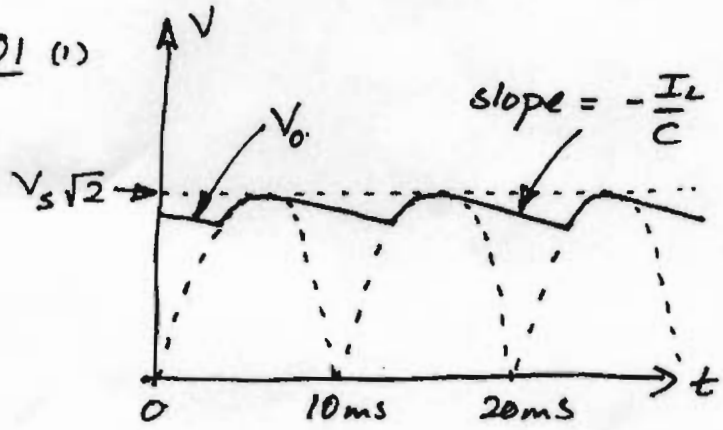
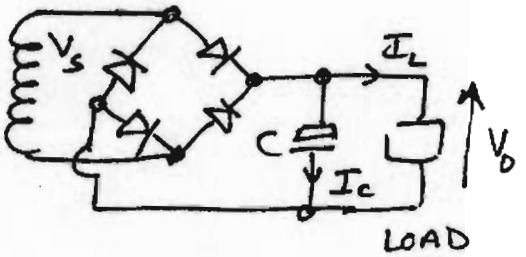
EEE103 June '05 Solutions.

Q1 (i)



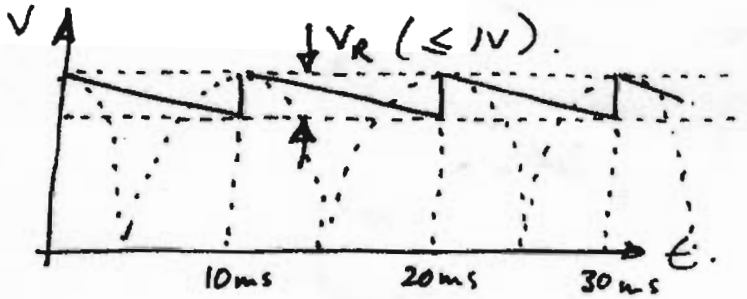


- assumes $V_p \gg 0.7$ so diode drops can be ignored
  I_L = constant.
  transformer, diodes & capacitor have no series resistance or inductance.

(ii) assume C discharges for one complete half cycle and that charging is instantaneous...

I_L is defined as a constant 150mA so...

$$I_L = C\frac{dV}{dt} = C\frac{V_R}{1/2f}$$



if V_R must be less than 1V...

$$1 \geq \frac{(1/f \times 2) \times I_L}{C}$$

or $C \geq I_L/2f = 150mA \times 10ms = \underline{1500\mu F}$.

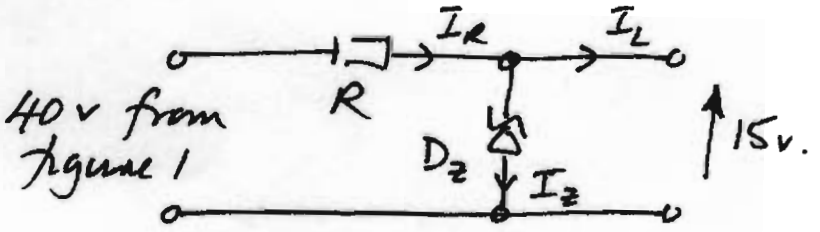
(iii) to get a V_0 of 40V, $V_s \approx \frac{40}{\sqrt{2}} = \underline{28V}$

This answer assumes that series resistance and inductance are zero and that the diode forward voltage drops can be neglected.

EEE103 Jun '05 sols cont....

Q1 cont...

(iv)



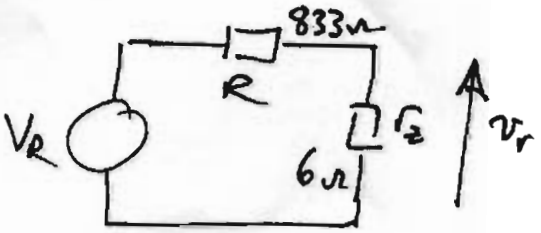
(v). $I_{R\,max} = I_{L\,max} + I_{z\,min}$

$= 30\,mA.$

$I_{R\,max}$ must be available through R when V_i is at its minimum. In this case V_i = const = 40v, V_o = const = 15v

$$\therefore R_{max} = \frac{V_i - V_o}{I_{R\,max}} = \frac{40-15}{30mA} = \frac{25}{.03} = \underline{\underline{833\,\Omega}}.$$

(vi) ripple equivalent circuit is ....

