Pulse Width Modulation (PWM) Overview

- A control technique used to obtain analogue output values from digital input signals (typically voltages).
- Commonly used by microcontrollers to provide changeable power to some form of load:
  - general examples may include controlling the brightness of LEDs, the speed of motors, or the position of servos.
- Achieved by modulating the amount of time a digital signal remains high (pulse width) during its period.

Duty Cycle

- Digital signals take on a square waveform where their value can be either high or low (figure 1).
- The ‘duty cycle’ describes the ratio of time the signal spends high (mark) and low (space) which creates an average constant value which lies within this range (figure 2).
  - A 0% duty cycle describes a digital signal that is constantly low with an average value of 0.
  - A 50% duty cycle describes a digital signal that is high and low for equal time periods with an average value of half the maximum.
  - A 100% duty cycle describes a digital signal that is constantly high with an average value of 1.
- Providing a means to control the pulse widths of the duty cycle therefore creates a control mechanism to supply a load with specific values of averaged power.
- Required duty cycles and pulse widths can be calculated using the following:
  - Signal time period $(T) = \frac{1}{f}$
  - Duty cycle (%) = $\frac{Pulse\ width}{Period}$ x 100

General advantages

- At suitably high frequency, the produced average output is linear, precise and stable.
- Highly suited to components such as transistors which operate in a digital fashion (on or off).

General disadvantages

- Low frequency PWM may become unsuitable to the application due pulses becoming more apparent:
  - Flickering may be visible on lights and LEDs.
  - Motors and servos may operate roughly.

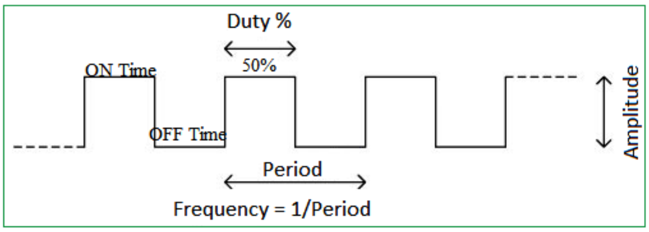

Figure 1: Square waveform

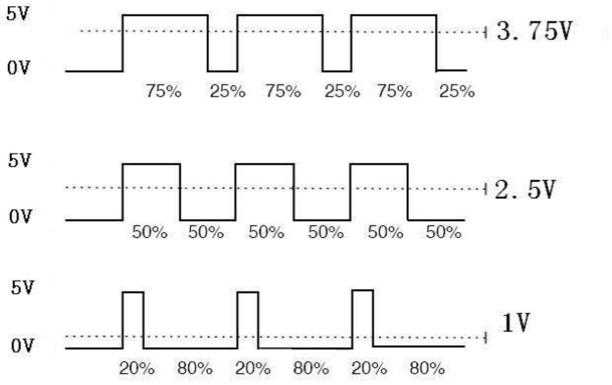

Figure 2: Duty Cycles and average value

Sources:

https://learn.sparkfun.com/tutorials/pulse-width-modulation/all

https://www.arduino.cc/en/Tutorial/Foundations/PWM

https://circuitdigest.com/tutorial/what-is-pwm-pulse-width-modulation