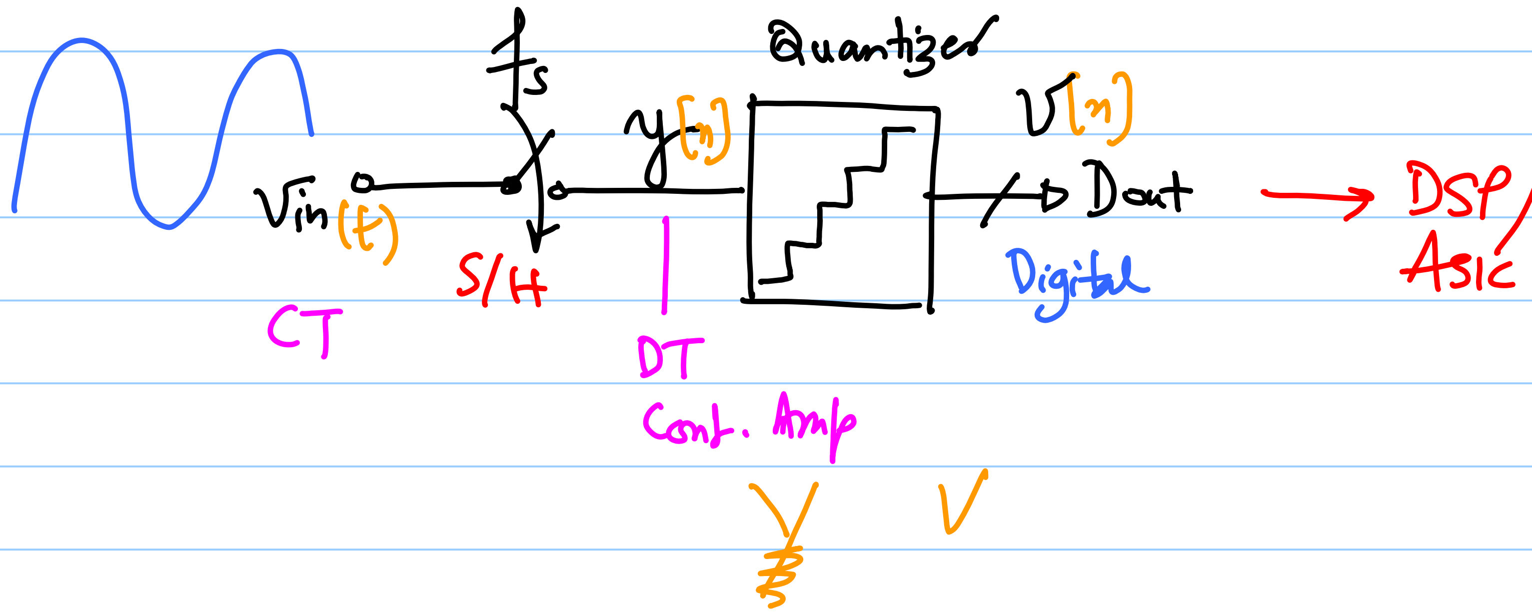
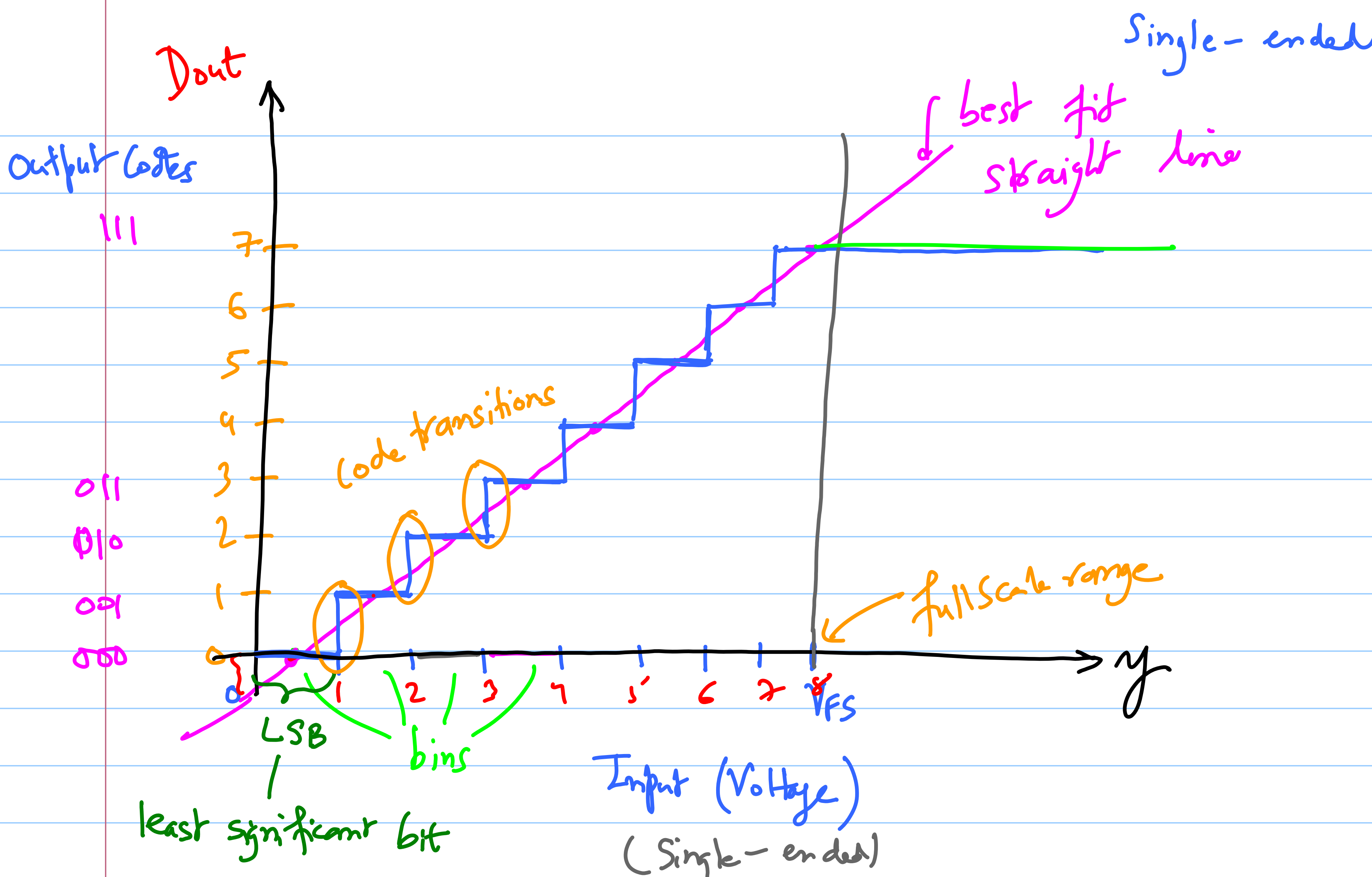
ECE 614 - Lecture 23

