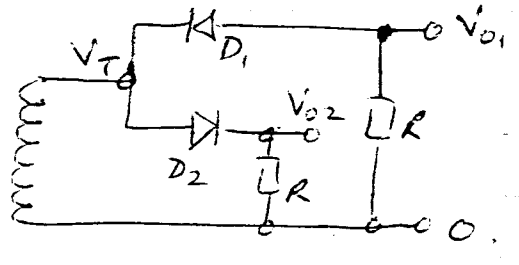
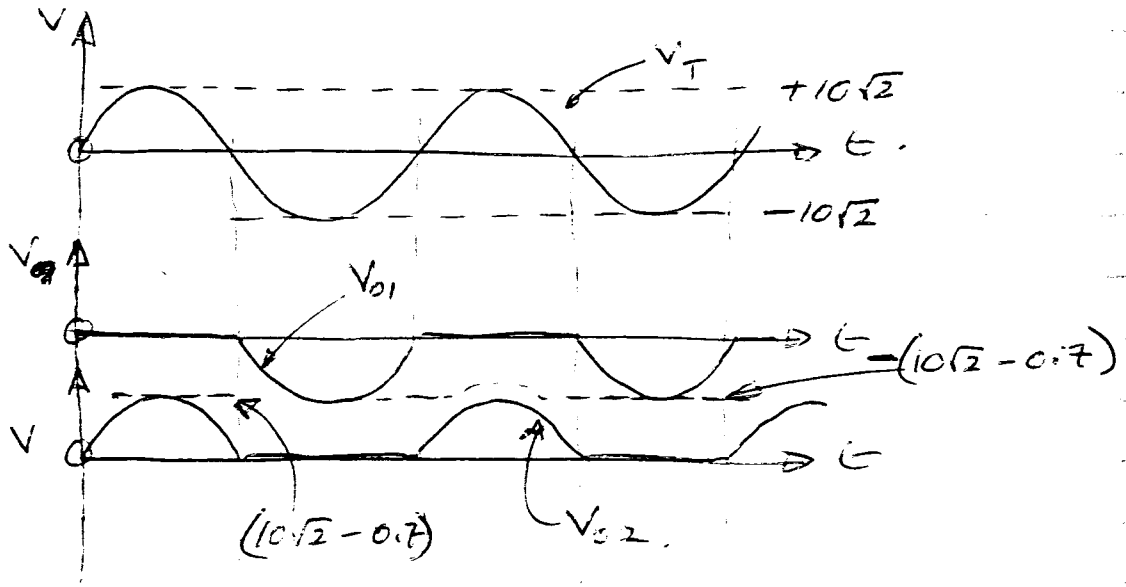
EEE103 Analogue Circuits June '01

Q1 (i) The ckt consists of two half wave rectifiers connected to a single transformer secondary.





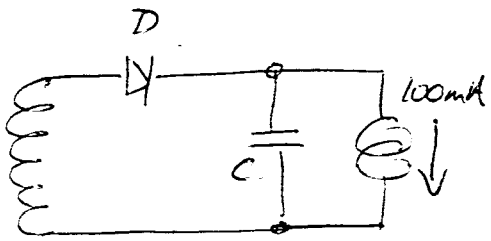
The diode has been assumed to have a 0.7V drop when in forward bias

(ii) Average value of $V_T = 0V$

Average value of $V_{01} = -\frac{(10\sqrt{2}-0.7)}{\pi} = \underline{-4.28V}$

Average value of $V_{02} = \frac{10\sqrt{2}-0.7}{\pi} = \underline{+4.28V}$

(iii) Since the supplies are symmetrical in polarity only one needs to be considered..



