



MOI UNIVERSITY

OFFICE OF THE CHIEF ACADEMIC OFFICER

UNIVERSITY EXAMINATIONS

2010/2011 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER EXAMINATION

**FOR THE DEGREE OF
BACHELOR OF ENGINEERING
IN
ELECTRICAL & COMMUNICATIONS
ENGINEERING**

COURSE CODE: ECE 352

COURSE TITLE: ANALOGUE ELECTRONICS III

DATE: 18TH APRIL, 2011 **TIME:** 9.00 A.M. – 12.00 NOON

INSTRUCTION TO CANDIDATES

- ANSWER ANY FIVE QUESTIONS.
- ALL QUESTIONS CARRY EQUAL MARKS.

THIS PAPER CONSISTS OF (4) PRINTED PAGES

PLEASE TURN OVER

QUESTION ONE

- With the aid of a well illustrated diagram show the basic steps of lithograph. What are the major functions of a photo resist? {5mks}.
- What do you understand by a current mirror? {4mks}.
- From the op-amp intermediate stage, derive the relationship which will put the output dc component to zero {5mks}.

QUESTION TWO

- A sinusoidal waveform may be obtained from a rectangular waveform $x(t)$ using the following expression:

$$\sin X = X - \frac{X^3}{3!} + \frac{X^5}{5!} - \frac{X^7}{7!} + \dots$$

Using the first two terms of the expression, give the arrangement to implement this in an electrical circuit {4mks}.

- Figure Qstn.2 shows waveform generator:

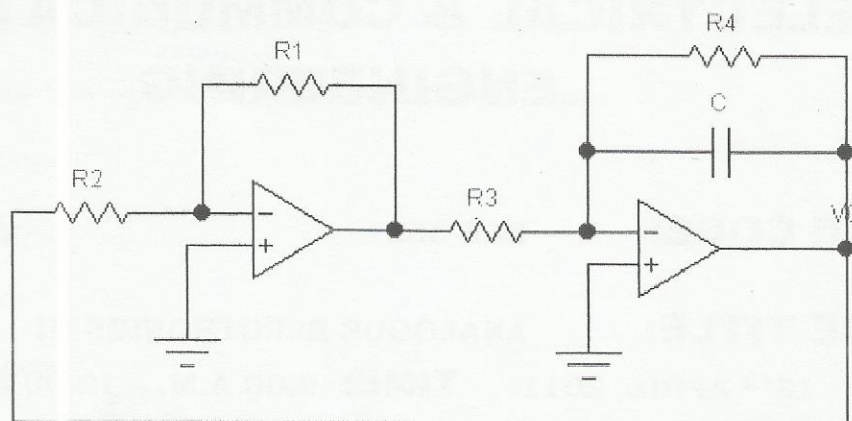


Figure Qstn.2

- Explain how the circuit works {2mks}.
- Arrive at an expression for frequency of the waveform {8mks}.

QUESTION THREE

- a) What is an ideal current source? List two types of current sources {5mks}.
 b) Why is it that the internal ^{resistance} current of an ideal current source is equal to infinity? {2mks}. ✓
 c) The figure Qstn.3 below shows a differential amplifier based on an ideal op-amp. *

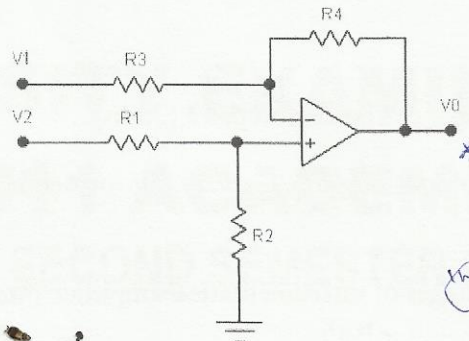


Fig. Qstn.3

- i. Find the output voltage V_o ✓
 ii. Show that the output corresponding to common-mode voltage $V_{CM} = \frac{V_1 + V_2}{2}$ is zero if $\frac{R_4}{R_3} = \frac{R_2}{R_1}$. Find V_o in this case.
 iii. Find the CMRR of the amplifier if $\frac{R_4}{R_3} \neq \frac{R_2}{R_1}$ {7mks}.

