RECOGNISING ACHIEVEMENT

Mark Scheme 2825/05
June 2002

Question 1

(a) Sine wave Amplitude = 2V (1)

Frequency = 1 / 0.25 ms (1) = 4kHz (1)

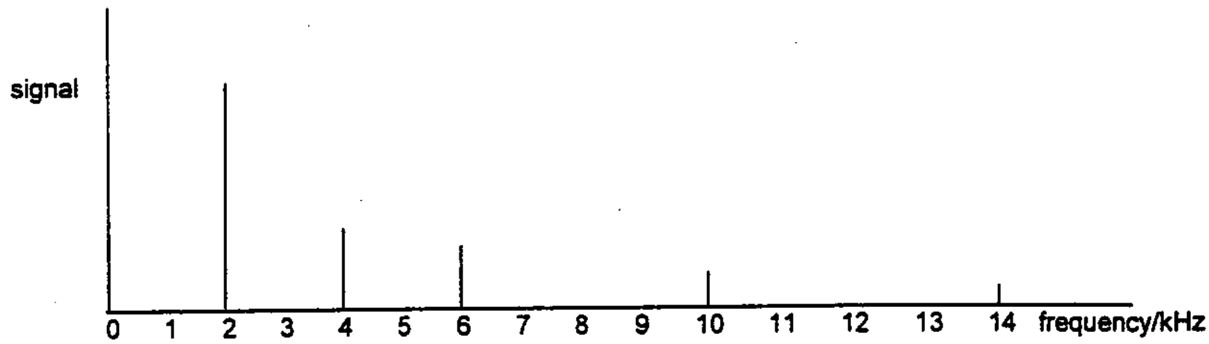
(b) Square wave Amplitude = 6V (1)

Frequency = 1 / 0.5 ms = 2kHz (1)

(c) vertical line at 2kHz (1)

vertical line at 4kHz (must be smaller than the 2kHz line) (1)

vertical lines at 6kHz, 10kHz, 14kHz of decreasing size (1)
(allow any other harmonic lines of higher frequency)



Question 2

1. Tuning circuit (allow "tuner") (1)

   Selects a (single) carrier frequency (or "radio station/transmission") from those picked up by aerial (1)

2 Radio-frequency (or RF) amplifier (1)

   Amplifies small RF signal from tuning circuit so that the demodulator can operate (1)

3 Detector (demodulator) (1)

   Removes the carrier frequency and extracts the audio frequency (1)

4 Audio-frequency amplifier (1)
   (Boosts the audio signal to drive the loudspeaker)

Question 3

(a) Virtual Earth = 0V (1)

(b) Any comment on output not being saturated (1)

Open-loop gain is very high (≈ 10^5) (allow "infinite") (1)

Output = high open-loop gain x (difference in potential between the two inputs) (1)

Difference in potential between two inputs ≈ virtually zero (1)

(Thus, as non-inverting input = 0V the inverting input must ≈ 0V)

Max 3

(c) Voltage gain = - 390 kΩ / 15 kΩ (1)

= - 26 (ignore negative sign) (1)

(deduct 1 mark if a unit is used unless answer = 28.3dB = 20 Log 26)

(d) Saturation is when the output voltage gets as close as possible to the supply line voltages
or
Input or gain produces (or tries to produce) an output greater than the supply rails
(1)

(e) Maximum input voltage = saturation voltage / voltage gain

= ± 13V / 26 (1)

= ± 0.5V (1) (Allow ± 15 / 26 = ± 0.58V)
(Allow ± 14 / 26 = ± 0.53V)

(0 marks for using open-loop gain)

Question 4

(a)(i) Signal-to-noise ratio = 35 = 10 log P_{min} / 1.9 x 10^{-6} (1)

Lowest signal power = $10^{3.5}$ x 1.9 x 10^{-6}

= 0.0060 W (1)

(ii) Maximum attenuation = 10 log 24 / 0.006 (1)

= 36 dB (1)

(b) Attenuation per unit length = 36 dB / 4.5 km

= 8.0 dB km^{-1} (1)

Reading from graph, maximum frequency at 8 dB km^{-1} is 4 MHz (1)

(or, from graph at 4MHz, attenuation is 8dB km^{-1} x 4.5 km = 36 dB)

(c) Bandwidth of each telephone call = 3.4 kHz - 0.3 kHz = 3.1 kHz (1)

(a) If each call is AM and double sideband then each call must be allocated 2 x 3.4 = 6.8 kHz of frequency space.

