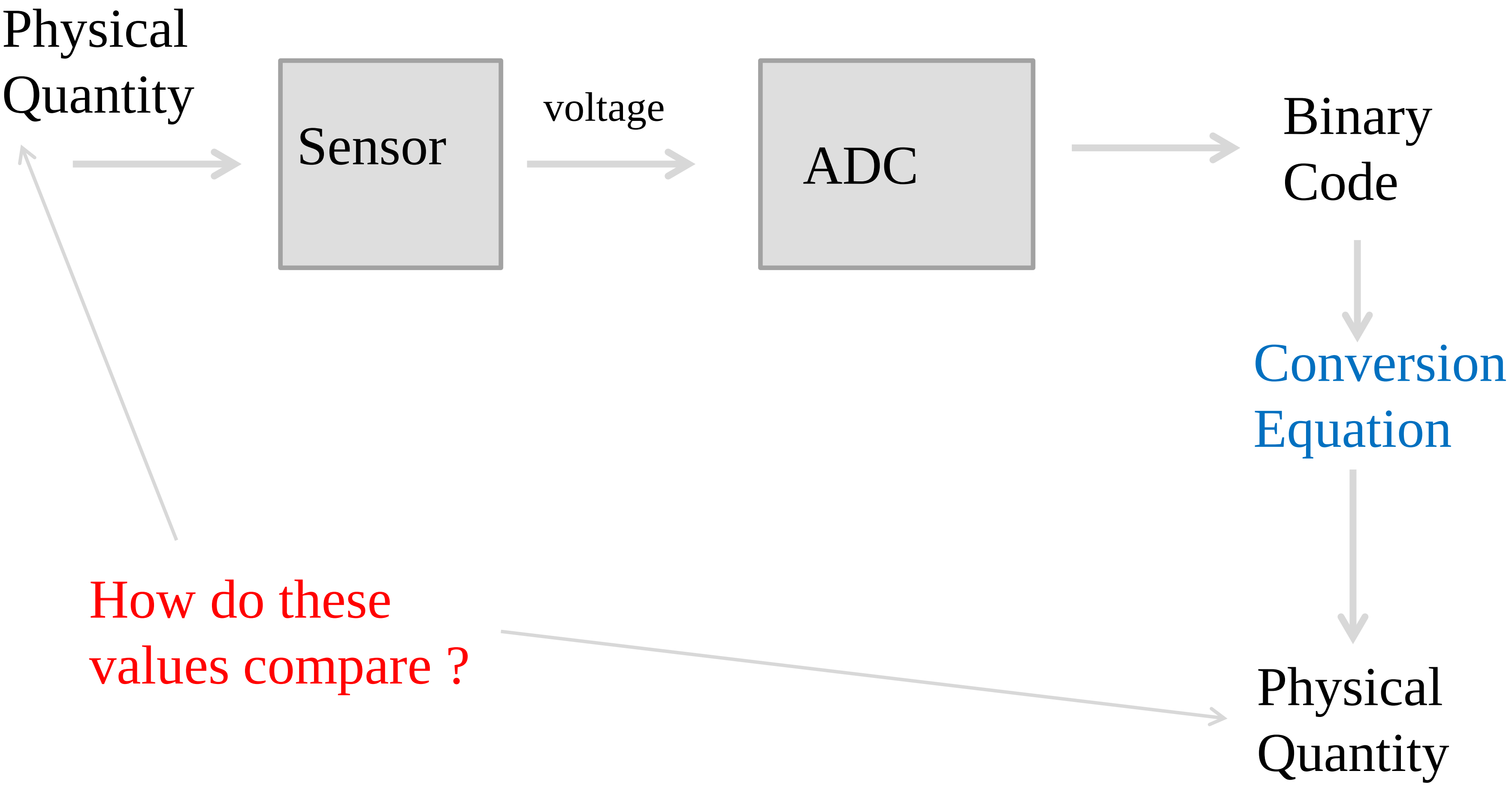
ECEN202 2024

ADDA L2

Analog to digital conversion

Our picture of the analog to digital conversion process



Physical Quantity

Sensor

voltage

ADC

Binary Code

Conversion Equation

Physical Quantity

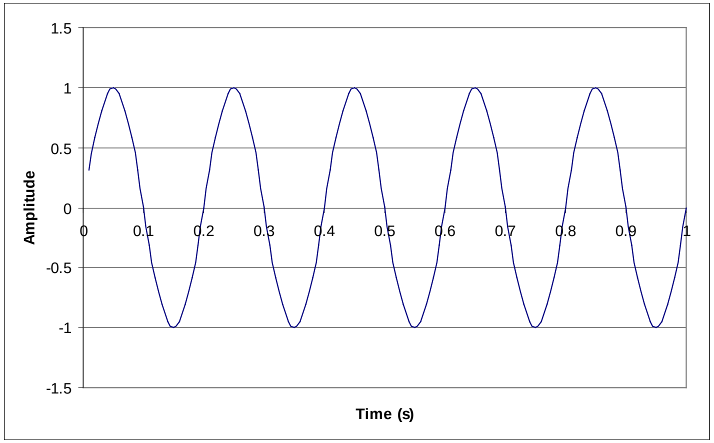
How do these values compare ?

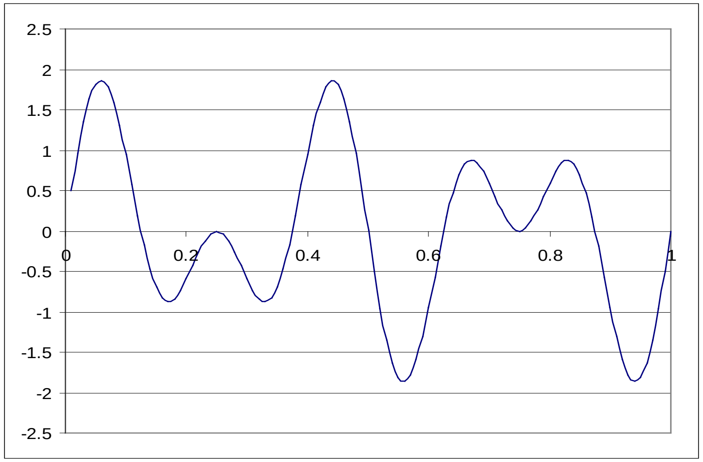
So ….:

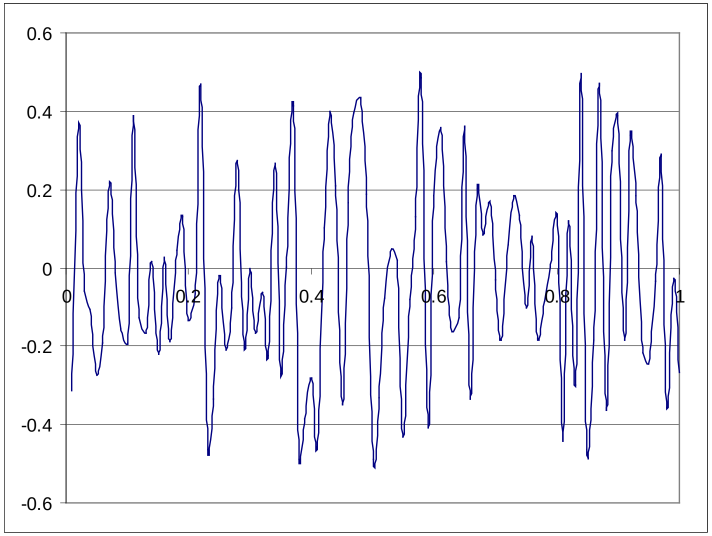
- We are interested in the sampling (measuring) of analog signals by digital system
- Analog signals vary continuously in both amplitude and time.
- In order to sample such a signal we must take a "snapshot" at a certain instant in time.
- Taking this "snapshot" will have errors and uncertainties in both amplitude and time – how big are the errors?
- For this process to be performed by a computerised system the analog signal need to be converted into a digital number – use binary code for the computer.

