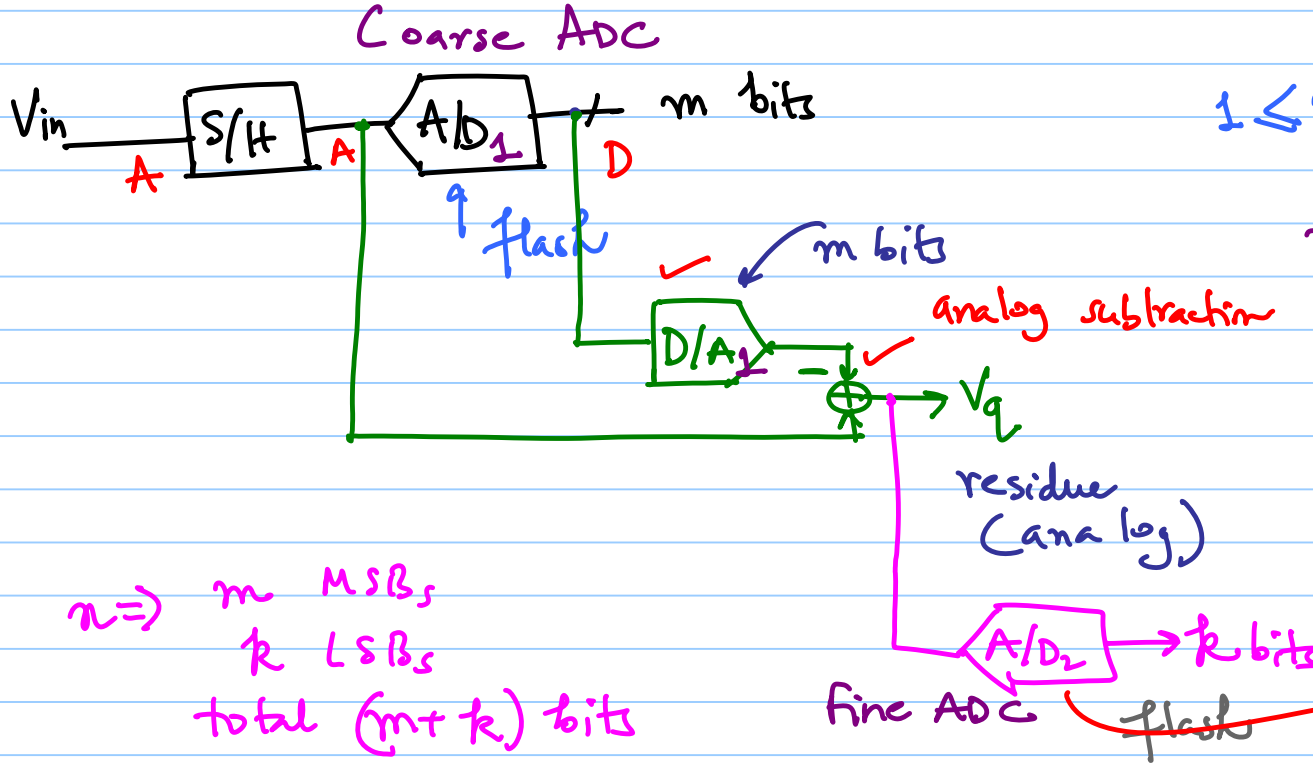
ECE 5/417 - Lecture 21

Note Title 4/4/2017

A/D ⇒ ADC

D/A ⇒ DAC



$1 \leq m \leq 8$

residue $\triangleq$ quantization error for a stage

$V_q = V_{in} - (m \text{ bits})$

$|V_q| < \frac{V_{LSB_1}}{2}$

$n \Rightarrow$ m MSBs, k LSBs, total $(m+k)$ bits