Assuming that the capacitor charges instantaneously at the peak of each +ve half sine wave,

$$I_L = C\frac{dV}{dt} = C\frac{V_R}{1/f} = C\frac{1}{20ms} = 100mA$$

$$\therefore C = 10^{-1} \times 20\times10^{-3} = \underline{2000\mu F}$$

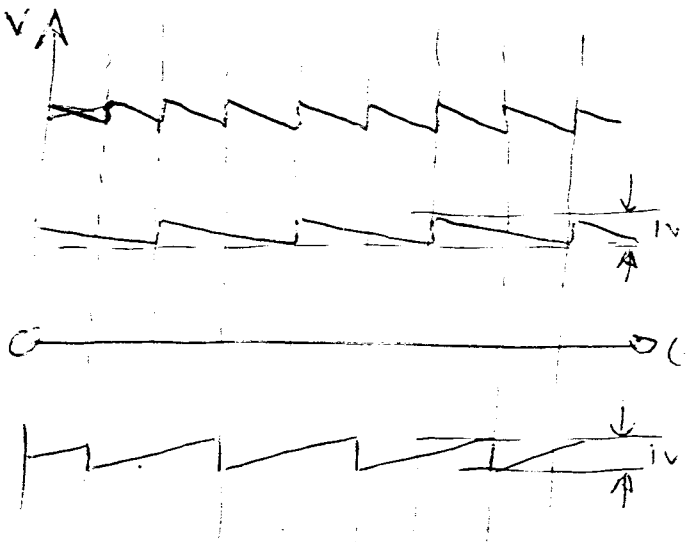
Q1 cont...

(iv) There are several possible answers here depending upon approximations made but they all fall within a fairly narrow range. One is....

$$V_{dc} = (V_{pk} - 0.7 - V_{R_L/2}) \times 2$$
$$= (10\sqrt{2} - 0.7 - 0.5) 2 = \underline{\underline{25.88\ V}}$$

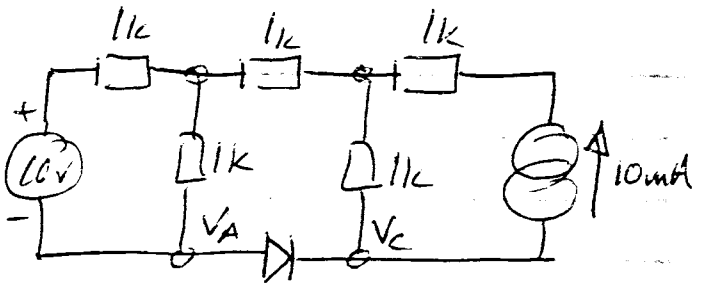
The positive end would be the V_{O2} end.

(v) The ripple across the load would still be 1V pk-pk but its frequency would be doubled to 100 Hz. This can be seen by drawing V_{O1} & V_{O2} w.r.t. common and looking at the difference as a function of time.



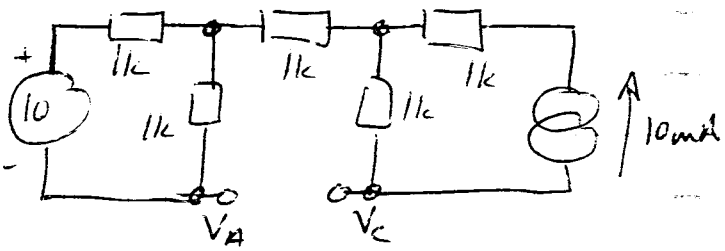
This basic explanation will get full marks.

Q2 (a) It is necessary to perform a trial to identify the conduction state of the diode..



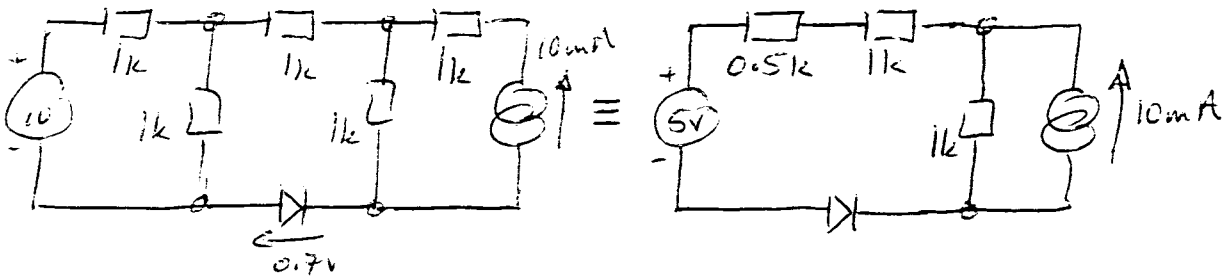
Replace diode by an open cct — ie assume it is not conducting — and calculate $V_A - V_C$