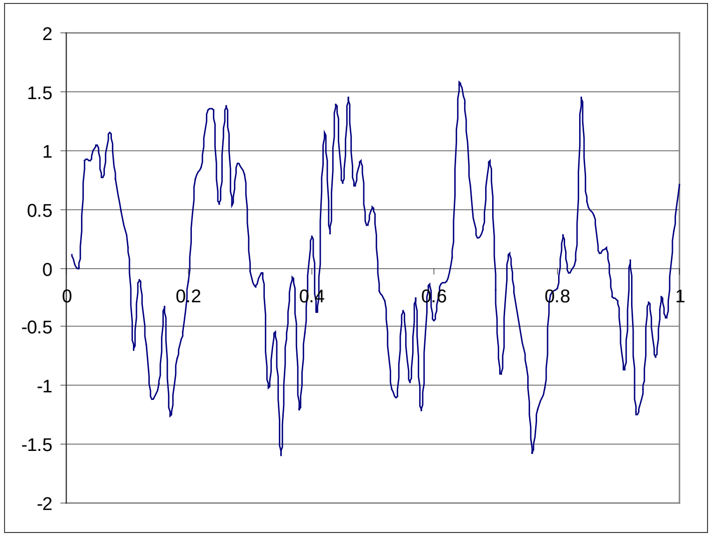
Some different analog waveforms:

Periodic or not!









We want to convert such an analog waveform into a digital format. To do this we must

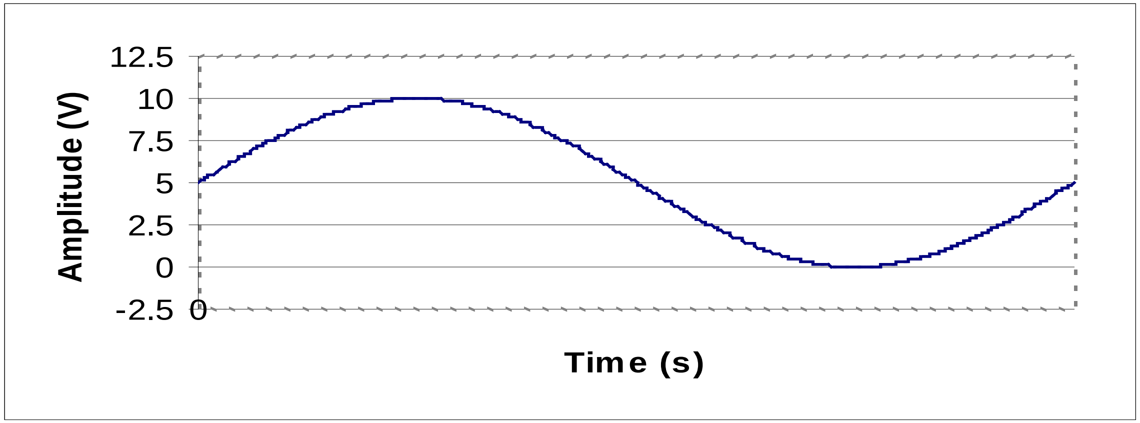
- Sample the analog waveform at certain time intervals
- Convert the amplitude of the signal at that time into a digital (binary) signal.
- Provide a time stamp for the time of sampling
- Convert the digital signal into a decimal number to make it comprehensible to the human operator
- Compare it to the original analog signal and see how well it represents this signal

Understand the limitations of the A to D process

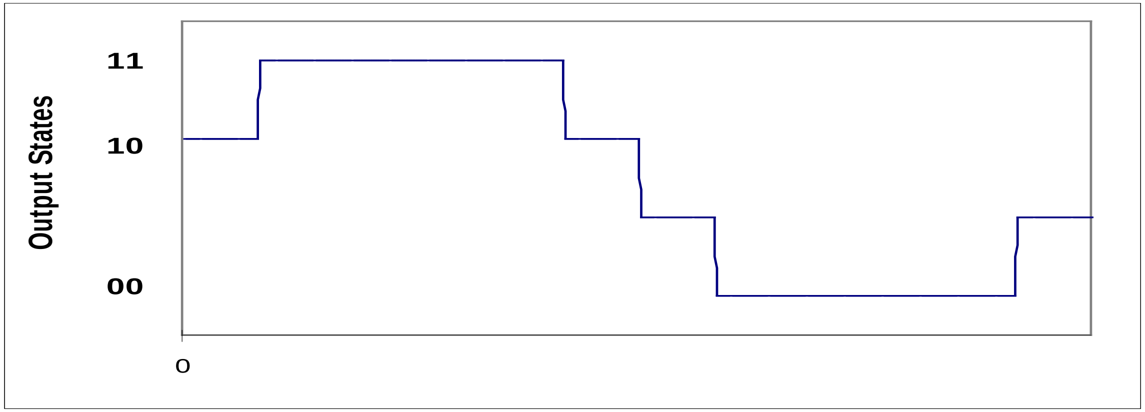
We can expect to have uncertainty (error) in both the voltage and time measurement of the ADC process. These can seriously influence the validity of our results. If we understand the ADC process we can minimise these errors – sample our signal with the best precision we can.