QUESTION FOUR

- a) Discuss the limitations of ICs {5mks}.
 b) In the circuit of a Schmitt trigger, $R_2 = 100\Omega$, $R_1 = 50K\Omega$, $V_{ref} = 0V$, $V_i = 1V_{pp}$ (peak-to-peak) sine wave and saturation voltage = $\pm 14V$. Determine the threshold voltages V_{UTP} and V_{LTP} {6mks}.
 c) What is the function of a peak detector {3mks}?

QUESTION FIVE

- a) What are the advantages of OTA over conventional Op Amps? {2mks}.

- b)
- Describe how an operational amplifier comparator may be used to generate a square waveform.
 - Derive the expression for the period of a symmetrical waveform {12mks}.

QUESTION SIX

- What are the advantages of Darlington pair? {2mks}.
- With the aid of a circuit diagram, explain the principle of operation of a Schmitt trigger {8mks}.
- Enumerate the advantages of instrumentation amplifier {4mks}.

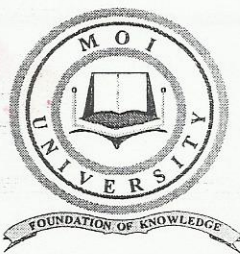
→ High CMRR
- op of A_1 & A_2 cancel to zero.
- A_1 & A_2 are approximately matched.

QUESTION SEVEN

- Draw a block diagram of a typical PLL and briefly explain the functions of each block {8mks}.
- How can one obtain a flat gain frequency response and improved signal to noise ratio in audio signals? {1mk}. By attenuating the signal in frequency in amplitude by amplifying.
- Define the following terms as applied in phase locked loops
 - Capture range ✓
 - Hold range ✓
 - Pull in time
 - Tracking range ✓
 - Lock range {5mks}. *

....the end.

Bonne chance



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MOI UNIVERSITY

OFFICE OF THE CHIEF ACADEMIC OFFICER

UNIVERSITY EXAMINATIONS 2011/2012 ACADEMIC YEAR THIRD YEAR SECOND SEMESTER EXAMINATION

FOR THE DEGREE OF BACHELOR OF ENGINEERING

COURSE CODE: ECE 352

COURSE TITLE: ANALOGUE ELECTRONICS III

DATE: 21ST MAY, 2012 **TIME:** 9.00 A.M. – 12.00 NOON

INSTRUCTION TO CANDIDATES

- ANSWER ONLY FIVE QUESTION
- ALL QUESTIONS CARRY EQUAL MARKS.

THIS PAPER CONSISTS OF (5) PRINTED PAGES

PLEASE TURN OVER

QUESTION ONE

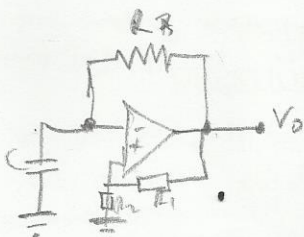
- What do you understand by a *current mirror*? Explain using a simple sketch diagram {3mks}.
- Sketch a sample and hold circuit diagram and explain how it works {7mks}.
- With the aid of a well illustrated diagram show the basic steps of lithograph. What are the major functions of a photo resist? {4mks}.

QUESTION TWO

- Draw a well annotated circuit diagram of a multivibrator (square wave generator) and explain how it works {5mks}
- An amplifier draws 900mA from its 12V d.c. supply. If 8W of audio output power is delivered to loudspeaker, calculate

- D.C. power {1mk}.
- Collector power dissipation {1mk}.
- Efficiency of the amplifier {1mk}.

