

UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 1996/97

April 1997

EEE 132 - Peranti Elektronik

Masa : [3 jam]

ARAHAN KEPADA CALON :

Sila pastikan bahawa kertas peperiksaan ini mengandungi **SEBELAS (11)** muka surat bercetak dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan ini.

Terdapat **SEBELAS (11)** soalan.

Jawapan bagi soalan-soalan daripada Bahagian A dan Bahagian B mestilah dalam 2 buku yang berasingan.

Agihan markah bagi soalan diberikan di sut sebelah kanan soalan berkenaan.

Jawab semua soalan di dalam Bahasa Malaysia.

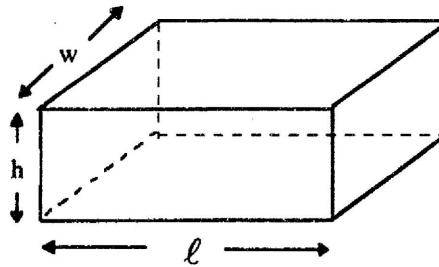
Anggapan:

Cas elektron $e = 1.6 \times 10^{-19} \text{ C}$

Angkatap Boltzmann = $1.38 \times 10^{-23} \text{ J}^\circ\text{K}$

BAHAGIAN A

1. (a) Satu bar Germanium mempunyai bentuk seperti Rajah S1.
A Germanium bar has the shape as shown in Figure S1.



Rajah S1
Figure S1

Diberi: $l = 1 \text{ cm}$
 Given: $h = w = 0.1 \text{ cm}$

Keboleherakan lubang $\mu_p = 2 \times 10^3 \text{ cm}^2 / \text{V.s}$
Hole mobility

Keboleherakan elektron $\mu_n = 4 \times 10^3 \text{ cm}^2 / \text{V.s}$
Electron mobility

Jika bar tersebut adalah intrinsik, ($n = p = n_i \approx 2 \times 10^{13} \text{ cm}^{-3}$ pada $T = 300^\circ \text{K}$) tentukan keberaliran, σ , dan rintangan, R , yang diukur di antara kedua hujung bar (hujung bar mempunyai luas permukaan wh dan $R = \frac{l}{\sigma wh}$).

If the bar is intrinsic ($n = p = n_i \approx 2 \times 10^{13} \text{ cm}^{-3}$ at $T = 300^\circ \text{K}$), find the conductivity, σ , and resistance, R , measured between the two ends (the end of the bar has a surface area of wh and $R = \frac{l}{\sigma wh}$).

(50%)

- (b) Apakah magnitud voltan Hall, V_H , bagi satu semikonduktor yang mempunyai kepekatan pembawa majoriti 10^{16} cm^{-3} jika lebar, $w = 1 \text{ mm}$, medan magnet, $B = 0.1 \text{ weber/m}^2$, dan bar tersebut membawa arus 10 mA melalui luas keratan rentas 10^{-2} cm^2 ?

What is the magnitude of the Hall voltage for a semiconductor that has a majority carrier concentration of 10^{16} cm^{-3} if the width, $w = 1 \text{ mm}$, magnetic field, $B = 0.1 \text{ weber/m}^2$, and the bar carries a 10 mA current through a cross sectional area of 10^{-2} cm^2 ?

(25%)

- (c) Lukis gambarajah jalur tenaga bagi pengalir, penebat dan semikonduktor. Beri ulasan mengenai keberaliran ketiga-tiga bahan tersebut dengan merujuk kepada elektron bebas mereka pada suhu bilik.

Draw the energy band diagrams for a conductor, an insulator and a semiconductor. Comment on the conductivities of the three materials with reference to the density of their free electrons at room temperature.

(25%)

2. (a) Satu simpang p-n silikon dibentuk daripada bahan jenis - p dengan keberintangan $1.3 \times 10^{-3} \Omega\text{m}$ dan bahan jenis - n dengan keberintangan $4.6 \times 10^{-3} \Omega\text{m}$ pada suhu bilik (293°K). Masa hayat bagi bahan-bahan p dan n ialah masing-masing $100 \mu\text{s}$ dan $150 \mu\text{s}$, dan luas simpang ialah 1.0 mm^2 .

