pop Flags | 10011101 | | | |
| ARITHMETIC | | | | |
| ADD = Add: | | | | |
| Reg/Memory with Register to Either | 000000dw | mod reg r/m | | |
| Immediate to Register/Memory | 100000sw | mod 0 0 0 r/m | data | data if s: w = 01 |
| Immediate to Accumulator | 0000010w | data | data if w = 1 | |
| ADC = Add with Carry: | | | | |
| Reg./Memory with Register to Either | 000100dw | mod reg r/m | | |
| Immediate to Register/Memory | 100000sw | mod 0 1 0 r/m | data | data if s: w = 01 |
| Immediate to Accumulator | 0001010w | data | data if w = 1 | |
| INC = Increment | | | | |
| Register/Memory | 1111111w | mod 0 0 0 r/m | | |
| Register | 01000 reg | | | |

| R/M \ MOD | 00 | 01 | 10 | 11 | |
|---|---|---|---|---|---|
| | | | | W = 0 | W = 1 |
| 000 | [BX] + [SI] | [BX] + [SI] + d8 | [BX] + [SI] + d16 | AL | AX |
| 001 | [BX] + [DI] | [BX] + [DI] + d8 | [BX] + [DI] + d16 | CL | CX |
| 010 | [BP] + [SI] | [BP] + [SI] + d8 | [BP] + [SI] + d16 | DL | DX |
| 011 | [BP] + [DI] | [BP] + [DI] + d8 | [BP] + [DI] + d16 | BL | BX |
| 100 | [SI] | [SI] + d8 | [SI] + d16 | AH | SP |
| 101 | [DI] | [DI] + d8 | [DI] + d16 | CH | BP |
| 110 | d16 (direct address) | [BP] + d8 | [BP] + d16 | DH | SI |
| 111 | [BX] | [BX] + d8 | [BX] + d16 | BH | DI |

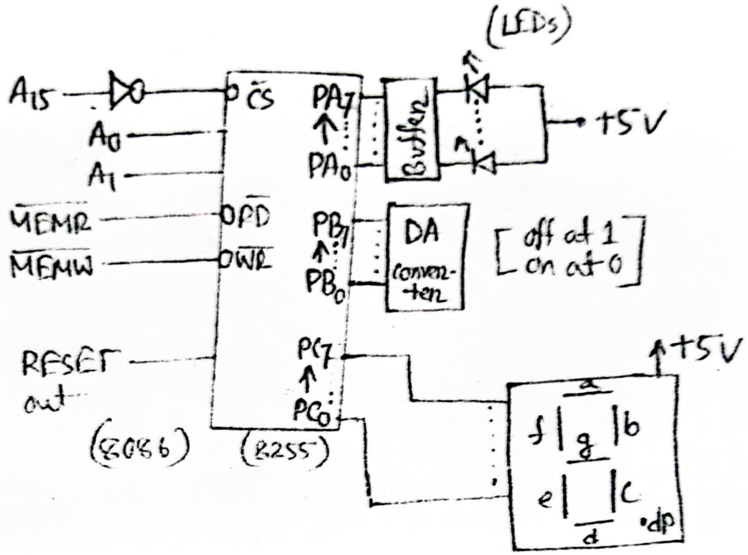
MEMORY MODE (MOD 00, 01, 10) REGISTER MODE (MOD 11)