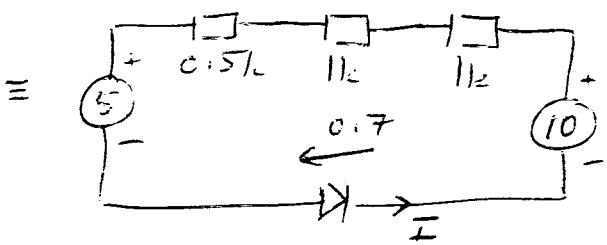
No current can flow through the bridging resistor, so the voltage on either side of it is the same. W.R.T. respect to this reference, $V_A = -5$ and $V_C = -10$ so $V_A - V_C = 5$



∴ The diode will conduct.

Now replace diode by a 0.7V source to work out forward current....

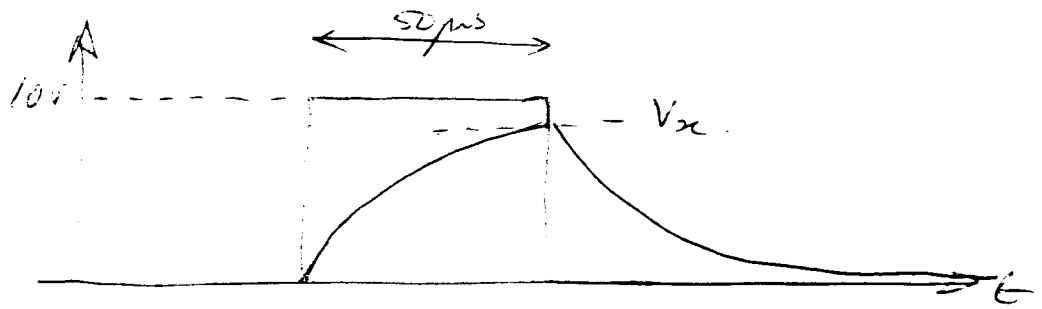




$$\therefore I = \frac{10 - 5 - 0.7}{2.5\text{k}\Omega}$$

$$= 1.72\text{ mA}$$

b(i)



For rising exponential $V(t) = 10(1 - e^{-t/\tau})$ $\tau = 30\mu s$

∴ after 50μs $V_{2c} = 10(1 - e^{-50/30}) = 8.11\text{ V}$

Q2 cont...

for the falling exp. $V(t) = V_x e^{-t/\tau} = 8.11 e^{-t/30\mu s}$.