Jika $\mu_p = 4.8 \times 10^{-2} \text{ m}^2/\text{Vs}$, $\mu_n = 0.135 \text{ m}^2/\text{Vs}$ dan $n_i = 6.5 \times 10^{16}/\text{m}^3$, kirakan arus bocor pincang balikan dengan menganggap kawasan-kawasan p dan n adalah jauh lebih panjang daripada panjang resapan.

A silicon p-n junction is formed from p-type material with a resistivity of $1.3 \times 10^{-3} \Omega.m$ and n-type material with resistivity of $4.6 \times 10^{-3} \Omega.m$ at room temperature (293 °K). The lifetimes of the minority carriers in the p-and n- materials are 100 μs and 150 μs respectively, and the junction area is 1.0 mm^2 . If the mobilities of the minority carriers are $\mu_p = 4.8 \times 10^{-2} \text{ m}^2 / \text{V.s}$, $\mu_n = 0.135 \text{ m}^2 / \text{V.s}$ and $n_i = 6.5 \times 10^{16} / \text{m}^3$, then calculate the reverse bias leakage current, assuming the p- and n- regions are much longer than the corresponding diffusion lengths of the minority carriers.

Nota : $p_n = \frac{n_i^2}{n_n}$ dan $n_p = \frac{n_i^2}{p_p}$

Note : and

(75%)

- (b) Nyatakan kesan suhu ke atas ciri-ciri I-V diod. Lukis juga graf I-V bagi satu diod pada dua suhu berlainan.

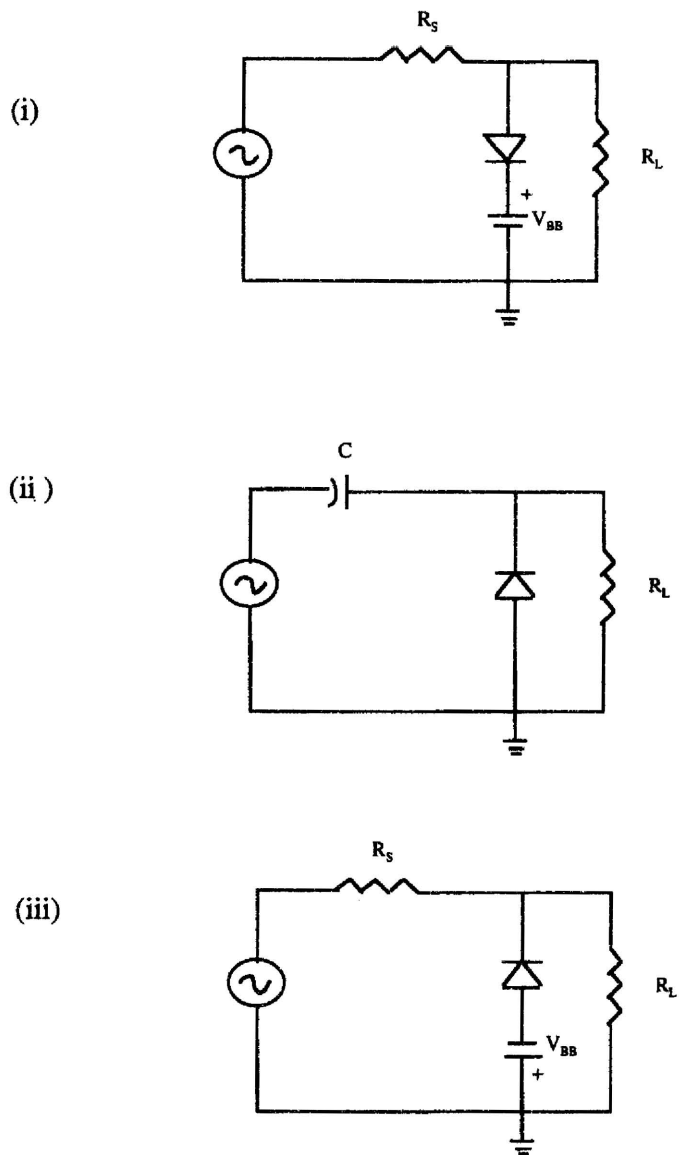
Explain the effects of temperature variation on the I-V characteristics of a diode. Draw the general shapes of I-V curves of a diode at two different temperatures.