d8 = 8-bit displacement d16 = 16-bit displacement

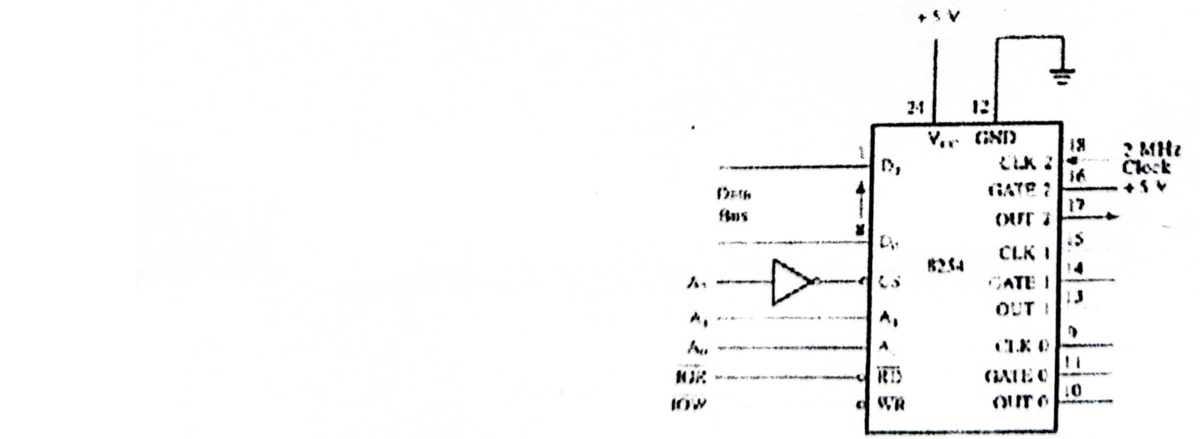
| REGISTER | | CODE |
|---|---|---|
| | W=1 | W=0 |
| AL | AX | 000 |
| BL | BX | 011 |
| CL | CX | 001 |
| DL | DX | 010 |
| AH | SP | 100 |
| BH | DI | 111 |
| CH | BP | 101 |
| DH | SI | 110 |

| SEGREG | CODE |
|---|---|
| CS | 01 |
| DS | 11 |
| ES | 00 |
| SS | 10 |

The End



(LEDs)
A15
CS
A0
A1
MEMR
MEMW
RD
WR
PA7
PA0
Buffer
+5V
PB7
PB0
DA
converter
[off at 1
on at 0]
RESET
out
PC7
PC0
+5V
a
f
g
b
e
c
d
dp
(8086)
(8255)

+5 V
24
12
GND
8254
CLK 2
GATE 2
OUT 2
CLK 1
GATE 1
OUT 1
CLK 0
GATE 0
OUT 0
2 MHz
Clock
+5 V
Data
Bus
RD
WR


Fig 8(b)

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Level-3, Term-II, EEE '20 Batch, Examination 2022 - '23, Date: 29 April 2025
Course Code: **EEE 365/EEE 495 (O)**, Title: **Digital Signal Processing**

**Full Marks 210** **Time 3 Hours**

*The figures in the margin indicates marks. Answer any 3 questions from each section. Use separate script for each section.*

## Section A

Q.1(a) With definitions and treat sketches differentiate between analog signal, discrete-time signal and digital signal. Write down some applications of DSP. 12

Q.1(b) State the Nyquist - Shannon sampling theorem and analyze the problem with "aliasing" 12

Q.1(c) $x(t) = 5\cos(2\pi\, 2000t) + 3\,Cos\,(2\pi\, 3000t)$, for $t \geq 0$ 11
is sampled at the rate of 8000 Hz.

i) Sketch the spectrum of the sampled signal up to 20 kHz.
ii) Sketch the recovered analog signal spectrum if an ideal lowpass filter with a cutoff frequency of 4 kHz is used to the filter the sampled signal.

Q.2(a) Represent the following signal in functional, tabular and sequence formats: 12

i) Unit sample sequence
ii) Unit step signal
iii) Unit ramp signal.

Q.2(b) Consider the system $y(n) = \tau[x(n)] = x(n^2)$ 12

$$\text{where } x(n) = \begin{cases} 1, & 0 \leq n \leq 3 \\ 0, & \text{elsewhere} \end{cases}$$

i) Sketch $x(n)$
ii) Determine $y(n)$ and sketch it
iii) Sketch $y_2'(n) = y(n-2)$
iv) Determine and sketch $x_2(n) = x(n-2)$
v) Determine and sketch $y_2(n) = \tau[x_2(n)]$
vi) Compare $y_2'(n)$ and $y_2(n)$ and determine if the system is time-invariant.

