

# Digital to Analog Converter

Last updated 4/28/22

# DAC Basics

- Digital to Analog Converter
  - Converts a digital word to a fixed analog voltage level
  - Many applications
    - Electronic music
    - Audio conversion – heart monitor
    - Video conversion – ultrasound
    - Mechanical conversion – valve opening %

# DAC Basics

- Digital to Analog Converter Performance
  - Resolution
    - n-bit digital word can represent  $2^n$  levels
    - 8-bit DAC → 256 levels
  - Frequency
    - Outputs are provided at a fixed rate – sampling rate
  - Accuracy
    - Linearity
    - Noise
    - Many others

# DAC Basics

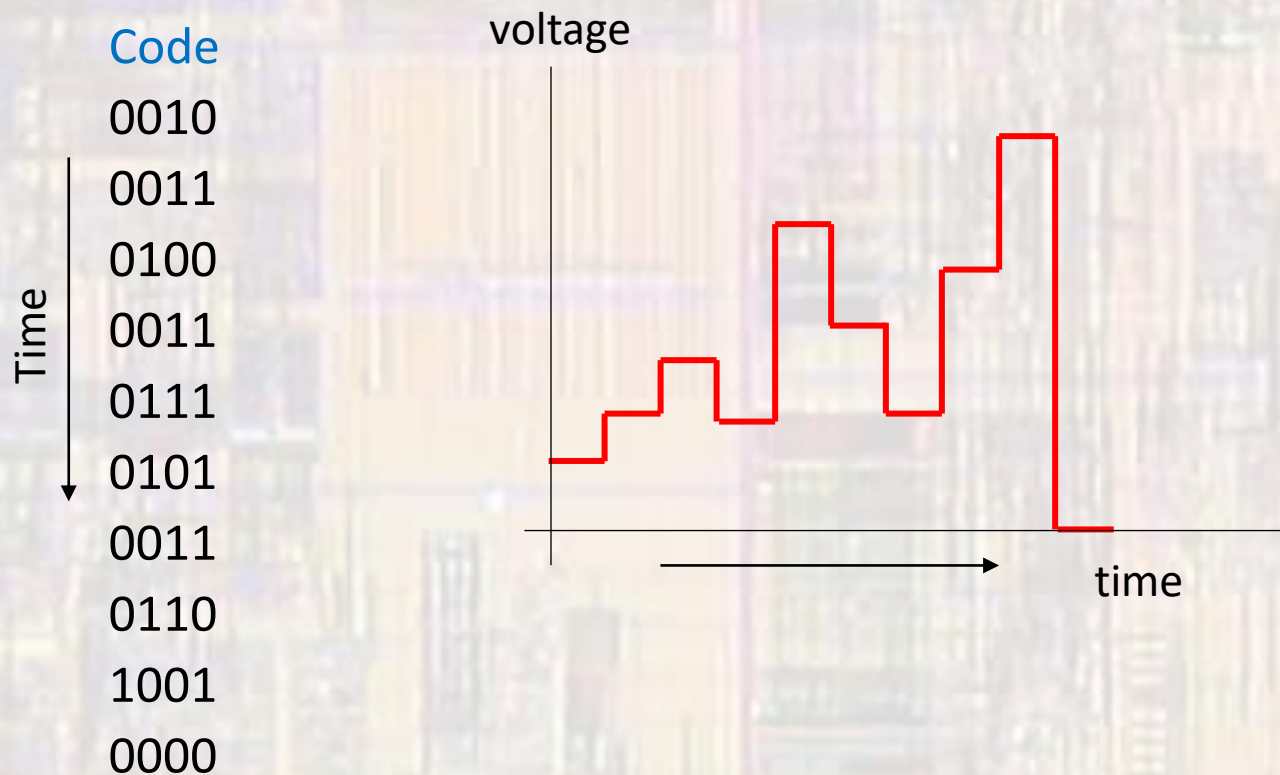
- Digital to Analog Converter Performance
  - 4 bit DAC, 5v range
    - $5\text{v} / 2^4 \rightarrow 0.3125\text{v/step}$