$\therefore$ time to fall to 5V is .... $5 = 8.11 e^{-t/30\mu s}$

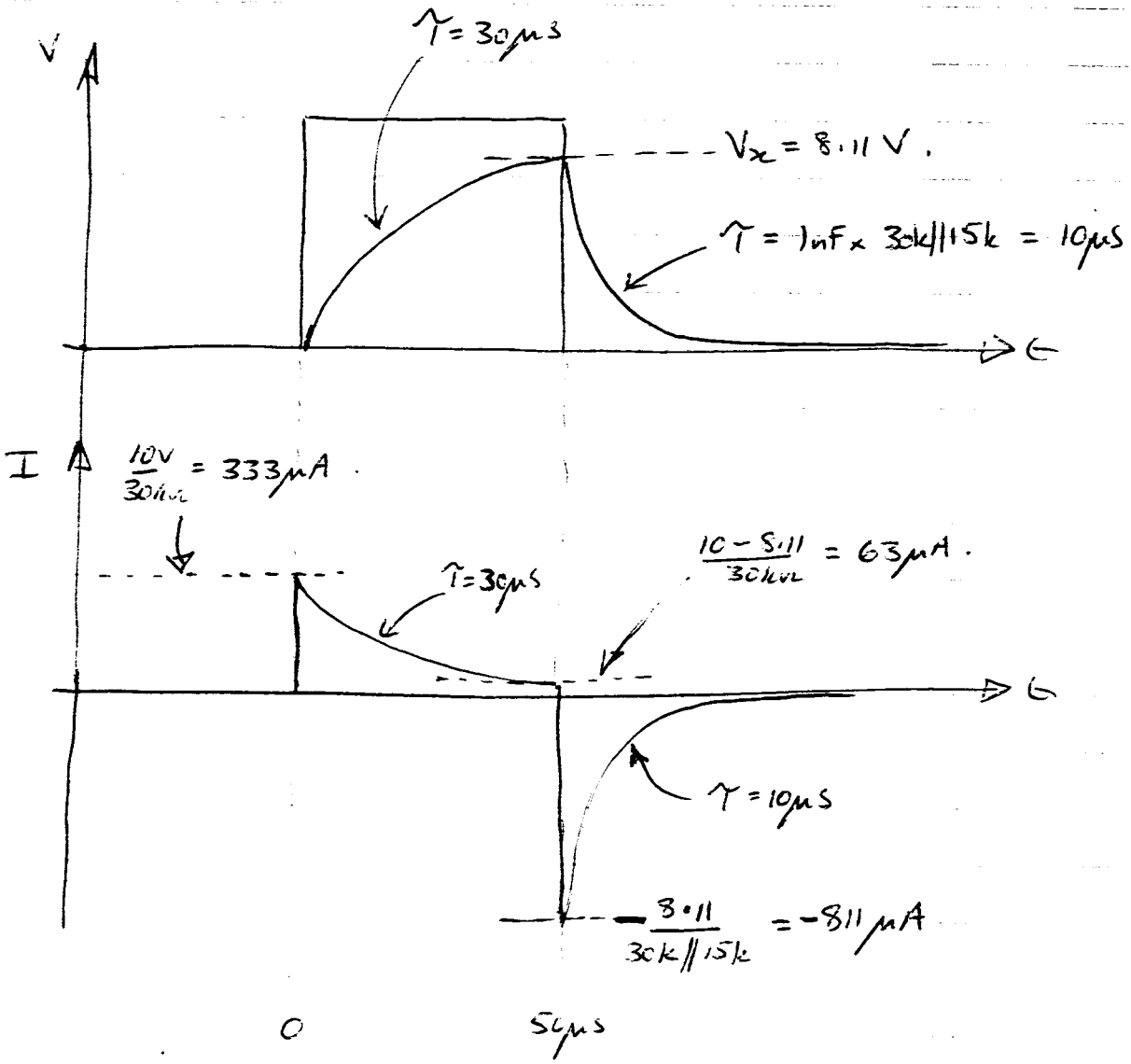
or $t = -30\mu s \ln\left(\frac{5}{8.11}\right) = 30\mu s \cdot 0.48 = 14.5\mu s$.

time for rising exp to reach 5V.. $5 = 10(1 - e^{-t/30\mu s})$

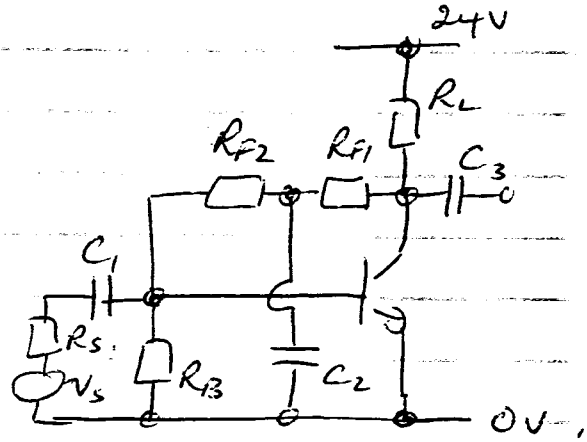
or $t = -30\mu s \ln(1 - 5/10) = 20.8\mu s$.

$\therefore$ Time above 5V = $50\mu s - 20.8\mu s + 14.5\mu s = \underline{\underline{43.7\mu s}}$

(b)(ii)



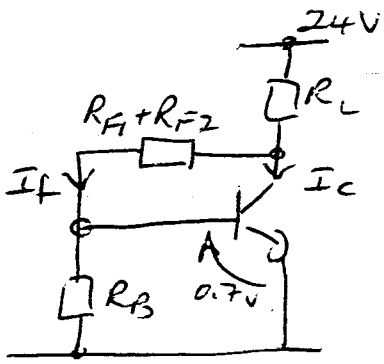
Q3 (i).