Q.2(c) Determine the response to the input signal 11

$$x(n) = \begin{cases} |n|, & -3 \leq n \leq 3 \\ 0, & \text{otherwise} \end{cases}$$

i) $y(n) = \frac{1}{3}[x(n+1) + x(n) + x(n-1)]$

ii) $y(n) = \sum_{k=-\infty}^{n} x(k) = x(n) + x(n-1) + x(n-2) + \cdots$

Q.3(a) The impulse response of LTI system is $ln(n) = \{1, \underset{\uparrow}{2}, 1, -1\}$ 12

Determine the response in details for the input $x(n) = \{\underset{\uparrow}{1}, 2, 3, 1\}$

Q.3(b) Compare digital vs. analog filters. What are the two general purposes of digital filters? 12

Q.3(c) "Good performance in the time domain results in poor performance in frequency domain and vice versa" – Explain using the moving average filter. 11

Q.4(a) Design moving average filters by convolution and recursion. 12

Q.4(b) Analyze single-pole low pass and high pass recursive filters with the necessary equations and figures. 12

Q.4(c) Discuss the direct form-I and Direct form-II realization of IIR filters. 11

## Section B

Q.5(a) Consider the system, 12

$$H(z) = \frac{1 - 2z^{-1} + 2z^{-2} - z^{-3}}{(1 - z^{-1})(1 - 0.5z^{-1})(1 - 0.2z^{-1})}\ ; ROC: 0.5 < |z| < 1$$

i) Sketch the pole-zero patterns. Is the system stable?
ii) Determine the impulse response of the system.

Q.5(b) Determine z-transform and Roc. Why do we use exponential function in z-transform? 11

Q.5(c) Find 12

$$z^{-1}\left[\frac{z^2}{(z+2)(z^2+4)}\right]$$

by the method of partial function.

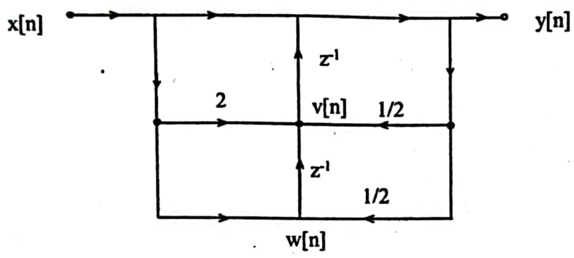
Q.6(a) Explain the structures for realization of LTI systems of direct form-I and direct form-II. 10

Q.6(b) Consider the signal flow graph shown in the below figure 15

$+ 1(1 - z^{-1})$

$z^{-2}(1 \cdot z^{-1}) - z^{-1}(1 - z^{-1})$

$z^{-2} - z^{-3} + z^{-2} - z^{-1}$




i) Using the node variables indicated, write the set of difference equations represented by this network.
ii) Draw the flow graph of an equivalent system that is the cascade of two first-order systems.
iii) Is the system stable? Explain.

Q.6(c) Draw the signal flow graph for the transposed direct form-II implementation of the LTI system with system function 10

$$H(z) = \frac{1 - \frac{7}{6}z^{-1} + \frac{1}{6}z^{-2}}{1 + z^{-1} + \frac{1}{2}z^{-2}}$$

Q.7(a) Establish the relation between z-transform and discrete Fourier transform. 10

Q.7(b) Determine the output sequence of $y[n]$ if $h[n] = \{1,1,1\}$ and $x[n] = \{1,2,3,1\}$ by using 15

i) Linear Convolution
ii) Circular Convolution without zero padding
iii) Circular convolution with zero padding.

Q.7(c) Given the sequences $x_1[n] = \{1,2,3,4\}$ and $x_2[n] = \{1,1,2,2\}$. Find $x_3[n]$ such that $X_3(k) = X_1(k)\,X_2(k)$. 10

Q.8(a) State and prove the Parseval's theorem. 10

Q.8(b) For $h[n] = \{3,2,1,1\}$ and $x[n] = \{1,2,3,3,2,1,-1,-2,-3,5,6,-1,2,0,2,1\}$ Find the output using overlap add method by assuming the block length as 7. 10

Q.8(c) What is Radix-2 DIT FFT algorithm? For $x[n] = \{1,2,4,8,16,32,64,128\}$, find the 8-point DFT using DIT FFT. 15

0.5 0.86j

The End

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Level-3, Term-II, EEE '20 Batch, Examination 2022 - '23, Date: 13 May 2025
Course Code: **EEE 367/EEE 359 (O)** Title: **Electronic Communication**

**Full Marks 210** **Time 3 Hours**

*The figures in the margin indicates marks. Answer any 3 questions from each section. Use separate script for each section.*

## Section A

Q.1(a) Define pulse modulation. Give some applications of pulse modulation. 10

Q.1(b) Consider a signal $g(t)$ is sampled by the with rate $Ts \leq 1/2w$, where $w$ is the band-width of $g(t)$. The sampled signal $g(t) = \sum_{-\infty}^{\infty} g(nT_s)\delta(t - nT_s)$ 15
Find the reconstruction relation of $g(t)$ from $g\delta(t)$. Then determine the necessary conditions of fully reconstruction of the signal.

