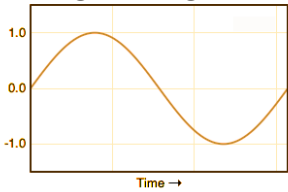


## Original signal



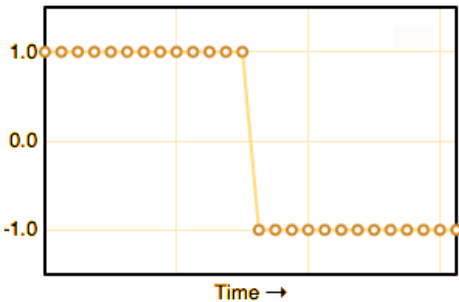
1

The second factor in the amount of information sent by a digital signal (the first was the number of samples per second - see sheet 1 of this series) is the number of bits in each sample.

Each sample is sent as a binary number.

Each digit in that number can either be one or zero. The number of digits in a binary number is called the number of **bits**.

If a sample contains only one bit then it can only have two levels, so in the case of a sine wave (shown above) sampled 25 times each cycle it would be converted back to a square wave like this:



4

If the signal contains four bits then it can give sixteen (that is  $2^4$ ) different binary numbers.

It can define sixteen different wave amplitudes, so when the sine wave signal is converted back it looks like this, which is much closer to the original shape.

If there are a greater the number of bits per sample then the signal is converted more perfectly but we then have to send more bits per second, using more bandwidth and costing more.

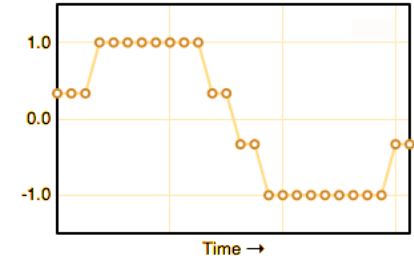
**5 Bandwidth used** (amount of information per second) = no. of samples per second x no. of bits per sample  
**Note that** if there are  $i$  bits in a sample **then the number of levels of information  $N = 2^i$**   
 Therefore, the number of bits needed per sample,  $i = \log_2 N$

## Digital Imaging and signaling 2 Bandwidth and bits per sample

The Fizzics Organization  
[www.fizzics.org](http://www.fizzics.org)  
[www.fizzics.co.uk](http://www.fizzics.co.uk)

2 If the signal contains two bits then it can give four different binary numbers:

00  
01  
10  
11



and so it can define four different wave amplitudes. So when the sine wave signal is converted back it looks like this:

3 If the signal contains three bits then it can give eight (that is  $2^3$ ) different binary numbers:

000, 001, 010, 011, 100, 101, 110, 111

and so it can define eight different wave amplitudes. So when the sine wave signal is converted back it looks like this:

