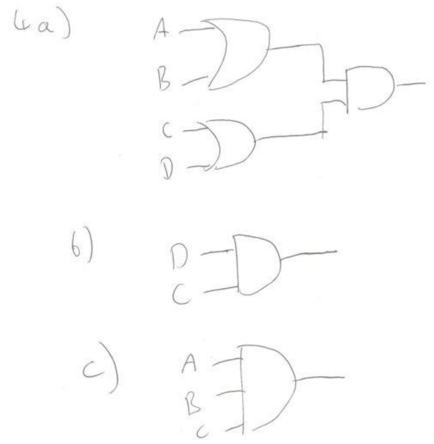
MM2EMD SOLUTIONS

Q1. $1/C_{eq} = 1/47 + 1/(10+33) = 0.044\ \mu F^{-1}$ [1]
So $C_{eq} = 22.45\ \mu F$ [1]
$Q = CV = 10 \times 22.45\times10^{-6} = 2.245\times10^{-4}$ C [1]

2) $Z = 15 + j\times2\pi\times50\times0.03 = 15 + j9.32\ \Omega$ [1]
$I = 20/(15 + j9.32) = 20\times(15 - j9.32)/ (15^2 + 9.32^2)$
$= 0.96\text{-}j0.60$ A [2]
$= 1.13A\angle{-31.2^\circ}$ [1]
$V = 15\times(0.96\text{-}j0.60) = 14.4\text{-}j9V = 15.95\ V \angle{-31.2^\circ}$ [2]

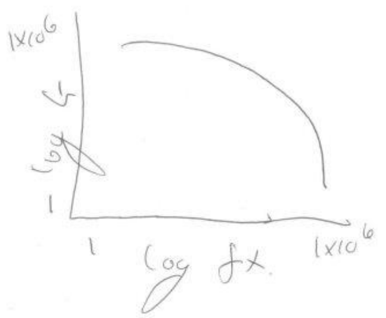
3) $Z_{ref} = Z\times(n_1/n_2)^2=(7+j3)\times3^2 = 63+j27\ \Omega$ [2]
which has a magnitude of $67.8\ \Omega$ [1]

4. AC+AD+BC+DB [1]
D.C [1]
A.B.C [1]



Appropriate circuits [1] each.

5. i) Marks, for high gain at DC, low gain at high frequency, correct scales, use of log scale. [5]



ii) Saturation and non linear gain. [3]

6. $\log(4\times10^{12})/\log(2)=42$ [4] (award 0 marks for a decimal number)

7 (a) n_s = 60f/p = 60× 50/2 = 1500 rev/min [1 for approach 1 for correct ans]
(b) Vp = VL/√3 = 415/1.73 = 239.6 V [1 for approach 1 for correct ans]
(c) s = (1500-1445)/1500 =0.03667 [1]
a= 4/20 = 0.2 [1]

$$T = \frac{3p}{2\pi f} \times \frac{V^2 as}{X_R (a^2 + s^2)}$$

$$= \frac{3 \times 2}{2\pi \times 50} \times \frac{239.6^2 \times 0.2 \times 0.0367}{20(0.2^2 + 0.0367^2)} = 9.72 Nm$$

[1 for method, 2 for correct numbers, 1 for answer]

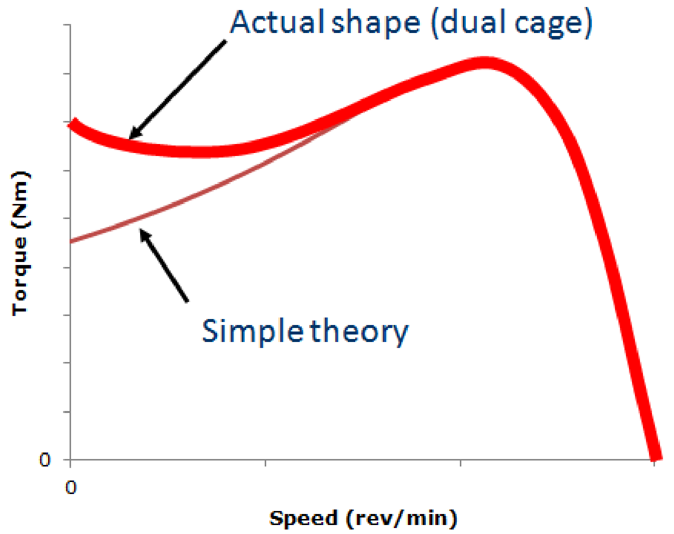
Power = Tω = 9.72×1445×60/(2×π) = 1470W [1 for method, 1 for answer]
d) At stall, s=1 [1]

