

UNIT VI



Analog to digital converter
And
Digital to analog converter

DAC performance specification

- ❖ Resolution
- ❖ Reference Voltages
- ❖ Settling Time
- ❖ Linearity
- ❖ Speed
- ❖ Errors

Resolution

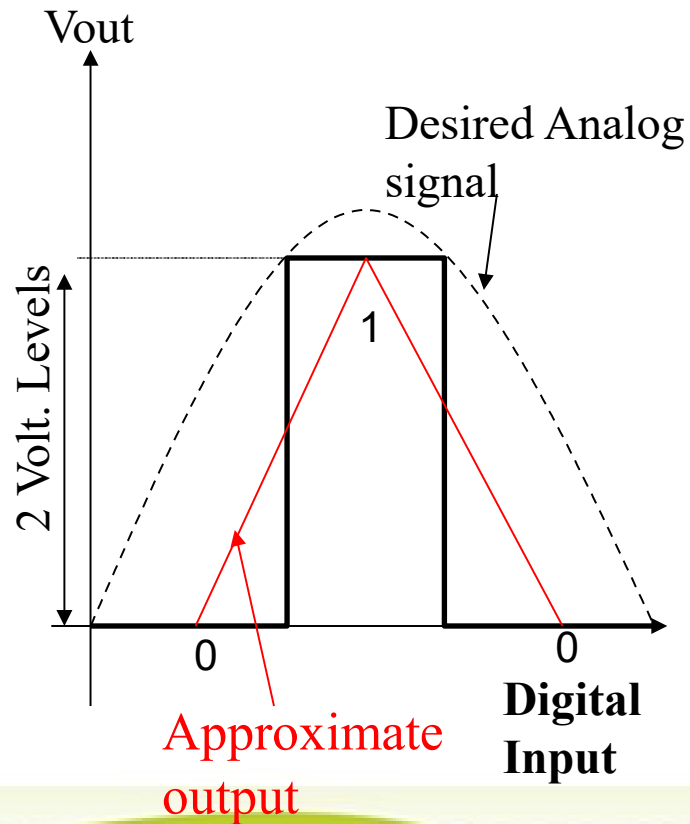
- ❖ **Resolution:** is the amount of variance in output voltage for every change of the LSB in the digital input.
- ❖ How closely can we approximate the desired output signal(Higher Res. = finer detail=smaller Voltage divisions)
- ❖ A common DAC has a 8 - 12 bit Resolution

$$\text{Resolution} = V_{LSB} = \frac{V_{\text{Ref}}}{2^N}$$

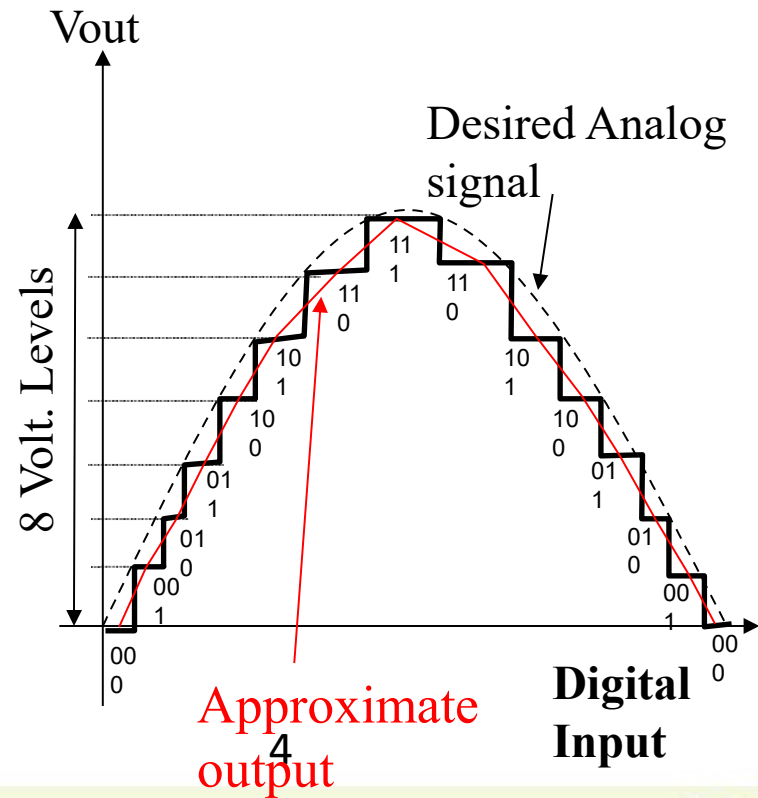
N = Number of bits

Resolution continue

Poor Resolution(1 bit)



Better Resolution(3 bit)

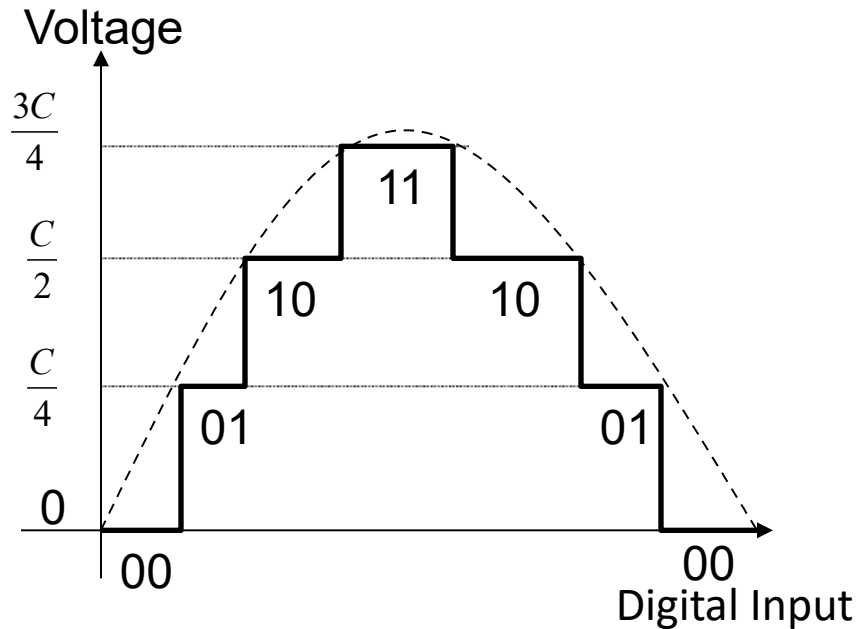


Reference voltage

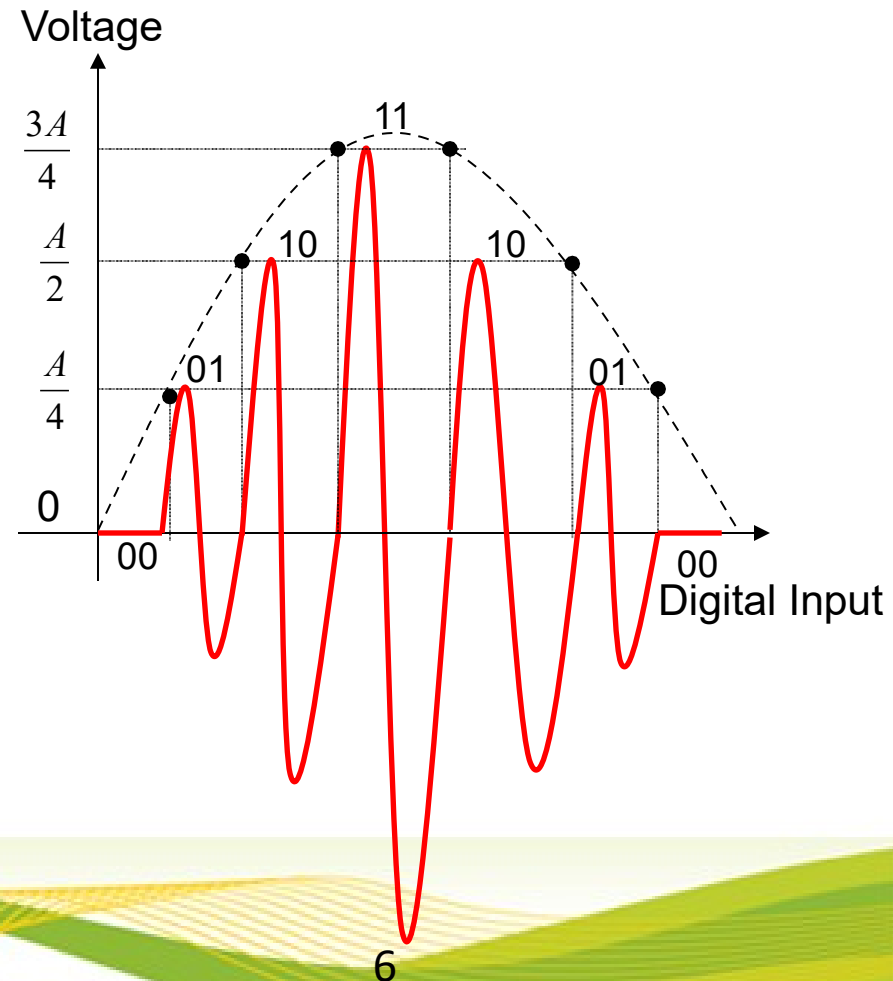
- ❖ Reference Voltage: A specified voltage used to determine how each digital input will be assigned to each voltage division.
- ❖ Types:
 - Non-multiplier: internal, fixed, and defined by manufacturer
 - Multiplier: external, variable, user specified