Note Title 11/13/2014

ADC





Single-ended
Dout
Output Codes
111
011
010
001
000
7
6
5
4
3
2
1
0
best fit straight line
code transitions
fullscale range
0
1
2
3
4
5
6
7
8
VFS
LSB
least significant bit
bins
Input (Voltage)
(Single-ended)

LSB $\rightarrow$ input must change by 1 LSB to flip the output code

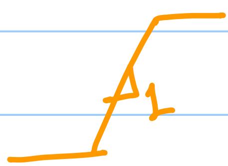
↳ in an ideal quantizer, the widths of all bins are equal $\Rightarrow$ 1 LSB

↳ D_{out} vs y

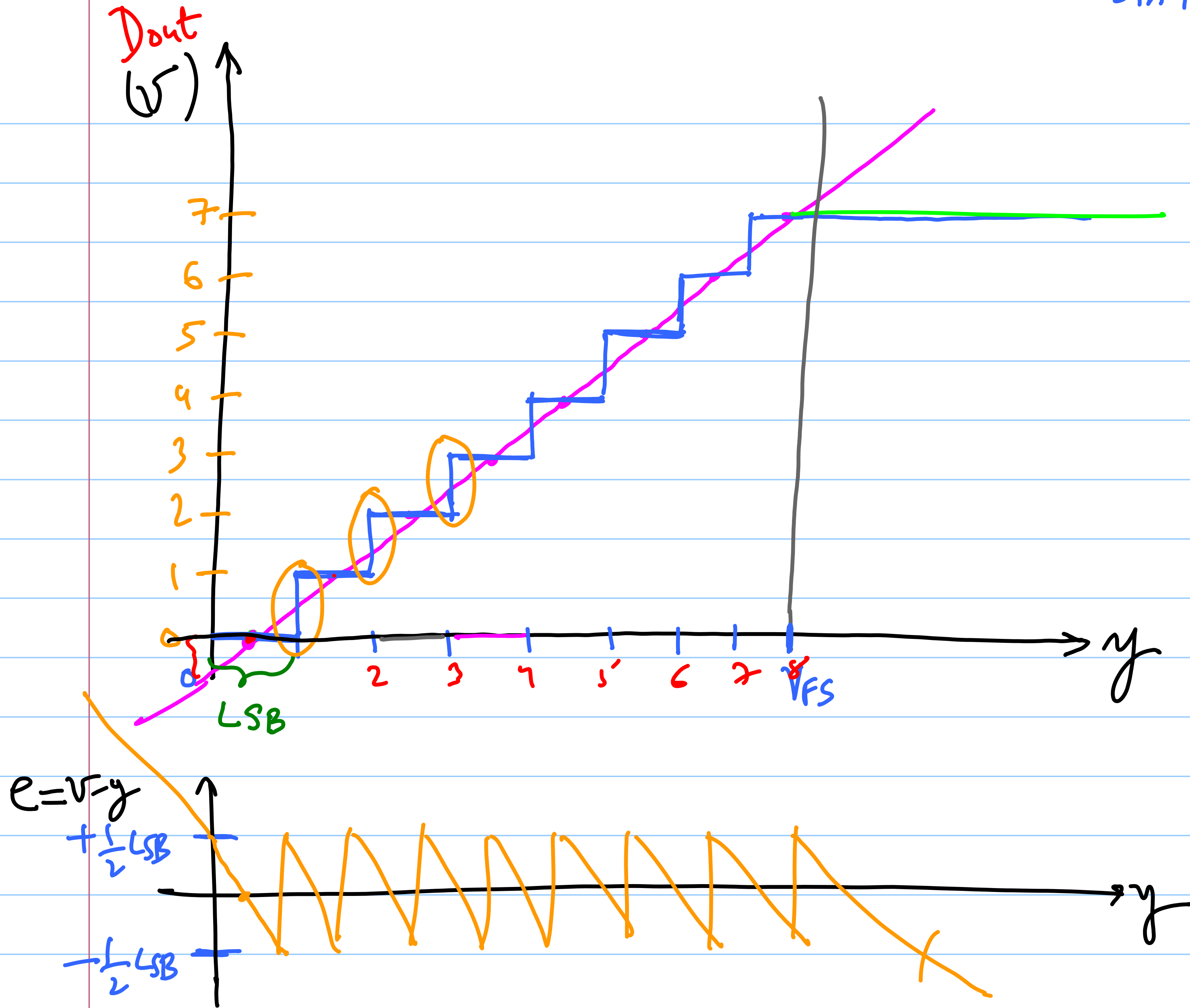
$\Rightarrow$ straight line slope $= 1$ and an offset of $\frac{1}{2}$ LSB