Will first look at a conceptual ADC process – then look at the construction and operation of some real ADCs.

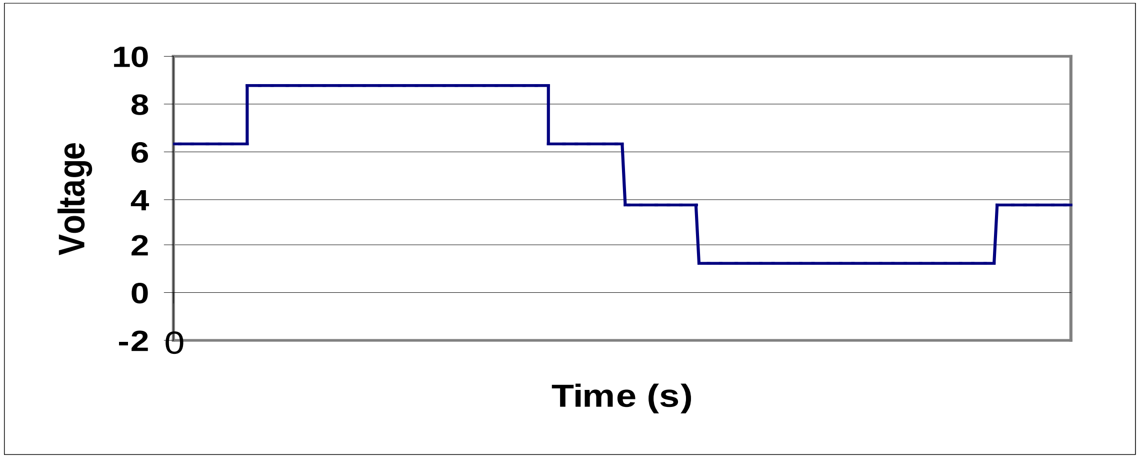
Analog Input



Digital (Binary) Conversion



Digital (Decimal) Output

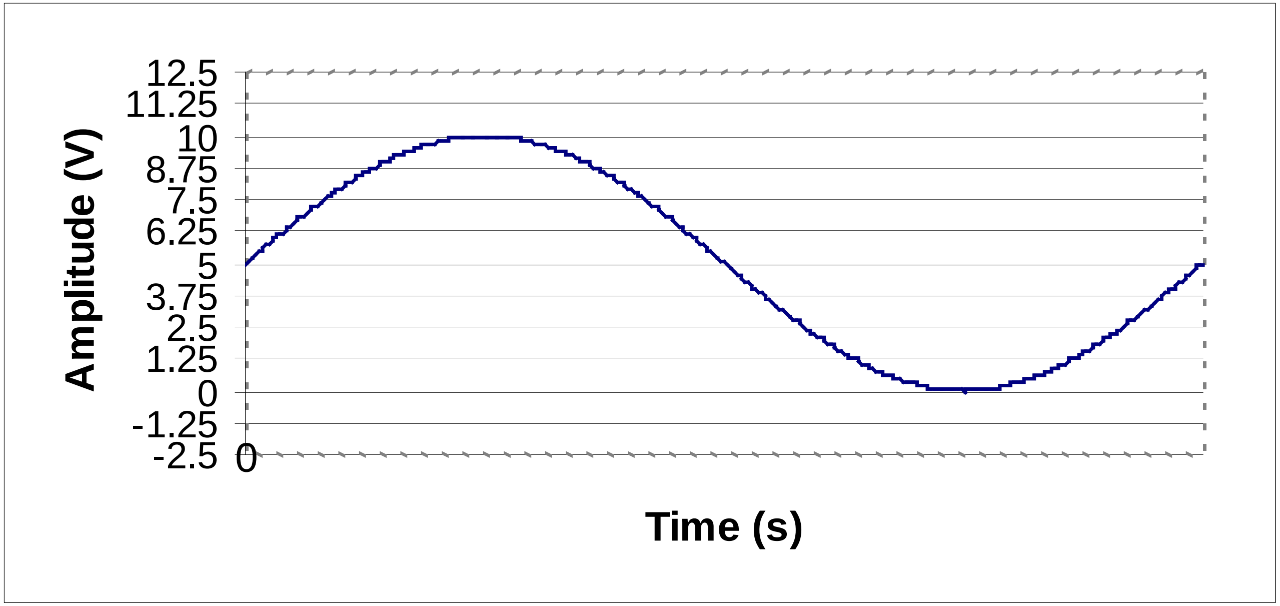


