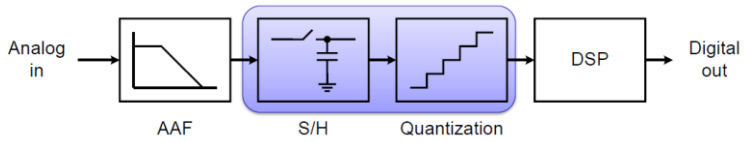
Analog Systems Design

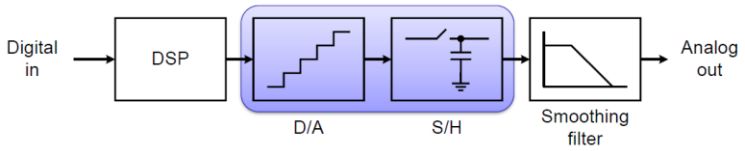
4. Data Converters Specifications 1 (DC characteristics)

1. ADC Vs DAC

   - ADC



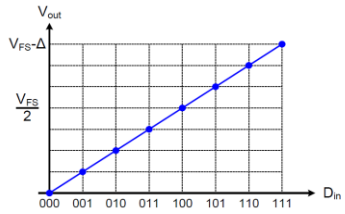
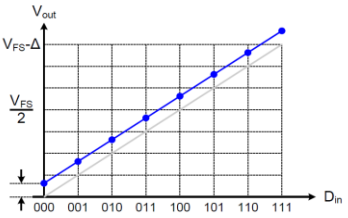
   - DAC



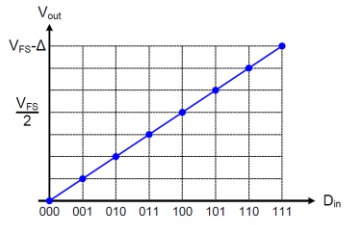
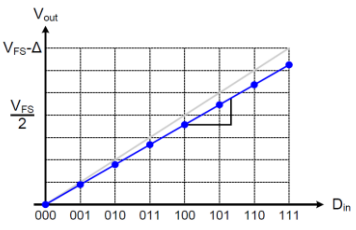
   - Signals could be **Unipolar** : 0 to FS or **Bipolar** : -FS to FS

2. Static DC Specifications

   - Offset error

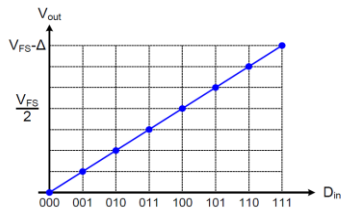
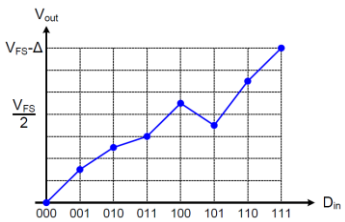
Definition		
The transfer function shifts up/down with the same slope		

   - Gain error

Definition		
Error in the transfer function slope		

      1) Offset error and Gain error can be calibrated by two points calibrations
         1. Trim the gain error (+/- error correction factor)
         2. Trim the gain error

   - DAC monotonicity

Definition		
The expectation of the DAC TF is increasing the input will increase the output (monotonic)		

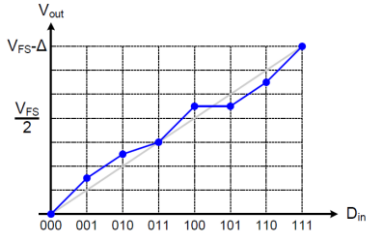
1) Non-monotonic means increasing the input will decrease the output at some points and it can be catastrophic in control loops (turn negative feedback into positive feedback)

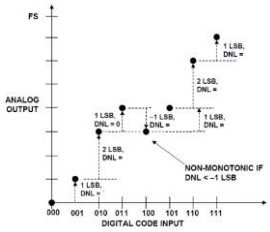
- Linearity

Generally linearity can be described based on two factors DNL and INL

1) DAC DNL

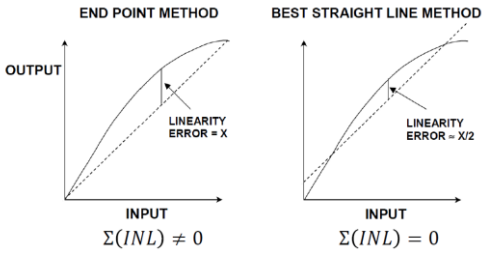
- DNL is the deviation of an output step from 1 LSB ($\Delta = V_{FS}/2$)
- $DNL_i = \frac{i^{th}\ step\ size - \Delta}{\Delta} \rightarrow$ ideal DNL of a step = 0
- If $DNL_i = -1 \rightarrow$ means that an output step does not changed when the input changed
- If $DNL_i < -1 \rightarrow$ means non-monotonicity





2) DAC INL

- INL can be measured relative to
  - Line joining the ideal end points → more accurate
  - A best fit straight line → may be misleading

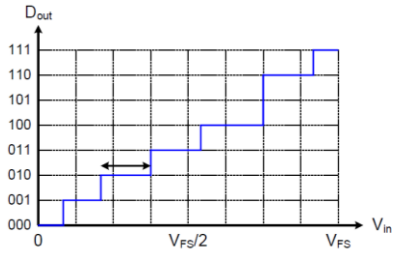


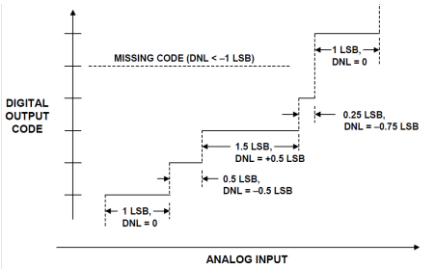
- The peak to peak INL remains the same

3) ADC DNL and Missing Codes and Monotonicity

- DNL and INL always measured on the analog axis
- DNL = deviation of code width from 1 LSB (= VFS/2N = Δ)
  - Wide code → +ve DNL, narrow code → -ve DNL
- What does DNL = -1 mean? → Missing Code
- Can it be < -1? → No مفيش حاجة اسمها كود بالعكس
- Can we characterize ADC non-monotonicity using DNL? → for ADC DNL is misleading
- Example

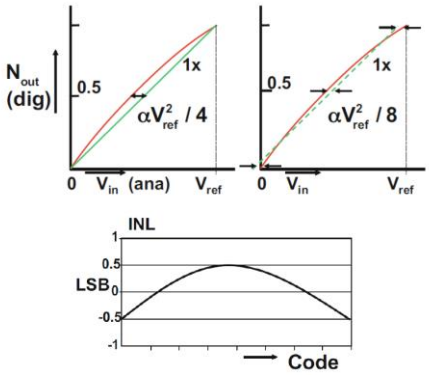
$$DNL_i = \frac{i^{th}\ \text{Step Size} - \Delta}{\Delta}$$



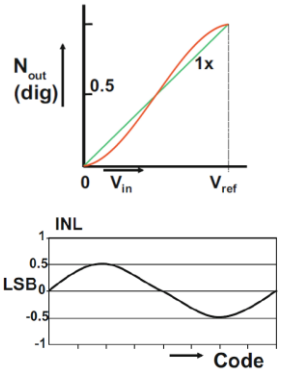


4) ADC INL

- The INL curve can tell you the order of ADC distortion and type of the ADC Differential or Single Ended
- 2nd Order distortion



- 3rd Order distortion



- DNL/INL plotted against digital code not analog input