Code	Output
0000	0.0v
0001	0.3125v
0010	0.625v
0011	0.9375v
...	
1101	4.0625v
1110	4.375v
1111	4.6875v

Note – the output cannot reach the maximum value

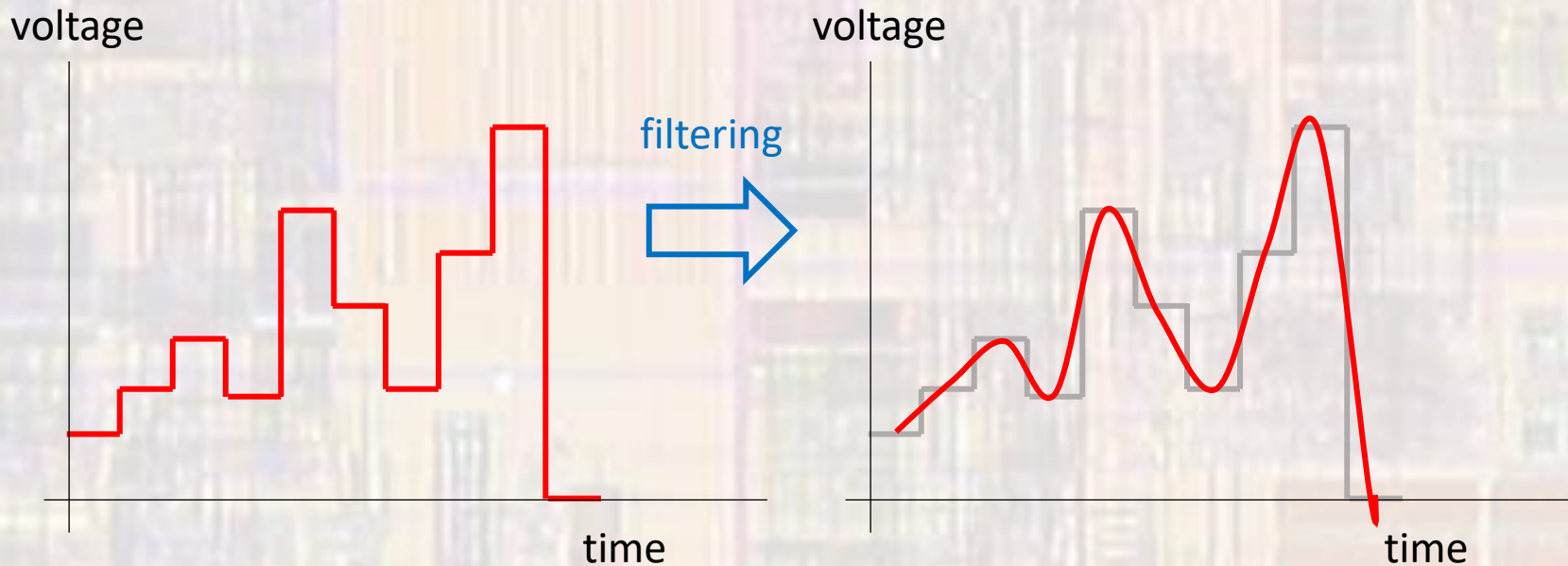
# DAC Basics

- Digital to Analog Converter Performance
  - 4 bit DAC, 5v range



# DAC Basics

- Digital to Analog Converter Performance
  - Typically, additional signal conditioning is required to 'clean up' the output
  - Low pass filter



# DAC Basics

- DAC Conversion Example

3.3V Vref  
8 bit converter

Code	Steps	Volts
0000 0000	0	0
0000 0001	1	0.013
0001 0000	16	0.206
0111 1111	127	1.637
1000 0000	128	1.650
1100 0000	192	2.475
1111 1111	255	3.287

$$\begin{aligned} & 3.3\text{v} / 2^8 \text{ steps} \\ & = 12.89\text{mv/step} \end{aligned}$$

# DAC Basics

- Digital to Analog Converter
  - Many types of D/A converters
    - Resistor DAC
    - Current DAC
    - Switched Capacitor DAC
    - Delta-sigma DAC
    - Pulse width modulator