We now have a (pretty poor) representation of an analog input signal in digital (both binary and decimal) format.

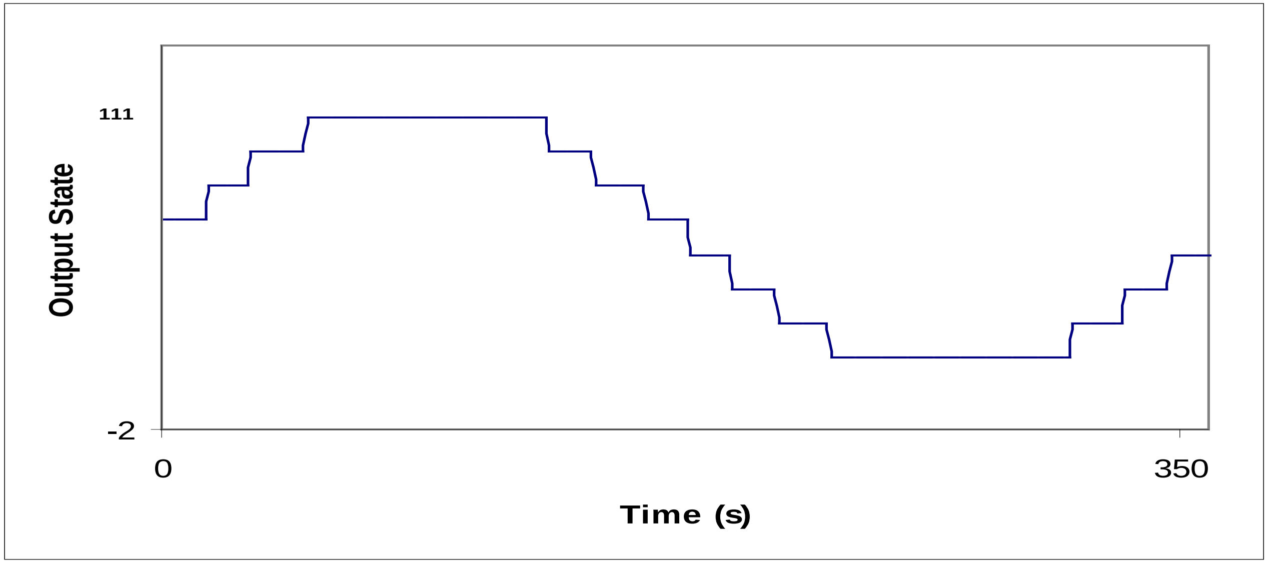
It is clear that this digital output is only a representation of the analog input. We can have an error of ± 1.25 V in the decimal output = ± half of a voltage step.

