RECOGNISING ACHIEVEMENT

TELECOMMUNICATIONS

Mark Scheme 2825/05
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1 (a) (i) RF period = 1 / 50 000 = 20 μs [1]

(ii) AF period = 1 / 5000 = 200 μs [1]

(iii) Graph : AM shape with 20 μs period carrier [1]

Sinusoidal envelope with period of 200 μs [1]

Explanation: The (instantaneous) value of a (5 kHz) audio signal (or information) controls (not modulates) the amplitude of the (50 kHz) carrier [1]

(b)

Any radio frequency undulating at audio frequency with approx same amplitude [1]

RF period (20μs) and AF period (200μs) correct [1]

(If two independent signals drawn with correct periods and same amplitudes allow 1 / 2)

Total: 7

2 (a) Op-amp powered to rails [1]

Any working inverting or non-inverting op-amp amplifier [1]

Realistic gain quoted (eg x 200 so saturation does not occur) [1]

Microphone correctly wired to op-amp input and 0V [1]

LED used as output transducer (ignore polarity and allow filament lamp) [1]

Series resistor used [1]

Series resistor of realistic value (eg few 100 Ω) [1] (MAX 6)

LED connected between op-amp output and −15V [1]
(or any means by which LED will be biased on eg summing amp)

Explanation Need for appropriate op-amp gain to drive LED but avoid saturation [1]

Need to bias LED so that it is on at all times [1]

(b) Photodiode used as input transducer (ignore polarity and allow LDR) [1]

Any working circuit (eg potential divider) with photodiode or LDR [1]

Series capacitor added to remove dc bias (or pot. divider set up between +15 and -15) [1]

Any working inverting or non-inverting op-amp amplifier [1]

Realistic gain quoted (eg x 100) [1]

Op-amp output connected to one end of loudspeaker [1]

Other end of loudspeaker correctly wired to 0V [1]

Explanation Need to amplify only the wobble in the light signal, hence the capacitor
(do not just accept the need for the signal to be amplified) [1]

Total: 17

3 (a) (i) Sampling frequency = $1 / 0.02 \times 10^{-3}$ [1]

= 50 kHz [1]

(ii) Signal frequency = 1 / period = $1 / 0.24 \times 10^{-3}$ = 4167 Hz [1]

accept 4 kHz or 4.5 kHz (for 11 squares) or 3.8 kHz (for 13 squares)

(b) Number of bits = 3 [1]

Because there are only 7 voltage levels (or 6 steps) [1]

And $2^{\text{number of bits}}$ = maximum number of voltage levels
(or some evidence of binary conversion) [1]

(c) Bit rate in line = sampling frequency x number of bits

= 50 000 x 3 = 150 k bit sec^{-1} [1]

(d) (i) Maximum bit duration = 1 / 150 000 sec = 6.67 μs [1]

(ii) highest pulse frequency = when bits arrive alternately ie 0101010101

= 150 000 / 2 [1]

= 75 kHz (Allow 1 / 2 for 150 kHz) [1]

(e) With a shorter bit duration there will be time spaces created between samples (or wtte) [1]
Time-division multiplexing can take place [1]
Where the digital samples from several other users can share the same line (or wtte) [1] Any [2]
Or
More samples can be allowed [1]
Greater definition of output signal relative to input [1]
Greater bandwidth of information [1]
(Any two valid points)

Total: 12

4 (a) Core is arrange to be about 7 λ so that it acts as a waveguide to light waves [1]
Light propagates in a single mode or travels directly down core [1]
All light rays take the same path [1]
This eliminates all modal or multipath dispersion [1]
Smearing of signals is reduced [1]
Faster frequencies can be transmitted [1]
(Any two points)

(b) Laser output power is much greater than that of LED (so uninterrupted transmission distance is much greater) or LED intensity is too small [1]
Laser emits a very narrow range of wavelengths so effect of material dispersion on pulse width is almost zero. [1]
Laser can be switched on and off faster than an LED [1]
Laser can be focussed to a spot of few μm diameter. [1]
(Any one point)

(c) Total attenuation $= 40 \times -0.25$ [1]

