OCR

RECOGNISING ACHIEVEMENT

A2 TELECOMMUNICATIONS

Mark Scheme 2825/5
January 2004

			Marking Points	Additional Guidance	Marks
1.	(a)	(i)	Amplitude modulation		1
		(ii)	Carrier frequency = 1 / period		1
			= 1 / 20μs = 50 kHz		1
		(iii)	Information frequency = 1 / 200μs = 5 kHz		1
	(b)		Power spectrum		
			three vertical lines		1
			Larger carrier line than two symmetrical sidebands		1
			Carrier located at 50kHz sidebands at 45 and 55.		1
	(c)		Bandwidth is the range of frequencies making up a signal		1
	(d)		Bandwidth of radio signal of Fig 1.2		
			= 2 × highest information frequency		1
			= 10kHz		1
	(e)		Why restrict bandwidth		
			To allow more users to share same waveband		1
			Explain modulation choice		
			LF waveband		
			Typical carrier frequency (30 – 300kHz)		1
			Form of modulation is AM		1
			Maximum audio range limited to about 4kHz	Any 2	1
					Max 2
			VHF waveband		
			Typical carrier frequency 30 – 300MHz)		1
			Form of modulation is FM		1
			Maximum audio frequency up to 15kHz		1
			Bandwidth of 180kHz can easily be accommodated	Any 2	1
					Max 2

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2.	(a)	(i)	Op-amp.		1
		(ii)	Output = y Non-inverting input = z Inverting input = x		1
		(iii)	The difference between the voltages at z and x is amplified by a huge amount (open loop again) to provide the voltage at y		1 1
	(b)	(i)	As the op-amp is not saturated, (Vz – Vx) must be small Because open loop gain is so large or amplifier tries to keep two inputs x and z at (roughly) the same voltage z is connected to 0V so x is also 0V		1 1 1
		(ii)	Current = V/I = 3 – 0/12k = 0.25 mA	(Allow ecf from (i))	1 1
		(iii)	Voltmeter V_B = voltage gain × V_A = –36/12 × 3 = –9V	(ignore omission of negative sign) (bald answer of 9 scores 1)	1 1
	(c)		Graph of V_B against V_A Linear graph through origin of negative gradient of slope – 3 saturation at ±14V (approx).		1 1 1 1

			Marking Points	Additional Guidance	Marks
3.	(a)		Noise is always present in any transmission cable. Noise power is constant along the transmission path. Signal loses energy as it passes along any transmission cable. Signal must be amplified before it becomes lost in the noise. Otherwise it would be impossible to distinguish signal from the noise.	Any three	1 1 1 1 1 Max 3
	(b)		27 dB = 10 log P_{out}/P_{in} Thus $P_{out}/P_{in} = 10^{2.7} \approx 500$		1 1
	(c)		Total attenuation = total power loss = total power gain from amplifiers $= 4 \times 27$ = 108 dB Attenuation per unit length = 108/24 = 4.5 dB km^{-1}	Or 27 dB/6km = 4.5	 1 1
	(d)	(i)	Power output = V × I = 50 × 4 = 200 W		1 1
		(ii)	Power input = 1/500 of 200 W = 0.4 W = V_{in} × 4A Thus V_{in} = 0.1V		1 1
		(iii)	Total resistance of cable = pd/current = (50 – 0.1)/4 ≈ 12Ω		1 1
		(iv)	Resistance = ρ × total length/Area = and total length = 2 × 6000m Area = $1.8 \times 10^{-8} \times 2 \times 6000/12.5$ = $1.73 \times 10^{-5} m^2$ (Diameter = 4.7mm)		1 1 1 1