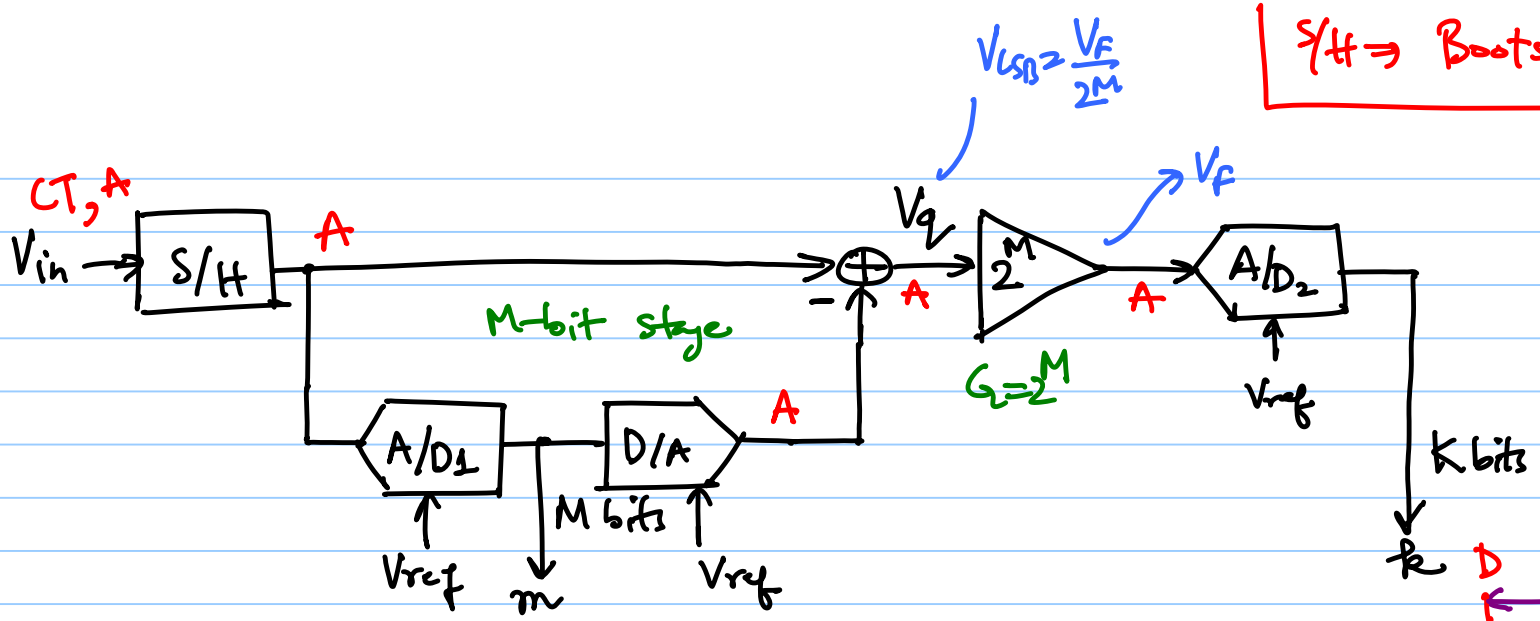
$V_{LSB_2} = \frac{V_{LSB_1}}{2^R}$

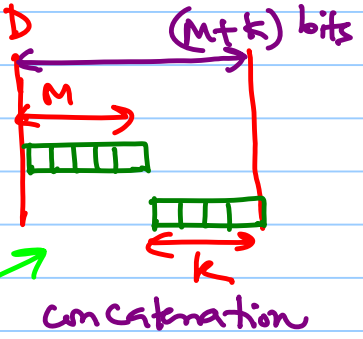
* Second A/D quantizes the quantization error (residue) of the first A/D converter.

* Concatenate the bits to get $n = m + k$ bits

* Two-step Flash ADC (without interstage gain)

