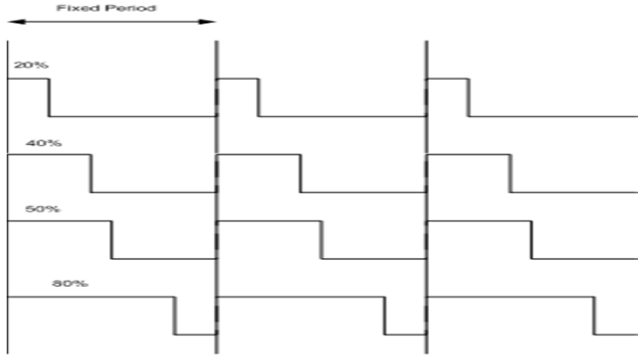
Chapter 4

Pulse Width Modulation, PWM

1

What is PWM Signal ?

- A PWM signal is a digital signal with fixed frequency but varying duty cycle.



PWM with varying duty cycles

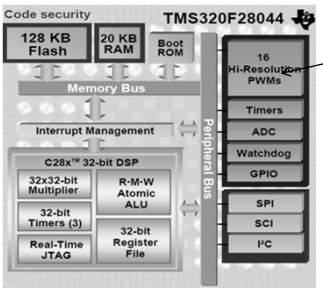
2

PWM Applications

- PWM is employed in a wide variety of applications, ranging from measurement and communications to power control and conversion
  - Eg1: Communications:
  - PWM is essentially a means of transmitting information in a series of pulses, where the data being transmitted is encoded on the width of the transmitted pulse
- Eg2: Power Delivery:
- • Reduce the total amount of power delivered to a load
- Examples: DC Motors, Light Dimmers, Anti-Lock, Breaking System.
- Eg3: Voltage Regulation

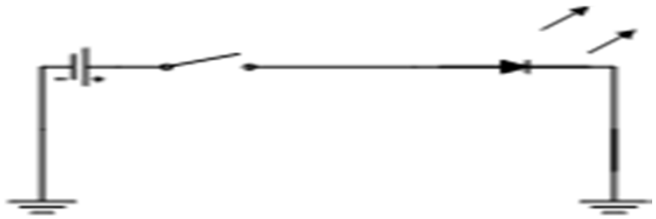
Applications of PWM (cnt)

- By controlling analogue circuits digitally, system costs and power consumption can be drastically reduced.
- Many microcontrollers and DSPs already include on-chip PWM controllers, making implementation easy.
- e.g.



PWM Generator

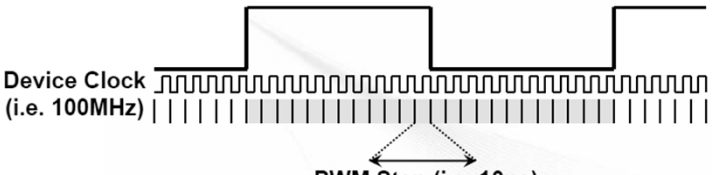
Eg: Dimmer using PWM



Simple PWM circuit

PWM 'DAC' Bits

PWM Period (or Frequency)
(determined by control loop B/W requirements)



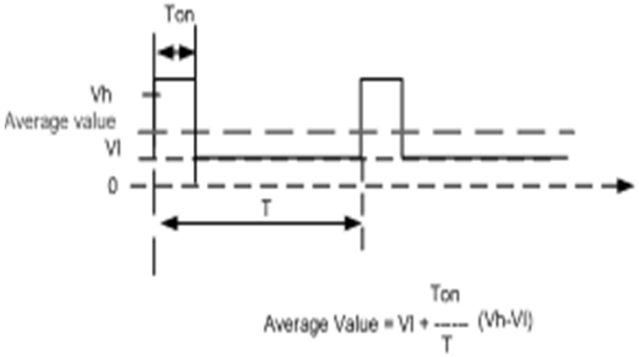
PWM Step (i.e. 10ns)
(minimum step typically tied to device clock period)

Equivalent 'DAC' Bits = $\frac{\log_2(\text{Number Of Steps In PWM Period})}{\log_2(2)}$

