Mark scheme for Option F

1 **a** **i** The amplitude is less as a result of attenuation.

There is an added random signal/signal is not smooth as a result of noise. **[2]**

Exam tip: you must be specific in your answers.

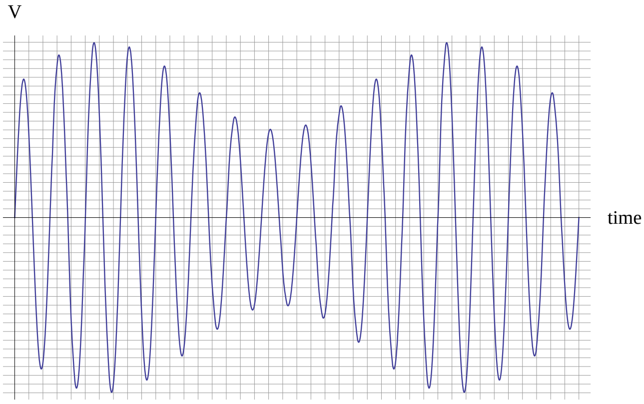
ii Both attenuation and noise would be substantially reduced. **[1]**

2 **a** The modification of the carrier signal,

so that it can transmit information. **[2]**

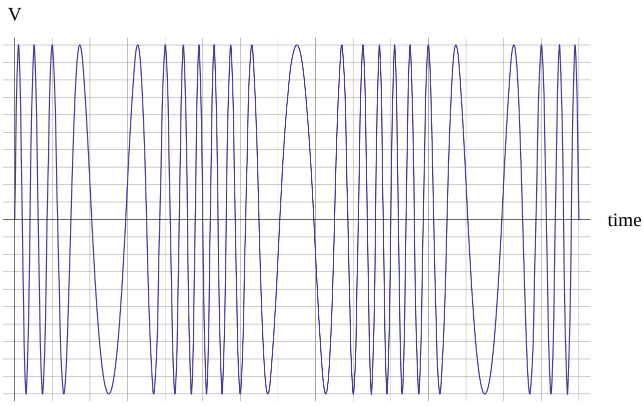
b In AM modulation the displacement of the information signal is added to the amplitude of the carrier.

The result is the typical AM modulated signal shown below.



In FM modulation the frequency of the carrier is changed according to the displacement of the information signal.

The result is the typical FM modulated signal below.



[4]

Exam tip: You may want to mention that the frequency of the modulated carrier is greatest when the information signal is large and positive and least when the information signal is large and negative.

c [4] max from

Advantages of FM compared AM:

Greater bandwidth.

Less noise/greater signal to noise ratio.

Same information can be transmitted with less power/Power is in sidebands/Amplitude of carrier small compared to sidebands.

Disadvantages of FM compared to AM:

More complex electronic circuitry in general.

Complex modulators and demodulators in particular.

The greater bandwidth of FM (which can be an advantage) can also be a disadvantage since bandwidth is hard to come by (you have to pay for it). **[4]**

d **i** There are about 23 full waves in the interval of 2.0 ms, so the period of the carrier is about $\frac{2.0}{23}$ ms, and so the frequency is

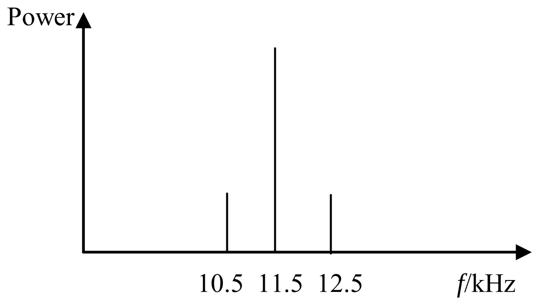
$\frac{23}{2.0}\times 10^3 = 11500(\text{accept} \pm 500)$ Hz. **[1]**

ii Trough to trough (or peak to peak) time is about $1.23 - 0.22 = 1.01$ ms, so frequency is $\frac{10^3}{1.01}$ Hz $= 990(\text{accept} \pm 50)$ Hz. **[1]**

iii Signal amplitude is $\frac{\max - \min}{2} \approx \frac{8-4}{2} = 2$ V. **[1]**

iv Bandwidth is double the information frequency so $2\times 990 = 1980(\text{accept} \pm 100)$ Hz $\approx (2.0 \pm 0.1)$ kHz. **[1]**

e



[2]

3 **a** **i** The signal is sampled every 0.20 ms, i.e. with a sampling frequency of $\frac{10^3}{0.20}\ \text{Hz} = 5.0\ \text{kHz}$. **[1]**

ii Bit rate $f \times n = 5.0\times10^3 \times 5 = 2.5\times10^4\ \text{bs}^{-1}$. **[1]**

iii Duration of one bit is the inverse of the bit rate, i.e. $\frac{1}{2.5\times10^4}\ \text{s} = 4.0\times10^{-5}\ \text{s}$. **[1]**

iv The sampled value is 21 V, i.e.
$21 = 16+4+1 = 1\times2^4 + 0\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 \rightarrow 10101$. **[1]**

b To reconstruct the signal the sampling frequency must be at least twice the highest frequency in the signal, i.e. 24 kHz.

The present sampling frequency is only 5.0 kHz, so it should definitely be increased. **[2]**

c Because the pulse gets wider (as a function of time), its period increases.

Hence the maximum frequency that can be transmitted decreases. **[2]**

4 **a** The attenuation in an optical fibre is highly dependent on wavelength.