↓

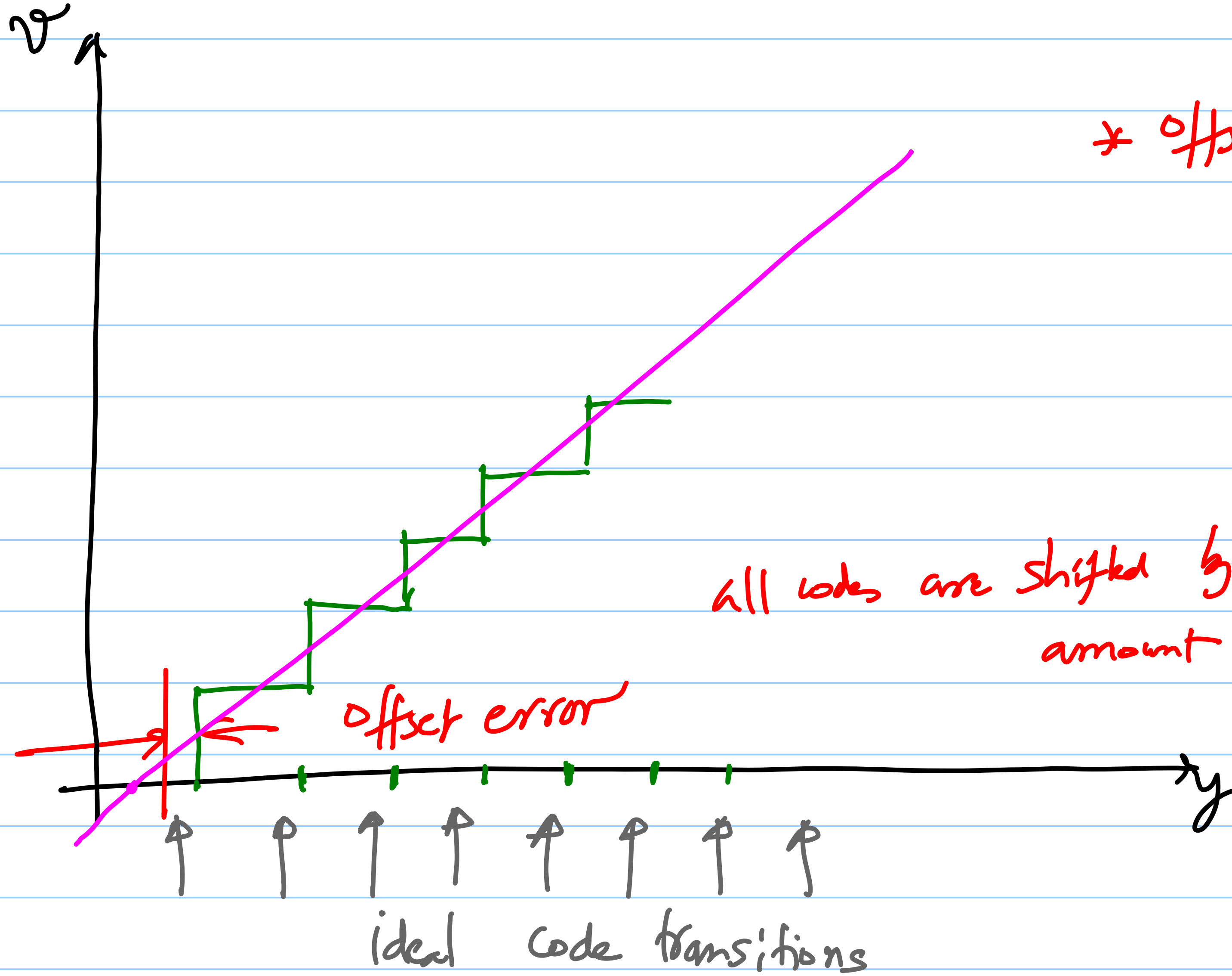
valid for the input within the V_{FS} of the quantizer



