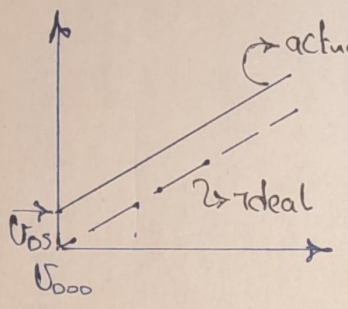
Lec6: Testing

(1) DAC static Testing

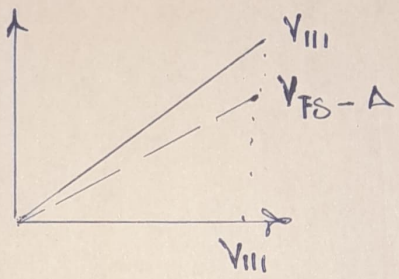
- As input is wide range we have many points to test so we automate it. by Computer-based test setup
- Most equipment can be Computer Controlled.

(2) DAC offset and Gain error

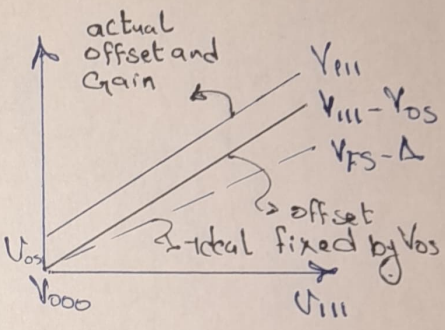
- measure offset error first then measure gain error.



- offset error is @ input all zeros.
  $V_{000} = V_{os}$



- Gain error i. =
  $\left(\frac{V_{111}}{V_{FS}-\Delta} - 1\right) \times 100$



- offset $V_{os} = V_{000}$
- Gain error i. =
  $\left(\frac{V_{111} - V_{os}}{V_{FS}-\Delta} - 1\right) * 100$

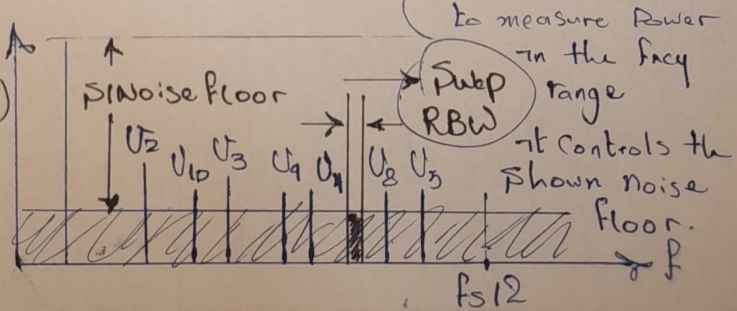
(3) DAC Dynamic Testing.

- Dynamic characteristic of DAC measured by two input
  1. Digital Sinusoidal → DAC → Spectrum analyzer.
     as it has a single tone, so if there are any unwanted components it will be real.

→ Spectrum analyzer resolution band-width (RBW) is equivalent to FFT bin size.

→ SNR = SINoise floor $- 10 \log_{10}\left(\frac{f_s/2}{RBW}\right)$

→ if RBW is low → the noise floor is clear → but slow



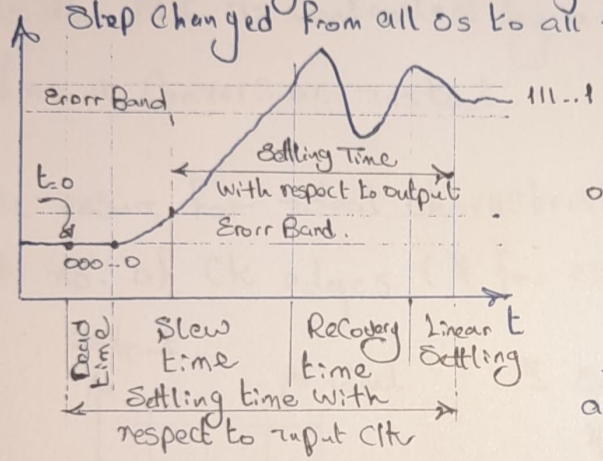
- SNR = SINoise floor − 10 log ($\frac{fs/2}{RBW}$)
- THD = $20\log_{10}\sqrt{(10^{-\frac{V2}{20}})^2 + (10^{-\frac{V3}{20}})^2 + \dots + (10^{-\frac{V6}{20}})^2}$ note we took the first 5-harmonic.
- SINAD = $20\log_{10}\sqrt{(10^{-\frac{SNR}{20}})^2 + (10^{-\frac{THD}{20}})^2}$

