FSK224 Test 1 – 2011

Memorandum

Q1.

1.1 $P = VI \quad \therefore \quad I = \frac{P}{V} = \frac{18\,W}{220\,V}\,(A) = \frac{18000}{220}\,mA$

$= 81.82\,mA$

Answer B

1.2

$R_{AB} = 1K \,||\, (2K || 3K)$

$= 1K \,||\, \left(\frac{2*3}{2+3}\right)K$

$= 1K \,||\, \frac{6}{5}K$

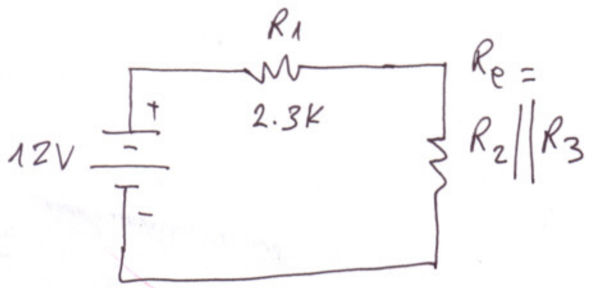
$= \frac{1 * \frac{6}{5}}{1 + \frac{6}{5}} = \frac{\frac{6}{5}}{\frac{11}{5}}K$

$= \frac{6}{11}K \quad \text{or} \quad \frac{6000}{11}\Omega$

Answer D

$= 545.45\,\Omega$

1.3



Answer D

$R_e = \frac{R_2 R_3}{R_2 + R_3} = \frac{5.6(8.9)}{5.6+8.9}K$

$\approx 3.437K$

$\Rightarrow$ Potential Divider i.e. $V_e = \left(\frac{R_e}{R_1 + R_e}\right)12 = \frac{3.437}{2.3+3.437} * 12 = 7.189V \approx 7.2V$

1.4

Transformer is step-up

$\Rightarrow V_{AB} = V_s = nV_p$

$= \frac{2}{1} * 120 V_{rms}$

$= \underline{240 V_{rms}} \Rightarrow$ Answer D

or $240\sqrt{2}\ V_{pk}$

$= \underline{339.41 V_{pk}}$

1.5

Zener diode is forward biased

$\Rightarrow$ Ordinary diode

i.e. $V_Z = V_D = 0.7V$

$\therefore$ KVL around the loop gives

$-12 + IR_1 + V_Z = 0$

$\Rightarrow -12 + 2I + 0.7 = 0$

$\therefore I = \frac{12 - 0.7}{2} mA$ Answer B

$= 5.65 mA$

1.6

LED is reverse biased $\Rightarrow$ only reverse saturation current flows $\rightarrow$ 0

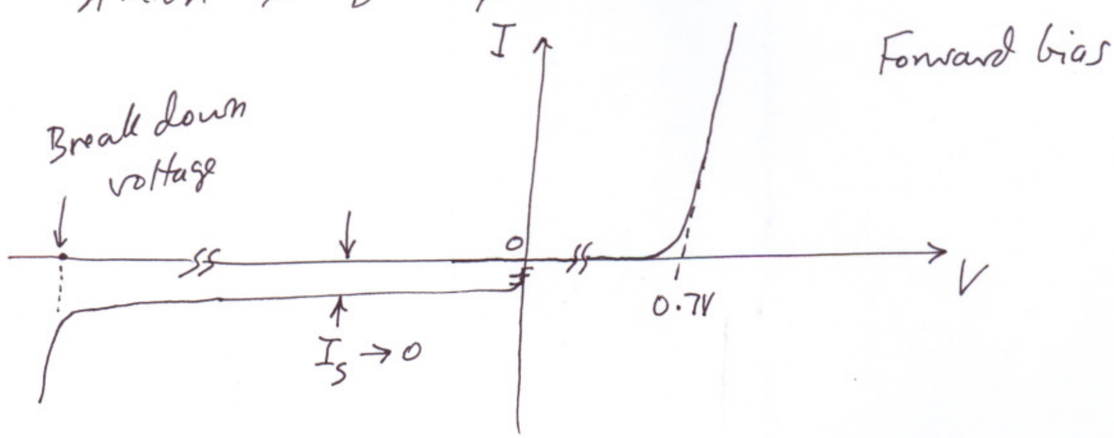
Answer D.

Q2

2.1 (i) KVL states that the algebraic sum of (all the) potential differences around a closed-loop in a circuit is zero.

(ii) KCL states that the algebraic sum of currents at a node in a circuit is zero.