(25%)

3. (a) Lukiskan bentuk gelombang keluaran untuk 1 kitar bagi litar-litar dalam Rajah S3 jika masukan mempunyai voltan puncak V_p . Sawar upaya, V_d , bagi setiap diod diambilkira.

Draw one cycle of the output voltage waveform for each of the circuits shown in Figure S3. The sinusoidal input has a peak voltage, V_p . Voltage drop, V_d , across each diode has to be considered.

...5/-



Rajah S3
Figure S3

(75%)

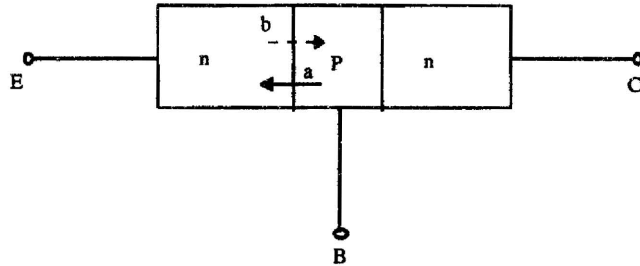
- (b) Terangkan 2 jenis keruntuhan dalam keadaan pincang balikan bagi diod zener.
Explain the two types of breakdown in a zener diode under reverse bias.

(25%)

...6/-

BAHAGIAN B

4. (a)



Rajah S4(a)

Figure S4(a)

Dari Rajah S4(a) di atas a adalah pengaliran lubang dari tapak ke pemancar dengan kadar 10^8 lubang/ μ s sementara b adalah pengaliran elektron dari pemancar ke tapak dengan kadar 10^{10} elektron/ μ s. Didapati arus tapak, i_B , adalah 16μ A. Tentukan arus-arus pemancar dan pengumpul.

From the above Figure S4(a), a is the flow of holes from base to emitter with the rate 10^8 holes/ μ s while b is the flow of electrons from emitter to base at the rate of 10^{10} electrons/ μ s. It is found that the base current, i_B , is 16μ A. Determine the emitter and the collector currents.

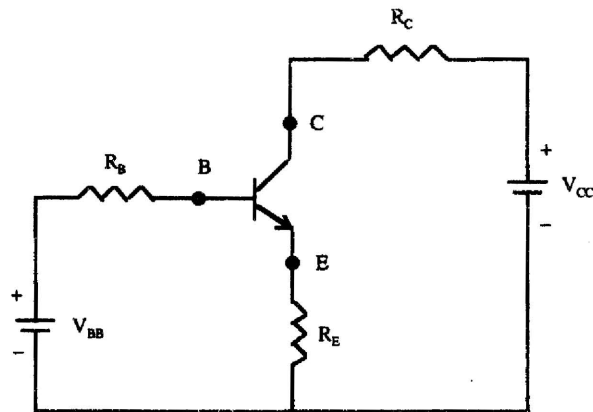
(40%)

(b) Transistor silikon seperti ditunjukkan dalam Rajah S4(b) di bawah mempunyai nilai-nilai berikut:-

The characteristics of the silicon transistor and the associated components shown in Figure S4(b) below have the following values:-

Arus Tapak (Base Current)	=	40μ A
I_{CBO}	=	0
V_{BB}	=	6V
R_E	=	1K Ω
β	=	80

...7/-



Rajah S4(b)
Figure S4(b)

