Mixed Signal Design

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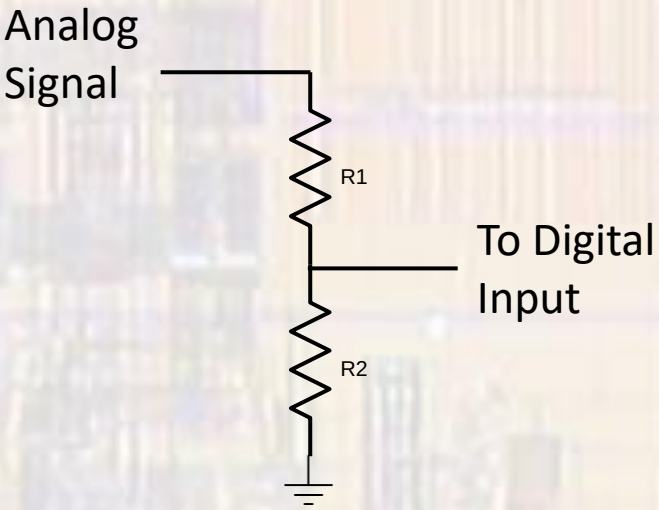
Mixed Signal Design

- Most of the real world is analog
  - Temperature, pressure, voltage, current, …
  - To work with these values in a computer we must convert them to/from digital representations
  - Analog to Digital Conversion
  - Digital to Analog Conversion

Analog to Digital Conversion

- 1 bit conversion
  - Rough conversion
    - We know CMOS gates transition around VDD/2
    - Use a resistor divider to convert the analog signal (desired switching level) to VDD/2



Analog signal ranges form 0V to 5V
Want the switching point to be 2.5V

Digital circuit runs at 3.3V (~1.65V transition point)

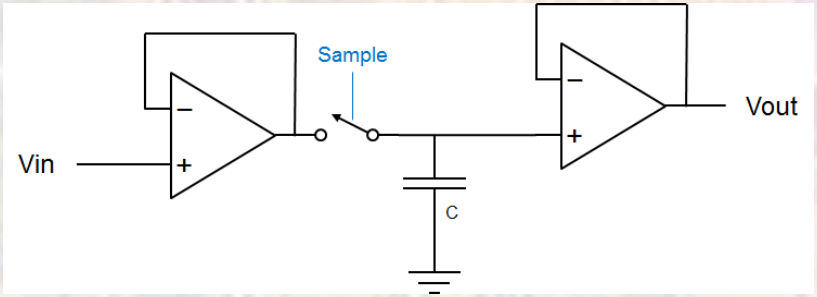
Choose: R2 = 50KΩ → R1 = 26KΩ

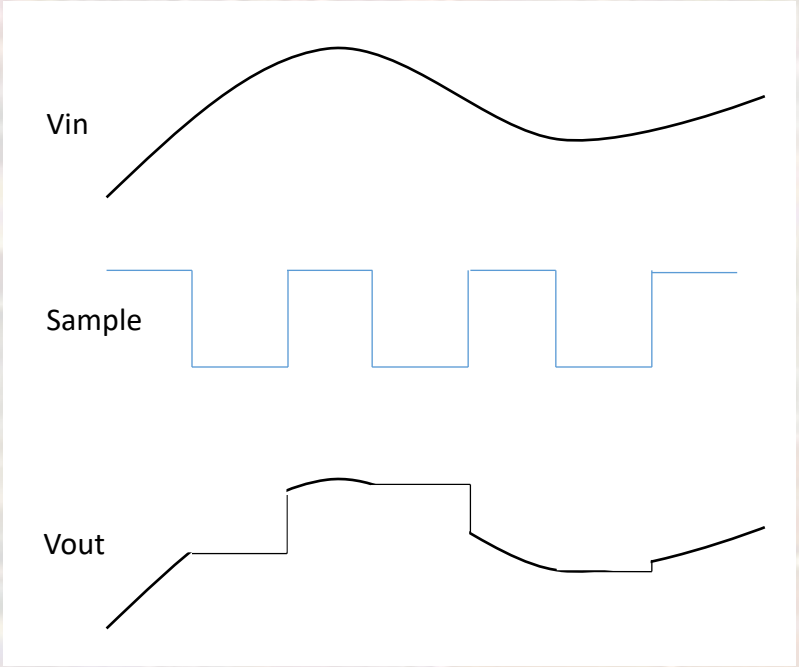
Analog to Digital Conversion

- N-bit conversion
  - Break the analog signal into 2^N steps
  - 3 steps in the conversion
    - Limit the input frequency range
    - Sample the input
    - Convert to the digital value

Analog to Digital Conversion

- N-bit Conversion
  - Step 2 – Sample the input
    - A to D Conversion takes a finite amount of time
    - What if the input changes during this time?
    - We must take a snapshot of the input → Sample and Hold