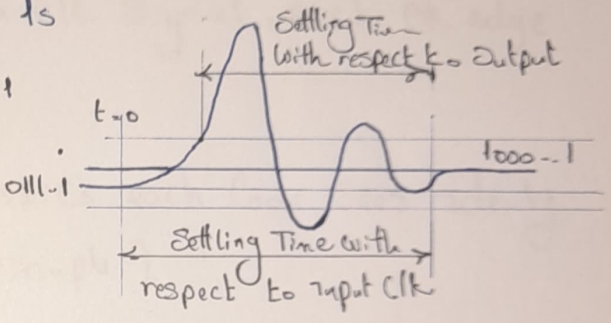
note: all in Unit of dBc

The ratio of update rate to test tone freq must be non-integer. otherwise the quantization noise appears as distortion :)

2 Step Signal → DAC → oscilloscope to plot both Clk and output

- Full scale Settling Time where digital Step Changed from all 0s to all 1s





- In mid scale transition all bits are switched, but may not switch simultaneously :)

(4) ADC static testing

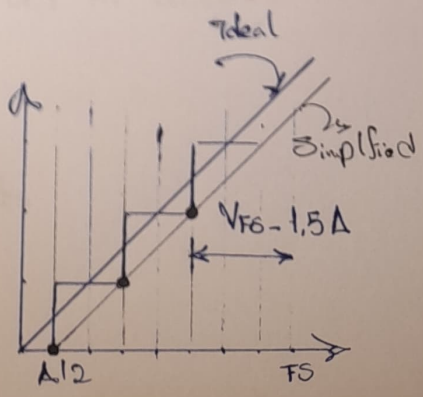
1 the ideal characteristics of ADC is the line which connects the code centers.

2 measuring code centers is very difficult. So we define the charctristics using code transition

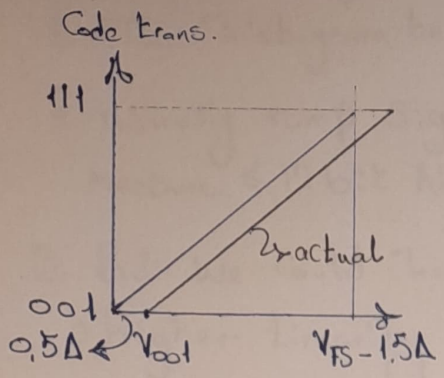
3 first point in the CCS @ $V_{LSB/2}$

4 Last point in the CCS @ $V_{FS} - 1.5\,V_{LSB}$

note. static Testing can be done by a very slow signal not only DC

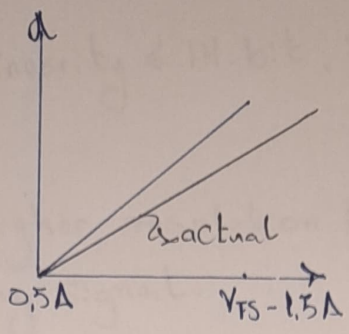


(5) ADC offset and Gain errors.



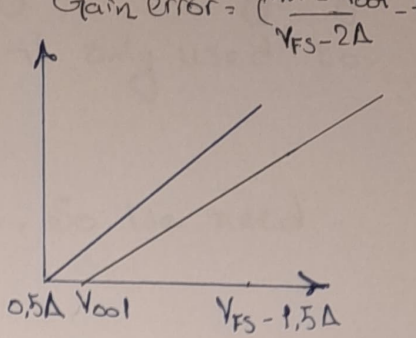
Offset error = $V_{001} - 0{,}5\Delta$

Gain error = 0



Offset error = 0

Gain error = $100 \times \left(\frac{V_{111} - 0{,}5\Delta}{V_{FS} - 2\Delta} - 1\right)$