- Figure Qstn 2 shows waveform generator. Arrive at an expression for frequency of the waveform generated {6mks}.



$$\Delta V = \frac{I_{Tr}}{C}$$

$$f = \frac{V_P}{R_3} \quad T_r = \frac{1}{2f}$$

$$\Delta V = \frac{1}{2f} \cdot \frac{V_P}{R_3} \cdot \frac{1}{C} = \frac{V_P}{2fR_3C}$$

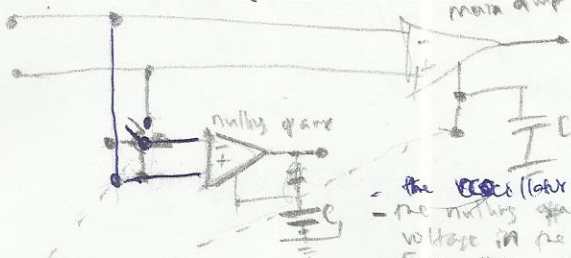
$$V_P = \frac{1}{2} V_r$$

$$\Delta V = V_P = \frac{V_r}{2fR_3C}$$

$$i = \frac{V_P}{R_2} = \frac{V_P}{R_1} \cdot V_P = \frac{R_1}{R_2} V_P \quad V_P = \frac{R_2}{R_1} i$$

$$I = \frac{R_1}{R_2} \left(\frac{1}{4fR_3C} \right)$$

$$f = \left(\frac{1}{4R_3C} \cdot \frac{R_1}{R_2} \right)$$

QUESTION THREE

- the V_{BE} (base) is responsible for the switching function
- the nulling op-amp corrects the offset voltage in the op-amp. It boosts the slow signal
- First the null op-amp corrects its own output error. The inputs are connected together and are connected to C_1
- Next, the inputs are connected across the supply and o/p coupled to C_2



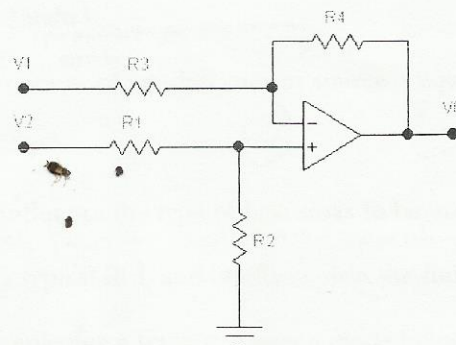
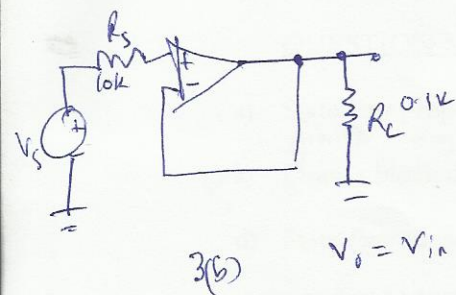
The current through R is neglected across the transistor collector. It has current I much smaller than I_E and I_B then $I_B \approx I_C$

As the diode current I_E is similar to the V_{BE} of the transistor then $I_D \approx I_B \approx I_C$

Since the base current is much smaller than I_E and I_C then $I_E \approx I_C$

- a) State four characteristics which make Op Amps useful {4mks}
- b) The figure Qstn.3 (b) shows a source connected to a load with a voltage follower. It is given that $R_S = 10K\Omega$ and $R_L = 100\Omega$
- Calculate V_0 {2mks}.
 - Calculate V_0 if the voltage follower is removed and the source connected to the load {2mks}.
- c) The figure Qstn.3(c) below shows a differential amplifier based on an ideal op-amp.

High R_{in}
Infinite gain
zero R_{out}
Infinite bandwidth



$$\frac{R_1}{R_1 + R_2} = \frac{R_3}{R_3 + R_4}$$

$$\frac{R_1 R_4}{R_1 + R_2} = \frac{R_3 R_4}{R_3 + R_4}$$

$$V_0 = \frac{R_4}{R_1 + R_2} V_1 = \frac{R_4}{R_3 + R_4} V_2$$

Fig. Qstn.3(c)

- Find the output voltage V_0
- Show that the output corresponding to common-mode voltage $V_{CM} = \frac{V_1 + V_2}{2}$ is zero if $\frac{R_4}{R_3} = \frac{R_2}{R_1}$. Find V_0 in this case.
- Find the CMRR of the amplifier if $\frac{R_4}{R_3} \neq \frac{R_2}{R_1}$ {6mks}.