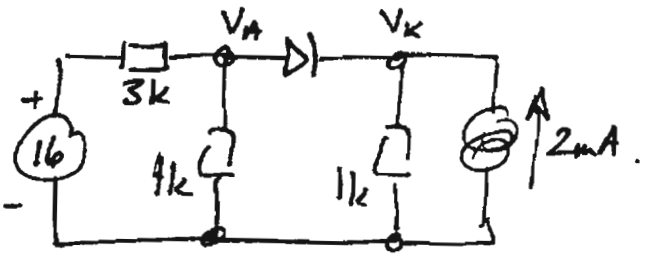


$\therefore v_r$ = output ripple (pk-pk)

$= V_R \times \frac{r_z}{R + r_z}$

$= 1 \times \frac{6}{839} = \underline{\underline{7.2\,mV}}$

Q2 (a) either start from here, assume diode is not conducting + work out V_A + V_K .....



$V_A = \frac{16.1}{4} = 4V.$

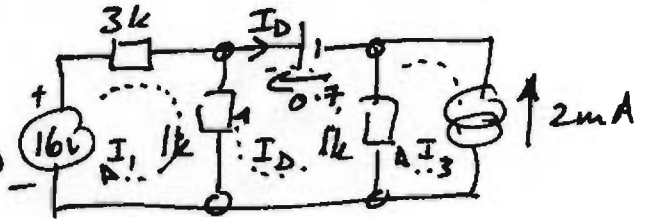
$V_K = 2mA \times 1k = 2V.$

$\therefore V_A - V_K = (4-2)V = 2V \longrightarrow$ diode will conduct.

EEE103 Jun'05 sols cont....

Q2 a cont...

replace diode by 0.7V source + work out current flowing between anode + cathode by some method.... eg loops



$16 = 3kI_1 + 1k(I_1 - I_D)$

$0.7 + (I_D - I_3)\,1k + (I_D - I_1)\,1k = 0$

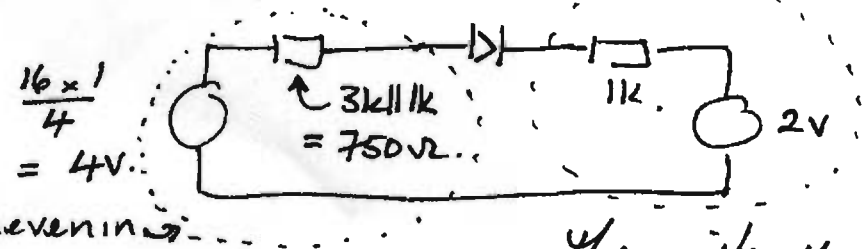
$I_3 = -2mA$.

$\therefore\ 0.7 + 2k\,I_D + 2V - 1k\,I_1 = 0$.

$16 - 4k\,I_1 + 1k\,I_D = 0$.

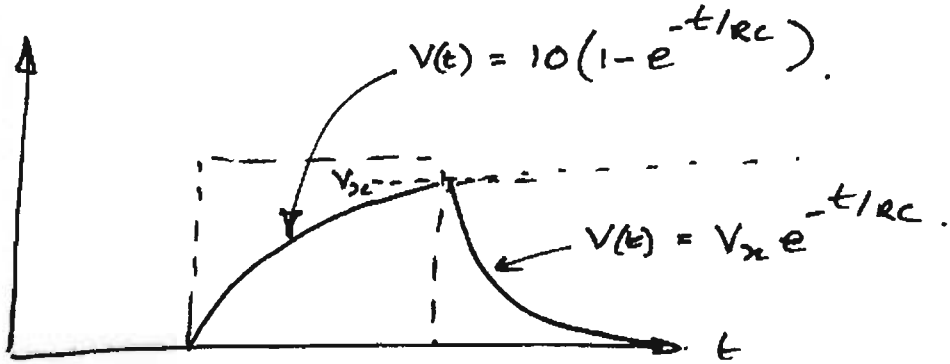
$10.8 - 16 + I_D(8k - 1k) = 0$ or $I_D = \frac{5.2}{7k} = \underline{\underline{743\mu A}}$.

or simplify cct to ..... norton → Thevenin



Then it is obvious that the diode will conduct and that the current will be $\frac{4 - 0.7 - 2}{750\Omega + 1k} = \frac{1.3}{1.75} = \underline{\underline{743\mu A}}$.