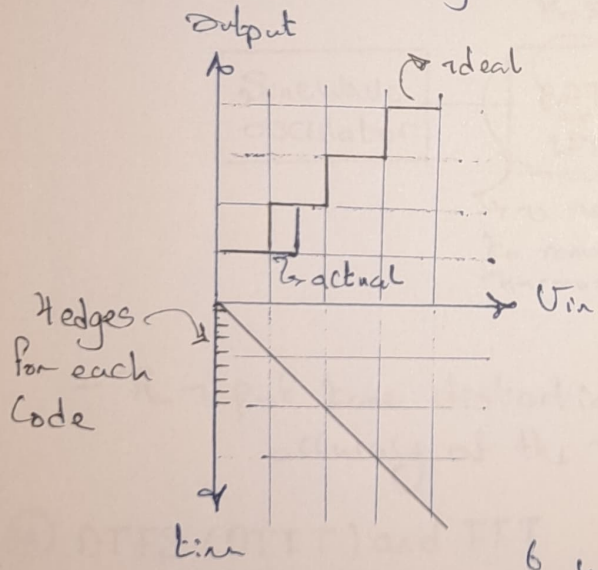
Offset error = $V_{001} - 0{,}5\Delta$

(6) Histogram (Code density test)

1 This test is done by adding ramp signal as analog input

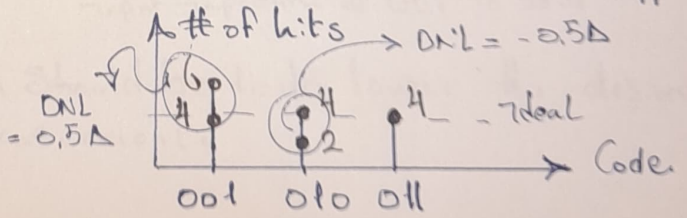
2 As the ADC is controlled by a clk signal, each clk edge define a conversion instant.

3 We ensure for ideal characteristics each code sees ideally # no. of clk edges (4 for example)



4 So ideally each code appears 4 times before output changes

5 So if we plot a Histogram for Code Vs no-of-hits (appear)



6 We get non-idealities in actual ccs

So, we have wide code and narwo code.

∴ The DNL and INL can be obtained as

$$DNL = \frac{\text{ideal no of hits} - \text{actual no. of hits}}{\text{actual no of hits}}$$

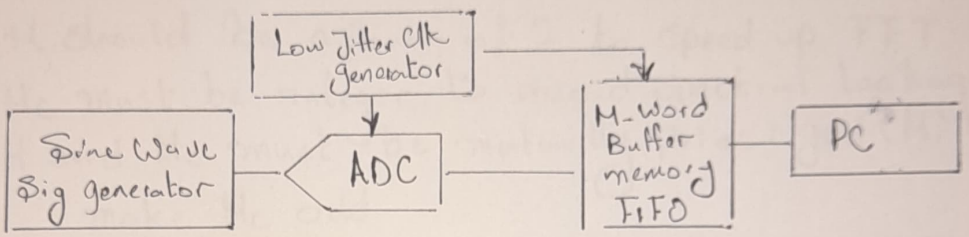
INL = CumSum (DNL)

8 no of ideal bits ↑ testing resolution but increase testing time

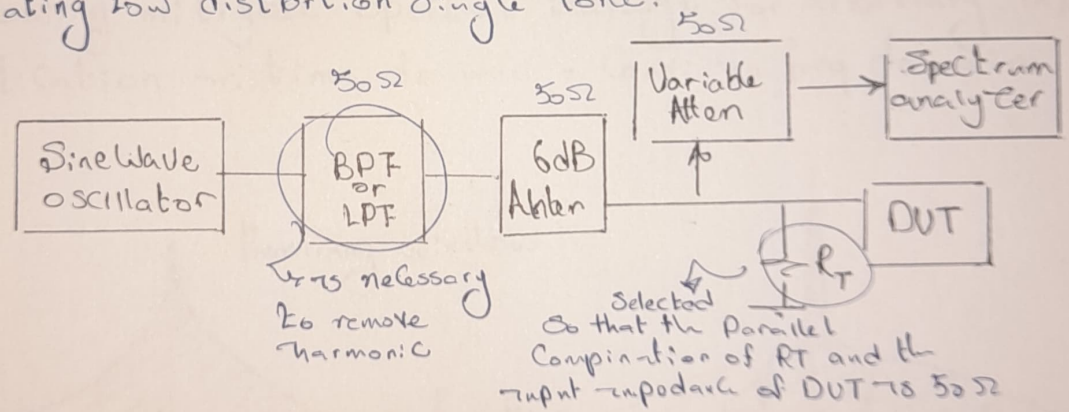
(7) Sine Wave Histogram test.