Reference voltage types

Non-Multiplier: ($V_{ref} = C$)



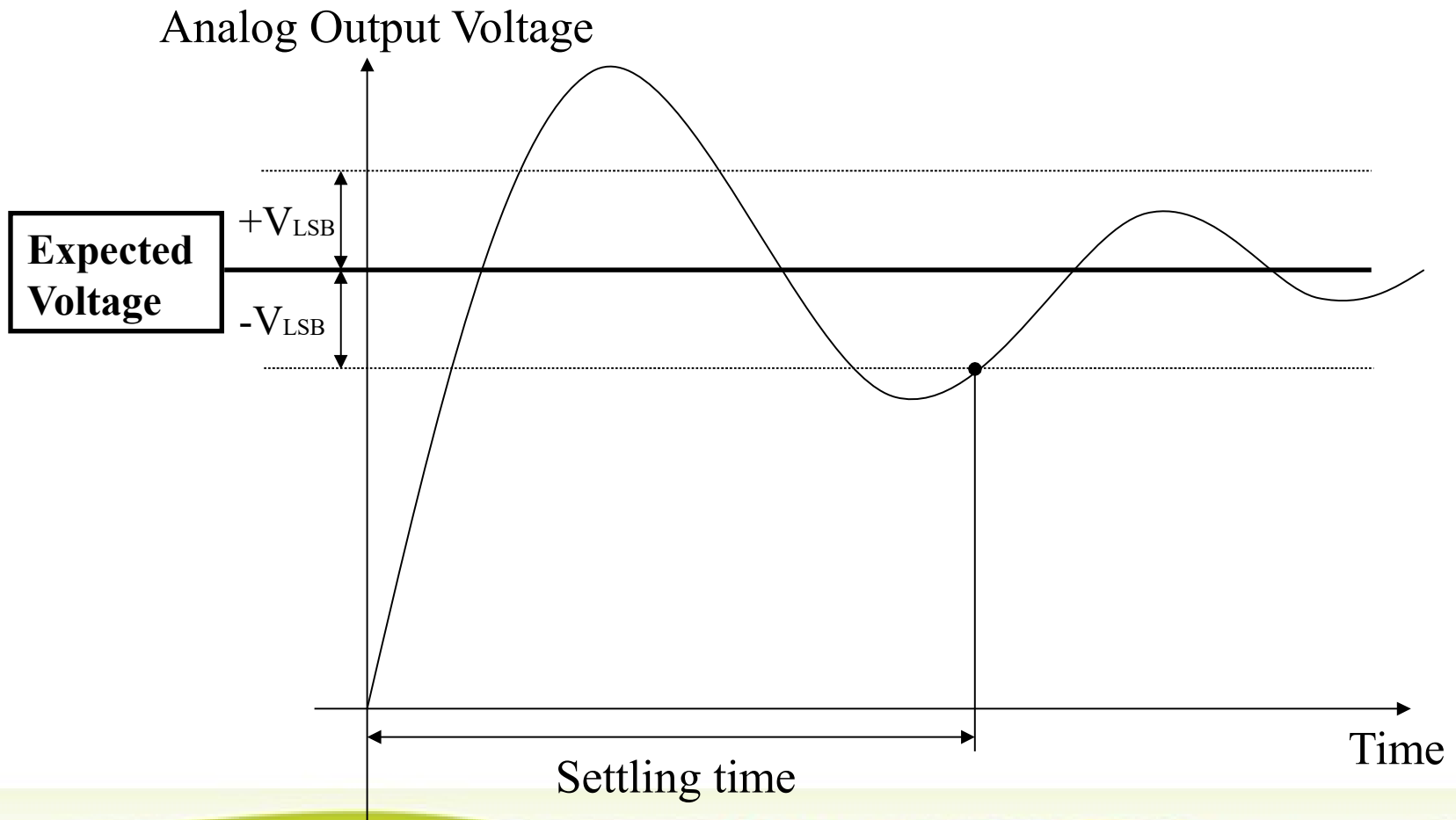
Multiplier: ($V_{ref} = A \sin(wt)$)



