OCR

RECOGNISING ACHIEVEMENT

A2 TELECOMMUNICATIONS

Mark Scheme 2825/05
June 2004

Question 1	Expected Answers	Marks

(a) Diagram Ionosphere labelled (1)

multiple reflections (allow 1 mark if only one reflection) (1)

(b) Short waves reflect/refract from ionosphere (1)

and the surface of the Earth (1)

(c) Carrier frequencies from 3 MHz to 30MHz (1) (1)

(d) Diagram of dipole (1)

Say carrier frequency is 15MHz

λ = c / f (1) = $3 \times 10^8 / 15 \times 10^6$

= 20 *m*

So dipole length = 10 m (length consistent with quoted frequency) (1)
(SW range from 50m to 5m)

Question 2	Expected Answers	Marks

(a) Attenuation progressive loss of signal / power / energy / strength (1)

noise unwanted power / energy / interference / cross-talk added to signal (1)

(b) Noise power is more or less constant along transmission path (1)

Unless amplification takes place the signal will become lost in the noise (1)

(Must mention *Noise* or make comment on *limitations of receiver*)
(Allow 1 mark for - *Signal power decreases along transmission line* - if not awarded in (a))

(c) Number of dB = $10 \log P_1 / P_2$

Signal-to-noise ratio 27 = $10 \log P_{min} / 15 \times 10^{-6}$ (1)

minimum signal power P_{min} = $15 \times 10^{-6} \times 10^{2.7}$ (1)

= 7.5 mW (1)

Total maximum attenuation = $10 \log 15 / 7.5 \times 10^{-3}$

= 33 dB (1)

Maximum uninterrupted distance = 33 / 6.6

= 5 km (1)

Can also answer : If input the signal power (15W) fell to the noise power (15μW) this would represent a 10^6 or 60 dB attenuation.
But signal is to be 27 dB above the noise
so the total attenuation must be 60 – 27 = 33 dB
Thus length = 33 / 6.6 = 5 km.

Question 3	Expected Answers	Marks

(a) Negative temperature coefficient as the temperature rises the resistance falls (wtte) (1)

(b) The potential at T is always positive (1)

and the amplifier is inverting (1)(allow 1 mark for *the voltmeter will read -ve voltages)*

(c) (i) Current = V / R (1)

= 15 / (6 + 1.5) (1)

= 2 mA (deduct 1 mark if error in unit) (1)

(ii) Potential at T = I R(1)
= 2 x 1.5 = 3V (1)

(iii) Voltmeter = voltage gain x voltage at T (1)

= - 250 / 100 x 3 (1)

= - 7.5V (ignore omission of –ve sign) (1)

(allow ecf from (ii) but deduct 1 mark if answer is greater than saturation)

(d) Temperature decreased Potential at T <u>increases</u> (1)
Output A becomes more and <u>more negative / increases</u> (1)
Eventually op-amp will <u>saturate</u> or voltmeter reaches fsd(1)

(e) (Limit of voltmeter = saturation level ≈ -15V)

Corresponds to a potential at T ≈ -15 / *gain* ≈ -15 / -2.5 ≈ 6 V (1)

Thermistor resistance ≈ 6V / current in 6 kΩ (1)

≈ 6 / (15 – 6) / 6

≈ 4 kΩ (1)

(*or* V_R / V_{Th} = (16 – 6) / 6= 6k / R_{Th} Hence R_{Th} = 6 x 6 / 9 = 4kΩ)

Question 4	Expected Answers	Marks

(a) In one second there are 3 signals x 5 samples x 4 bits = 60 bits (1)

Maximum bit duration = 1 / 60 second = 0.0167 s (1)

(b) Maximum frequency by Nyquist criterion ≈ half sampling frequency

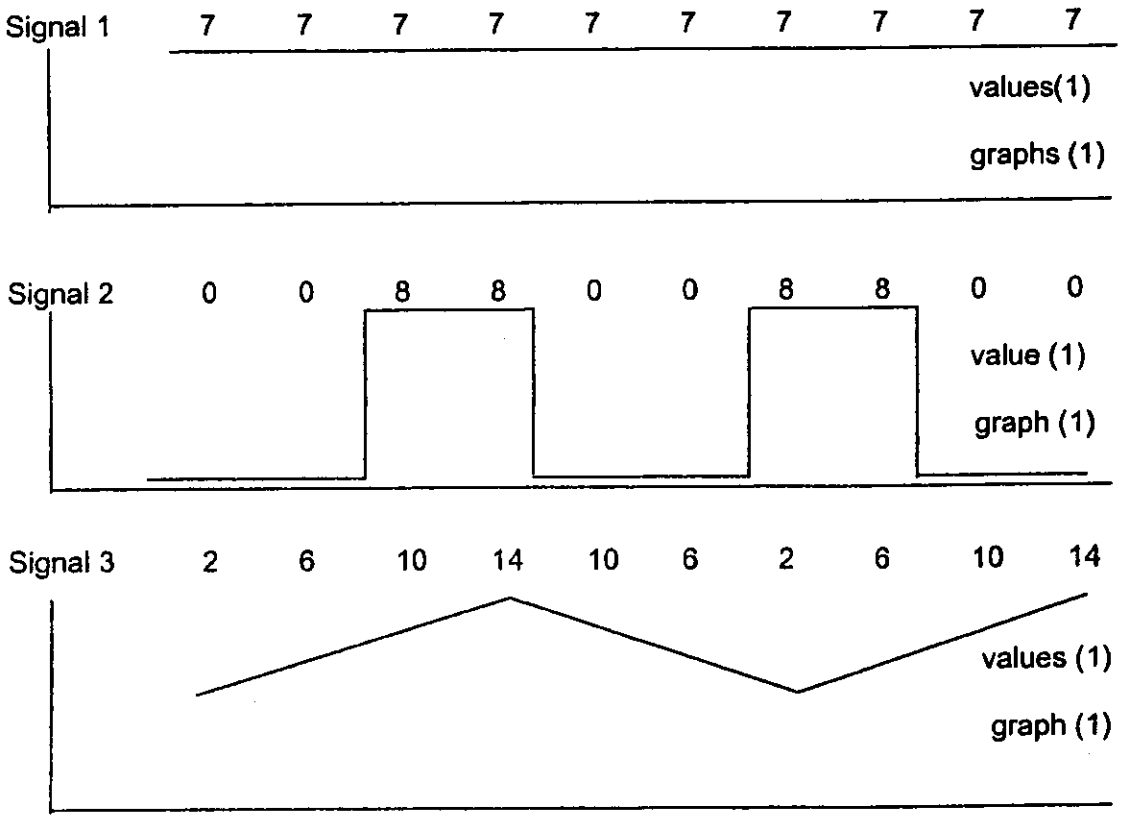
≈ 0.5 x 5 ≈ 2.5 Hz (1)