$-10\ \text{dB} = 10 \log P_{out} / 25 \times 10^{-3}$ [1] [1]

$P_{out} = 25 \times 10^{-1}\ \text{mW}$

(d) Intensity = power / area

$= 2.5 \times 10^{-3} / \pi \times (4.5 \times 10^{-6})^2$ [1]

$= 3.9 \times 10^{7}\ \text{W m}^{-2}$

$= 39\ \text{MW m}^{-2}$ [1]

(e) Signal-to-noise $= 35\ \text{dB} = 10 \log 2.5 \times 10^{-3} / P_{noise}$ [1]

Noise power $P_{noise} = 7.9 \times 10^{-7}\ \text{W}$ [1]

Total: 10

5 (a) PSTN system for a normal phone call :

There is a continuous switched line between the two callers made up of wire-pairs and/or coax / optic fibre / satellite link [1]

A normal phone call works in real time (or wtte) [1]
(ie the two callers share the line which connects them for as long as they wish to use it)

PSTN for Internet use :

File Transfer Protocol (or HTTP) causes data to be broken into packets [1]

Packets contain limited volume of information + addresses etc [1]

Packets are not transmitted as one continuous stream [1]

Packets from the same database do not necessarily follow the same switched line / route [1]

Packets do not necessarily arrive in the same order as that in which they were sent [1]

Any four points

(b) Many jobs have been created to provide technical maintenance for Internet [1]

Many jobs have been created to provide software for Internet [1]

Many jobs have been created to sell goods and services over the Internet [1]

Internet provides alternative to traditional shopping [1]

Internet allows people with little expertise easy access to huge volumes of information [1]

Internet allows remote information gathering (eg medical without visiting doctor) [1]

Internet allows many individuals to work from home [1]

Any four valid points

Total: 10

6 (a) Wavelength λ = c / f = 3×10^8 / 600×10^6 [1]

= 0.5 m (deduct mark if incorrect unit) [1]

(b) The real TX and its reflected image interfere [1]

At odd numbered floors the waves arrive in phase and a strong signal is received or there is constructive interference [1]

At even numbered floors the waves arrive out of phase and a weak signal is received or there is destructive interference [1]

(c) (i) Separation a = 2 x 10 = 20 m [1]

(ii) Using the formula for two source interference x = 8 m [1] = λ D / a [1]

The source – screen distance D = x a / λ [1]

= 8 x 20 / 0.5

= 320 m [1]

(d) When the lake surface is choppy, the reflected signal is scattered away from aerials [1]

Thus aerials only receive the direct line-of-sight signal from the transmitter [1]

(Any two sensible points)

Each floor could have a highly directional aerial receiving direct transmissions only [1]

Description or diagram of either parabolic dish with dipole at focus or Yagi array [1]

Or, one single directional aerial could be placed on top of building

with cable feeds to each floor [1]

Or polarisation by reflection could be utilised [1] **(Any two sensible points)**

Total: 14

7	(a)		Quieter Less pollution/more environmentally friendly	Or other valid point, eg petrol supplies finite, safety(batteries less of fire hazard), can utilise renewable energy	2
	(b)		$P = VI$ 750 Wh = 750/12 = 62.5 Ah	0/3 for wrong ans no working 0.75/12=0.0625 (2/3) 3/3 for correct ans.	1 1 1
	(c)	(i)	No. of batteries = 960/16 = 60 No of kWh = 0.75 x 60 = 45 kWh = 45 x 1000 x 3600 =162 MJ	-1 for each error 1.62×10^8 MJ (2/3)	1 1 1
		(ii)	Work done = Fd D = $162 \times 10^6/300$ = 540 km	Allow 1sf if working shown	1 1 1
	(d)	(i)	Mass of petrol = 162/50 kg = 3.24 kg Volume = m/ρ (stated or implied) =3.24/700 = 4.6×10^{-3} m^3	Ecf Or equivalent	1 1 1 1
		(ii)	Energy lost/not 100% efficient As heat etc.	General comment + detail	1 1
	(e)		Compare :- • mass, • size, • likely performance of petrol vs batteries, • sensible statement about range Concluding comment	Any 3 from 4	3