S/H ⇒ Bootstrapped switches

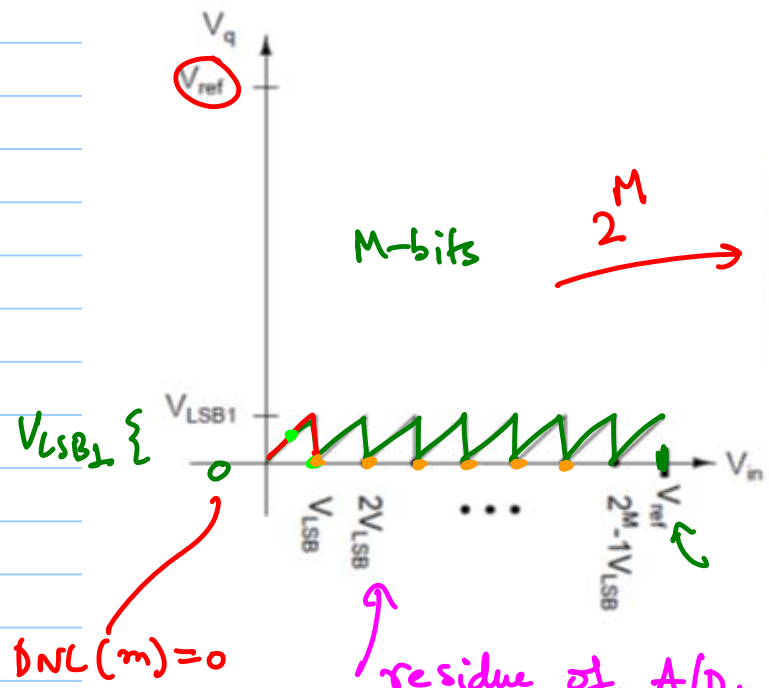




Total resolution ⇒ N = M + k bits

Digital output ⇒ $2^k m + k$

Example : M=3bits, k=2bits



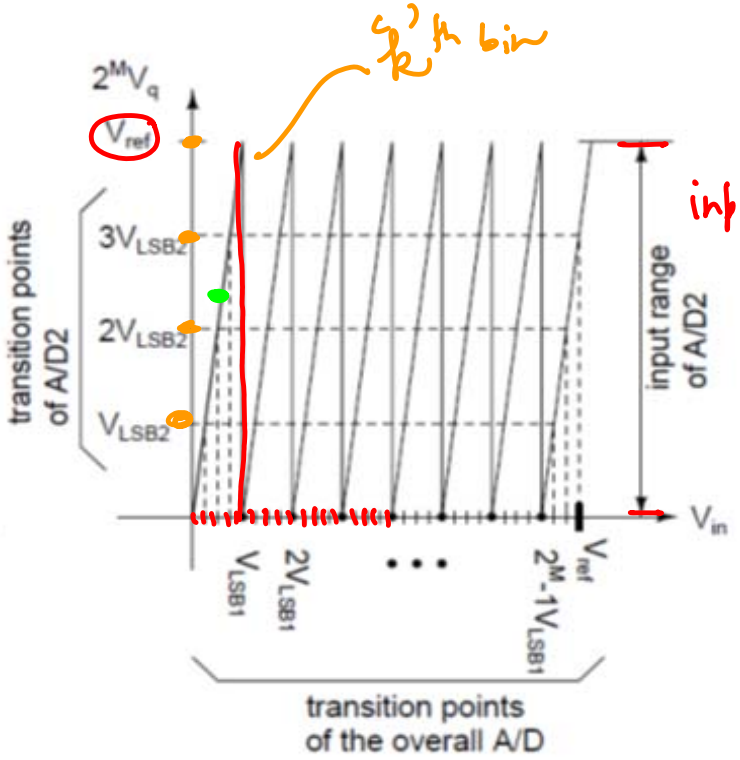
V_{LSB_1} {

M-bits

2^M

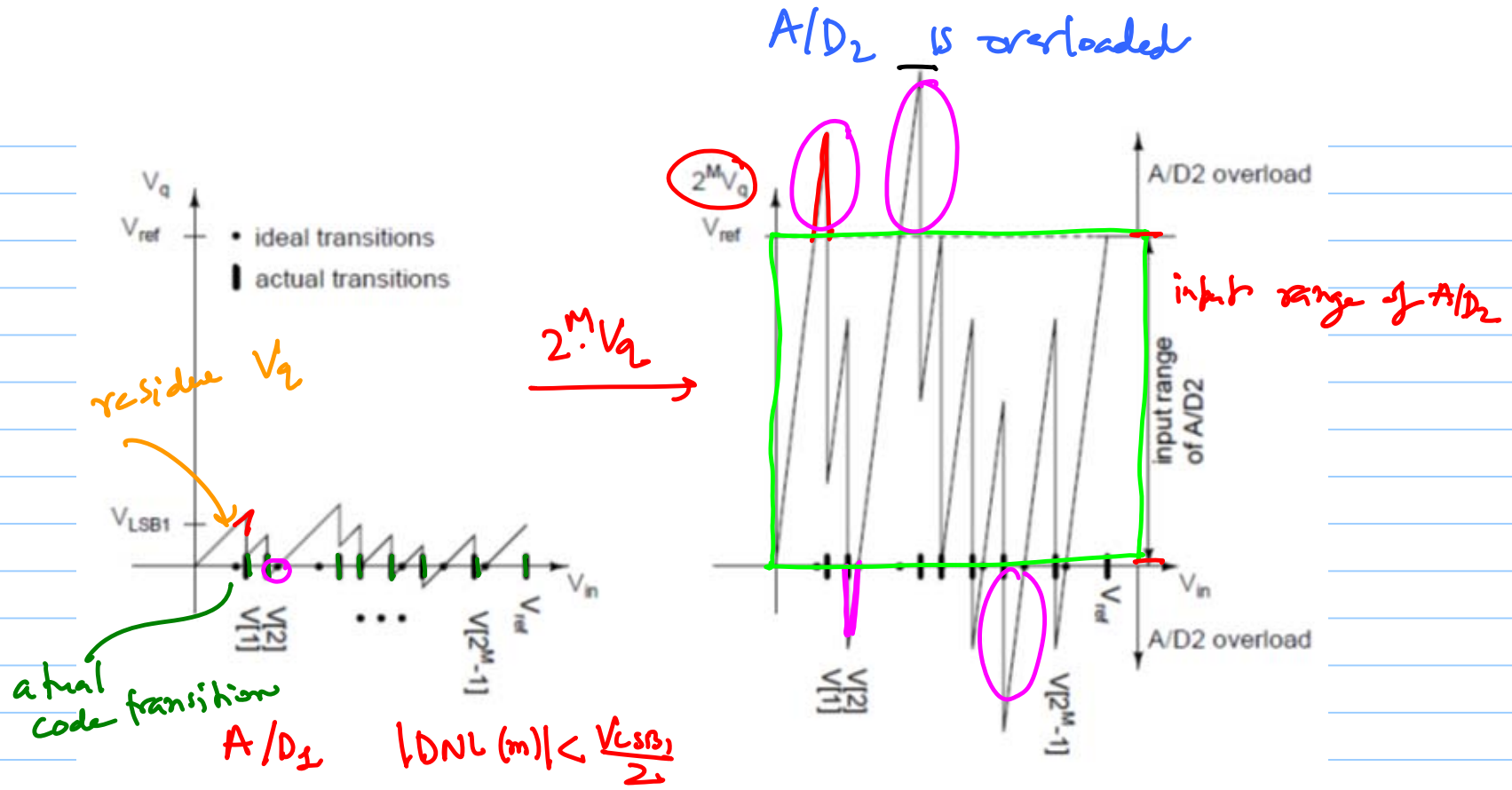
DNL(m)=0

residue of A/D_1



