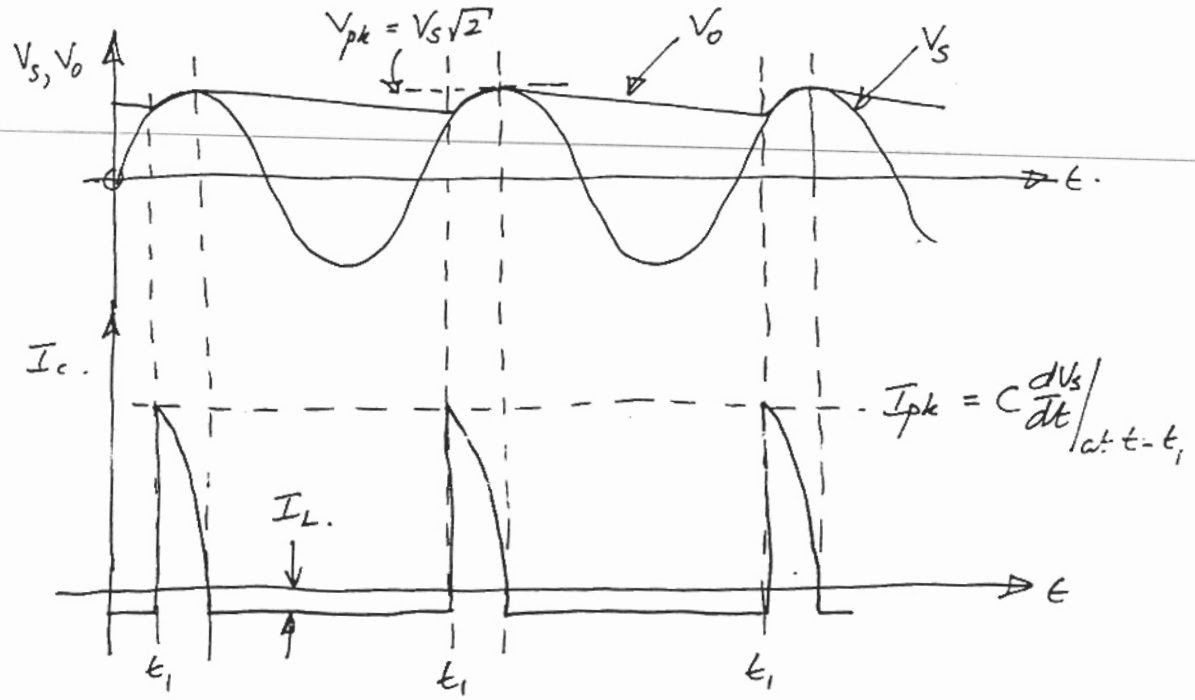
EEE 103 June 2004. Solutions

Q1 (i)



(ii) The half wave rectifier shown has a whole half period when energy must be supplied to the load from the storage element C. A full wave rectifier circuit has a smaller period of time for which C must supply the load so for a given ripple performance, a smaller C can be used and this in turn leads to smaller I_{cpk}.

(iii) If the components used are assumed to be ideal, as in part (i), $V_{OAVE} \approx V_{pk} = 30\,V$

$$\therefore\ V_s = \frac{30}{\sqrt{2}} = \underline{\underline{21.2\,V}}.$$

If the diodes are assumed to have a forward drop of 0.7V and $V_{OAVE} = V_{pk} - V_R/2$.

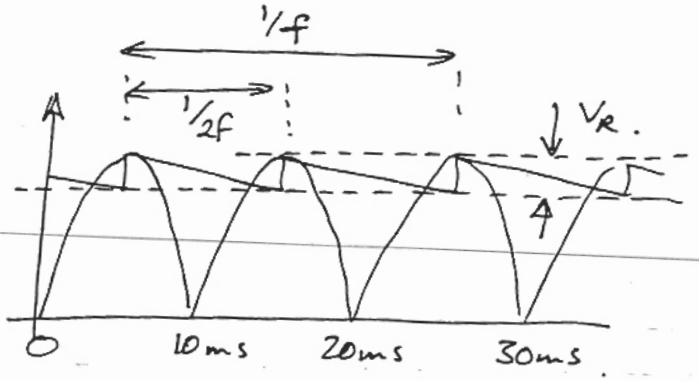
$$V_s\sqrt{2} - 2\times 0.7 = 30 + V_R/2 = 30.5$$

$$\text{or}\quad V_s = \frac{30.5 + 1.4}{\sqrt{2}} = \underline{\underline{22.6\,V}}.$$

Either answer will do providing assumptions are stated.