$$T = \frac{3p}{2\pi f} \times \frac{V^2 as}{X_R (a^2 + s^2)}$$

$$= \frac{3 \times 2}{2\pi \times 50} \times \frac{239.6^2 \times 0.2 \times 1}{20(0.2^2 + 1^2)} = 10.54 Nm$$

[1 for method, 1 for numbers, 1 for ans]

Torque likely to be more in practical motor as deep bar or dual cage rotor often used [1]



[2 for correct shapes, 2 for axes and labels]

e) Electrical power =3 V_p I_p cos φ = 3 ×239.6 × 3.25 × 0.68 = 1588W [3]
Efficiency = mechanical output/electrical input = 1470/1588 = 0.925 = 92.5% [2]

f) Three phase supply results in rotating magnetic field inside stator [2]
This causes relative motion between field and rotor [1]
This causes current to flow in conductors in rotor [2]
Current in conductors causes them to be experience force [1] – the bigger the current, the more drag [1]
Force causes rotor to be dragged around by rotating magnetic field [1]– the bigger the relative motion, the more torque drags rotor around [1]

(Use discretion on marks)
8(a) I=V/R = 100/25=4 [2] so MMF = NI = 800*4=3200 A-turns [2]

b) Assume negligible reluctance in core compared with air gaps so MMF is all across gaps [2]; also uniform flux across each gap [1]. Total gap length is 0.02 m.
$H=NI/l=3200/0.02 = 160000$ A/m [3]
Air so $\mu=\mu_0\mu_r \approx\mu_0$ [2] so $B=\mu_0 H = 4\pi\times10^{-7}\times160000 = 0.2$T [2]
Per pair of poles: $F=B^2A/(2\mu_0) = 0.2^2\times0.005/(2\times4\pi\times10^{-7})=79.6$N [2]
So total lifting force = 2F = 2×79.6 = 159.2 N [2]

c) $H=NI/l$ = 3200/0.4=8000 A/m [3]

From graph B=1.8T [2]
Per pair of poles: $F=B^2A/(2\mu_0) = 1.8^2\times0.005/(2\times4\pi\times10^{-7})=6445$ N [2]
So total lifting force = 2F = 2×6445 = 12891 N [2]
Assumes uniform flux across each gap [2] and negligible air gaps so neglect reluctance of air gaps. [2]

d) Pneumatic cylinder [2] operated by solenoid valve [2]. This requires a transistor or similar device [2] to amplify the logic signal, probably with a resistor and a power supply [1].

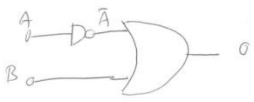
9.
a.

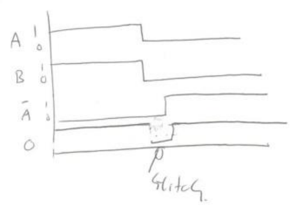
A	B	C	O
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

[4 marks]

A circuit [3] that looks like ABC+ABC′+AB′C [3 marks]

b. Race times are caused by digital components taking a finite time to respond to a change in input.

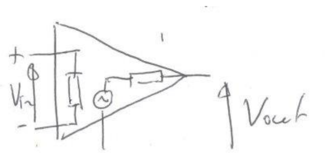




[2 marks]

A good example would be the timing diagram of the following circuit AB’
[3 marks]

c. Marks for a diagram [2] with the input resistance [1], output resistance [1] and all terminals visible and labelled [1].