(c) Photodiode / phototransistor / LDR picks up light signal
Amplification and conversion to electrical signal
Receiver must be synchronised with transmitter in some way
So that 4-bit samples are taken in every 1/15 second
Each 4-bit sample is swallowed by a serial-to-parallel converter
Each parallel 4-bit word is input to a DAC
Explanation of function of DAC (any relevant point up to five)

The bit duration can be decreased (or bit rate increased)
The number of bits per sample can be decreased
The time between samples can be increased (or sampling frequency decreased)
(any two)

(d)

(i)



(graphs in reverse order or asymmetrical square wave scores 6 / 6)
(Assumption of sequential monitoring, even if delay is incorrect scores 6 / 6)

(ii) Frequency of signal 2 = 1 / period = 1 / (4 x 1/5) = 1.25 Hz (1)

Question 5	Expected Answers	Marks

(a) Cladding (glass) Core (glass) (1)

(b) The index refers to refractive index (1)

The refractive index in core is different from that in cladding *(or words to that effect)* (1)

(c) Any reflection of light ray down core *(ignore angles but light must stay in core)* (1)

(d) Rays from same light pulse travel by different paths down core

Different paths are not all of same length

Speed of all rays in core is independent of path followed

Thus rays from same pulse arrive at other end at different times

Causing output pulse to stretch in time

Successive pulses then merge or smear into one another at output and cannot be resolved

[5 max]

Monomode fibres

have a core which is only a few wavelengths in diameter

so light rays all travel by same path

so all take same time to reach other end [2 max]

(Allow accurate answer on graded index fibres)
(Allow answer where refractive index of cladding is almost equal to that of the core so as to make the critical angle very large)
(Allow 1 mark for a suitable diagram)

[7 max]

Question 6	Expected Answers	Marks

(a) Orbit of large radius drawn in equatorial plane (1)

Direction shown as same as that of Earth (1)

(Radius of orbit should be ≈ 6 x Earth radius but in drawing it must be > 2 x R)

(b) Period of satellite is 24 hours (1)

(c) Huge distances mean huge loss in signal powers to/from satellite (≈ 200 dB loss)

Signal power received is extremely small

Parabolic dish focuses increased power on to receiver

To increase received signal-to-noise ratio

Transmitter parabola directional (almost parallel waves)

Receiving dish can pick out satellite/s from one direction (any **four** relevant points)

(d) Use of geostationary satellites

Weather monitoring

TV Broadcasting (1)

Relay system / telephone / internet link

(do not allow GPS)

7 (a) (i)	Mass	= 0.15 × 5 × 60	1
		= 45 kg	1
(ii)	Energy required	= 45 × 4200 × (38 – 8) Must have temperature difference	1
		= 5.67×10^6 J	1
(b) (i)	Work done	= Force × distance turned (Allow F.d)	1
		= 80 × 2 π × 0.2	1
		= 100 J	
(ii)	Power produced	= Energy per rev. × Number of rev. per second	
		= 100 × 1.3	
		= 130 W	1
(iii)	Total number of revolutions	= 5.67×10^6 / 100	
		= 56700	1
(iv)	Time for pedalling	= 56700 / 1.3	1
		= 43615 secs	
		= 12.1 hours	1
c (i)	Total resistance in heater circuit	= *EMF* / current Must see some evidence of equation used and physics of problem other than V = IR eg $R_{total} = R_1 + R_2$	1
		= 24 / 5	
		= 4.8 Ω	1
	Resistance of element	= 4.8 – 1.2	1
		= 3.6 Ω	
(ii)	Length or wire	= RA / ρ	1
		= 3.6 × 0.32 × 10^{-6} / 1.5 × 10^{-7}	1
		= 7.68 m	1
d	Discussion on energy losses	Work done against friction in bearings etc	1
		Power loss from resistance of generator and connecting wires	1
		Heat radiated from tank	1

In one second student outputs 130 J of which only 120 J to generator
and only 90J to tank
Thus pedalling time will be longer by factor 130 / 90 giving a new time of 17.5 hours. 2

(Any explained energy loss plus extra time calculations scores up to 2 marks)
(Any correct calculation of extra time scores 1 mark)

Maximum 4 marks for question

Up to 3 marks for intelligent discussion (but ignore sound)
Up to 2 marks for calculation **Max 4**