Q1 cont...

(iv) • assume I_L = const.
• assume that C discharges for a whole half cycle.

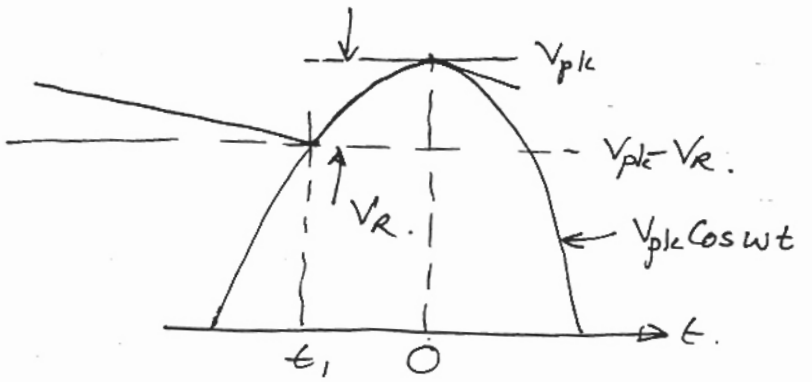


Since I_L = const, $I_L = C\frac{dV}{dt} = C\frac{V_R}{1/2f} = C V_R 2f$.

$\therefore C = \frac{I_L}{2 V_R f} = \frac{2}{2.1.50} = \underline{20{,}000\mu f}$.

(v)

to find t_1, use a model like ⟶.



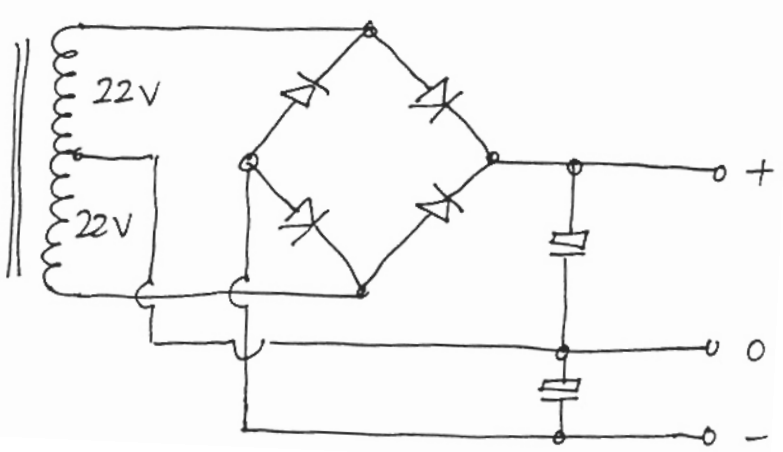
$V_{pk} - V_R = V_{pk}\cos\omega t_1$

or $\omega t_1 = \cos^{-1}\frac{V_{pk} - V_R}{V_{pk}}$

or $t_1 = \omega^{-1}\cos^{-1}\left(\frac{V_{pk} - V_R}{V_{pk}}\right) = (2.\pi.50)^{-1}\cos^{-1}\frac{29}{30}$

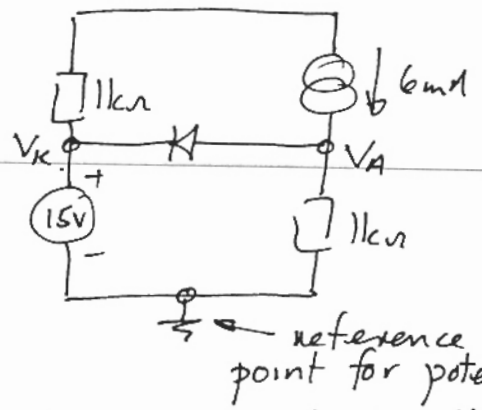
$= \underline{0.82\,ms}$.