Settle time

- ❖ **Settling Time:** The time required for the input signal voltage to settle to the expected output voltage (within $\pm V_{\text{LSB}}$).
- ❖ Any change in the input state will not be reflected in the output state immediately. There is a time lag, between the two events.

Settle time continue

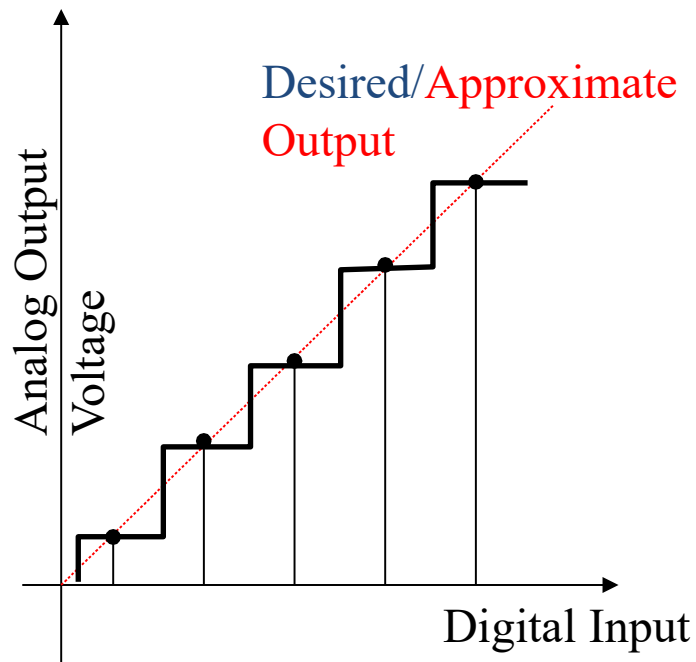


Linearity

- ❖ **Linearity:** is the difference between the desired analog output and the actual output over the full range of expected values.
- ❖ Ideally, a DAC should produce a linear relationship between a digital input and the analog output, this is not always the case.

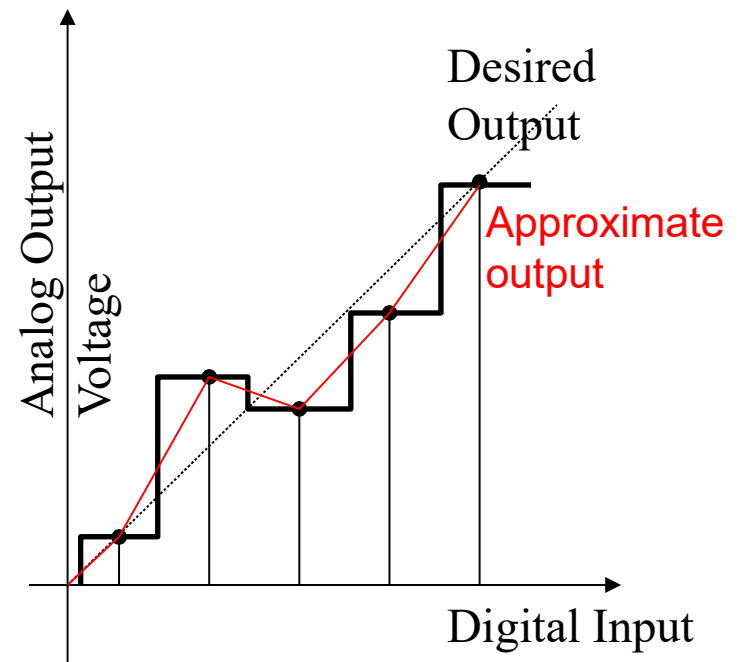
Linearity continue

Linearity(Ideal Case)