C_1 and C_3 are coupling capacitors — their purpose is to act as short circuits to a.c. signals but open cets to d.c. voltages. They prevent the circuit d.c. conditions being upset by the nature of the source and load.

C_2 is a decoupling capacitor. It prevents signal feedback from collector to base by short circuiting any signal at the junction of R_{F1} + R_{F2} to ground.

(ii)



(iii) There are two equations needed to solve this circuit, since there are 2 unknown currents.

Assuming I_B is negligible...

$$24 = I_f(R_B + R_{F1} + R_{F2}) + (I_f + I_c)(R_L) \quad \text{——①}$$

$$0.7 = I_f R_B \quad \text{——②}$$

directly from ②, $I_f = \frac{0.7}{R_B} = 194\mu A$

so ① becomes

$$24 = 194\mu A\,(3.6k\Omega + 27k\Omega + 27k\Omega) + (194\mu A + I_c)\,5.1k\Omega$$

$$\therefore \frac{24 - 12.116}{5.1k\Omega} = I_c = \underline{2.3\,mA}$$

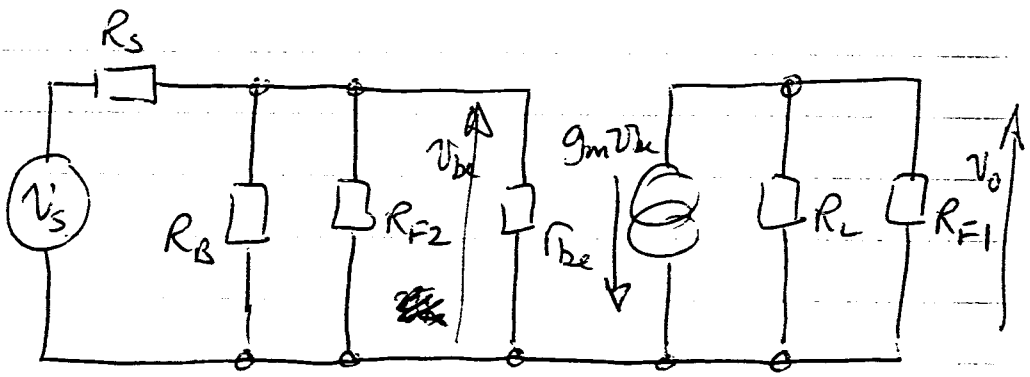
$$\therefore V_{ce} = 24 - (I_c + I_f)R_L = 24 - 2.494 \times 5.1 = \underline{11.3V}$$

Q3 cont...

$$g_m = \frac{e I_C}{kT} = \frac{2.3\,mA}{.026\,V} = 88\,mA/V.$$

$$r_{be} = \beta / g_m = \frac{500}{0.088} = \underline{5.65\,k\Omega}$$

(iv)



(v)
$$v_o = -g_m v_{be}(R_L \| R_{F1}) = -0.088 \times 4.29\,k\Omega\, v_b$$
$$= -377.5\, v_{be}.$$

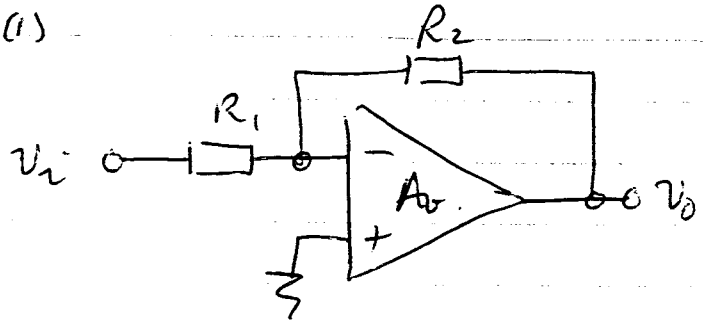
$$v_{be} = v_s \frac{r_{be} \| R_{F2} \| R_B}{R_S + r_{be} \| R_{F2} \| R_B} = v_s \frac{2.03k\Omega}{600\Omega + 2.03k\Omega}$$