(vi)



EEE103 June 2004.

Q2 (a). Try a test: assume diode does not conduct, replace it with an open circuit and work out $V_A - V_K$.



due to 15V:

$V_K = 15V$ (by inspection)

$V_A = 0V$ (by inspection) (the 6mA source looks like an open circuit)

due to 6mA

$V_A = 6V$ ($= 6mA \times 1k\Omega$).

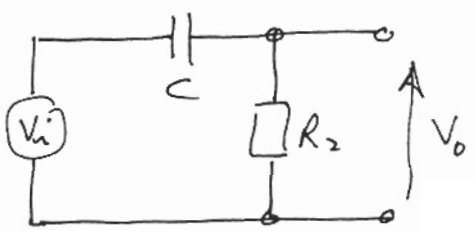
$V_K = 0V$ (since 15V replaced by a short ct).

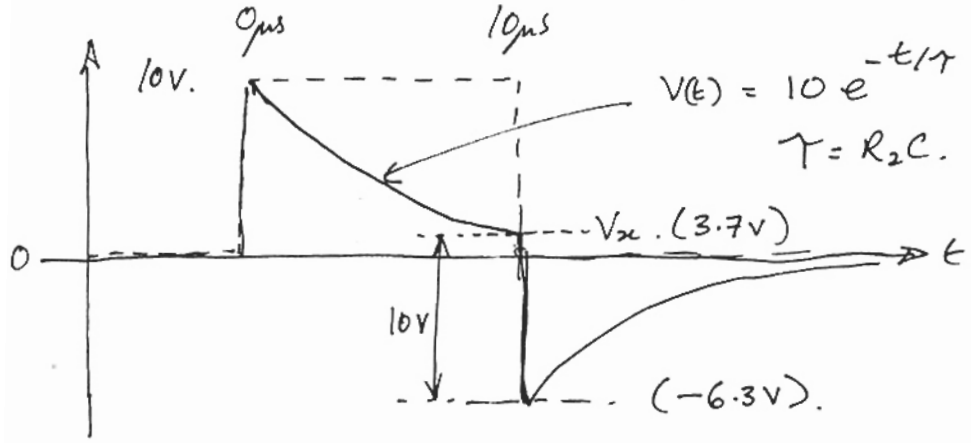
$\therefore V_A = 0 + 6$, $V_K = 15 + 0$

$\therefore V_A - V_K = 6 - 15 = -9V$

$\therefore$ diode is indeed reverse biased and does not conduct. Reverse bias = $\underline{9V}$.

b(i)





$V_x = 10e^{-\frac{10\mu s}{10ms}} = 10e^{-1} = \underline{3.7V}$

Q2 cont....