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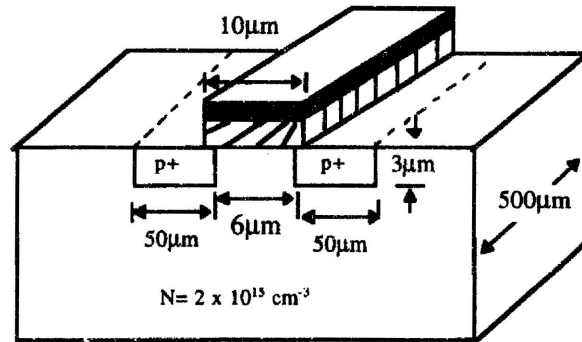
Determine

- (i) I_{EQ}
- (ii) R_B
- (iii) Jika $V_{CC} = 15V$ dan $R_C = 3K\Omega$, cari V_{CEQ}
If $V_{CC} = 15V$ and $R_C = 3K\Omega$, find V_{CEQ}

(60%)

5. (a) Keratan lintang bagi suatu transistor MOS adalah seperti berikut:-
The cross-section for a MOS transistor is as follows:-

...8/-



Rajah S5(a)

Figure S5(a)

Data-data lain yang diberikan adalah:-

Other given data are:-

$W = 500 \mu\text{m}$ (lebar salur)
(channel width)

$\mu_h = 250 \text{ cm}^2 \text{ V}^{-1}\text{s}^{-1}$

$V_T = -2.5 \text{ V}$

$t_{ox} = 90\text{nm}$ (ketebalan get oksida)
(oxide thickness)

$\epsilon_{ox} = 3.85$

- (i) Tentukan V_{GS} yang diperlukan bagi kendalian transistor pada titik kuisien $I_{DS} = 2\text{mA}$ dalam kawasan arus-tepuan sementara menggunakan nilai V_{DS} yang minimum mungkin.

Determine V_{GS} needed for operation at quiescent point $I_{DS} = 2\text{mA}$ in saturation region while using the minimum possible value for V_{DS} .

- (ii) Hitungkan parameter-parameter model : C_{ds} , C_{gs} dan C_{gd} (anggap simpang-simpang langkah dan $g_o \approx 0$)

Calculate model parameters: C_{ds} , C_{gs} and C_{gd} (assume step junctions and $g_o \approx 0$)

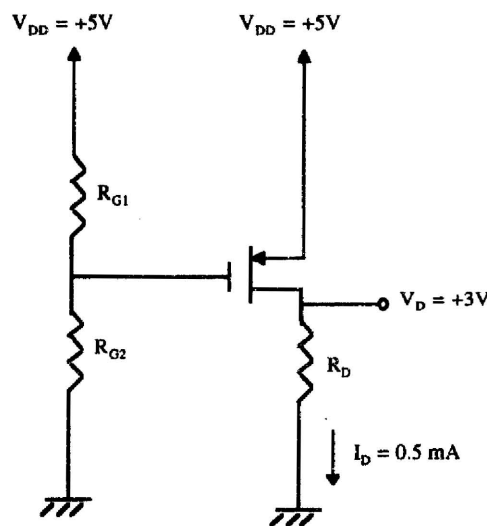
(60%)

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- (b) Rekabentuk litar di bawah supaya transistor kendali pada tepuan dengan $I_D = 0.5 \text{ mA}$ dan $V_D = +3V$. Anggap transistor PMOS jenis-peninggian mempunyai $V_T = -1V$ dan $K = 0.5 \text{ mA/V}^2$ dan $\lambda = 0$.
Apakah nilai terbesar R_D sementara mengekalkan pengoperasian kawasan tepuan.

Design the circuit below so that the transistor operates at saturation with $I_D = 0.5 \text{ mA}$ and $V_D = +3V$. Assume PMOS transistor, enhancement-type, with $V_T = -1V$ and $K = 0.5 \text{ mA/V}^2$ and $\lambda = 0$.

What is the largest value of R_D while maintaining operation in saturation region.