2.2 (a) Silicon $\Rightarrow V_D = V_\phi \approx 0.7V$



Reverse bias

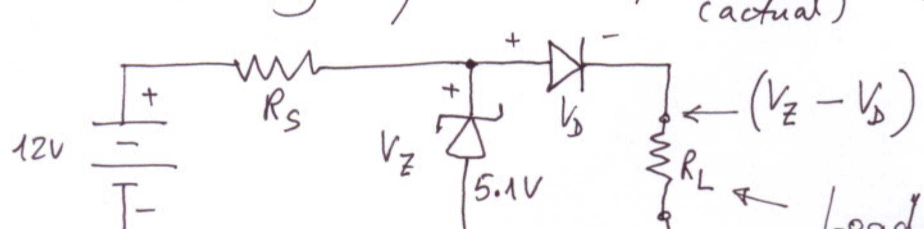
I_S = reverse saturation current.

(b) $P_Z =$ 5 Watt

$V_Z = 5.1V$

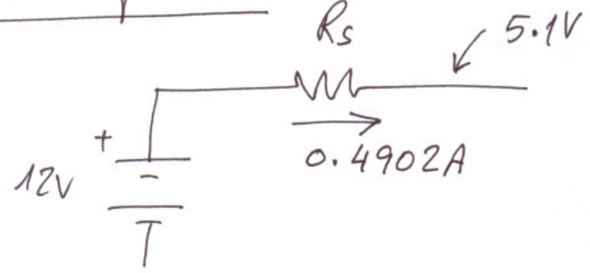
$\therefore I_Z = \frac{P_Z}{V_Z} = \frac{5}{5.1} A$

Derating by 50% $\Rightarrow I_{Z\,(actual)} = \frac{1}{2} \times \frac{5}{5.1} A = 0.4902 A$



where $V_D = 0.7V$ Refers to a silicon diode's barrier potential.

Value of R_s



$$R_s = \frac{V_s}{I_s}$$

$$= \frac{12 - 5.1}{0.4902} \frac{V}{A} \quad (\Omega)$$

$$= 14.076\,\Omega$$

Power dissipation in R_s

is $P_s = V_s I_s$

$= (12-5.1)(0.4902)$ Watts

$= 3.382\,W$ (minimum required value)

Therefore use at least <u>$14\,\Omega$, $3.38\,W$ tolerant series resistor</u>

<u>2.3</u> Single wound output ⇒ 4 diodes in bridge configuration.

$V_p = 220\,V_{rms} / 50\,Hz$ (South Africa)

$V_{o\,(DC)} = +12V$ ⇒ use 7812 linear regulator, with at least 2V across regulator,

$$\Rightarrow V_{CAP\,(filter)} = 12 + 2 = 14V_{(min.)} = V_{pk.\,(secondary)}$$

Hence filter capacitor must have at least 16 Volt rating.

Factoring in two diode drops, the <u>peak</u> value of V_S is then

$$V_{S\,(PK)} = V_{CAP\,(filter)} + 2V_D = 14 + 2(0.7) = 15.4V$$

Hence $$V_{S\,(RMS)} = \frac{V_{S(PK)}}{\sqrt{2}} = \frac{15.4}{\sqrt{2}}V = 10.89V \approx 11V$$

Hence transformer turns ratio is

$$n = \frac{V_P}{V_S} = \frac{220V}{11V} = 20$$

(minimum).

Optional for you FSK 224 students:

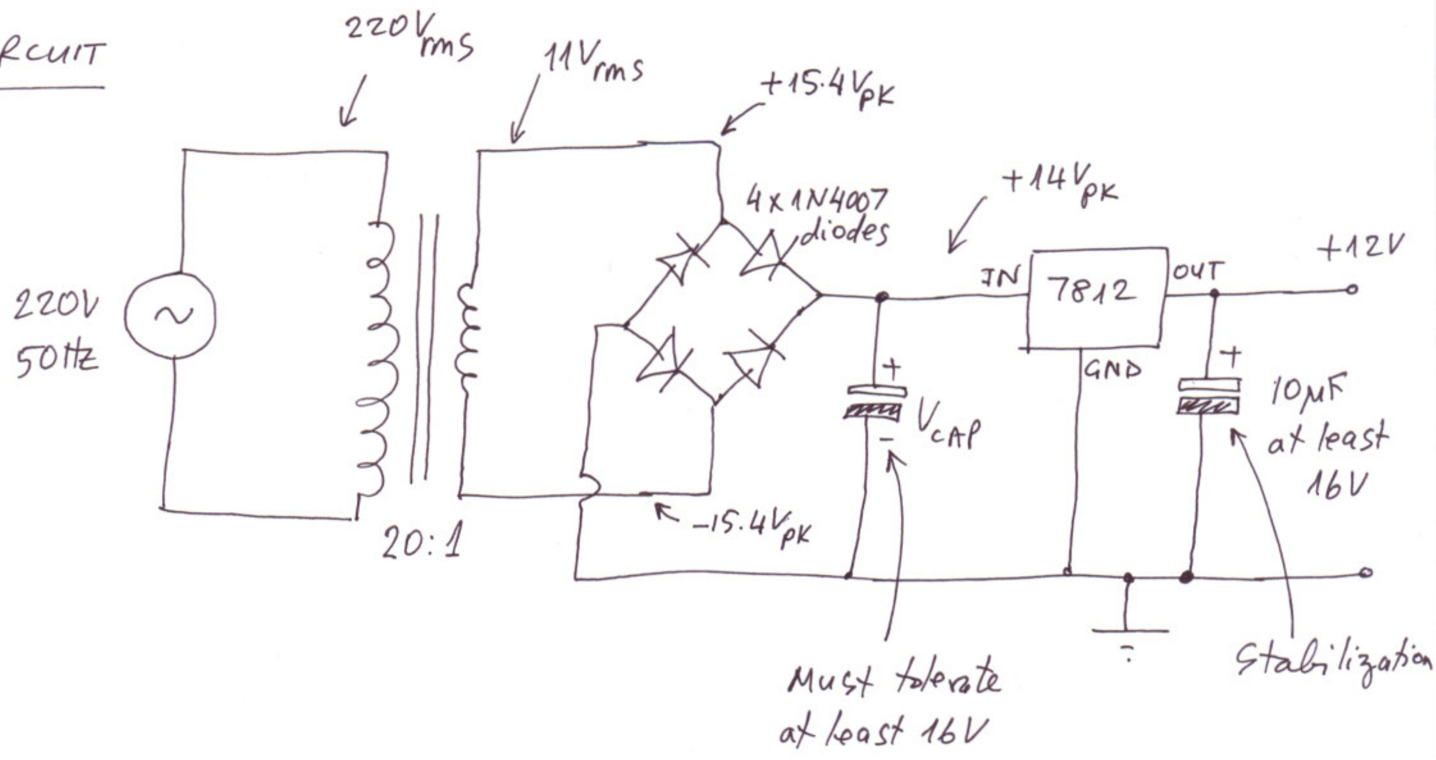
Also, it should be able to handle $1A_{PK}$ output

⇒ its power rating (or V-A capacity) is

$$V_{S\,(RMS)} \times I_{RMS} = 11 \times \frac{1}{\sqrt{2}} VA$$

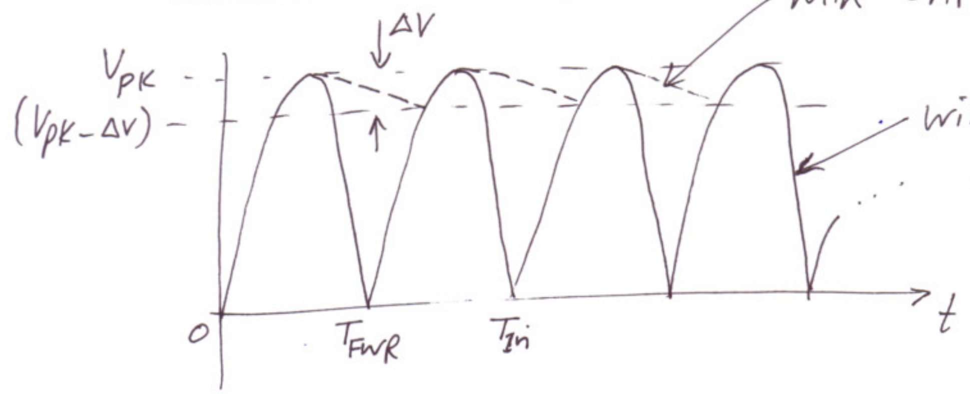
$$= 7.8 VA$$

<u>CIRCUIT</u>



2.3

(b) Full-wave Rectifier



Assuming ideal diodes

$$\Delta Q = C\Delta V$$

$$I \approx \frac{\Delta Q}{\Delta t} \approx \frac{C\Delta V}{T_{FWR}} \quad \text{where } T_{FWR} = \frac{1}{2} T_{IN}$$