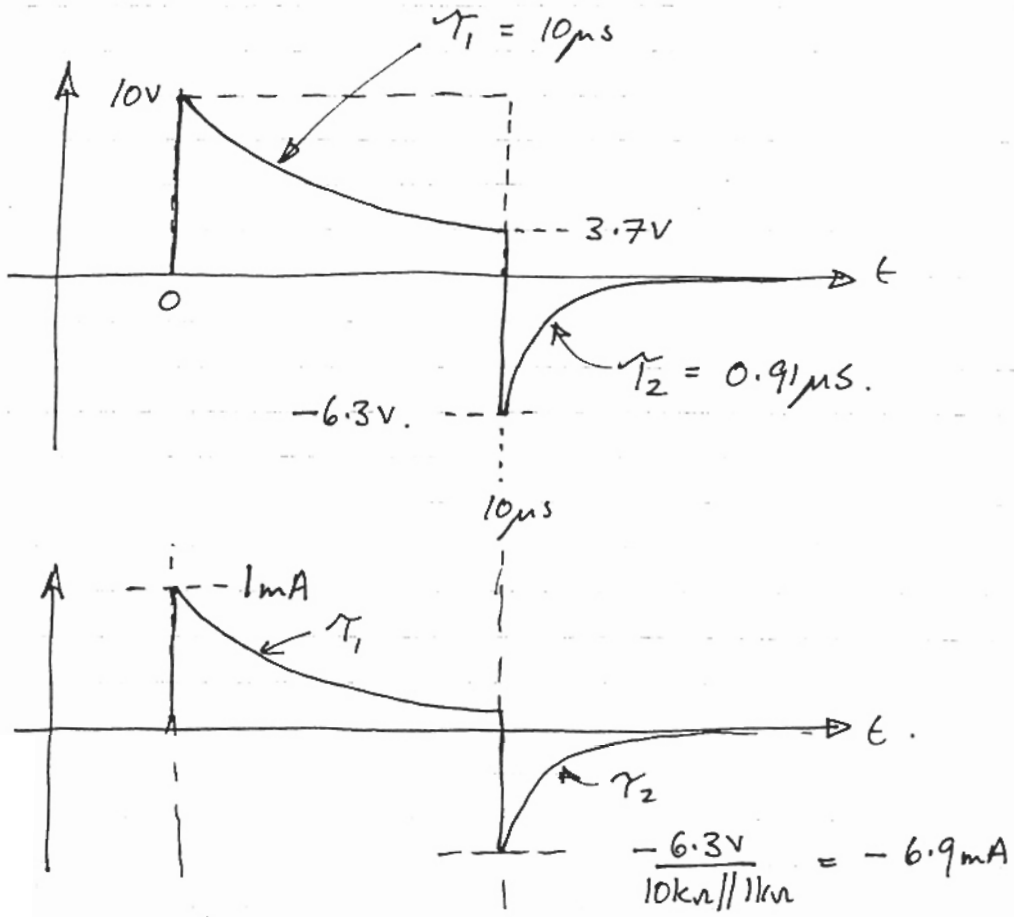
$V(t) > 5V$ for the time it takes $10e^{-t/\tau}$ to fall to 5V...

$5 = 10e^{-t/10\mu s}$ or $e^{-t/10\mu s} = 0.5$

or $-t = 10\mu s \cdot \ln 0.5$

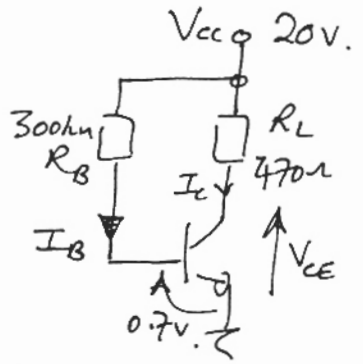
or $t = 10\mu s \ln 2 = \underline{6.93\mu s}$.

(b) (ii)



EEE103 June 2004.

Q3. (i) The purpose of the bias circuit is to define stable operating conditions for the transistor and in particular to control collector current.



(ii) The base current, I_B, is given by:

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{20 - 0.7}{300k\Omega}$$

$$= 64.3\mu A.$$

For an h_{FE} of 100, $I_C = 6.43mA$
For an h_{FE} of 500, $I_C = 32.15mA$.

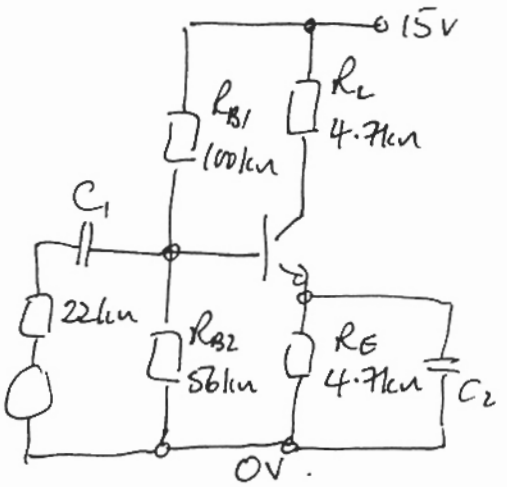
When $I_C = 6.43mA$ $V_{CE} = V_{CC} - I_C R_L$
$= 20 - 6.43 \times 0.47 = \underline{17V}$.