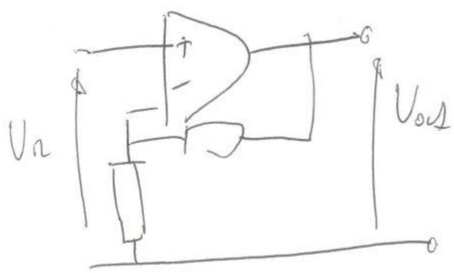


$V_{out} = V_{in} A.$

$R_{out} = 0\Omega$

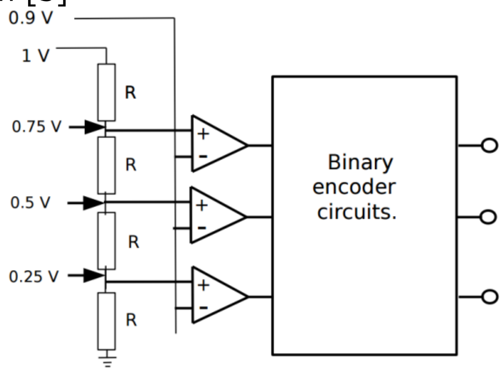
$R_{in} = \infty\Omega.$

d. *Marks for correctly drawn non-inverting op-amp [3]



*Any correct derivation of the closed loop gain expression [2].
*Assumptions: V-=V+. [1]
*Any sensible values that make A=1+Rf/Rg go to 10. [1]

e. Flash converters don’t need to count up and are therefore faster. [2]
Diagram [3]

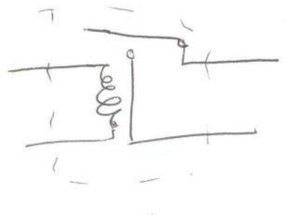


f. 20/2^2

[3 marks]

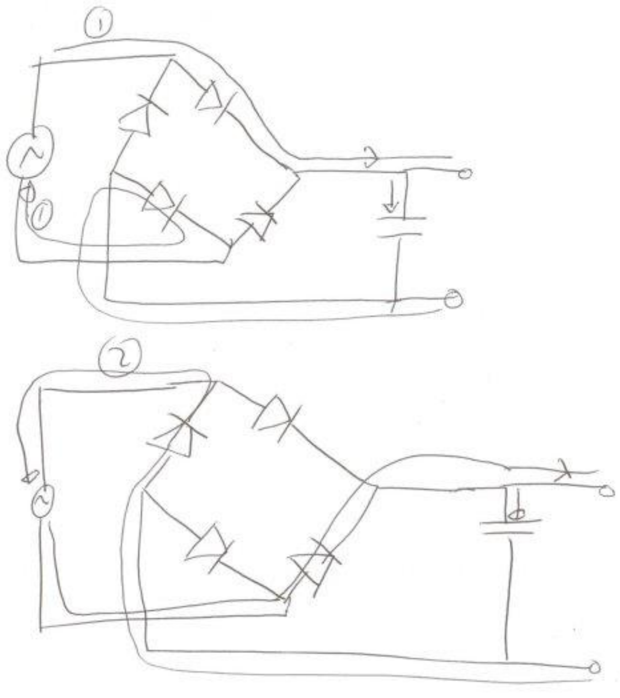
10.

a. The diagram must have a coil and a switch in it. [3] The advantages are electrical isolation [1] but the disadvantages are high power consumption and slow switching speed. [1]



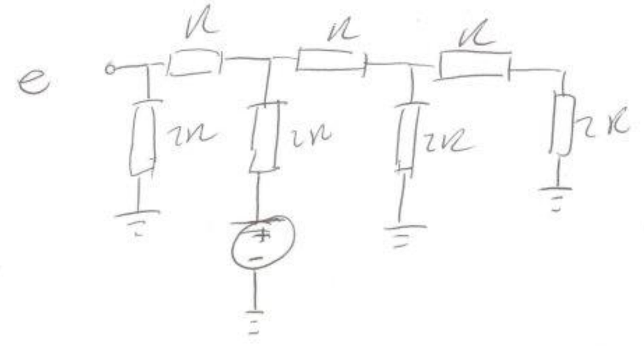
b. The diagram must have show charge being present/absent in a channel. [2] The slow switching speed is due to the need to charge and discharge the gate which is a bit like a capacitor. [3]

c. A correct diagram of a bridge rectifier [5], with a capacitor [1] and arrows showing how charge flows during the charge/discharge cycles, for both negative and positive. [4]



d. 100mA/(50*0.1) = 0.02 F [3]. Use a voltage regulator. [2]

e. A correct diagram of a 4bit R2R ladder [5].



0.5 V would appear on the output [1]. A very good attempt simplifying the R2R ladder circuit to prove the output would be 0.5 V [4].