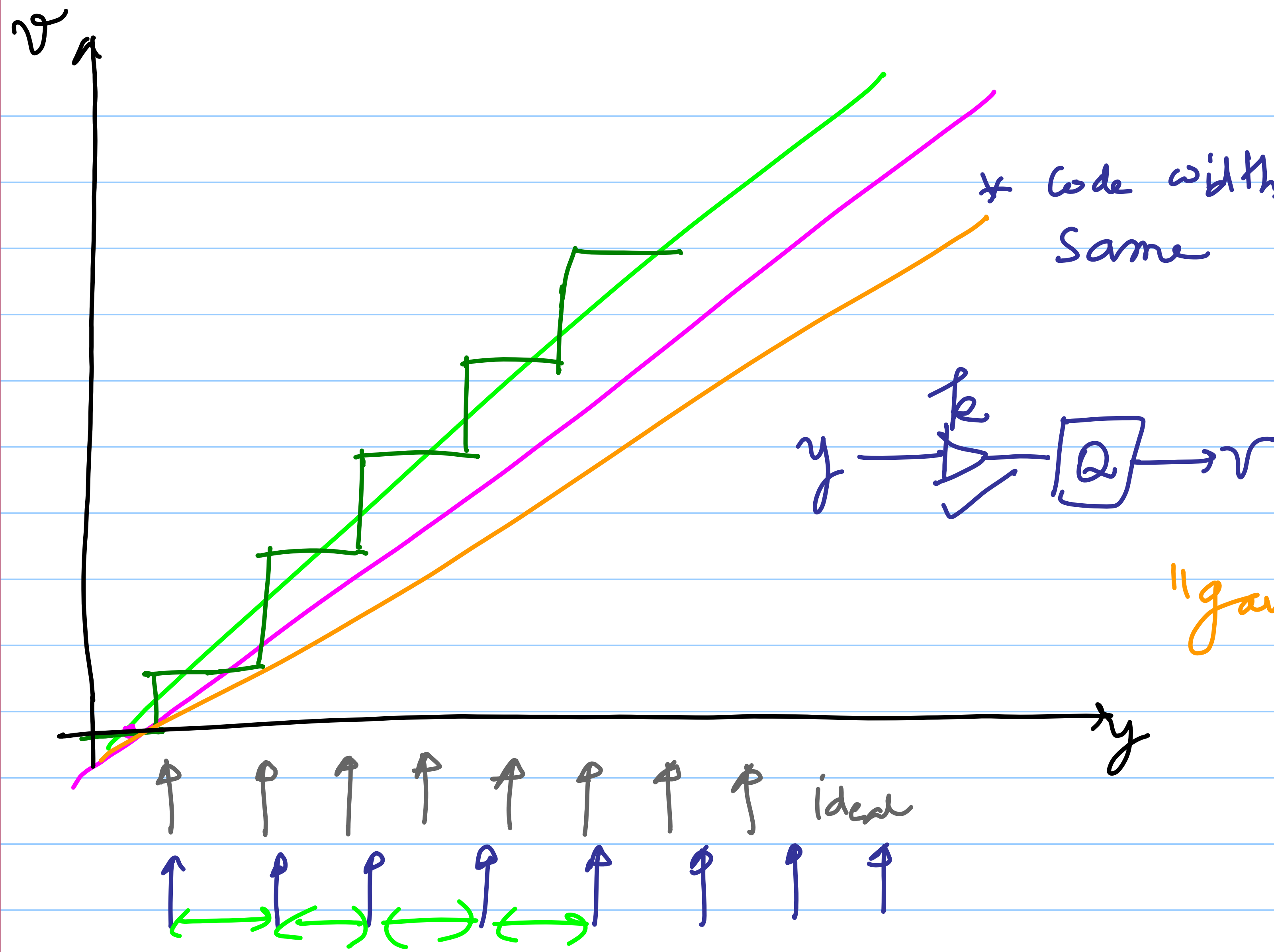
Sin le- ended



* offset error

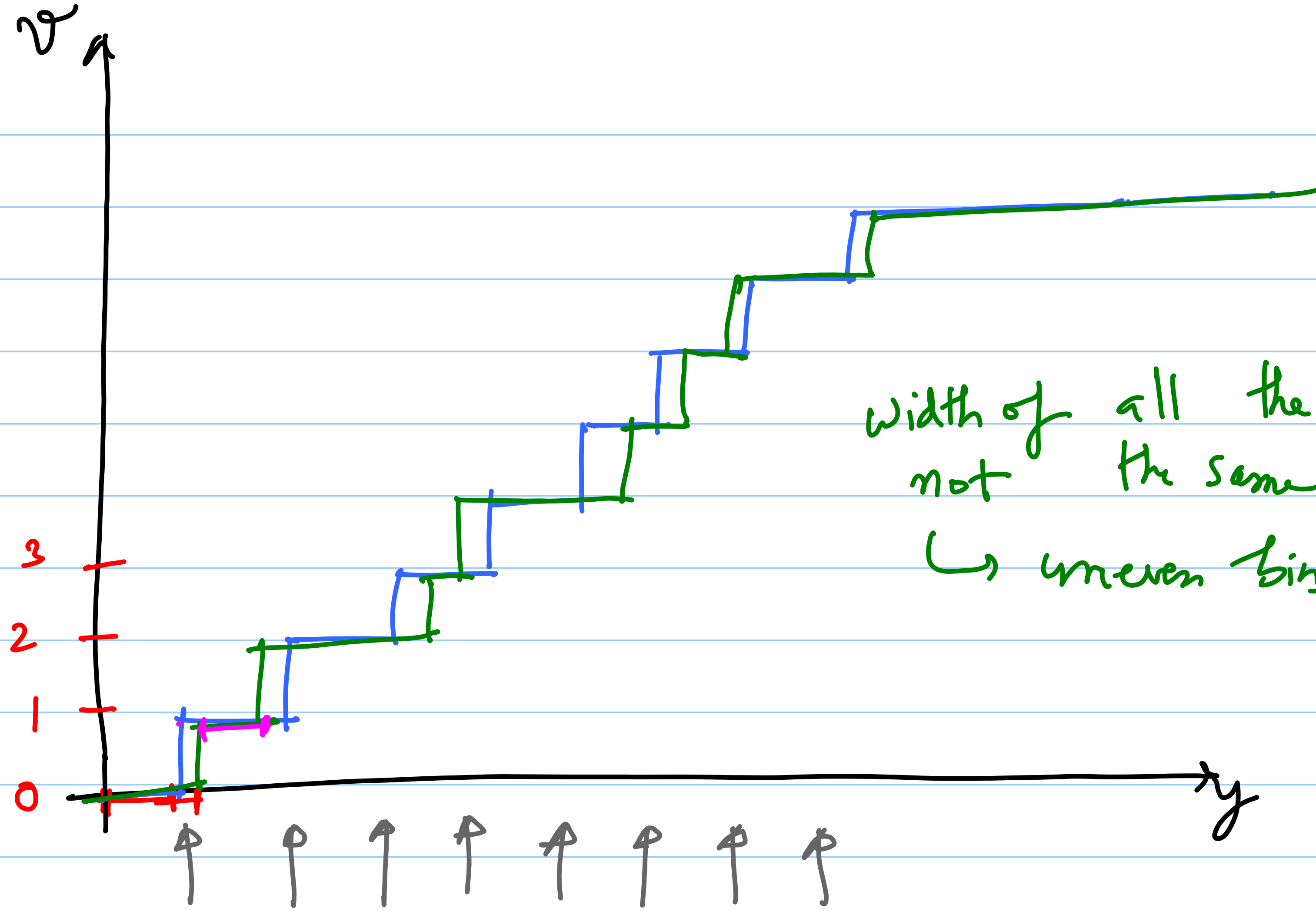


all codes are shifted by the same amount



* Code widths are Same

"gain error"