Perfect Agreement

NON-Linearity(Real World)



Miss-alignment

Speed

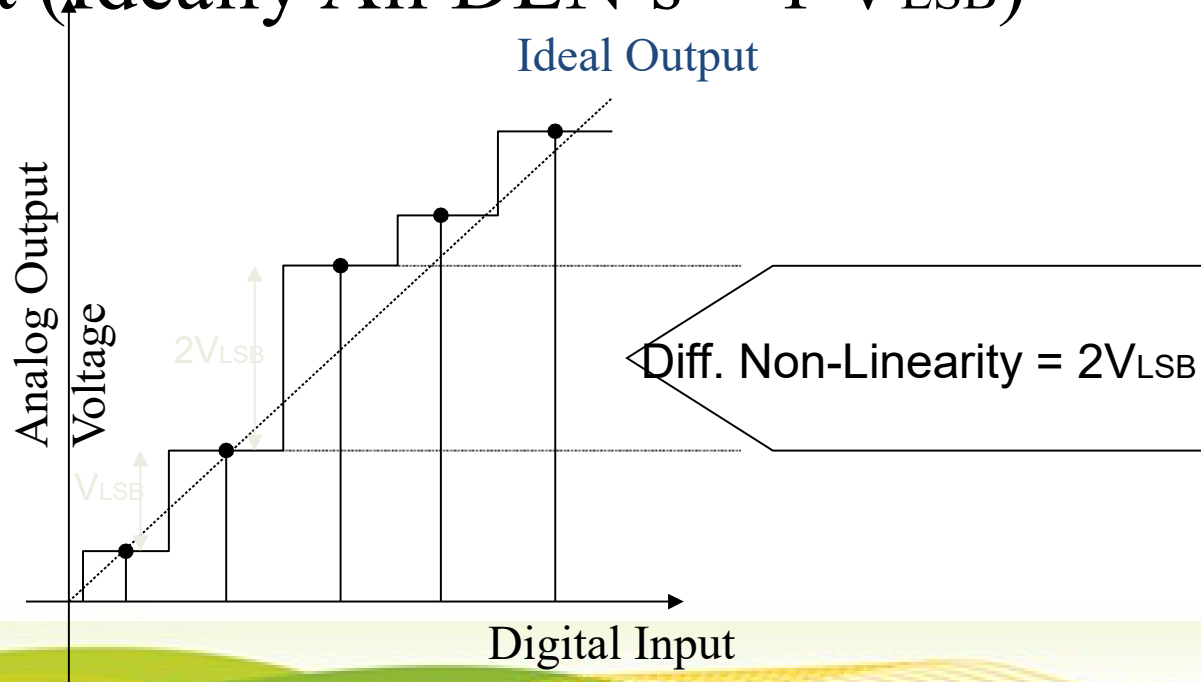
- ❖ **Speed:** Rate of conversion of a single digital input to its analog equivalent
- ❖ Conversion Rate
 - Depends on clock speed of input signal
 - Depends on settling time of converter