Q.1(c) Classify pulse modulation and draw their waveforms. 10

Q.2(a) How do you generate analog signal to PCM signal? Explain quantization error. 10

Q.2(b) Consider a sinusoidal signal is quantized by R bits per sample. For linear quantization, show that the output SNR of the quantizer is 1.8+6R dB. 13

Q.2(c) Why multiplexing and Multiple access is needed in communication system? Explain FDM and TDM with their merits and demerits. 12

Q.3(a) Define thermal noise. Show that "Narrowband filtered noise can be represented by $n(t) = n_s \cos \omega_c t - n_s \sin \omega_c t$". 12

Q.3(b) Define figure of merit. Show the figure of merit of DSB-SC and SSB-SC are the same in coherent detection. 10

Q.3(c) Show that the figure of merit of FM depends on the square of modulation index $\beta$. 13

Q.4(a) Explain why colour TV uses YUV instead of RGB. 10

Q.4(b) Explain the working principle of a complete TV transmission system with block diagram. 13

Q.4(c) What is RADAR? After deriving the basic RADAR equation, how do you determine the maximum range of the RADAR? Explain. 12

## Section B

Q.5(a) Define overmodulation in AM. Explain some methods to prevent overmodulation in AM. 10

Q.5(b) What is image frequency in a superheterodyne receiver? How can you solve the image frequency problem? 10

Q.5(c) In coherent detection, it is necessary to have an additional mechanism to maintain the local carrier in the receiver in perfect synchronization with the local carrier in the transmitter. How can Costas receiver help in this regard? 15

Q.6(a) Explain the importance of Pre-emphasis and De-emphasis in FM Broadcasting. How it works? Explain with proper circuit diagram. 13

Q.6(b) How do you produce SSB-SC signal without using a bandpass filter? Give your answer with proper diagram and equations. 12

Q.6(c) Write short note on 10

i) VSB Broadcasting
ii) PLL communication system.

Q.7(a) Bangladesh Sattelite-1 (BS-1) is at 119°1E and the earth station is at Gazipur (90°4E, 24N). 10

Find earth station's elevation angle to BS-1. Assume the earth radius = 6378 km and the orbital height = 35786 km.

Q.7(b) VSAT always needs a large station at another end. Why there has to be a large station or Hub? 10

Q.7(c) Briefly discuss the different methods of G/T measurement for VSAT. 15

Q.8(a) Explain the working principle of a diode-based envelope detector. Explain how an envelope detector would extract the baseband signal. 10

Q.8(b) Why does envelope detector work well for standard AM but not for DSB-SC? 5

Q.8(c) What is coherent detection? What are the techniques for recovering the carrier signal for the product detection? 10

Q.8(d) Why uplink and down link frequency are widely separated? Why downlink frequency is lower than uplink frequency? 10

The End

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Level-3, Term-II, EEE '20 Batch, Examination 2022 - '23, Date: 22 April 2025
Course Code: **EEE 361/EEE483 (O)**, Title: **Power Electronics**

**Full Marks 210** **Time 3 Hours**

*The figures in the margin indicates marks. Answer any 3 questions from each section. Use separate script for each section.*

## Section A

Q.1(a) Define power electronics. Differentiate between electronics and power electronics. 10

Q.1(b) Draw the two-transistor model of an SCR and define the following equation: 12

$$I_A = \frac{\alpha_2 I_G + I_{cBO1} + I_{cBO2}}{1-(\alpha_1+\alpha_2)}$$

From the above equation, explain how an SCR is turned ON by applying a small current pulse at the gate.