width of all the codes are not the same

↳ uneven bins

Code transitions

Width of a code "0" $\Rightarrow (1+\varepsilon_0)\,LSB$

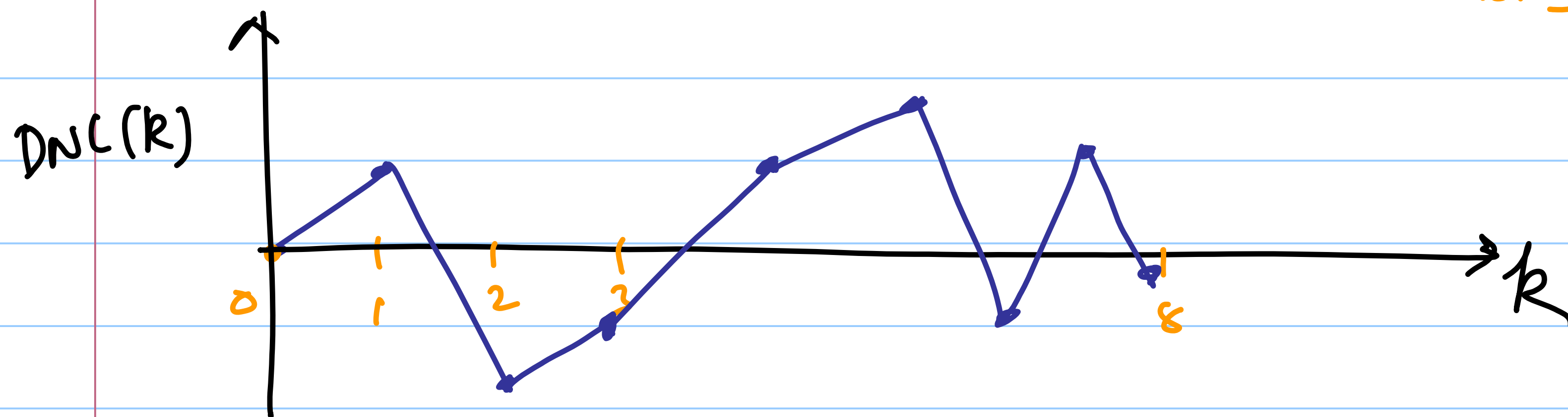
"1" $\Rightarrow (1-\varepsilon_1)\,LSB$