Errors

- ❖ Non-linearity
 - ✓ Differential
 - ✓ Integral
- ❖ Gain
- ❖ Offset

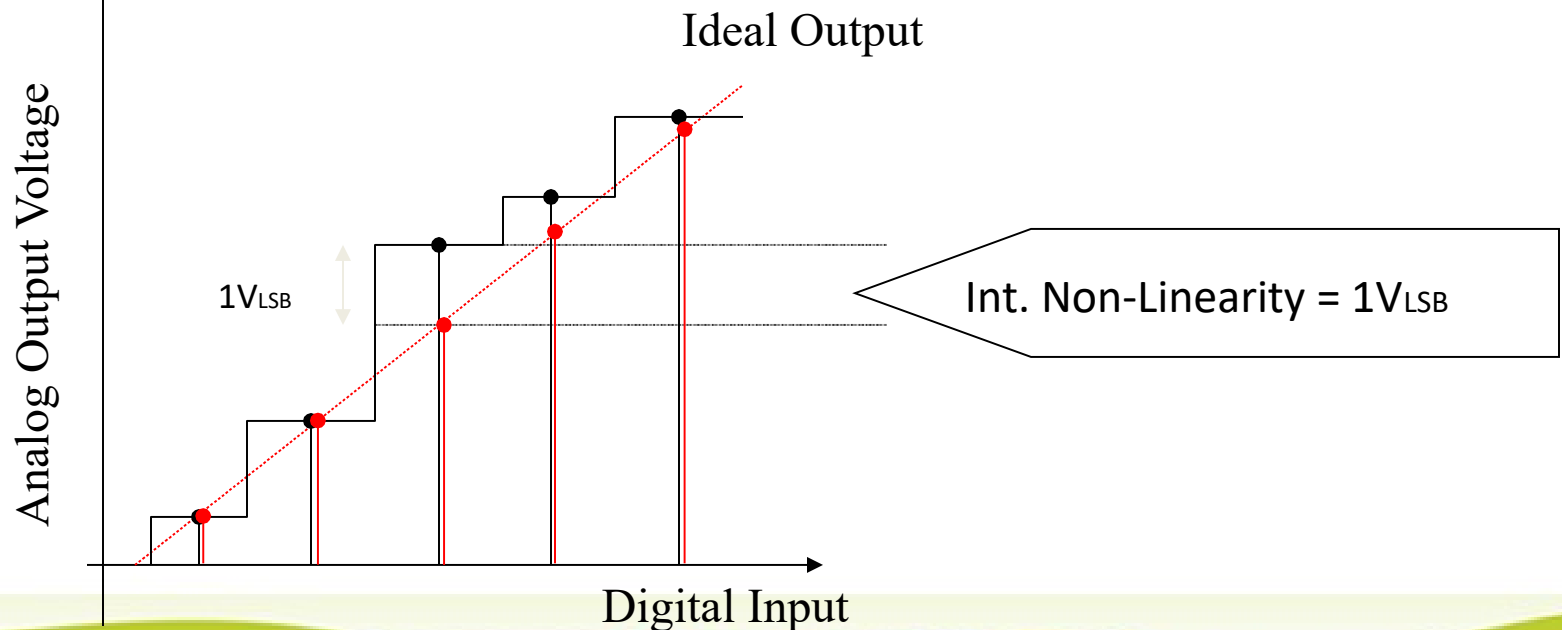
Non linearity: differential

- ❖ **Differential Non-Linearity:** Difference in voltage step size from the previous DAC output (Ideally All DLN's = $1 V_{\text{LSB}}$)



Non linearity: integral

- ❖ **Integral Non-Linearity:** Deviation of the actual DAC output from the ideal (Ideally all INL's = 0)

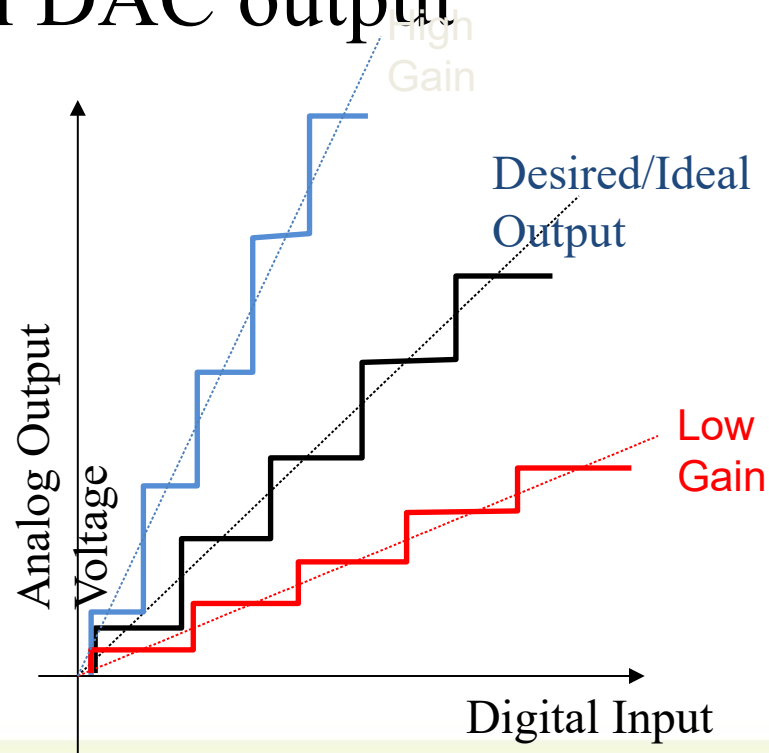


Gain error

- ❖ **Gain Error:** Difference in slope of the ideal curve and the actual DAC output