$$\therefore f_{FWR} = 2 f_{IN}$$

$$I = 2 f_{IN} C \Delta V$$

$$\text{or} \quad C = \frac{I}{2 f_{IN} \Delta V}$$

Note:
$I = 1A$
$\Delta V \approx V_{pk} - V_{CAP\,(min)}$
$f_{IN} = 50Hz$

(c) $C = 250\mu F = 250.10^{-6} F$

$\Delta V = 0.25V$

$V = 12V$

$f_{IN} = 50Hz$ $\Rightarrow$ $C = \dfrac{V}{2 f_{IN} R_L \Delta V}$

$I = \dfrac{V}{R_L}$ $\Rightarrow$ $R_L = \dfrac{V}{2 f_{IN} C \Delta V}$

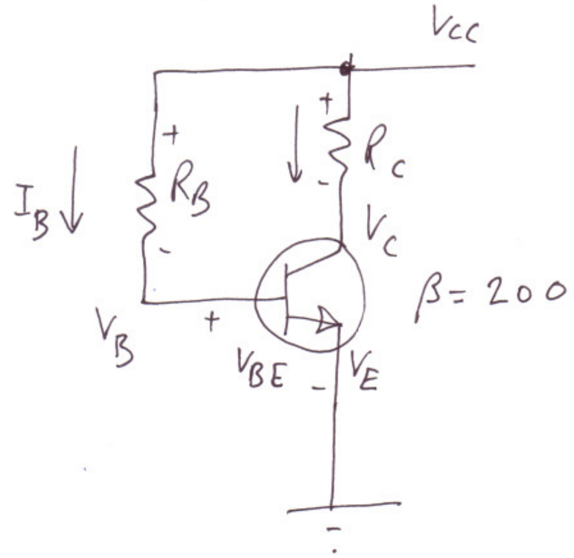
$$= \frac{12}{2(50)(250).10^{-6} * 0.25} \Omega$$

$$= 1920\Omega$$

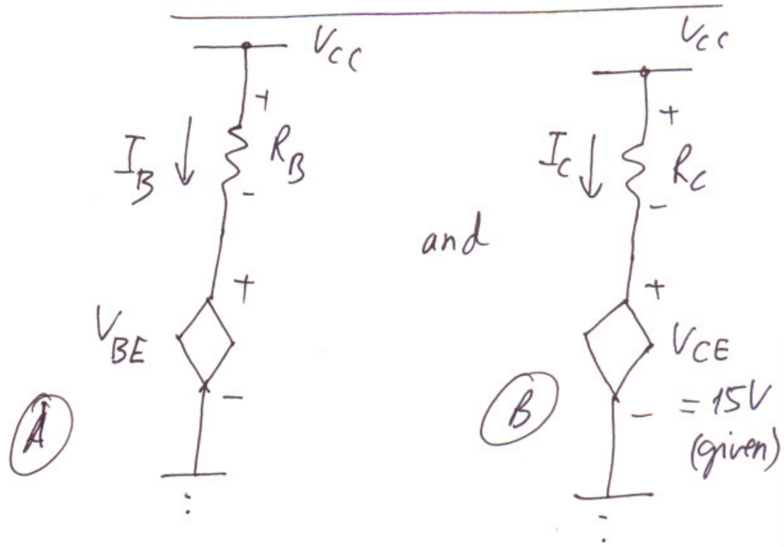
$$= 1.92 K\Omega$$

2.4

For bias point calculation, eliminate <u>all</u> capacitors.



Two KCL loops exist:



Using (A)

$$-V_{cc} + I_B R_B + V_{BE} = 0$$

$$\Rightarrow -30 + I_B R_B + 0.7 = 0 \quad -(1)$$

Using (B)

$$-V_{CC} + I_C R_C + V_{CE} = 0 \quad -(2)$$

$$\Rightarrow -30 + I_C (2.2) + 15 = 0$$

$$\Rightarrow I_C = \frac{30-15}{2.2} \text{ mA}$$

$$= 6.818 \text{ mA}$$

(or $6818 \mu A$).

$$\therefore I_B = \frac{I_C}{\beta} = \frac{6818}{200}$$

$$= 34.09 \mu A \quad -(3)$$

(or $0.03409 mA$)

(3) into (1)

$$\Rightarrow R_B = \frac{30-0.7}{0.03409} \frac{V}{mA} \; (K\Omega)$$

$$= 859.47 K\Omega$$

$$R_B \simeq 860 K\Omega$$

2.5

(a) V_{Relay} (WORST case) $= V_{CC} - V_{CEO}$, where $V_{CEO} = 0V$

$= 24 - 0$

$= 24V$

$\therefore I_{Relay}$ (max.) $= \frac{V_{Relay}}{R_{Relay}} = \frac{24\ V}{96\ \Omega}$ (A) $= 0.25A$ (or 250mA)

For switching processes, derate β by some factor, e.g. 90%, 50% etc...

i.e. $\beta_{SWITCH} = \frac{500}{10} = 50$

(this is done to guarantee that switching does happen).

$\therefore I_B = \frac{I_C}{\beta_{SWITCH}} = \frac{250}{50} = 5mA$

$\therefore R_B = \frac{V_{CC} - V_{BE}}{I_B} = \frac{24 - 0.7}{5} \frac{V}{mA}$ (K)

(See previous question on KVL (A))

$= 4.66K\Omega$

Use 4.7K standard.

(b) Missing EMF protection diode.
⇒ Transistor will damage as switching.
Add the diode