Mark scheme for Extension Worksheet – Option F, Worksheet 3

1 X is an analogue to digital converter; Y is a serial to parallel converter; X takes an analogue signal as input and returns a binary word of a specified number of bits for each sample of the signal; at Y the bits arrive one by one and once they all arrive they are put into a binary word whose bits are simultaneously fed in the DAC. [4]

2 X is the tuning circuit; and Y is an audio amplifier (AF); the tuning circuit isolates the frequency of the carrier wave one wants to receive; the signal that leaves the demodulator is very weak and needs to be amplified so that the loudspeaker can be driven, this amplification takes place in the AF. [4]

3 **a** The bit rate *B* is $B = fn = 2000 \times 8 = 16$ kHz [1]

b The bit duration is $\frac{1}{B} = \frac{1}{16 \times 10^3} = 6.25 \times 10^{-5}$ s [1]

4 Dispersion means that signals arrive at their destination at different times due to either different speeds (material dispersion) or different paths followed (modal dispersion); this implies that signals get wider reducing the maximum frequency that can be transmitted. [2]

5 The main source of attenuation in an optical fibre is the impurities in the glass core of the fibre. [1]

6 The power loss in dB after 5.0 km is 15 dB; hence $10\log\frac{P_{out}}{P_{in}} = -15$; and so

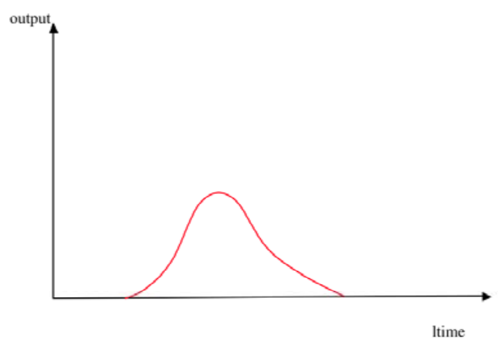
$\frac{P_{out}}{P_{in}} = 10^{-1.5} = 3.2 \times 10^{-2}$ [3]

7 The attenuation is strongly dependent on wavelength; and is minimum for IR wavelengths. [2]

8 $10\log\frac{P_{out}}{P_{in}} = 8.0$; so $\frac{P_{out}}{P_{in}} = 10^{0.8} \Rightarrow P_{out} = 10^{0.8} \times P_{in} = 10^{0.8} \times 0.30 = 1.89$ mW [2]

9 Much higher bandwidth; reduced crosstalk. [2]

10 **a** See diagram: shorter; and wider;



[2]

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b It is shorter because of attenuation that reduces the power of the signal; and wider because of dispersion that makes different components of the signal arrive at different times. [2]

c The fact that the signal is wider; this means that the period of the carrier is bigger, i.e. the frequency smaller. [2]

11 **a** $10\log\frac{P_{rec}}{P_{em}} = -150$; so $P_{rec} = 30\times10^{-15.0}$; $P_{rec} = 30\times10^{-12}$ W [3]

b $I = \frac{P_{em}}{4\pi d^2} \Rightarrow d = \sqrt{\frac{30\times10^3}{4\pi\times2.6\times10^{-8}}}$; $d = 300$ km [2]

c The power received is $P_{rec} = IA = 2.6\times10^{-8}\times2.5 = 6.5\times10^{-8}$ W; hence the power loss is $10\log\frac{6.5\times10^{-8}}{30\times10^3} = -117 \approx -120$ [2]

d Because the radiation is directed towards the satellite and is not emitted in every direction. [1]

e The downlink frequency must be different because the signal going down would have to be strong; and if at the same frequency it would be picked up by the satellite's receiver. [2]

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