Let's improve this representation by adding another output state (or bit)

Analog Input

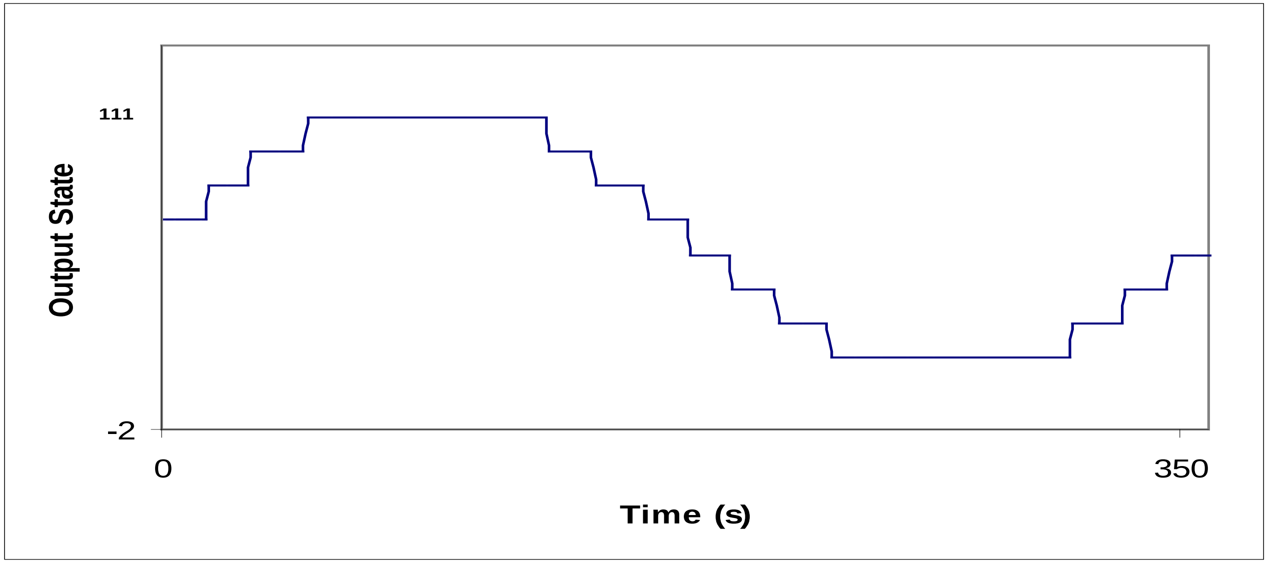


Digital (Binary) Output



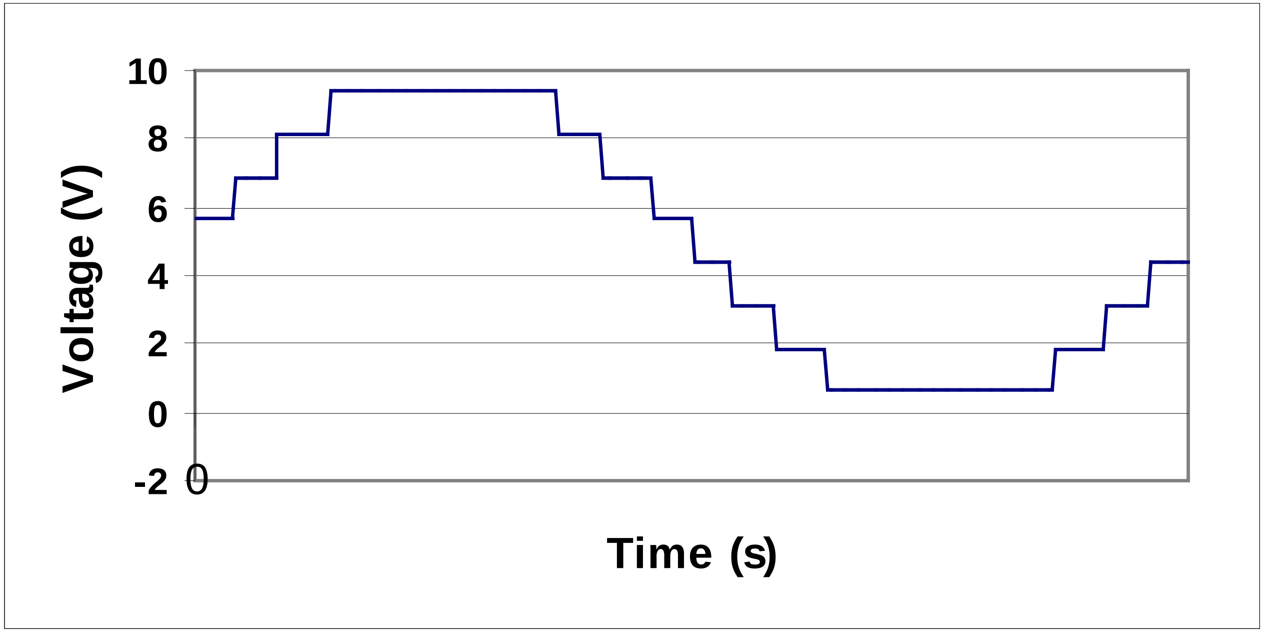
Digital (Binary)