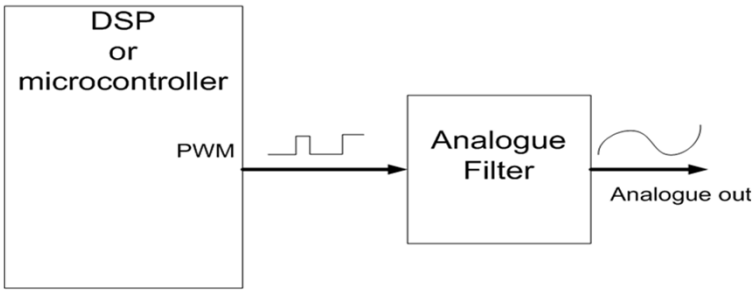
i.e. Number Of Steps In PWM Period	Equivalent 'DAC' Bits
10000	13.29
1000	9.97
100	6.64

PWM DAC

- Pulse Width Modulation DAC
  Average Value is the Desired Output

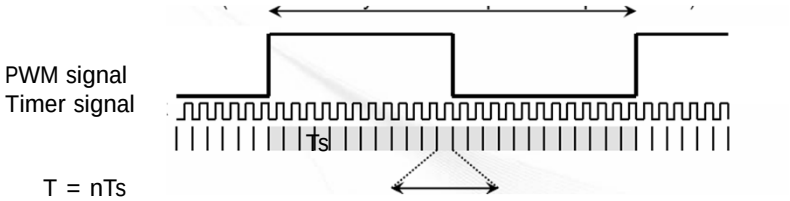


PWM DAC



PWM DAC block diagram

PWM DAC Resolution



T = nTs
Ts = PMW step
Count = the number of steps
2^n= number of steps.
n = Resolution of the PWM DAC

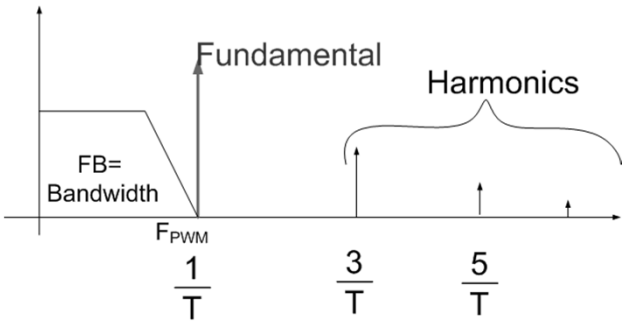
$$\log 2^n = \log count$$
$$n \log 2 = \log count$$
$$n = \frac{\log count}{\log 2}$$

PWM DAC Frequency

- The update rate of the ADC is equivalent to the frequency of the PWM output.
- The frequency of the PWM signal and the desired resolution are required to calculate the frequency of the PWM timer.

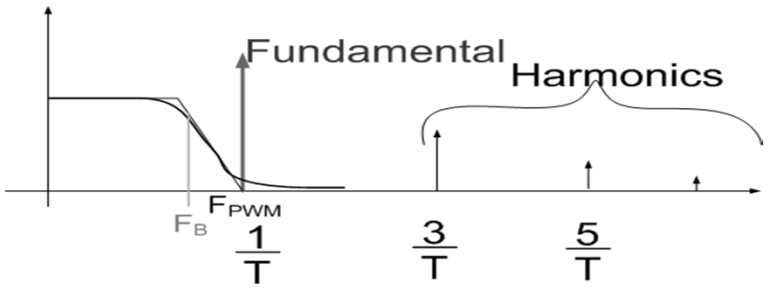
$$f_{clock} = f_{PWM} x 2^n$$
$$f_{clock} = \text{Required PWM timer frequency.}$$
$$f_{PWM} = \text{PWM signal frequency} = \text{DAC rate.}$$

Filtering the PWM signal



$$F_b \leq (F_{PWM} = \frac{1}{T})$$

Filtering the PWM signal



$$F_{PWM} = KF_B \qquad with \quad k >> 1$$

Eg if K = 5 and F_B = 4 kHz
Than F_{PWM} = 5 x 4 kHz = 20kHz

PWM Filter

Low-pass filters can be built with resistor-capacitor combinations:
The corner frequency is given by $f = 1/(2\pi RC)$
e.g. R = 160 Ω, C = 1 uF, f = 1000 Hz.

In practical situation many filters are cascaded to increase the order of the filter and subsequently attenuate the fundamental and harmonics