			Marking Points	Additional Guidance	Marks
4.	(a)		An analogue signal is analogous/(wtte) with the physical property which generated it An analogue signal varies continuously in time An analogue signal can have any value between two limits		1 1 Max 2
	(b)		A digital signal is a coded piece of information A digital signal does not vary continuously with time (on/off) A digital signal can have only two values		1 1 1 Max 1
	(c)		Pulse Code Modulation		1
	(d)		Sampling occurs at repeated intervals Each sample is converted to digital by ADC Voice frequencies must be filtered / limited before sampling (300Hz – 3.4kHz) To avoid alias signals Sampling frequency is 8000Hz Output of ADC is a parallel word Each word is made up of 8 bits Thus 8000 × 8 = 64000 bits sec^{-1} produced by call Bits are sent individually/one at a time by parallel-to-serial converter Receiver amplifies and removes noise Receiver swallows bits as they arrive and pass into serial-to-parallel converter Parallel outputs passed to DAC Output of DAC filtered smooth and passed to loudspeaker	Must have these two points Any 3 Must make at least 2 points	1 1 1 1 1 1 1 1 1 Max 3 1 1 1 1 Max 2
	(e)		Disadvantages Complex/expensive Consumes larger bandwidth than direct analogue transmission Advantages Digital can have noise removed Digital can be easily stored in memories Digital can be easily manipulated by computer Digital can be encrypted Digital can be companded	1 max Any 2 Must made at least one disadvantage to score all three	Max 1 Max 2

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5.			**Space Waves**		
			(or description:		
			e.g. line-of-sight waves)		1
			above 30 MHz		1
			VHF FM radio		
			TV		
			Radar		
			Aircraft		
			communication/navigation		
			Microwave links		
			Satellite communications		
			Mobile phone network		1
			Sky Waves		
			(or description:		
			e.g. ionospheric reflections)		1
			3 – 30MHz		1
			International radio broadcasts		
			Amateur radio		
			Ship to shore communications		1
			Surface Waves		
			(or description:		
			e.g. bending around the earth)	Accept Ground Waves	1
			below 3MHz		1
			AM radio broadcasting		
			Long range navigation		
			Submarine communication		1

6	(a)	(i)	Idea of zig-zag path 3-5 reflections, i = r. reflection at boundary Refractive index of light guide > air (allow denser) Provided $i \geq C$, TIR occurs.	Any 3	1 1 1
		(ii)	$\sin C = 1/n$ $C = \sin^{-1}(1/1.58) = 39.3°$.		1 1
	(b)	(i)	$E = hc/\lambda = 6.63 \times 10^{-34} \times 3 \times 10^{8}/413 \times 10^{-9}$ $= 4.82 \times 10^{-19}/1.6 \times 10^{-19} = 3.01$ eV	Photon energy eV conversion	1 1
		(ii)	10^4 photons = 3.01×10^4 eV % conversion = $3.02 \times 10^4 \times 100\%/1.5 \times 10^6 = 2\%$		1 1
	(c)	(i)	$hc/\lambda = 2.2 \times 1.6 \times 10^{-19}$ $\lambda = 6.63 \times 10^{-34} \times 3 \times 10 /(2.2 \times 1.6 \times 10^{-19})$ = 566 nm	 560- 570 nm	1 1
		(ii)	the work function is greater than the photon energy / no photoelectron emission	Or equivalent	1
		(iii)	$hf = \phi + \frac{1}{2} m_e v_{max}^2$ $hf - \phi = (3.02 - 2.2) \times 1.6 \times 10^{-19} = 1.31 \times 10^{-19}$J $v_{max} = \sqrt{(2 \times 1.31 \times 10^{-19}/9.1 \times 10^{-31})} = (5.0\text{-}5.4) \times 10^5$ ms^{-1}	Or hf = ϕ + KE Omit eV conversion: 2/3 KE = 3eV or 2.2eV: 1/3	1 1 1
	(d)	(i)	3^{12} = 531000	Allow 3^{13} = 1590000	1 1
		(ii)	$Q = ne = 531000 \times 1.6 \times 10^{-19} = 8.5 \times 10^{-14}$ C $I = Q/t = 8.5 \times 10^{-14}/3 \times 10^{-9}$ $= 2.8 \times 10^{-5}$ A	 Q=e: 1/3	1 1 1