Q.1(c) Explain the resonant pulse commutation process to turn off an SCR with necessary circuits and waveforms. 13

Q.2(a) What is inverter? Explain the operation of a 3-Φ voltage source square wave inverter (based on gate pulse width of 120) with necessary circuits and draw the line to line and line to neutral voltage waveforms. 18

Q.2(b) What is multilevel inverter? Design a 7-level inverter and draw its output voltage waveforms. 17

Q.3(a) Describe the phenomenon of a 1-Φ full-wave controlled rectifier with R and R-L load. 18

Q.3(b) For the controlled half-wave rectifier with R-L-E load and where L is large, as shown in Fig. 3(b) 12

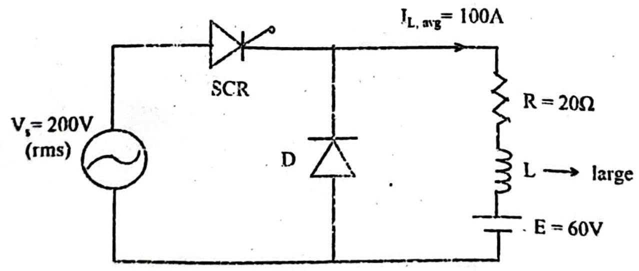


Fig. 3(b)

Find the trigger angle α, if the average value of the load current $I_L$ = 100A.

Q.3(c) Write the advantages of free-wheeling diode. 5

Q.4(a) Draw the $V_{L-L}$, $V_{L-n}$ of input voltage, output voltage and output current of a 3-Φ full wave-controlled rectifier (where α = 60°). 20

Q.4(b) The dielectric heating load consists of three layers of wood, each 0.20" thick, two layers of glue, each 0.04" thick and an air gap of 0.01". The power factor of the wood is 3.5% and that of glue is 4.5%. The dielectric constants are 3 and 4.5 respectively. The applied voltage is 6000V at 8 MHz. Find -- 15

i) Voltage gradient of the airgap,
ii) Power density applied to the glue,
iii) Power density applied to the wood.

## Section B

| | | |
|---|---|---|
| Q.5(a) | State and derive inductor volt-sec balance principle. Why you need inductor volt-sec balance in the study of DC-DC converter? | 12 |
| Q.5(b) | Show the relationship between the output voltage ($V_o$) and input voltage ($V_d$), in terms of the duty ratio (D) of a boost converter. | 10 |
| Q.5(c) | What are the effects of parasitic in a DC-DC converter? Mention some mitigation techniques from these effects. | 13 |
| Q.6(a) | What is MPPT? How does MPPT work with DC-Dc converter? | 8 |
| Q.6(b) | With neat sketch of waveforms and circuit diagram, explain the buck converter operation in CCM mode and show that $\Delta V_c = \frac{\Delta I}{8fc}$. | 14 |
| Q.6(c) | A buck-boost converter has an input voltage Vs = 14V, Duty cycle k = 0.35, $f_s$ = 25 kHz. The inductance L = 185μH, and filter capacitor, C = 225μF. The average load current $I_a$ = 1.75A, Determine the -<br>i) Average output voltage,<br>ii) Peak-peak output ripple voltage,<br>iii) Peak-peak ripple current of inductor,<br>iv) Peak current of the transistor. | 13 |
| Q.7(a) | What do you understand by integral cycle control and phase control of AC voltage controllers? Explain with necessary diagrams. | 12 |
| Q.7(b) | For a single-phase full wave AC voltage controller with resistive load, derive the expression for –<br>i) Output RMS voltage,<br>ii) Load power factor and<br>iii) RMS value of thyristor current. | 13 |
| Q.7(c) | Which type of problem do you encounter while controlling a 1- full wave AC voltage controller with R-L load? Explain with necessary diagrams and also mention how to overcome it. | 10 |
| Q.8(a) | Mention some features and application of cycloconverter. | 8 |
| Q.8(b) | With necessary waveshapes, show that in case of a single-phase cycloconverter, the output frequency can be reduced by one-fourth of the input frequency. | 12 |
| Q.8(c) | For a single-phase full wave AC voltage controller with R-L load, find out the steady-state and transient-state currents of a thyristor. Perform the different case studies depending on the values of delay angle α and load angle φ. | 15 |