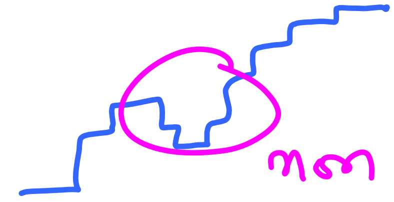
Differential non linearity (DNL)

k^{th} code

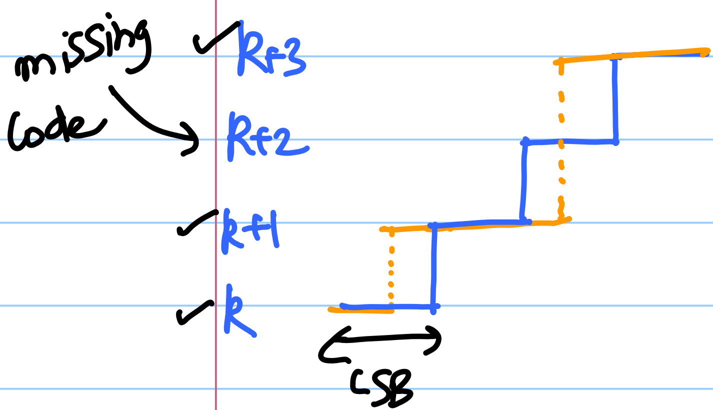
$$DNL(k) = \frac{\text{Width of code "}k\text{"} - 1LSB}{1LSB}$$