When $I_C = 32.15mA$, $V_{CE} = 20 - 32.15 \times 0.47 = \underline{4.9V}$.

So for $h_{FE} = 100$, $I_C = 6.43mA$ & $V_{CE} = 17V$
$h_{FE} = 500$, $I_C = 32.15mA$ & $V_{CE} = 4.9V$

This bias circuit is poor because it fails to control the important parameter I_C.

(iii) Assume I_B negligible...
V_B is then defined by potential division..



$$V_B = \frac{15 \times R_{B2}}{R_{B1} + R_{B2}} = \frac{15 \times 56}{156}$$

$$= \underline{5.38V}.$$

$$\therefore V_E = 5.38V - 0.7$$
$$= 4.68V$$

and $I_E \approx I_C = \frac{V_E}{R_E} = \frac{4.68V}{4.7k\Omega} = \underline{1mA}.$

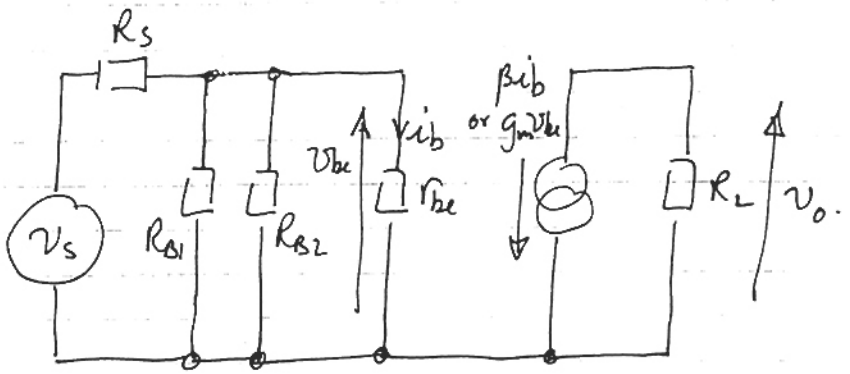
Q3 cont...

$$V_C = V_{CC} - I_C R_L = 15 - 1mA \times 4.7k\Omega$$
$$= \underline{10.3\,V}.$$

$$g_m = \frac{eI_C}{kT} = \frac{1mA}{0.026} = \underline{38.5\,mA/V}$$

$$r_{be} = \beta/g_m = \frac{600}{38.5\times10^{-3}} = \underline{15.6\,k\Omega}.$$

(iv).



(v) If C_3 were omitted, R_E would have the same stabilising effect on the signals as it has on the d.c. conditions. In other words, the circuit voltage gain would be drastically reduced.

Since $\Delta V_E \approx \Delta V_B$ ($V_{BE} \approx$ constant).

$$\Delta I_C = \frac{\Delta V_E}{R_E} \approx \frac{\Delta V_B}{R_E}$$

$$\Delta V_o = -\Delta I_C R_L \approx -\frac{\Delta V_B}{R_E} R_L$$

$$\therefore \frac{\Delta V_o}{\Delta V_B} = \text{gain} \approx -\frac{R_L}{R_E} = \underline{-1}.$$

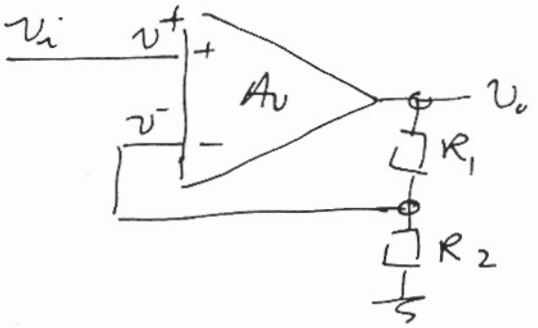
EEE103 June 2004

Q4 (a) (i) "non-inverting" means that the phase of the output signal is the same as that of the input signal ... ie a positive going change on the input leads to an amplified positive going change on the output.