The End

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Level-3, Term-II, EEE '20 Batch, Examination 2022 - '23, Date: 15 April 2025
Course Code: **EEE 369/EEE 473 (O)**, Title: **Semiconductor Physics and Devices**

**Full Marks 210** **Time 3 Hours**

*The figures in the margin indicates marks. Answer any 3 questions from each section. Use separate script for each section.*

## Section A

Q.1(a) Discuss the splitting of energy bands and hence creation of band gap in solids. Illustrate your demonstration by taking diamond atom as an example. 10

Q.1(b) Draw the energy-band diagram of a compensated semiconductor showing ionized and un-ionized donors and acceptors. 10

Q.1(c) Assume the Fermi energy level is 0.30 eV below the conduction band energy $E_c$. Assume T=300K. 15

i) Determine the probability of a state being occupied by an electron at $E = E_c + \frac{kT}{4}$.

ii) If $E_c$= 0.7eV; calculate the temperature at which, there is a 1% probability that a state 0.30 eV below the Fermi energy level will not contain an electron.

Q.2(a) In silicon, the electron concentrations given by $n(x)=10^{15}\, e^{-x/L_n}$ cm$^{-3}$ for $x \geq 0$ and the hole concentration is given by $p(x)=5\times10^{15}\, e^{+x/L_P}$ cm$^{-3}$ for $x \leq 0$. The total current density is defined as the sum of the electron and hole diffusion current densities at $x = 0$. Calculate the total current density, where $L_n=2\times10^{-3}$ cm and $L_P=5\times10^{-4}$ cm, $D_n$=25 cm$^2$/s and and $D_P$=10 cm$^2$/s. 16

Q.2(b) For a one-sided junction show that the inverse capacitance squared is almost function of applied reverse bias voltage. 7

Q.2(c) The conductivity of a semiconductor layer varies with depths as $\sigma(x)= \sigma_o \exp(-x/d)$ where $\sigma_o=20(\Omega\text{cm})^{-1}$ and d=0.3μm. If the thickness of the semiconductor layer is t =1.5μm, determine the average conductivity of this layer. 12

Q.3(a) Derive the excess minority carrier concentrations at the depletion region edges generated by the forward-bias voltage and then show in a figure w.r.t. equilibrium carrier concentration. 10

Q.3(b) In a p$^+$n Si junction, the n-side has a donor concentration of $10^{16}$ cm$^{-3}$. If $n_i=10^{10}$ cm$^{-3}$, relative dielectric constant $\varepsilon_r$=12, calculate the depletion width at a reverse bias of 100V? what is the electric field at the mid-point of the depletion region on the n-side? 10

Q.3(c) An abrupt Si junction (area = 0.0001 cm$^2$) has the following parameters: 15

| n side | p side |
|---|---|
| $N_d = 5\times10^{17}$ cm$^{-3}$ | $N_a = 10^{17}$ cm$^{-3}$ |

Draw and label the band diagram, and calculate the difference between the Fermi level and the intrinsic Fermi level on both sides. Calculate the built-in potential at the junction in equilibrium and the depletion width. What is the total number of exposed acceptors in the depletion region?

Q.4(a) The continuity equation for minority carrier distribution can be written as follows: 10

$$D_n \frac{\partial^2(\Delta n_p)}{\partial x^2} - \mu_n \varepsilon \frac{\partial(\Delta n_p)}{\partial x} + G - \frac{\Delta n_p}{\tau_{no}} = \frac{\partial(\Delta n_p)}{\partial t}$$

where, $\Delta n_p$ is the charge in minority carrier concentrations on p-side.
With appropriate assumptions and boundary conditions, show that

$$\Delta n_p(x) = n_p(x) - n_{po} \doteq n_{po}\left[\exp\left(\frac{V_a}{\phi_T}\right) - 1\right] exp\left(\frac{x_p + x}{L_p}\right)$$

$V_a \rightarrow$ applied-forward bias voltage.
$\phi_T \rightarrow$ thermal voltage.
$x_p \rightarrow$ width of the depletion region on p-side.