QUESTION FOUR

- In the circuit of a Schmitt trigger, $R_2 = 100\Omega$, $R_1 = 50K\Omega$, $V_{ref} = 0V$, $V_i = 1V_{pp}$ (peak-to-peak) sine wave and saturation voltage $= \pm 14V$. Determine the threshold voltages V_{UTP} and V_{LTP} {6mks}.
- Design a logarithmic amplifier with an arrangement to compensate for temperature effects. Deduce its output voltage {6mks}.
- State two advantages of OTA over conventional Op Amps {2mks}.

QUESTION FIVE

- For the difference amplifier of Figure Qstn.5(a) show that $R_1/R_2 = R_3/R_4$ {4mks}.

$$\frac{R_1 R_2}{R_1 + R_2} = \frac{R_3 R_4}{R_3 + R_4}$$

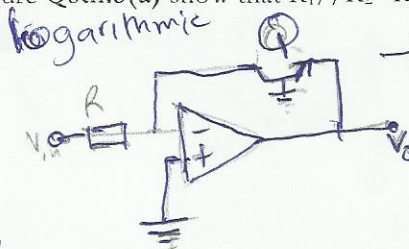
$$\frac{V_1 R_2}{R_1 + R_2} = \frac{V_2 R_4}{R_3 + R_4}$$

$$V_{02} = -\frac{R_4}{R_3} V_2$$

$$V_0 = 0$$

$$V_{01} = \left(\frac{R_1 + R_2}{R_2} \right) V_1$$

$$\frac{R_4}{R_3} V_2 = \left(\frac{R_1 + R_2}{R_2} \right) V_1$$



$$I = \frac{V_i}{R}$$

$$I = I_0 \exp\left(\frac{2V_{BE}}{kT}\right)$$

$$\ln \frac{I}{I_0} = \frac{2V_{BE}}{kT}$$

$$V_{BE} = \frac{kT}{2} \ln\left(\frac{I}{I_0}\right)$$

$$V_0 = -V_{BE}$$

$$V_0 = -\frac{kT}{2} \ln\left(\frac{I}{I_0}\right) = -\frac{kT}{2} \ln\left(\frac{V_i}{I_0 R}\right)$$

- It is a variable gain amplifier
- Outputs can be connected in parallel
- Input pair can be switched ON and OFF, allowing for quick applications

logarithmic

12/4 < 67

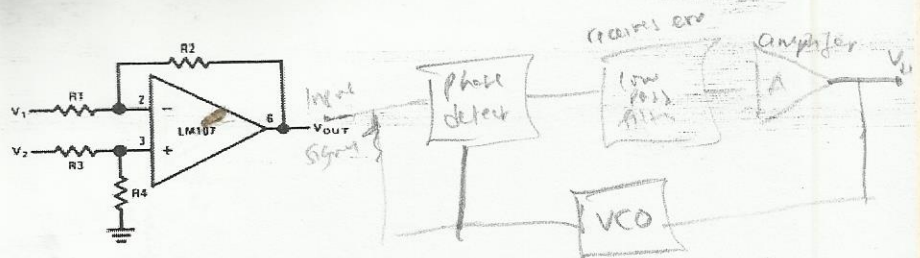


Figure Qstn.5(a)

- b) State *three* factors that affect overall efficiency of a power amplifier {3mks}.

- c) List *five* limitations of ICs {5mks}.

- d) Why is it that the internal current of an ideal current source is equal to infinity? {2mks}.

QUESTION SIX

- a) State *three* properties that influence the type of heat sinks to be used in any application {3mks}.

- a) State *three* properties that influence the type of heat sinks to be used in any application {5mks}.
 fin efficiency, material, thermal resistance, spreading resistance, material properties (color)
- ✓ a) Draw a block diagram of a typical PLL and briefly explain the functions of each block {8mks}.

- d) State *three* advantages of employing a transistor over a diode in logarithmic amplifiers {3mks}.