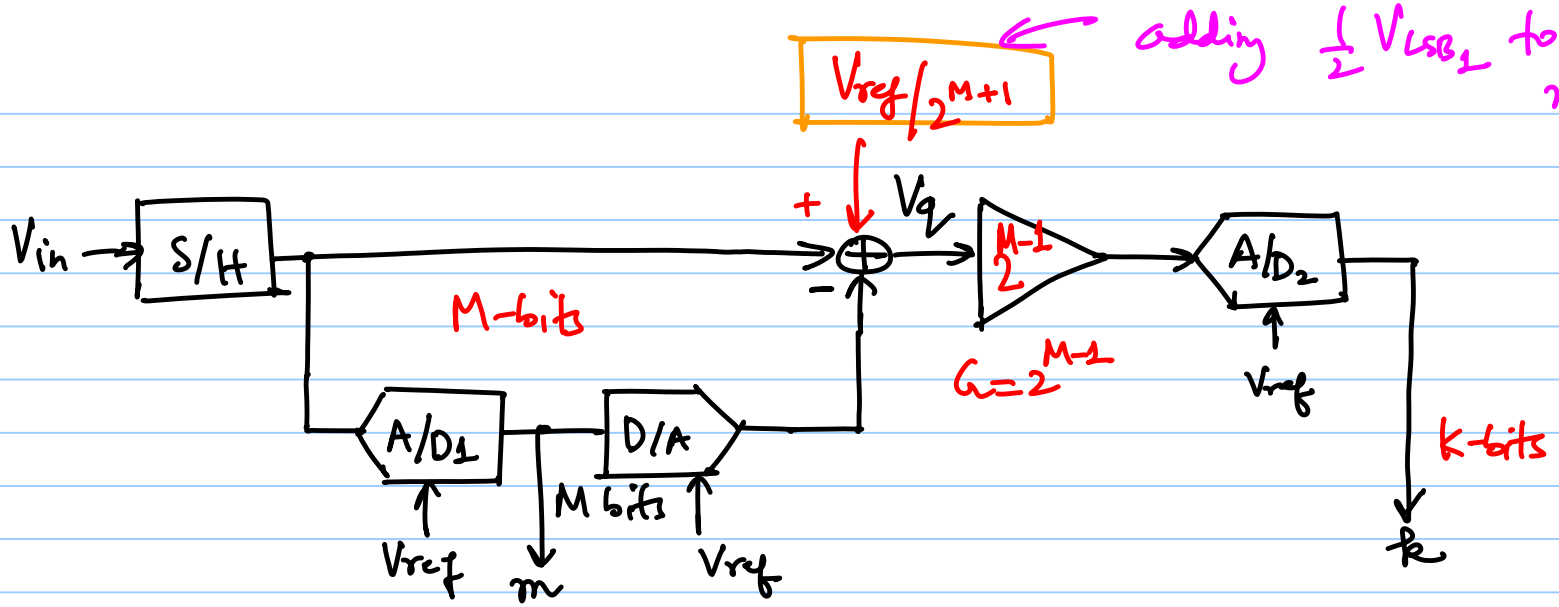
input range of A/D_2

* 2^MV_q exactly fits the input range of A/D_2


A/D2 is overloaded
V_q
V_{ref}
ideal transitions
actual transitions
residue V_q
V_{LSB1}
V_{in}
$V_{[2]}$
$V_{[1]}$
$V_{[2^M-1]}$
V_{ref}
actual code transition
A/D1
$|DNL(m)| < \frac{V_{LSB1}}{2}$
$2^M V_q$
$2^M V_q$
V_{ref}
A/D2 overload
input range of A/D2
input range of A/D2
V_{in}
A/D2 overload
$V_{[2]}$
$V_{[1]}$
$V_{[2^M-1]}$
V_{ref}

* A/D_1 transitions in error by 0.5 LSB $\Rightarrow \frac{V_{ref}}{2^{M+1}}$

↳ V_q is limited to $\left(-\frac{V_{ref}}{2^{M+1}}, \frac{3V_{ref}}{2^{M+1}}\right)$