(b) (i)



$RC = 6\mu s$.

$V_{2c} = 10(1 - e^{-10/6}) = 10(1 - 0.189) = \underline{\underline{8.11\,V}}$

$\therefore$ falling exp $= 8.11\,e^{-t/6\mu s}$

EEE103 Jan 05 sols cont...

Q2b cont... and time taken for this to fall to 5V is

$$5 = 8.11\, e^{-t/6\mu s}$$

or $\ln\frac{5}{8.11} = -\frac{t}{6\mu s}$ or $t = 6\mu s \ln\left(\frac{8.11}{5}\right) = 2.9\mu s$.

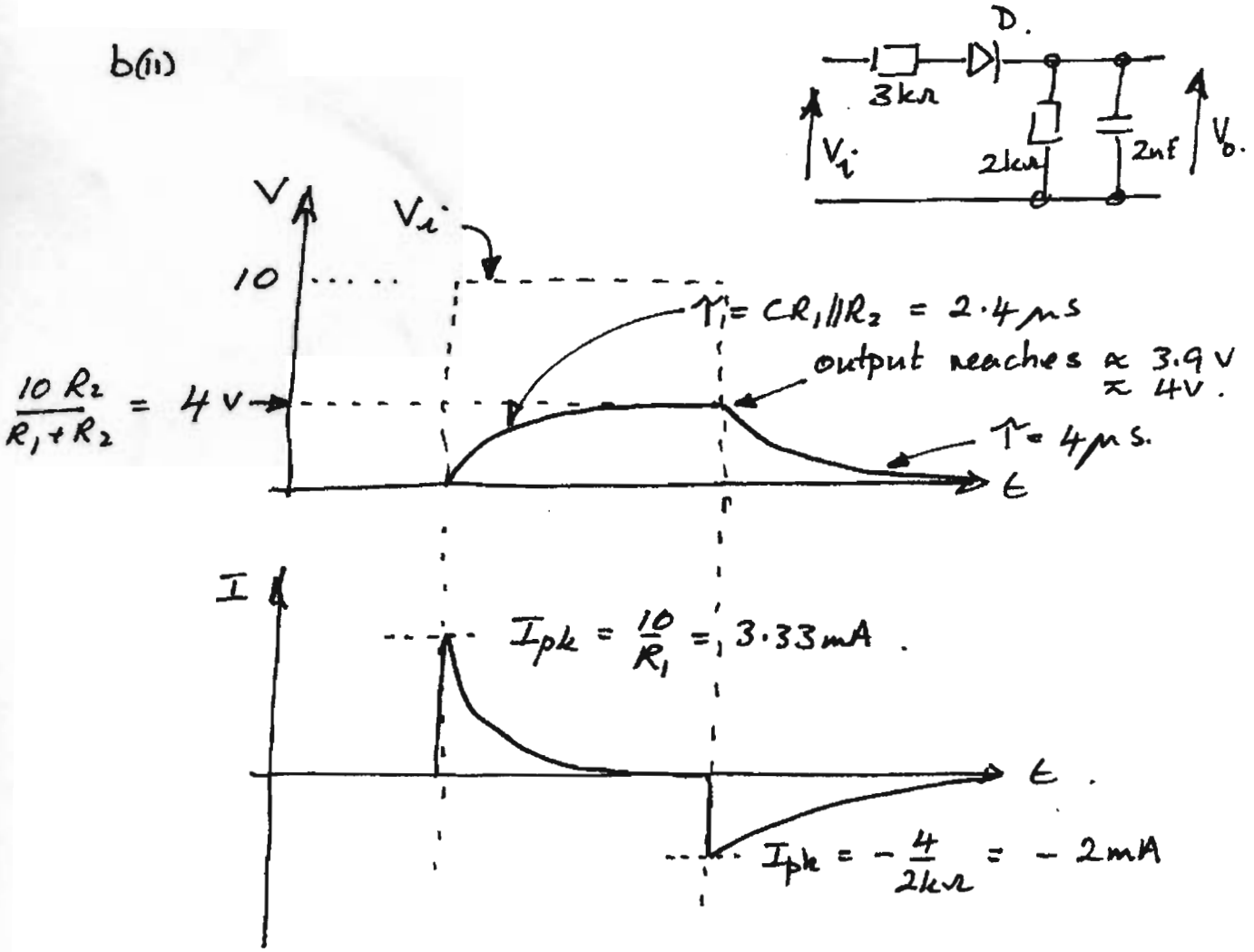
. time taken to rise to 5V during pulse is

$5 = 10\left(1 - e^{-t/6\mu s}\right)$ or $e^{-t/6\mu s} = 1 - 0.5 = 0.5$

$\therefore\ t = 6\mu s \ln 2 = 4.16\mu s$.