Maximum number of calls by f.d.m. = bandwidth of cable / bandwidth of AM call (1)

= (4 x 10^{6} – 10 x 10^{3}) / 6.8 kHz (1)

= 586 (1)

(if answer is simply, 3.99MHz / 3.1kHz = 1287 then allow 2 marks unless clearly explained ie argument using single sideband suppressed carrier transmission with only 3.1 kHz bandwidth)

(if answer is simply, 3.99MHz / 6.2kHz = 643 then allow 2 marks)

(ii) During 1 second, the actual duration of any one call = 8000 x 8 x 0.25 x 10^{-6} (1)

= 0.016 second (1)

Thus maximum number of calls by t.d.m. = 1 / 0.016

= 62 (1)

(iii) f.d.m. allows greater number of calls but assumes a huge collection of (brick wall) filters
can be set up to separate any call from its neighbours in frequency space.
f.d.m. is AM and thus noise is difficult to remove (1) for F.d.m
t.d.m. allows all the advantages of digital communication, viz :
t.d.m. allows elimination of noise, storage in memory, error correction, data transfer, computer control, etc.
(do not allow "not affected by noise")
(do not allow "cheaper / expensive and simpler / more complex") (1) (1) for t.d.m

Question 5

(a)

(i) Current in lamp = power / voltage (1)

= 24 / 12 = 2.0 A (1)

(ii) Total resistance of cable = $\rho l / A$ (1)

$= \dfrac{1.8 \times 10^{-8} \times 2 \times 250}{0.2 \times 10^{-6}}$ (1)

= 45 Ω (1)

(iii) Battery voltage required = 12V + pd across cables

= 12 + 2 x 45 (1)

= 102 (1) V (1) (unit mark)

(if only one length of cable in (ii) gave R_{cable} = 22.5 Ω then e.c.f gives battery voltage = 57V)

(b) Efficiency of system = 24W / 102 x 2

= 0.12 (1) (allow e.c.f.)

(c) With 26 letters there would need to be a 5 bit code because 26 > 2^4
Thus each letter on average would require at least 5 light pulses
And this would take about 3 seconds on average — discussion of coding (1)

Transmission time ≈ 50 x (3s + 1s interval) — interval between codes (1)

≈ 200 seconds. — corresponding calculation (1)

(d)

(i) Diagram : Battery, switch , LED/lamp in house A. (do not penalise omission of series R but circuit must allow light to be switched on and off) (1)
Optic fibre labelled between two houses (1)

No receiver required in other house because B can look directly into fibre (but if receiving circuit drawn then it must be sensible)

(ii) Advantages
Lower voltage battery much safer
Electrical components (LED + LV battery) are cheaper and more efficient
Optic fibre less likely to corrode in weather
Optic fibre cannot be tapped
Optic fibre cheaper than copper cable (allow, although probably not true here)
Optic fibre is a single cable/link where wire is doubled/needs return
Optic fibre does not lose as much power as cable (1) (1)

(do not allow "time shorter" or "less noise" or "less interference")

Question 6

(a) (i) Frequencies used are microwaves or UHF or SHF or are in the order of GHz. (1)

Dipole aerial length is λ / 2 or c / 2f so is in the order of cm for this frequency. (1)

(do not award any marks for a woolly statement that "the frequencies used are high so the wavelength is low")

(ii) The power transmitted is low because it is necessary that the handset does not broadcast over too great a range (1)
Small range means that the same frequencies can be reused (1)
Low power means safety or minimising the health risk from the long term use of handset (1)
Low power means portable batteries last longer (1)
Allow high frequencies do not require much power to propagate (or wtte) Max (2)

(iii) Country is divided into cells (1)

Radius of cell decreases as the number of users increases (1)
At the centre of each cell is a receive/transmit aerial system and base station (1)
Different frequencies used by neighbouring base stations (1)
Handset transmits to any surrounding base station (1)
Each base station is linked to a cellular exchange (1)
The cellular exchange monitors and controls which base station communicates with handset (1)
(Any relevant point up to 3 marks) max (3)

The cellular exchange allows access to the public telephone network (1)

