How is information added to a wave? – From GCSE Bitesize BBC 2014

Signals are encoded and sent from a transmitter to a receiver, where they are decoded.

Optical fibres can carry more information than an ordinary cable of the same diameter.

Signals can be either analogue or digital. Digital signals maintain their quality over longer distances than analogue signals.

Transmitting and receiving

Signals are sent from a transmitter to a receiver. This can be done in many ways: using *microwaves* or *radio waves* through the Earth's atmosphere and through space, or through cables using *optical fibres.*

All signals, as they travel, decrease in *amplitude* This means that if they are transmitted over long distances they must be amplified (made bigger) along the way.

Analogue and digital

Before a sound or piece of information is transmitted, it is encoded in the transmitter in one of the ways described below - analogue or digital. The receiver must then decode the signal to produce a copy of the original information or sound.

Analogue signals vary continuously in amplitude, frequency or both. *Digital* signals are a series of pulses with two states - on or off. Digital signals carry more information per second than analogue signals and they maintain their quality better over long distances.

Optical fibres

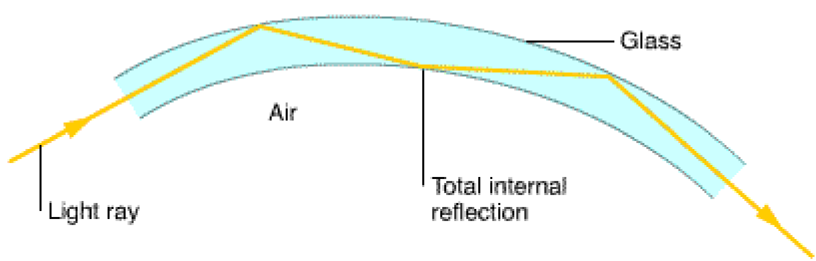
Information such as computer data and telephone calls can be converted into signals in several different ways. They can be:

- made into electrical signals carried through electrical cables (eg copper wires).
- transmitted through the atmosphere as *microwaves*
- transmitted through the atmosphere as *radio waves*
- converted into visible light signals or *infrared* signals, which are carried by optical fibres

Optical fibres

An optical fibre is a thin rod of high-quality glass. Very little light is absorbed by the glass. Light getting in at one end undergoes repeated *total internal reflection*, even when the fibre is bent, and emerges at the other end.

Optical fibres can carry more information than an ordinary cable of the same thickness. The signals in optical fibres do not weaken as much over long distances as the signals in ordinary cables. This means that they do not need to be amplified as often as signals in copper cables.



Optical fibre

Analogue v digital

You should be able to recognise analogue and digital signals, and to outline the advantages of digital signals.

Analogue signals

Music and speech vary continuously in *frequency* and *amplitude*. In the same way, analogue signals can vary in frequency, amplitude or both. The diagram shows a typical **oscilloscope trace** of an analogue signal which varies in the same way as the sound signal it represents.

Modulation

A wave that has been modified to carry a signal is said to have been modulated. There is more than one way to do this.