1. The Histogram test depends on the linearity of testing sig.
2. usually ramp signal linearity ≤ 14-bit, So it only used to measure ≤ 12 bit ADC
3. But we Could have higher resolution ADC. So we need a higher linearity testing signal.
4. SineWaves Can be generated with extremly high linearity and low noise with appropriate Filtering.

(8) ADC Dynamic testing.



- Generating low distortion single tone.



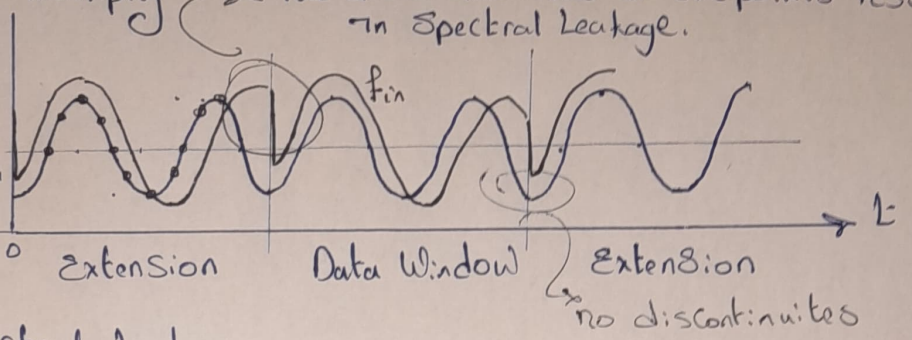
- The input tone distortion should be 10dB lower the desired accuracy of the measurments

(9) DTFS (DTFT) and FFT

1. The DFT operates on a finite Number (N) of digitized time Samples
2. When these Samples are repeated and placed "end-to-end" they appear periodic to the Transform
3. Practically, FFT is used to Compute DFT
4. The FFT is Simply an algorithm that reduces the mathematical Computations

5 Spectral Leakage.

It is equivalent to multiply the input sine wave by a rect window puls which has $\frac{\sin x}{x}$ freq resp.



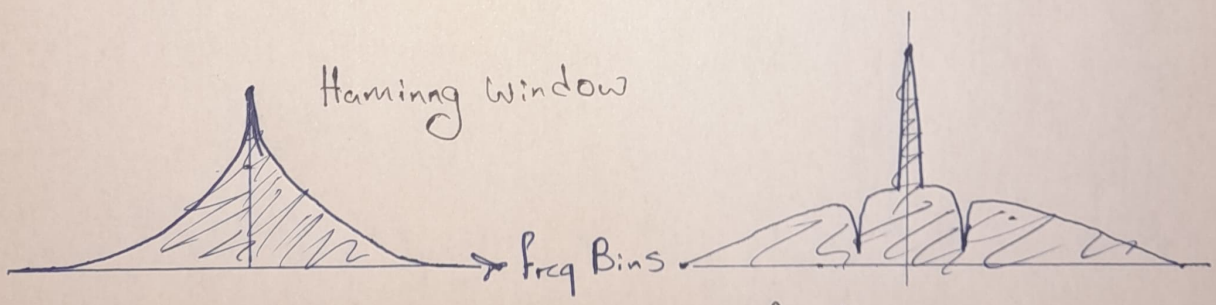
6 to prevent Spectral Leakage

the window we take should over an integer no. of cycles.

$$T_{Measure} = M \times T_S = M_c \times T_{in} \rightarrow \frac{f_S}{f_{in}} = \frac{M}{M_c}$$

Where: M should be a power of 2 to speed up FFT
M_c must be integer to avoid Spectral Leakage.
M and M_c must be mutually prime: $\gcd(M, M_c) = 1$
make M_c odd

7 Windowing mitigate Spectral Leakage for arbitrary input
Multiplication in time domain = Conv. in freq domain



8 increasing no of bins (FFT points) reduces the noise floor

note: noise power = $M/2 \times$ Noise floor = Const