(iv) Handset has a transmission range of only a few kilometres (1)
In remote areas, mobile phone company, for economic reasons, may not have built base station (1)
Signal can be blocked by hills / buildings / surroundings (1)
UHF waves suffer little diffraction / travel by line of sight (1) Max (2)

(b) Mobile phones are small and easily portable (1)
Person to person communication is now fast and simple (1)
The costs per call have been dramatically reduced due to increased number of users (1)
People feel less isolated and vulnerable (1)
Working practices have now changed so that workers on the move keep in touch (1)
No longer a need to search for phoneboxes / write letters / make visits / etc (1)
Huge volume of information potentially available anywhere / link to internet (1)
Peer group pressure (fashion accessory?) (1) max (3)

Any further relevant point

7. (a) sensible feature **and** reason one mark for each up to a maximum of 4, e.g.**(4)**
- Graph has low value over the first 6 h **and** ref. to low demand as most people are sleeping
- Demand peaks at mid-day **and** ref. to (electricity consumed for) cooking
- Demand peaks at 1800 / 1900 h **and** ref. to (consumption for) cooking
- Peaks greater in January at tea time / 1700 h **and** ref. to heating and cooking at the end of work
- Demand does not fall below a min. value **and** ref. to reason such as street lights / storage heaters
- Similar shapes of graphs for January and August **and** suggestion that the pattern of the day is similar
- Graph for January is higher than for August **and** ref. to more energy needed for heating
- Graph has a steep slope in morning **and** ref. to industry switching on appliances (allow 'graph goes up in the morning as people go to work)

(b) look for reference to **time** in both marking points one mark for each up to a maximum of 2, e.g.**(2)**
- it takes time for (added) coal to burn or / it takes time for coal to give out heat at the required rate
- coal fires do not go out straight away or / it takes time to cool down
  allow alternative response here if a sensible comment is made about the problems / costs associated with allowing a power station to cool i.e. it is uneconomical to get going again

(c)(i) 66 +/- 2 GW Allow single unlabelled line on graph if it lies in the range (1)

(ii) 74 – graph value e.g. 66 = 8 GW allow 73.5 to 74 GW for peak value (1)
A bald answer of 8 GW with no graph value gets 1 mark

(d)(i) Δ gpe = mgΔh or words or numbers **clearly** arranged to show the change in gpe
e.g. Δgpe = m x 9.8 x 100 (1)
power = energy converted / time taken or numbers **clearly** arranged to show power
e.g. power = 1.0×10^9 = m x 9.8 x 100 / 1 (1)
volume = mass / density or equivalent (1)
calculation e.g. volume (s^{-1}) = $1.02 \times 10^6 / 1.0 \times 10^3 = 1.02 \times 10^3$ m^3 (s^{-1}) (1)

(ii) 1.0×10^3 = 35 x area of reservoir **(1)** **or** Vol / s x time = total volume
total volume = $1.0 \times 10^3 \times 4 \times 60 \times 60$ (1)
area = 28.6 m^2 (in one second) **(1)** **or** total volume = 1.44×10^7 m^3 (1)
area for 4 h = 28.6 x 4 x 60 x 60 **or** $1.44 \times 10^7 = 35 \times l^2$ (1)
= 4.11×10^5 m^2 **(1)**
$(4.11 \times 10^5)^{0.5}$ = 641 m (648m) **(1)or** $(4.11 \times 10^5)^{0.5}$ = 641 m (648m) (1)

(iii) Two comments relevant to the feasibility **ecf (ii)** one mark for each to a maximum of 2 e.g. **(2)**
- ref. to physical dimensions / very large area needed
- drop of 100 m may be a problem with regard to geographical siting
- 7 more lakes needed to meet the demand **ecf (c)**
- argument for this type of pumped storage facility may gain credit if *rapid* response to change in demand is mentioned
- use of peak power at night to store energy as gpe
- sensible comment on a *stated* effect on the environment e.g. destroys habitat / affects ecology **do not allow any reference to costs or noise**

(iv) look for energy conversions for both marks one mark each to max. 2 e.g. **(2)**

- turbine is inefficient as some of the ke of water is converted into heat
- conversion to heat energy is due to friction in turbine / friction in generator / friction in pipes
- some ke retained by water after passing through turbine / not all ke given to turbine