Output



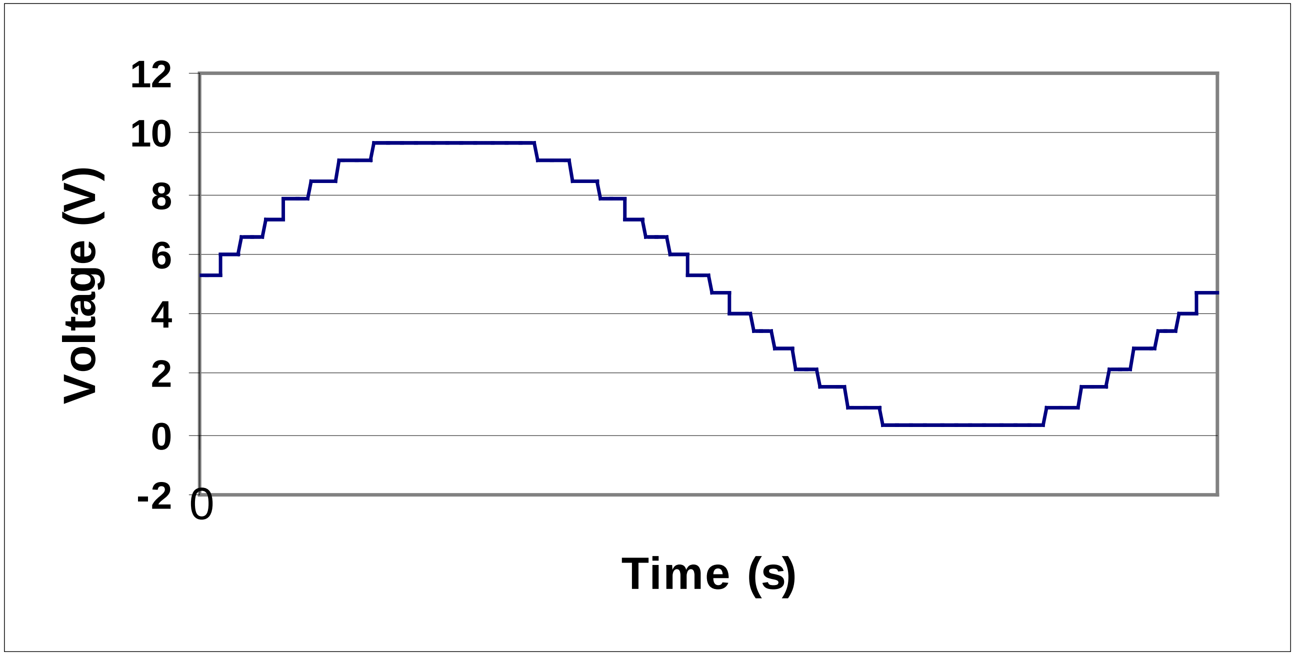
Digital (Decimal)

Output



A 3-bit converter now gives us a much better approximation of the analog input with the error (uncertainty) in the decimal output considerably smaller.

This digital output will be further improved in the case of a <u>four bit converter</u>



The number of different binary numbers that can represent the analog input = $2^{\text{no of bit}}$ in each case.