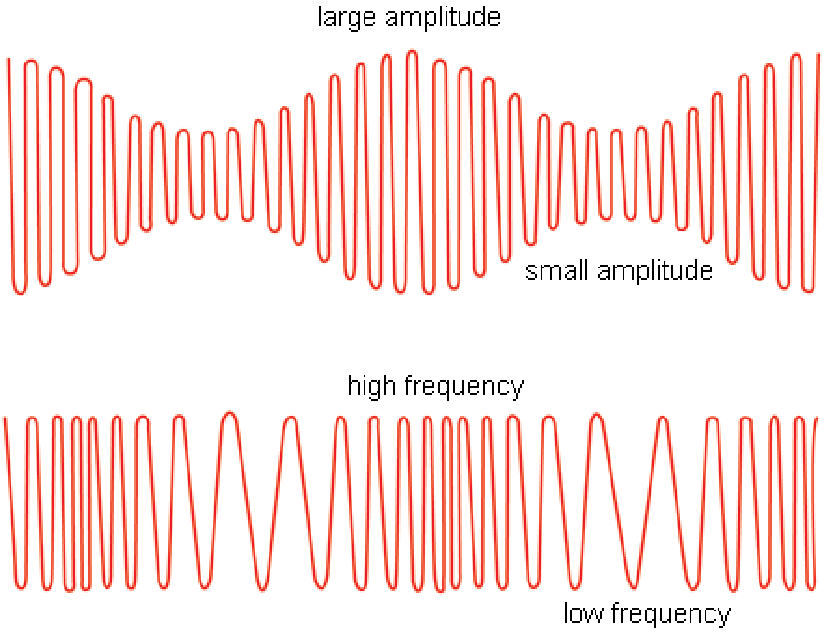
FM radio and AM radio (Frequency Modulated and Amplitude Modulated) are two ways in which radio waves are transmitted.

In **Amplitude Modulation**, the radio wave varies in amplitude to match the changes in the sound wave.

In **Frequency modulation**, the radio wave varies in frequency to match the changes in the sound wave.

Oscilloscope trace of an analogue signal

The diagram shows amplitude modulated and frequency modulated signals.



Amplitude modulated and frequency modulated signals

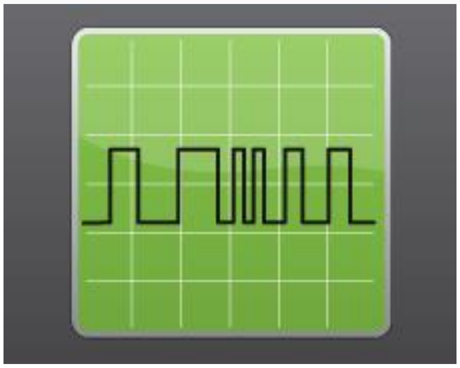
The upper trace is **amplitude modulated**. The amplitude changes from large to small to large again to copy the changes in the sound wave being carried by the radio wave. The frequency does not change.

The lower trace is **frequency modulated**. The frequency changes from high to low to high again to copy those same changes in the sound wave being carried by the radio wave. The amplitude does not change.

Digital signals

Digital signals are a series of **pulses** consisting of just two states, **ON (1) or OFF (0)**. There are no values in between. The

sound is converted into a digital code of 0s and 1s, and this coded information controls the short bursts of waves produced by a source. DAB radio is Digital Audio Broadcast radio – it is transmitted as digital signals. The diagram shows a typical oscilloscope trace of a digital signal.



Oscilloscope trace of a digital signal

Advantages of digital signals

Digital signals carry **more information** per second than analogue signals. This is the same whether optical fibres, cables or radio waves are used.

Digital signals maintain their **quality** over **long distances** better than analogue signals. You will notice far less noise and crackle in a DAB radio programme than in an ordinary FM or AM radio programme.

Analogue v digital (Higher Tier)

You should be able to explain why **digital signals** maintain their **quality** better than analogue signals.

Noise

All signals become **weaker** as they travel long distances. They may also pick up random extra signals. This is called **noise**, and it is heard as crackles and hiss on radio programmes. Noise may also cause an **Internet connection** to drop, or slow down as the modem tries to compensate.

Analogue signals

Noise adds extra random information to analogue signals. Each time the signal is amplified the noise is also amplified. Gradually, the signal becomes less and less like the original signal. Eventually, it may be impossible to make out the music in a radio broadcast against the background noise, for example.

Digital signals

Noise also adds extra random information to digital signals. However, this noise is usually lower in amplitude than the 'on' states of the digital signal. As a result, the electronics in the amplifiers can ignore the noise and it does not get passed along. This means that the **quality** of the signal is maintained. This is one reason why television and radio broadcasters are gradually changing from analogue to digital transmissions. They can also squeeze in **more programmes** because digital signals can carry more information per second than analogue signals.