QUESTION SEVEN

- a) From the op-amp intermediate stage, derive the relationship which will put the output dc component to zero {5mks}.

- b) Define the following terms as applied in phase locked loops

- i. Capture range range of freqs between ω_1 and ω_0 at VCO design centre that will permit the VCO output to synchronise with the input signal
- ii. Hold range range of freqs at which the PLL will maintain steady state phase tracking
- iii. Pull in time time it takes the loop to acquire the signal and achieve lock condition
- iv. Tracking range range of freqs at which the PLL can maintain tracking without losing lock
- v. Lock range {5mks}. range of freqs

- 1) The circuit diagram of Figure Qstn.7(c) has an open loop gain of 10,000. $R_F=98k\Omega$, $R_1=2k\Omega$.

- Determine the closed loop gain {2mks}.
- If the input voltage is 1mV compute the output voltage and the error voltage {2mks}.

$$A_1 = \left(\frac{R_1 + R_2}{R_1} \right) \frac{1}{2} = \frac{2 + 98}{2} = 50$$

$$A_v = \frac{V_o}{V_i} = 50$$

$$V_0 = V_i \times 60$$

$$V_{ref} = \left(\frac{2}{2+108} \right) \times 50 = 1 \text{ mV}$$

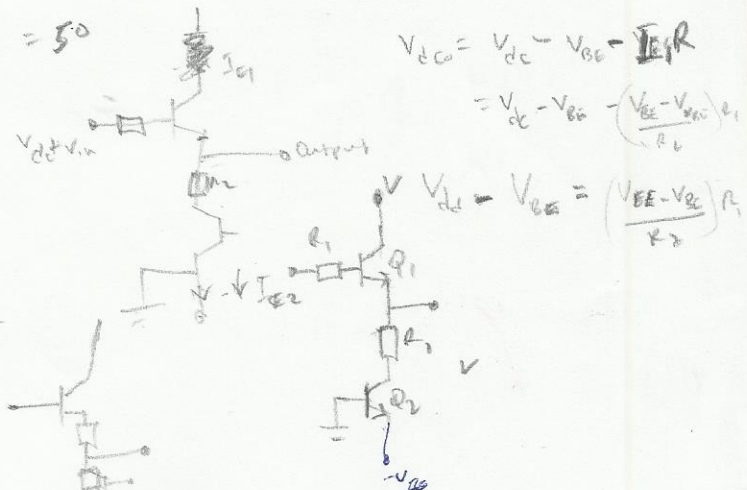
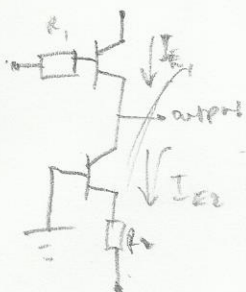
$$\text{error voltage} = V_{\text{REF}} - V_{\text{in}} = 1 - 1 = 0$$

$$I_{B1} = I_{B2} = \frac{V_{BE} - V_{BE}}{R_2}$$

$$V_{dc} = V_{dc} - V_{BE} - I_E R$$

$$= V_{dc} - V_{BE} - \left(\frac{V_{BE} - V_{BE(sat)}}{R_1} \right) R_1$$

$$V_{dc} = V_{BES} = \left(\frac{V_{EE} - V_{BE}}{R_2} \right) R_1$$



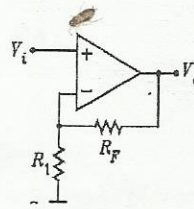


Figure Qstn.7 (c)

....the end.

Bonne chance

1, 1, 6, 4, 2
⑤⑤

ECE 352: ANALOGUE ELECTRONICS III. CAT 1.

Instructions to candidates:

- Attempt all questions.
 - Marks will be awarded to clear, legible work. Slovenly work will be penalized.
1. Describe the most important process in the fabrication of integrated circuits
 2. The differential amplifier shown in Qstn.2 is desired to have the following specifications:

Voltage gain, $\frac{V_{out}}{V_{in}} = 150$

Maximum output voltage swing = 12V peak-to-peak.

Input resistance seen by the signal source = 10K ohm.