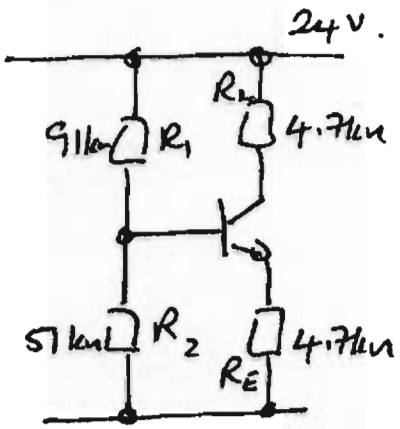
So $t_{>5V} = 10\mu s - 4.16\mu s + 2.9\mu s = \underline{\underline{8.74\mu s}}$.

b(ii)



EEE103 Jun '05 sols cont....

Q3 (i) + (ii).



$V_B = 24 \times \frac{51}{51+91} = \underline{\underline{8.62\,V}}$.

$V_E = V_B - 0.7 = \underline{\underline{7.92\,V}}$.

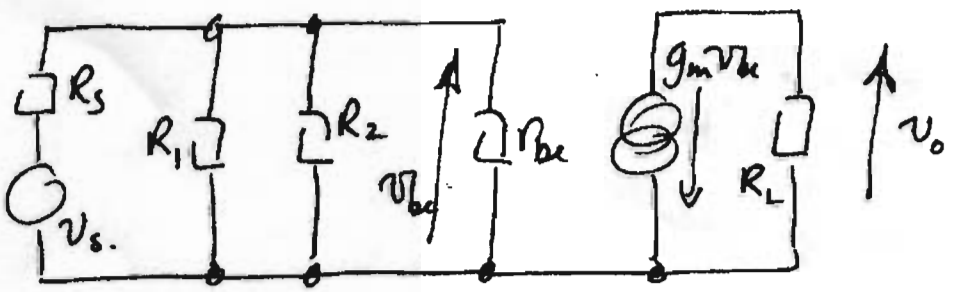
$I_C \approx I_E = \frac{V_E}{R_E} = \frac{7.92}{4.7k\Omega} = \underline{\underline{1.69\,mA}}$.

$\therefore V_C = V_{CC} - I_C R_L = 24 - 1.69 \times 4.7k\Omega = \underline{\underline{16.1\,V}}$.

$g_m = \frac{e I_C}{kT} = \frac{1.69mA}{.026} = \underline{\underline{65\,mA/V}}$.

$r_{be} = \beta / g_m = \frac{400}{.065} = \underline{\underline{6.2k\Omega}}$.

(iii)



(iv) $v_o = -g_m v_{be} R_L$

$v_{be} = \frac{v_s . R_1 \| R_2 \| r_{be}}{R_s + R_1 \| R_2 \| r_{be}}$.

$\therefore \frac{v_o}{v_s} = -g_m R_L \frac{R_1 \| R_2 \| r_{be}}{R_s + R_1 \| R_2 \| r_{be}}$.

$R_1 \| R_2 \| r_{be} = 5.21\,k\Omega$.

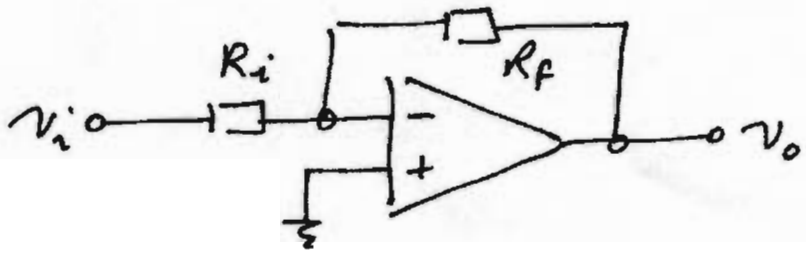
$\therefore \frac{v_o}{v_s} = -0.065 \times 4.7k\Omega \times \frac{5.21}{6.21} = \underline{\underline{-256.3}}$.