(ii) $\frac{v_o}{v_i} = \frac{R_1+R_2}{R_2}$ if $A_v \to \infty$.

(iii) If $A_v \not\to \infty$ one must do a more detailed analysis ...

Assume op-amp inputs draw zero current



$$v^- = v_o \frac{R_2}{R_1+R_2}$$

$$v^+ = v_i$$

$$v_o = A_v(v^+ - v^-)$$

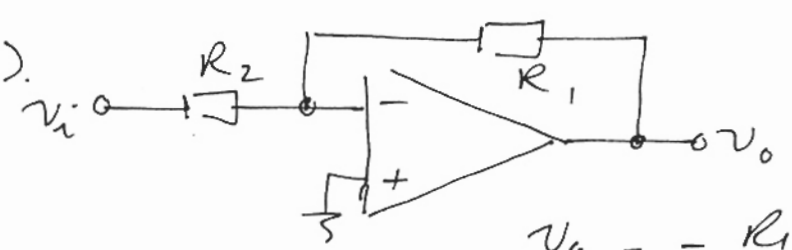
$$= A_v\left(v_i - v_o \frac{R_2}{R_1+R_2}\right).$$

$$\frac{v_o}{A_v} + v_o \frac{R_2}{R_1+R_2} = v_i$$

$$v_o\left[\frac{1}{A_v} + \frac{R_2}{R_1+R_2}\right] = v_i$$

$$\therefore \frac{v_o}{v_i} = \frac{1}{\frac{1}{A_v} + \frac{R_2}{R_1+R_2}}.$$

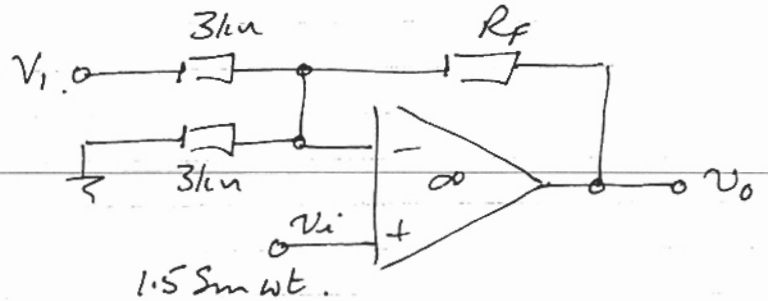
(iv).



$$\frac{v_o}{v_i} = -\frac{R_1}{R_2}.$$

Q4 cont...

(b).



To find non-inverting a.c. gain, replace the d.c. source, V_1, by its Thevenin equivalent impedance to ground — ie a short cct to ground. The two 3kΩ resistors are then clearly in parallel and the gain acting on v_i is

$$\frac{v_o}{v_i} = \frac{R_F + 3k\Omega \,//\, 3k\Omega}{3k\Omega \,//\, 3k\Omega} = \frac{R_F + 1.5k\Omega}{1.5k\Omega}.$$

Since the output ac is required to be 10v pk-pk and the input voltage is 3v pk-pk (1.5v pk)..

$$\frac{v_o}{v_i} = \frac{10}{3} = \frac{R_F + 1.5k\Omega}{1.5k\Omega}$$

$$15k\Omega = 3R_F + 4.5k\Omega$$

$$\text{or} \quad 3R_F = 10.5k\Omega \quad \text{or} \quad R_F = \frac{10.5}{3}k\Omega = \underline{3.5k\Omega}$$

To get a d.c. o/p of 5v with no a.c. input, ground v_i. v^- is a virtual earth so no current flows through the lower 3kΩ resistor and

$$\frac{V_o}{V_1} = -\frac{R_F}{3k\Omega} = -\frac{3.5}{3}$$

and since V_o must be +5

$$\frac{5}{V_1} = -\frac{3.5}{3} \quad \text{or} \quad V_1 = -\frac{5 \times 3}{3.5} = \underline{-4.29\,V}$$