High Gain Error: Actual slope greater than ideal

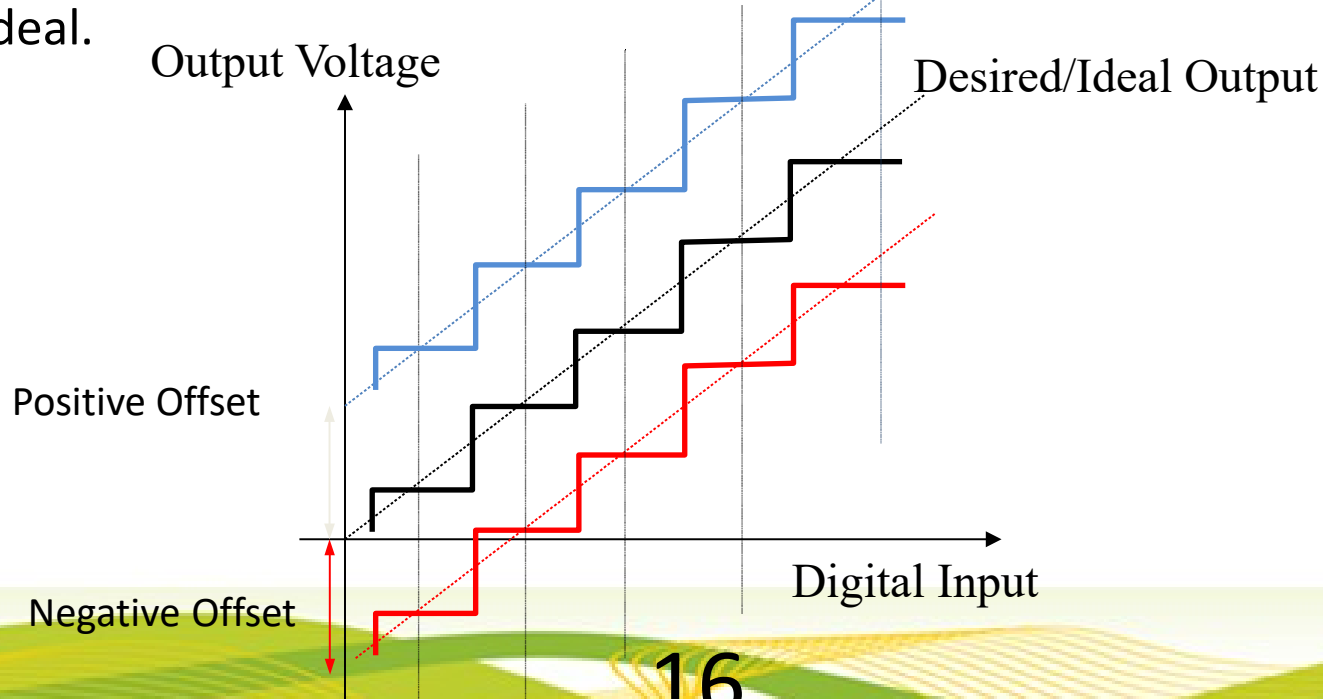
Low Gain Error: Actual slope less than ideal



Offset

❖ **Offset Error:** A constant voltage difference between the ideal DAC output and the actual.

- The voltage axis intercept of the DAC output curve is different than the ideal.



Applications of DAC

- ❖ Digital Motor Control
- ❖ Computer Printers
- ❖ Sound Equipment (e.g. CD/MP3 Players, etc.)
- ❖ Function Generators/Oscilloscopes
- ❖ Digital Audio

Quick Quiz

What is the resolution of a digital-to-analog converter (DAC)?

- **A.**It is the comparison between the actual output of the converter and its expected output.
- **B.**It is the deviation between the ideal straight-line output and the actual output of the converter.
- **C.**It is the smallest analog output change that can occur as a result of an increment in the