If I know DNL(k) → defines the entire ADC characteristics





DNL



$DNL(k+3) = 0.7$

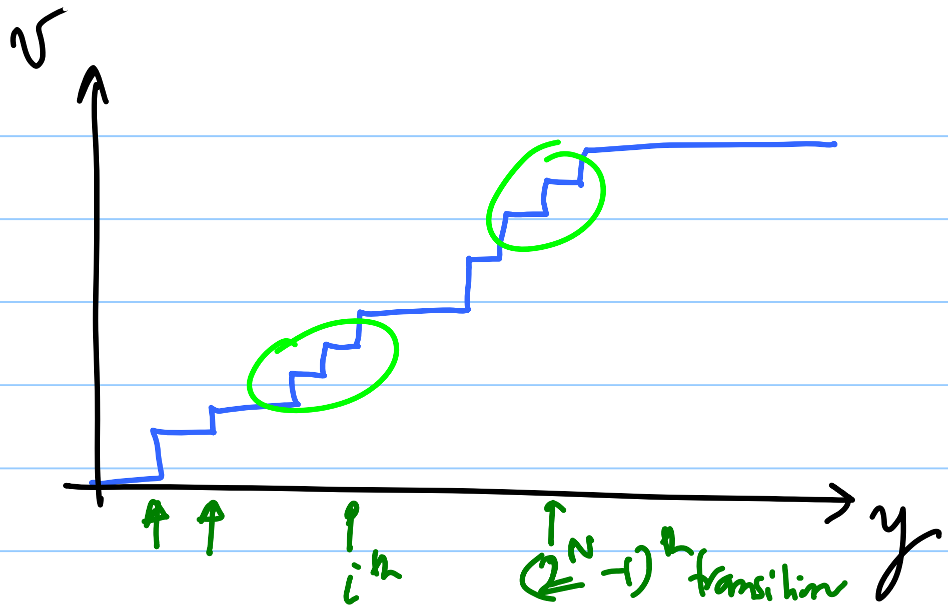
$DNL(k+2) = \cancel{?}\ -1 \rightarrow$ code width $= 0$ $\quad (-1)$

$DNL(k+1) = +0.6$

$DNL(k) = -0.3$

$|DNL| \leq 0.5\ LSB \quad \forall k$

is sufficient to ensure no missing codes.



Method I :

$$LSB = \frac{X_{2^N-1} - X_1}{2^N - 2}$$

Method II : Numerically fit a straight line (LMS)

↳ remove offset & gain error from the staircase

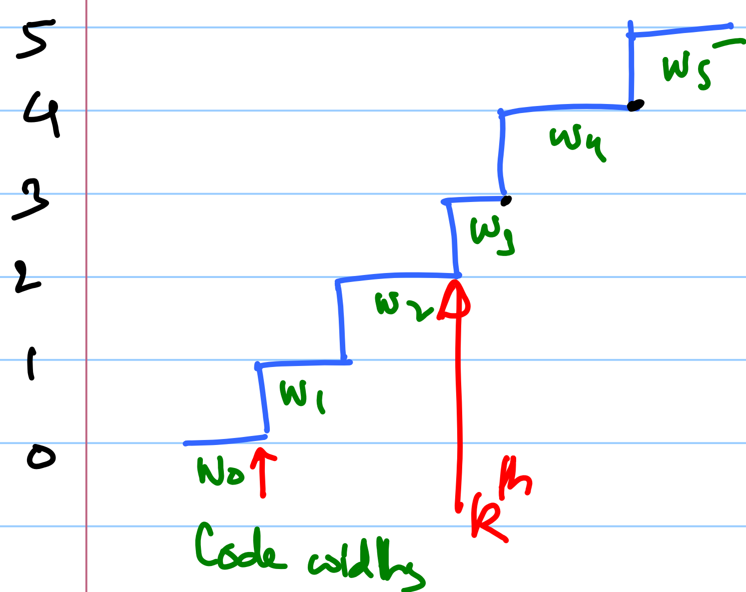
↳ from the slope compute ideal LSB size

$\Rightarrow$ Compute DNL(k)

* DNL gives a sense of local nonlinearity

* INL (integral non linearity) is another common metric.