The attenuation is least for infrared wavelengths.

Exam tip: mention the first marking point.

The frequency is high enough.

To allow a very large bandwidth for transmission of data. **[4]**

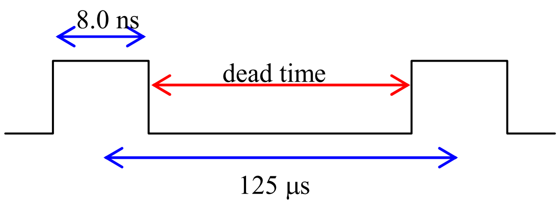
b **i** $\frac{1}{8.0\times10^{3}} = 1.25\times10^{-4}$ s **[1]**

ii The duration of one bit is much less than the time in **i**.

And so other signals may be transmitted on the same line in between the first signal. **[2]**

iii The space in between two samplings ('dead time') is (see **figure**) $1.25\times10^{-4}\text{ s} - 8\times1.0\text{ ns} = 1.24992\times10^{-4}$ s.

And so can fit $\frac{1.24992\times10^{-4}}{8.0\times10^{-9}} = 15624$ additional samples/signals.



[1]

Exam tip: Always draw a diagram if you think it will help you explain things better.

iv Because of dispersion, the signals will spread and so the large number calculated in **iii** will not fit without merging into each other.

In addition, error correcting codes and other control codes are sent along with the signals so there would again be less space. **[2]**

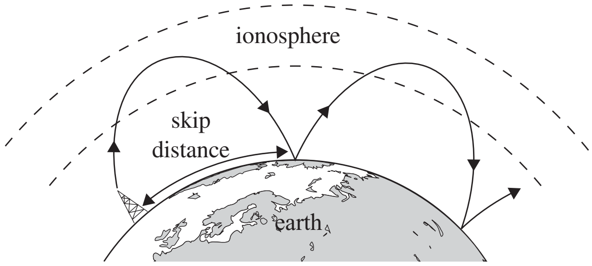
c When the signal to noise ratio is 18 dB, the power of the signal is $18 = 10\log\frac{P}{6.0\times10^{-6}}$ and so $P = 0.3786$ mW.

The power loss in the signal is therefore $10\log\frac{0.3786}{3.2} = -9.27$ dB;

And so the distance without amplification is $\frac{9.27}{2.1} = 4.4$ km; **[3]**

5 a (Sky) waves bouncing off **ionosphere**,

and moving around the other side of the earth.



[2]

b i TV signals use higher frequencies than sky waves

and only allow line-of-sight communication. **[2]**

ii Most likely through the use of a satellite. **[1]**

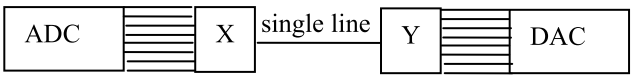
6 **a** As it stands, 8 bits are simultaneously transmitted from the ADC to the DAC in 8 separate wires.

To have 8 separate wires run down a long distance would be very expensive and not practical.

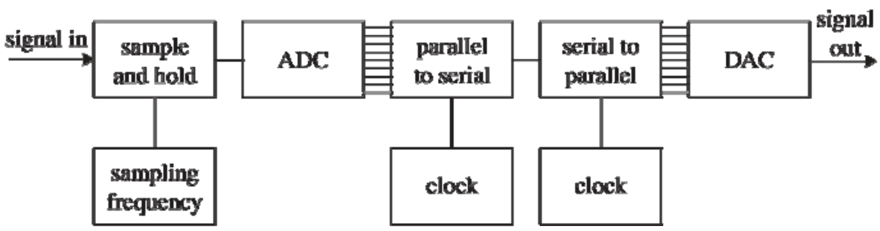
In addition, because of dispersion the 8 bits would take slightly different times to arrive, so if the distance is quite large the order in which they are received may be wrong. **[3]**

b One possibility is to include a single transmission line as shown,

but this requires a parallel-to-serial box X and a serial-to-parallel box Y.

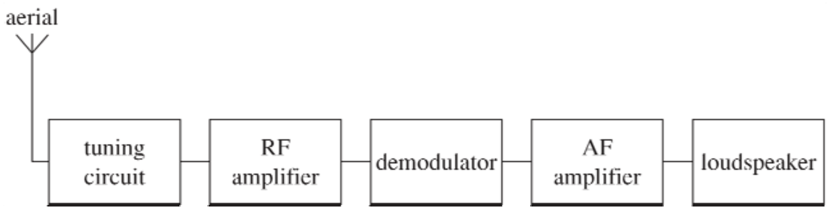


OR



[2]

c



[1] for each of four correct components. **[4]**

7 **a** High input resistance.

High gain. **[2]**

b **i** –6.0 V. **[1]**

ii +6.0 V. **[1]**

c **i** $G = 21 = 1 + \frac{R}{8.0}$.

$R = 160\ \text{k}\Omega$. **[1]**

ii (Saturation occurs for voltages greater than $\frac{6.0}{21} \approx 0.29\ \text{V}$ in magnitude), and so here the output is $V = GV_{\text{IN}} = 21 \times 0.04 = 0.84 \approx 0.8\ \text{V}$. **[1]**

iii The output will saturate to $-6.0\ \text{V}$. **[1]**

d When the phone is turned on it will send out a signal that identifies the phone.

The signal is picked up by a nearby base station and is then sent to the cellular exchange.

The base station that receives the strongest signal from the phone is allocated to the phone by the computer at the cellular exchange,

along with a frequency. **[4]**