EEE103 Jun '05 sols cont....

Q3 cont....

(v) students need to understand here that if C_2 is missing, $\Delta V_B \propto \Delta V_E$. Since $I_c \approx I_E$, $\Delta I_c \approx \Delta I_E$ and since $R_L = R_E$, a ΔI_c will cause equal and opposite voltage changes at the emitter + collector & thus at the base and collector. The answer then is C_2.

Q4 (a) (i)



(ii) "inverting" means that the output signal is an upside down, amplified version of the input signal. All frequency components of the input signal are phase shifted by 180°.

(iii) a "virtual earth" is a circuit node whose potential is always virtually at (very close to) earth potential.... although it isn't actually connected to earth.

In the cct above the inverting input node is the virtual earth.

The virtual earth arises because the gain of the op-amp is very high. The gain operates on the difference between the two input voltages, which must therefore be very small for a finite & sensible value of V_o. If v^+ is connected to ground and $v^+ - v^- \approx 0$, v^- must be close to ground potential.

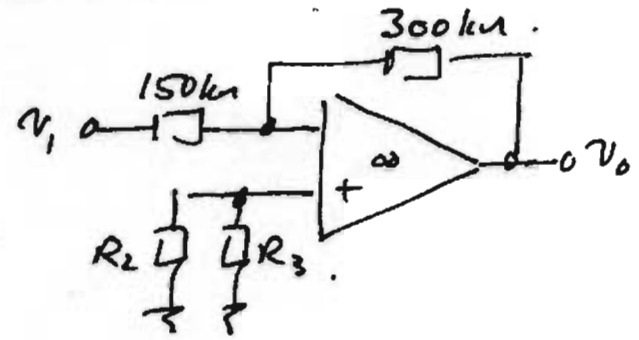
(iv) $R_f = 10 R_i$

EEE103 Jun '05 sols cont....

Q4 cont..

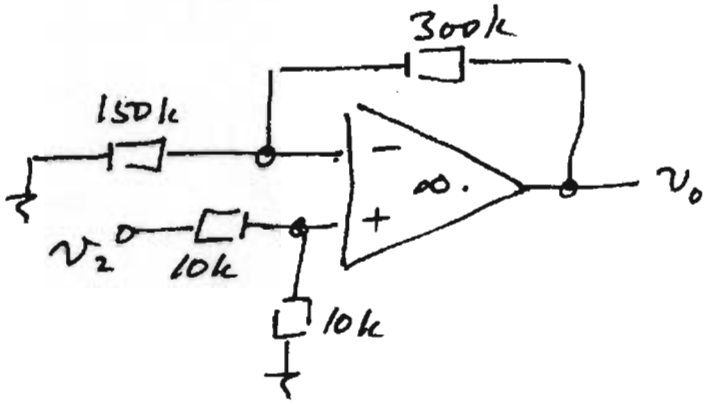
(a) (v) Input resistance = R_i

(b). (i)



$$\frac{V_o}{V_1} = -\frac{300}{150} = \underline{\underline{-2}}.$$

(ii).



$$V^+ = \frac{V_2}{2}.$$

$$\frac{V_o}{V^+} = \frac{300k + 150k}{150k}$$

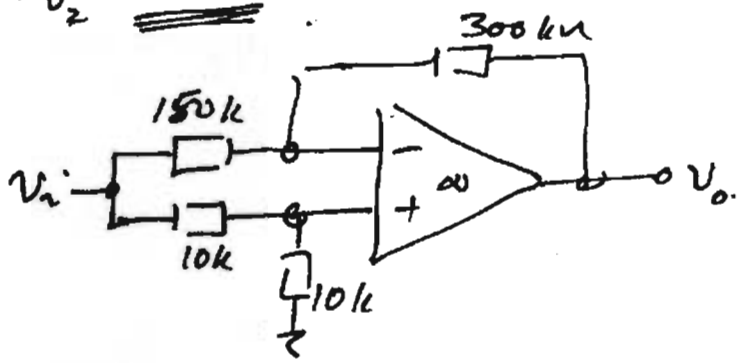
= non-inverting gain of circuit

= 3.

sof. if $V_o = 3V^+$ + $V^+ = \frac{V_2}{2}$, $V_o = \frac{3}{2}V_2$

or $V_o/V_2 = \underline{\underline{1.5}}$.

(iii).



using the results to parts (i) + (ii).

$$V_o = -2V_i + 1.5V_i = -0.5V_i$$

or $V_o/V_i = \underline{\underline{-0.5}}$.