Given that $h_{FE} = 130$ for all the transistors find:

- i. Resistor R_C
- ii. Power supplies $\pm V$
- iii. Bias resistor R_B

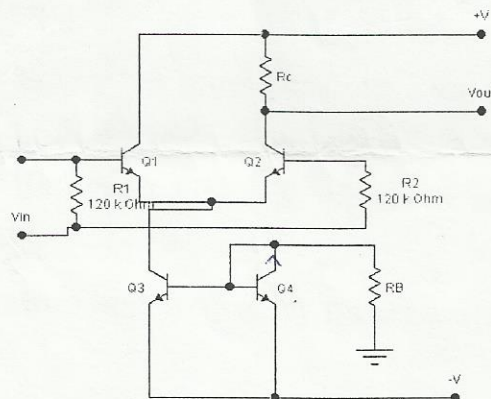
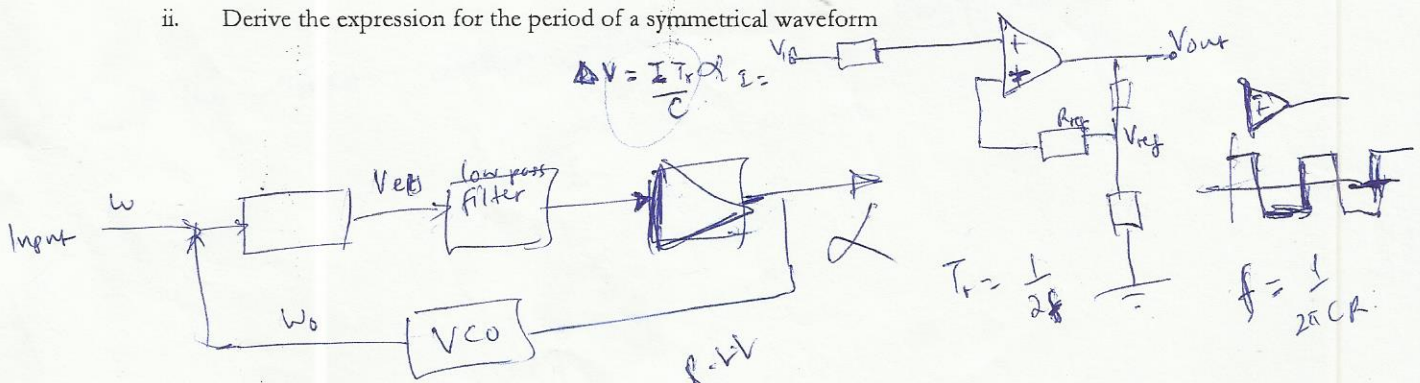


Fig. Qstn.2

3. Explain briefly how the dc offset error voltages and currents that occur in real operational amplifiers are caused by mismatch of the input transistor
4. With the aid of a circuit diagram, explain how low frequency response of an Op-Amp may be obtained.
5.
 - i. Describe how an Op-Amp comparator may be used to generate a square waveform
 - ii. Derive the expression for the period of a symmetrical waveform



$$A_v = \frac{R_c}{M}$$

$$V_c = V_{cc} - I_{cfc} R_c = \beta M$$

$$M = \frac{R_{in}}{2 R_{cfc} h_{FE}} = \frac{I_c}{I_b}$$

$$V_{be}' = \frac{h_{ie}}{h_{FE}} = \frac{10000}{130}$$

$$R_{in} = 10 = \frac{0.025}{I_E}$$

$$I_T = 2I_E = \frac{V - V_{BE}}{R_B}$$

$$R_{in} = \beta$$



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UNIVERSITY EXAMINATIONS 2009/2010 ACADEMIC YEAR THIRD YEAR SECOND SEMESTER EXAMINATIONS FOR THE DEGREE OF BACHELOR OF TECHNOLOGY

COURSE CODE: ECE 352

COURSE TITLE: ANALOGUE ELECTRONICS III

DATE: 15TH APRIL 2010

TIME: 2.00 PM - 5.00 PM.