Q.4(b) Sketch the geometry for measuring the Hall effect and illustrate the entire procedure. 10

Q.4(c) Impurity concentrations of $N_d=3\times10^{15}$ cm$^{-3}$ and $N_a=10^{16}$ cm$^{-3}$ are added to Si at T=300K. Excess carriers are generated in the semiconductor such that the steady-state excess carrier concentration are $\delta_n=\delta_p=4\times10^{14}$ cm$^{-3}$ 15

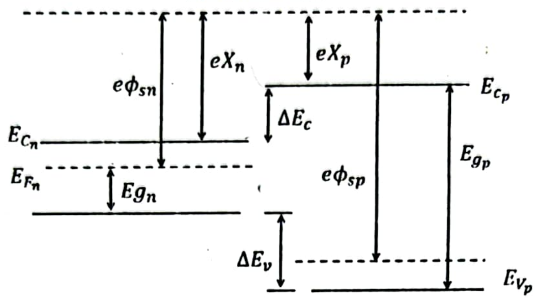
i) Determine the thermal-equilibrium Fermi level with respect to the intrinsic Fermi level.

ii) Find $E_{Fn}$ and $E_{Fp}$ with respect to $E_{Fi}$

## Section B

Q.5(a) A Schottky diode has to be designed on surface of an n-type semiconductor and an ohmic contact on the other side. The electron affinity is 5eV, and the Fermi potential is 0.25eV. What should be the values of work functions of the two metals? (Give your answer as greater or less than certain values). Sketch the band diagram of the structure. 13

Q.5(b) A nP material is used to form a heterojunction. The band diagram of the system before the materials are brought into contact is shown in the below figure. 17




Draw the energy band diagram of the heterojunction at thermal equilibrium with necessary assumptions, derive the expression for:

i) Electric field in both regions.
ii) Electrostatic potential along the junction.
iii) Space charge width in both regions.

Q.5(c) What is the difficulty in abrupt heterojunction and how can it be mitigated? Draw the band diagram of a $n^+p$ (AlGaAs-GaAs) system. 5

Q.6(a) At which condition the JFET is working as a constant current source? Draw the schematic view of channel region at that condition and also the I-V characteristics. Why an electric field is generated in the pinch-off condition in a JFET? 10

Q.6(b) Draw a schematic of "normal" AlGaAs-GaAs HEMT and explain the operation of this device for both D and E mode AlGaAs-GaAs HEMT. Draw the energy band diagram for this device when it operates in E-mode for a 15

i) slight forward bias gate voltage
ii) with a larger forward bias gate voltage.

Q.6(c) What are the non-ideal effects show in JFET? Explain channel length modulation and velocity saturation effect. 10

Q.7(a) What are the advantages of Heterostructure solar cell? Why low band gap materials are used as a top cell in heterostructure solar cell, explain with an example? Explain the operating principle of heterostructure solar cell using band diagram. 12

Q.7(b) Draw the total static current characteristics of a tunnel diode. Show the generation of excess current in tunnel diode using band diagram. 10

Q.7(c) Explain the principle of population inversion in a LASER diode and how it leads to stimulated emission and explain the role of optical cavities in LASER diode. 13

Q.8(a) What kind of strain is formed between these two configuration AlGaN/GaN, GaN/AlGaN ($E_{AlGaN}$>$E_{GaN}$)? How is it possible that the average time an injected hole spends in transit across the base $\tau_t$ is shorter than the hole lifetime in base $\tau_p$? 12

Q.8(b) Consider an npn silicon bipolar transistor at T=300 K has uniform doping of $N_E=10^{19}\ cm^{-3}$ $N_B=10^{17} cm^{-3}$ and $N_C=7\times10^{15}\ cm^{-3}$. The transistor is operating in the inverse-active mode with $V_{BE}= -2V$ and $V_{BC}= 0.565V$. 12

i) Sketch the minority carrier's distribution through the device
ii) Determine the minority carrier concentration at $x = x_B$ and $x'' = 0$.

Q.8(c) What are the advantages and disadvantages of less carrier concentration in doping in base with respect to emitter in BJT. How this can mitigate? Draw the practical doping profile of a HBT and also explain why in HBT, the emitter doping is less than conventional BJT with the help of band diagram of pnp HBT. 11

The End