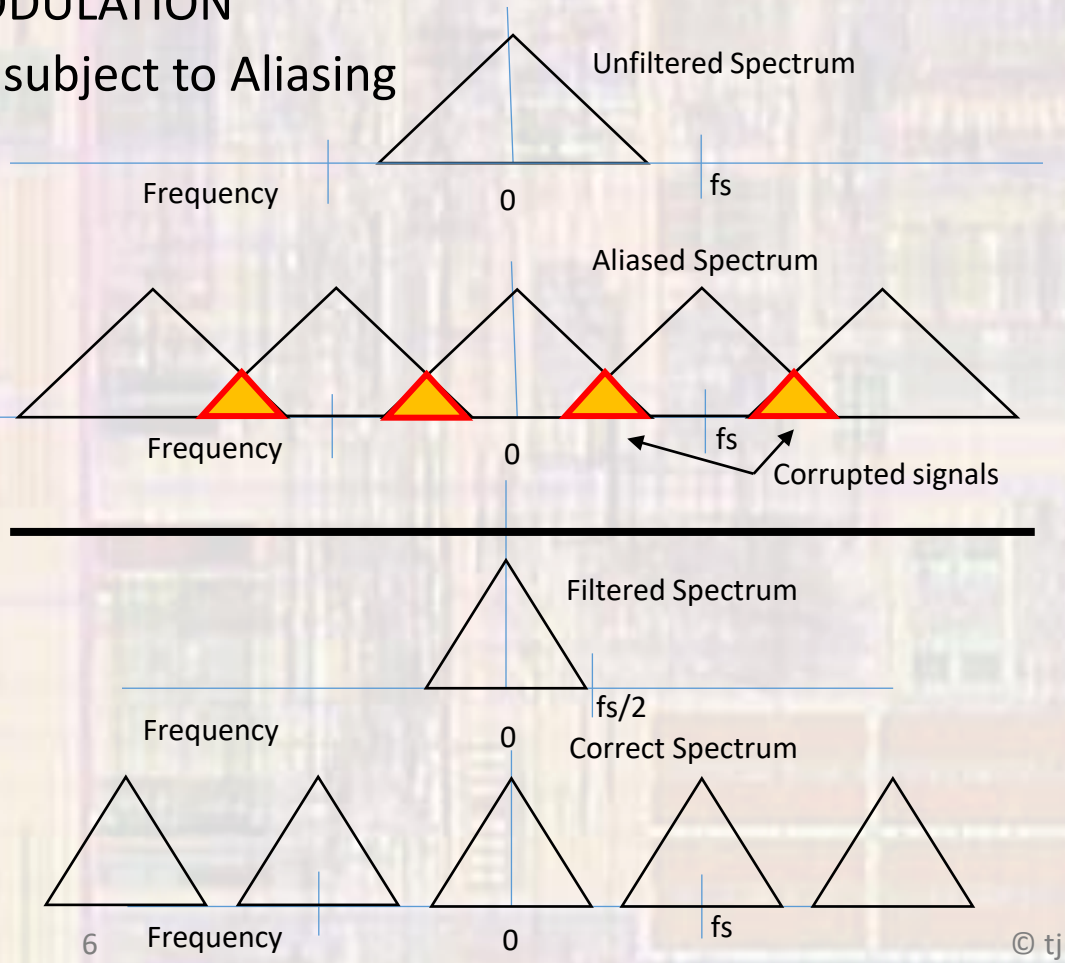




Analog to Digital Conversion

- N-bit Conversion
  - Step 1 – Limit the input frequency range
    - Sampling is a kind of MODULATION
    - Modulation systems are subject to Aliasing
    - Fin < fs/2
    - Fs: Nyquist rate

→ LPF the input (anti-aliasing filter)



Analog to Digital Conversion

- N-bit Conversion
  - Step 3 – Convert to the digital value
    - Various methods can be used to do the conversion

    - Provide a reference voltage
    - Break the reference voltage into 2^N equal steps
    - Assign a digital value according to the number of steps required to reach the input

5V reference
10bit conversion → 2^{10} steps = 1024 steps → 5V/1024steps = 4.88mV/step

3.2V input → 3.2V/4.88mV/step = 655.36steps → 655 steps
Output is: 655 in 10 bit binary → 10 1000 1111 = 0x28F

Digital to Analog Conversion

- N-bit Conversion
  - Convert the digital value to an analog value
    - Various methods can be used to do the conversion

    - Provide a reference voltage
    - Break the reference voltage into 2^N equal steps
    - Assign an analog value according to the number of steps represented by the digital value

3.3V reference
8 bit conversion → 2^8 steps = 1256 steps → 3.3V/256steps = 12.89mV/step

0xA2 input = 1010 0010 → 162 steps
Output is: 162 steps * 12.89mV/step = 2.088V