INSTRUCTION TO CANDIDATES

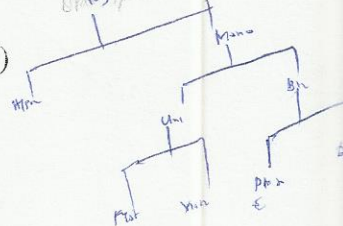
- SEE INSIDE
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7

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Question one

- List the four advantages of ICs (4mks)
 reduced cost, reduced size, increased speed, increased reliability, low power consumption, compatibility
- With a well illustrated schematic diagram classify the ICs. (3mks)

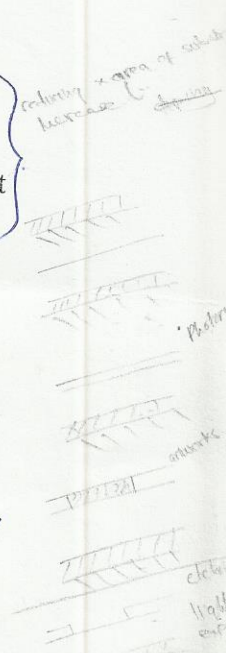


*Crystal growth of silicon
Ingot slice
Wafer
Hoped cleaning*

- List the steps involved in preparation of si-wafer (5mks)
- Give the importance of SiO₂ in plannar process. (2mks)

Question two

- Give two important advantages of ion implantation technique (4mks)
- List package configurations that you know (3mks)
 metal can, ceramic, push-on-le-p...
- How do you reduce the collector series resistance of the IC transistor? (2mks)
- With a well illustrated diagram show the basic steps of lithograph. What are the major functions of a photoresist? (5mks)



Question three

- PR is a photosensitive organic material which contains three ingredients, name them. (3mks)
- With aid of a diagram differentiate between positive and negative resist. (4mks)
- What is a mask? (1mks)
 - Briefly explain the parameters that determine the performance of exposure tool. (6mks)

Question four

- What is an ideal current source? List two types of current sources. (5mks)
- Why is it that the internal current of an ideal current source is equal to infinity? (2mks)
- The differential amplifier shown in figure 4.c is desired to have the following specifications:

Voltage gain, $V_{out}/V_{in} = 100$
Maximum output voltage swing = 10V peak-to-peak.
Input resistance seen by signal source = 5K ohm.
Given that $h_{FE} = 125$ for all the transistors, find:

$V_{out} = A_v \cdot \frac{R_c}{R_c + R_L}$
 $100 = \frac{A_v \cdot R_c}{R_c + R_L}$
 $100 = \frac{A_v \cdot R_c}{R_c + 1000}$
 $100(R_c + 1000) = A_v \cdot R_c$
 $100R_c + 100000 = A_v \cdot R_c$
 $100000 = (A_v - 100)R_c$
 $4000 = (A_v - 100)R_c$

$64 + 1.25 \times 10^3 \times 1000$
 $12V - 0.7 = 1.25 \times 10^3$
 $R_c = \frac{V_{out}}{I_c}$
 $R_c = \frac{10V}{1.25 \times 10^{-3}A}$
 $R_c = 8000 \Omega$
 $R_c = 8K \Omega$

$R_c = \frac{V_{out}}{I_c}$
 $R_c = \frac{10V}{1.25 \times 10^{-3}A}$
 $R_c = 8000 \Omega$
 $R_c = 8K \Omega$

- i) Resistor R_c (2mks)
- ii) Power supplies $\pm V$ (2.5mks)
- iii) Bias resistor R_B . (2.5mks)