$$= 0.77\, v_s$$

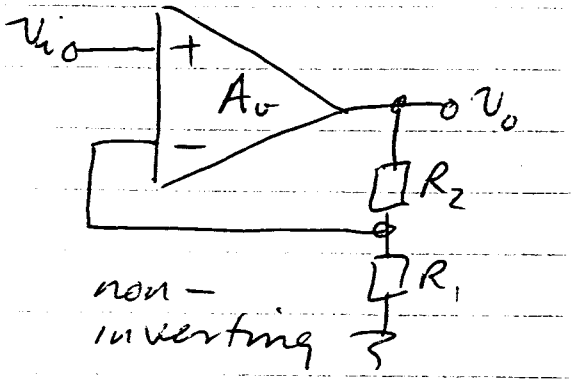
$$\frac{v_o}{v_s} = \frac{v_o}{v_{be}} \times \frac{v_{be}}{v_s} = -377.5 \times 0.77$$

$$= \underline{-291}$$

Q4(a) (i)



inverting



non-inverting

$$\text{gain} = -R_2/R_1 \qquad \text{gain} = \frac{R_1+R_2}{R_1}$$

Assumption in both cases is that $A_v \gg \frac{R_1+R_2}{R_1}$.

(ii) the difference between the two circuits from the source point of view is input resistance. Since the inverting input node in the inverting amplifier case is a virtual earth, the circuit input resistance is R_1 — typically a few 10s of kΩ. For the non-inverting case, the input goes directly into the operational amp & the input resistance will be between 10^6 & 10^{15} Ω depending on amplifier technology.

(b) (i) The 25–42 V voltage being sensed must be potentially divided by R_1+R_2 so that 42 V becomes 4 V or less.

$$\therefore 4 = \frac{42 R_2}{R_1+R_2}$$

$$4R_1 = 38R_2 \quad \text{or} \quad \frac{R_1}{R_2} = \frac{38}{4} = \underline{\underline{9.5}}$$

Q4 cont...

b)(ii) There are several ways of doing this. Using superposition, the lowest value of v^+ (corresponding to a potentially divided 28V) equates to an output of 0V while the highest v^+ corresponds to $V_B = 42V$.

$V_B = 42V \quad v^+ = 4V$

$V_B = 28V \quad v^+ = 4 \cdot \frac{28}{42} \cdot \frac{4}{6} = \frac{16}{6} = 2.67V$

$$v_o = 5 = 4 \cdot \frac{R_F + R_3 \| R_4}{R_3 \| R_4} + \left(-5 \cdot R_F/R_3\right) \quad \text{——①}$$

$$v_o = 0 = \underbrace{2.67 \cdot \frac{R_F + R_3 \| R_4}{R_3 \| R_4}}_{\text{component of } v_o \text{ due to } v^+} + \underbrace{\left(-5 \cdot R_F/R_3\right)}_{\text{component of } v_o \text{ due to 5V on } R_3} \quad \text{——②}$$

from ① and ②, $\frac{R_F + R_3 \| R_4}{R_3 \| R_4}$ can be eliminated

$$5 = 4 \left[\frac{5 \, R_F/R_3}{2.67} \right] - 5 \, R_F/R_3$$

$$1 = \left(-1 + \frac{4}{2.67}\right) R_F/R_3 \quad \text{or} \quad R_F/R_3 = \underline{\underline{2.0}}$$

from ② $\quad 0 = 2.67 \, \frac{R_F + \frac{R_3 R_4}{R_3 + R_4}}{\frac{R_3 R_4}{R_3 + R_4}} - 10$

$$3.75 = \frac{(R_3 + R_4) R_F + R_3 R_4}{R_3 R_4}$$

$$= \frac{R_F}{R_4} + \frac{R_F}{R_3} + 1 = \frac{R_F}{R_4} + 2 + 1$$

ie $\frac{R_F}{R_4} = 0.75$