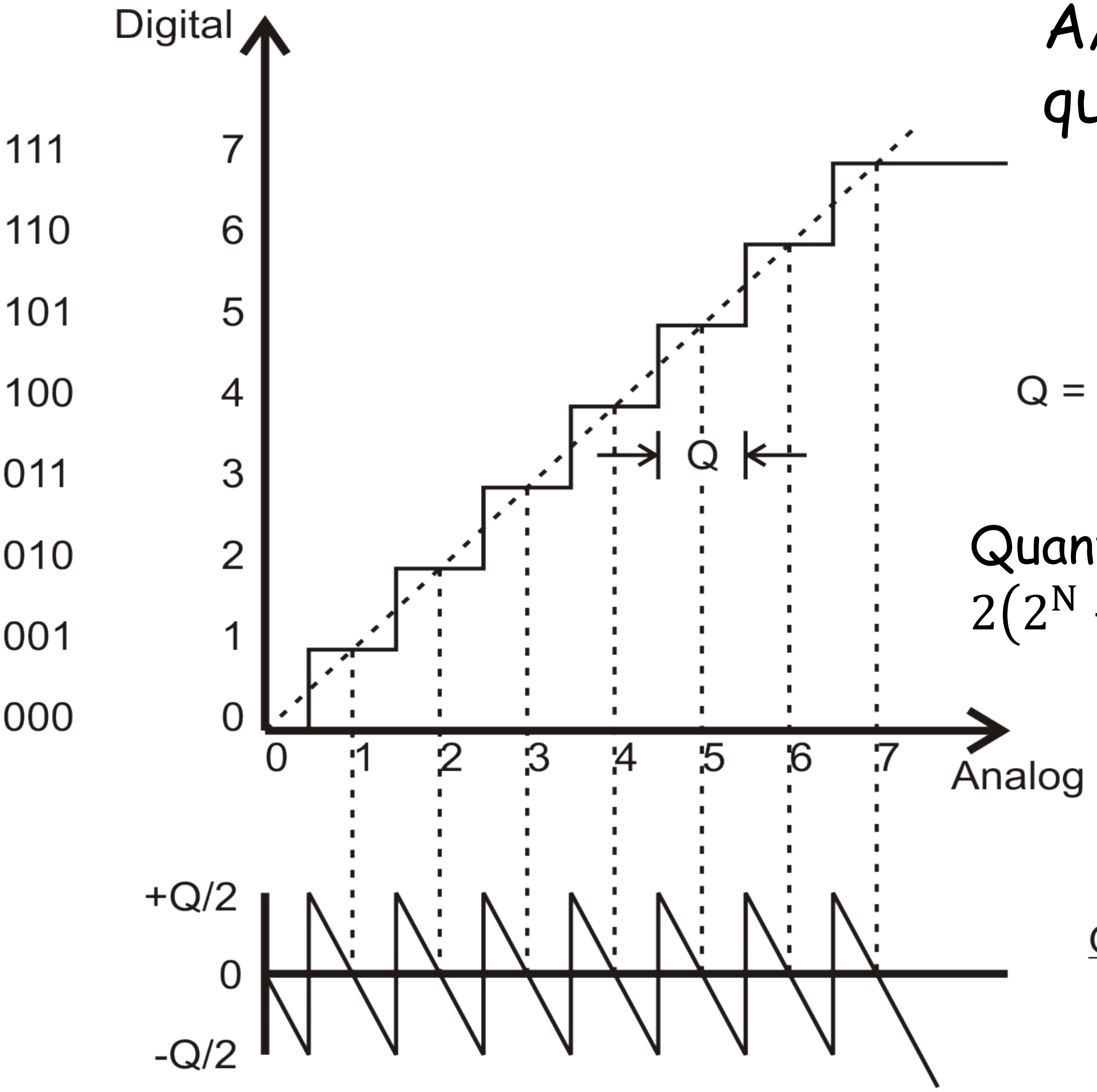
The number of steps between the levels would thus be $2^{\text{no of bit}} - 1$.

The precision with which the input signal can be represented increases as the number of bits increases.

However, the use of more bits would also increase the complexity of the circuitry

If the input signal is higher than half the input range, the MSB will remain turned on.

Quantisation is the process of converting a continuous analog signal into a set of discrete output levels.



A/D conversion involves quantisation and coding

Quantisation error is 1 part in $2(2^{N}-1)$ for an n-bit device