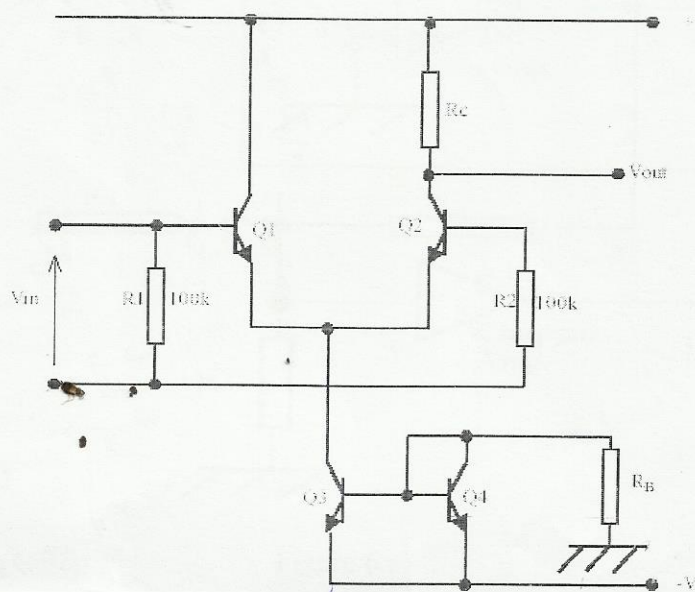


Figure 4.c

Question five

- a) With aid of a diagram show that for a Widlar current source $I_{c1} \approx I_{ref}$ (10mks)
- b) Design a Widlar current source for generating a constant current $I_o = 10\mu A$. Assume $V_{cc} = 10V$, $V_{BE} = 0.7V$, $\beta = 125$. Use $V_T = 25mV$ (4mks)

• Question six

- a) For the diagram shown in figure 6.a, show that

$$A1 = \frac{R2}{R3A2}$$

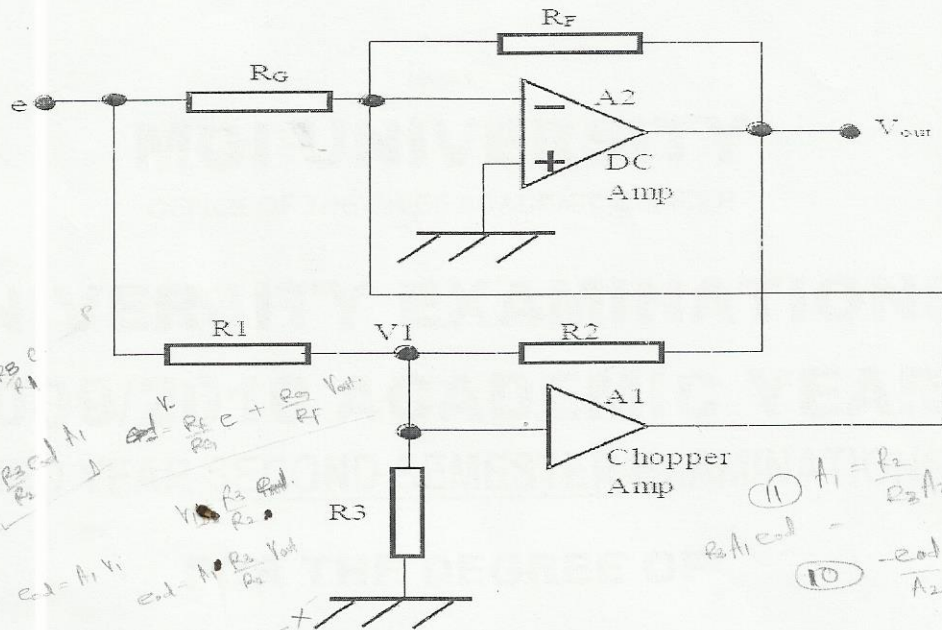


Figure 6.a.

- b) Give the disadvantages of chopper based amplifiers. (2mks)
 c) Show that for a PLL in lock;

$$V_d(t) = \frac{K_d V_i V_o A}{2} \cos \phi$$

Question seven

- a) What are the advantages of the OTA? (4mks)
 b) With aid of a diagram show how PLL is applied in frequency translation. (6mks)
 c) In the regenerative comparator circuit, assume that $R_2 = 100\Omega$, $R_1 = 50k\Omega$, $V_{ref} = 0V$, $V_i = 1V_{pp}$ sine wave and saturation voltage $= \pm 14V$. Determine threshold voltages V_{UT} and V_{LT} . (4mks)

