OCR

RECOGNISING ACHIEVEMENT

TELECOMMUNICATIONS

Mark Scheme 2825/05
January 2003

1. (a)	Silence Spectrum B		(1)	
	The power spectrum is of an unmodulated carrier (wtte)		(1)	
	Pilot Tone Spectrum C		(1)	
	The carrier is modulated by a single frequency		(1)	
	Music Spectrum A		(1)	
	The sidebands contain a spectrum/range of audio frequencies		(1)	
(b)(i)	200kHz		(1)	
(ii)	2kHz		(1)	
(iii)	8kHz		(1)	
(iv)	Long Wave (Low Frequency)		(1)	
(v)	Maximum number = (300 – 30) kHz / 8kHz		(1)	
	= 33 stations		(1)	
(c)	Broadcast FM radio produces a large bandwidth (180kHz)		(1)	
	If FM were used only one station could operate within the waveband (wtte)		(1)	[14]

2. (a)(i) Voltage at X = 0V (1)

(ii) Current is 2 kΩ = pd / 2 kΩ (1)

= (40 mV – 0) / 2 kΩ = 20 μA (1)

(iii) Current in 160 kΩ = 20 μA (1)

because no current enters the input of the op-amp (1)
or, the op-amp has an infinite input impedance

(iv) V_{out} = - 20 μA x 160 kΩ or V_{out} = - 80 x 0.04 = - 3.2 V (1)

= - 3.2 V (1)

(v) Maximum input voltage = saturation voltage (accept 13 – 15V) / voltage gain

= ± 14 / 80 (1)

= ± 0.175 V (1)

(b) Overall voltage gain = - 480 / 12 x – 68 / 3.4 x –1 / 10 formula (1)
= - 80 three gains (1)
multiply together (1)

(c)(i) Both amplifiers are inverting amplifiers
So both have output which is 180° out of phase with input (1)

(ii) The input impedance of Fig.2.1 is 2 kΩ

the input impedance of Fig.2.2 is 12 kΩ (1)

(iii) The bandwidth of Fig.2.2 is greater than that of Fig.2.1

Because the bandwidth is limited by the maximum gain in any stage

And Fig.2.1 has the greatest gain (x 80) of all the stages shown (1)

(iv) The maximum input voltage before saturation for Fig.2.1 is 0.175 V (as above)

The maximum input for Fig.2.2 is limited by the first two op-amp gains (1)

And this is ± 14V / (40 x 20) = ± 0.0175 V (1) [17]

3. (a) Suitable drawing of analogue signal (1)
Suitable drawing of a digital signal (1)
An analogue signal is analagous to the physical property which generated it
It varies continuously in time
It can have any value between two limits
Digital signal is a coded representation of a piece of information
It does not vary continuously in time
It can only have one of two values. (any four points) (1) (1) (1) (1)

(b) At the local exchange the analogue voltage (ie call) is sampled (8000 Hz) by ADC (1)

Each sample in converted into a parallel 8-bit word. (1)

Each bit in the 8-bit word is transmitted serially (1)

(c) The serial digital signal is applied to a serial to parallel converter (1)

Each 8-bit word is applied to a DAC (1)

DAC output becomes the analogue signal to the receiving telephone (1)

(d) Advantages of pcm are all the advantages of digital signals.

Elimination of noise
Computer control
Storage in memories
Error correct codes
Encryption
Time-division multiplexing (any two valid points) (1) (1) [14]

4. (a) Refractive index of core must be greater than that of cladding (1)

To allow total internal reflection in core (1)

(b) Speed of light in core = $3 \times 10^8 / 1.5$ (1)

= 2×10^8 ms^{-1} (deduct mark if wrong unit) (1)

(c) Shortest time = distance / speed

= $4000 / 2 \times 10^8$ (1)

= 20 μs (1)

(d) Longest time = $(4000 / \text{Sin } 65.4) / 2 \times 10^8$ (1) (1) Expansion of answer with explanation or drawing (1)

= 22 μs

(e) Emerging pulse should have the following characteristics.

Any curved shape of duration longer than 1 μs (1)

Duration of pulse is 3 μs (ie 1 μs actual pulse + 2 μs extra time) (1)

Starts at 21 μs (ie 1 μs start time plus 20 μs minimum) (1)

Ends at 24 μs (1)

Area of emerging pulse is same as area of input pulse (1)

Any (4)

(e) Pulses would have to be separated by approximately 3 μs

So maximum frequency ≈ 1 / 3 μs (1)

≈ 333 kHz (1)

(g) Smearing (1) [16]

5.

Space waves	VHF UHF SHF EHF (allow, any waveband where f>30 MHz)	(1)	
	Propagates by line of sight	(1)	
	Maximum terrestrial range allow 20km to 100km	(1)	
Surface waves	VLF LF MF (allow, any waveband where f<3 MHz)	(1)	
	Propagates by long wavelengths bending round curvature of Earth	(1)	
	Maximum terrestrial range 1000 km (in MF) (but can be world wide in LF)	(1)	
Sky waves	HF (allow, waveband where 30 MHz>f>3 MHz)	(1)	
	Propagates by reflections between Earth's surface and ionosphere	(1)	
	Maximum terrestrial range world wide	(1)	[9]

6. (a) (i) (ii)	1015 N (accept 1010-1020) 130 N (accept 125-135) both correct	1	[1]
(b)	$F = ma$ $(1015-130) = 1100a$ so $a = 0.80\ ms^{-2}$ (accept 0.80-0.81)	1 1 1	[3]
(c)	18 ms^{-1} (accept 15-21) find largest difference between force graphs and note speed *or* clear from graph	1 1	[2]
(d)	49.7 ms^{-1} (accept 49.5 - 50.0) speed is max. when driving force equals/balanced by drag force	1 1	[2]
(e)	220 N work done = force x distance = 220x1000 (=$2.2x10^5$ J)	1 1 1	[3]
(f)	work done = $3.5(2)x1000 = 3.5(2)x10^5$ J accept $(3.5 - 3.6)x10^5$	1	[1]
(g)	distance travelled on 1 litre at 31 ms^{-1} = 2.2x16/3.5(2) = 10.0 km (9.8 - 10.1)	1 1	[2]
(h)	ke = $\frac{1}{2}mv^2$ = ½ x $1100x31^2$ (= $5.29x10^5$ J)	1	[1]
(i)	(ke lost =) heat gained = $mc(\theta_2 - \theta_1)$ $5.3x10^5 = 8x460\ \Delta\theta$ $\Delta\theta$ = 144 K so θ_2 = 144 + 15 = 159 °C assumption: brakes initially at 15 °C (1) all heat is dissipated in brakes (1) *or* other valid assumption (not Law of Energy) any 1	 1 1 1	[3]
(j)	$W = Fd$ $5.3x10^5 = 9300d$ so d = 57 m assumption: no work done against (other) drag forces car is on horizontal road *or* other valid assumption	 1 1	[2] [20]