INL(k) $\triangleq$ deviation in LSB of the code transition wrt the ideal transition



$$DNL(k) = \frac{W_k - 1LSB}{1LSB}$$

Ideal transition of the k^{th} code $\Rightarrow k \cdot LSB$

$$INL(k) = \frac{\sum_{i=0}^{k-1} W_i - k \cdot LSB}{1\,LSB}$$

Difference in terms of LSBs b/w the measured transition at "k^{th}" code wrt the ideal transition of the k^{th} code

In terms of ideal LSB size

$$INL(k) = \sum_{i=0}^{k-1} W_i - k$$

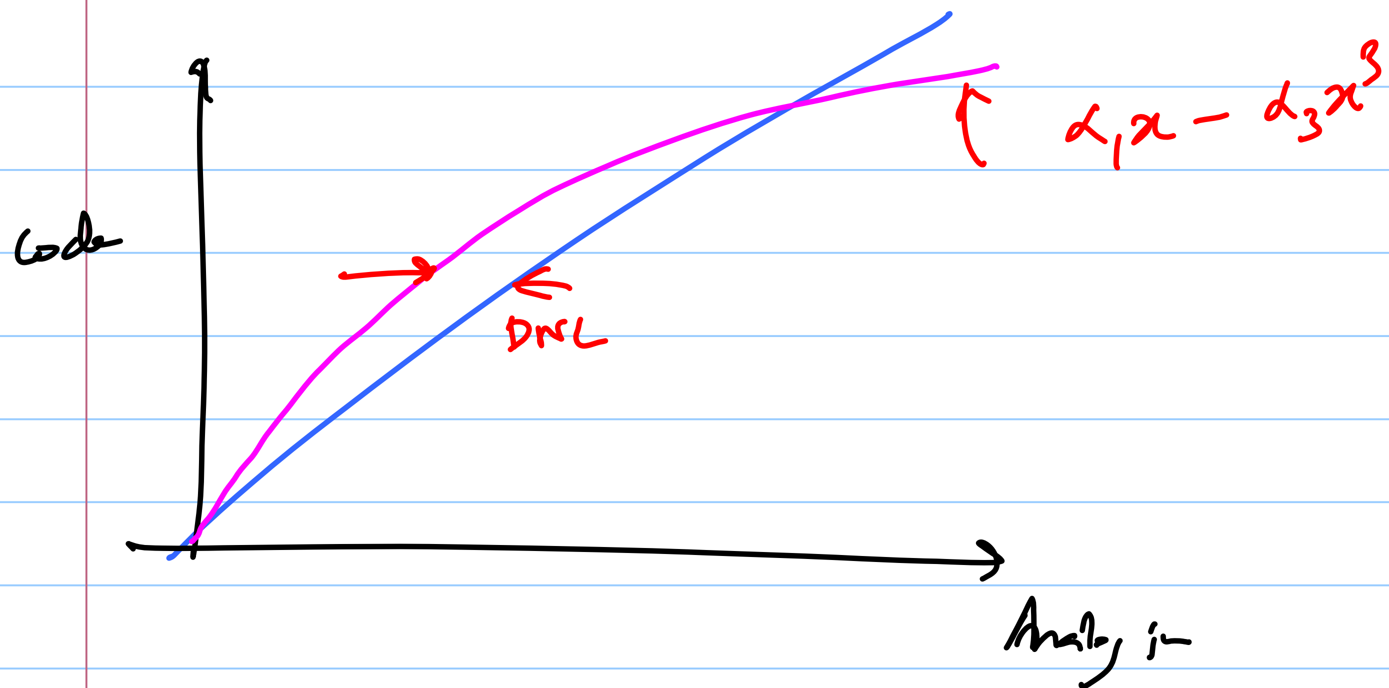
$$INL(k+1) = \sum_{i=0}^{k} W_i - (k+1)$$

$$INL(k+1) - INL(k) = W_k - 1 = DNL(k)$$

$$\mathrm{DNL}(k) = \underbrace{\mathrm{INL}(k+1) - \mathrm{INL}(k)}_{\text{discrete differentiation}}$$

* INL is the running sum of the DNL

"Static measurements" ⇒ put in a sufficiently slow ramp input, the output will be the staircase.



Code
$\alpha_1 x - \alpha_3 x^3$
DNL
Analog in