(40%)

Rajah S5(b)

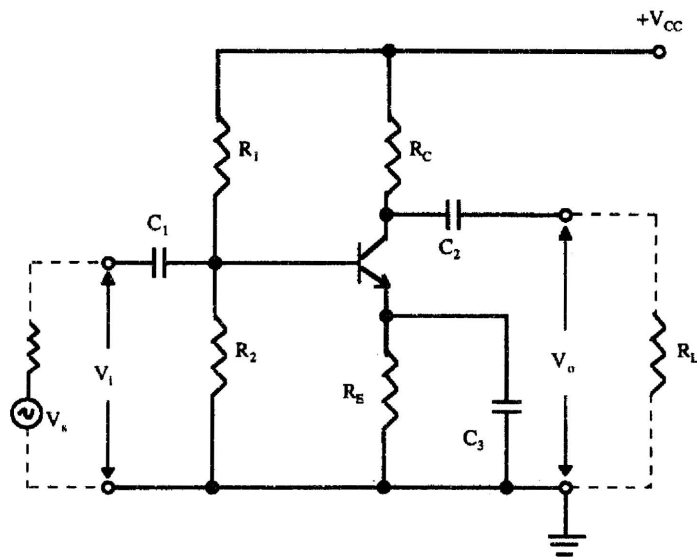
Figure S5(b)

6. (a) Suatu penguat pemancar sepunya seperti dalam Rajah S6(a) berikut mempunyai komponen-komponen berikut:-

A common emitter amplifier as shown in Figure S6(a) below has the following component values:-

$$R_1 = 27K\Omega, R_2 = 12K\Omega, R_C = 5.6K\Omega$$

$$R_E = 5.6K\Omega, R_L = 47K\Omega$$



Rajah S6(a)
Figure S6(a)

Parameter-parameter transistor adalah:-

Transistor parameters are:-

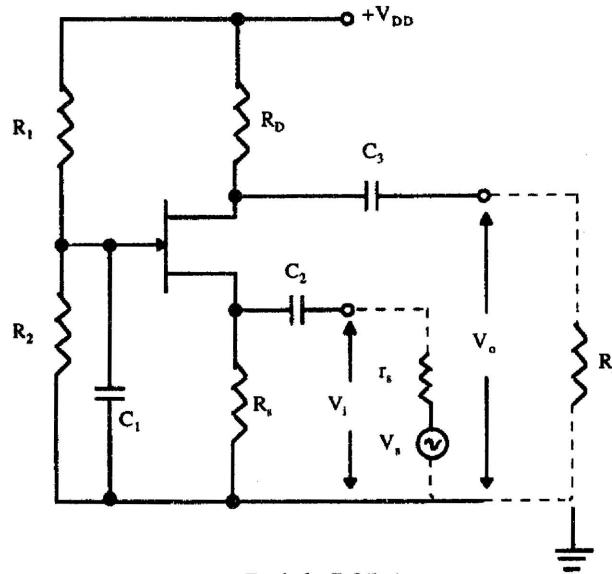
$$h_{ie} = 1\text{K}\Omega, h_{fe} = 85 \text{ \& } h_{oe} = 2\mu\text{S}.$$

Hitungkan Z_i , Z_o dan A_v .

Calculate Z_p , Z_o and A_v .

(40%)

- (b) Litar get sepunya mempunyai:-
Common gate circuit has the following values:-



Rajah S6(b)

Figure S6(b)

$$R_1 = 3.9\text{M}\Omega, R_2 = 2.2\text{M}\Omega, R_S = 1.5\text{K}\Omega$$

$$R_L = 27\text{K}\Omega, R_D = 3.3\text{K}\Omega$$

FET mempunyai $g_m = 3.5 \text{ mA/V}$ dan $r_d = 70\text{K}\Omega$.

FET has $g_m = 3.5 \text{ mA/V}$ and $r_d = 70\text{K}\Omega$.

Hitungkan Z_i , Z_o dan A_v .

Calculate Z_i , Z_o and A_v .

Hitungkan voltan keluaran bila

$$V_s = 100 \text{ mV} \text{ dan } r_s = 600\Omega$$

Calculate output voltage when

$$V_s = 100 \text{ mV} \text{ and}$$

$$r_s = 600\Omega$$

(60%)

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