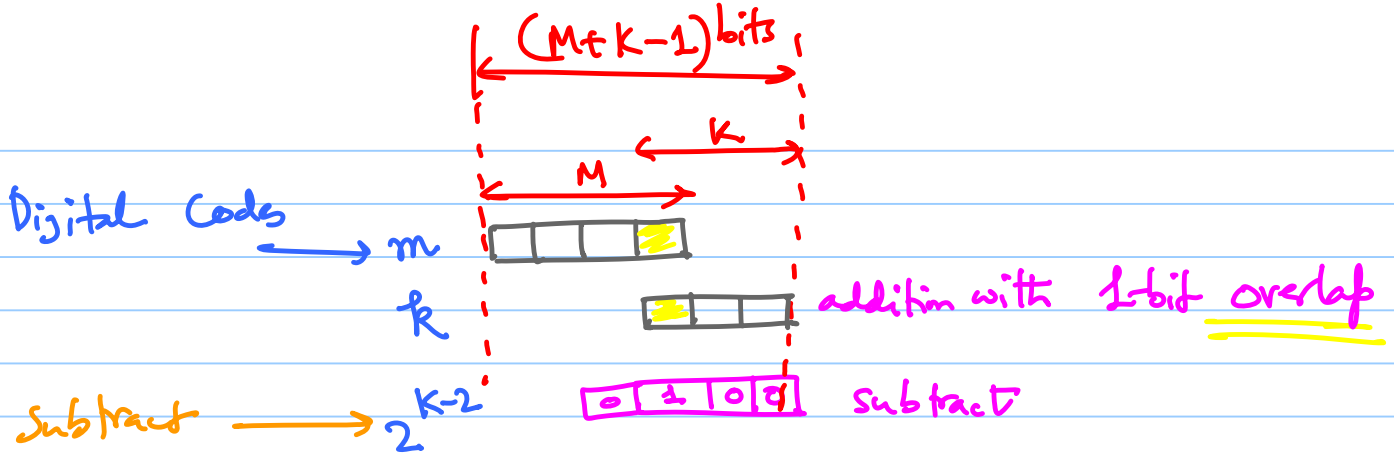


Total resolution : $N = M + K - 1$

Digital output : $n = 2^{K-1} m + k - 2^{K-2}$

2^{K-1}: shift by $(K-1)$ bits

2^{K-2}: subtract the $\frac{1}{2}$ LSB added to the residue

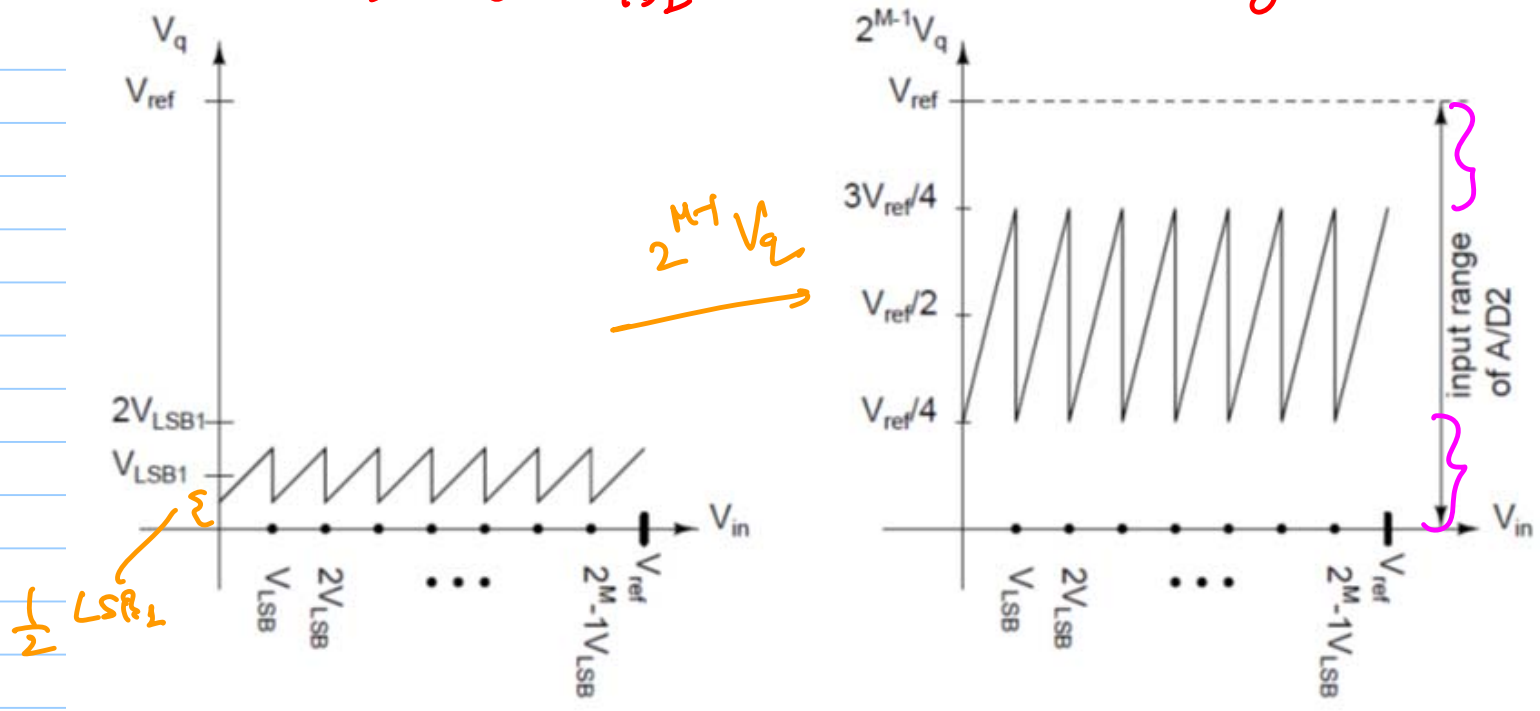


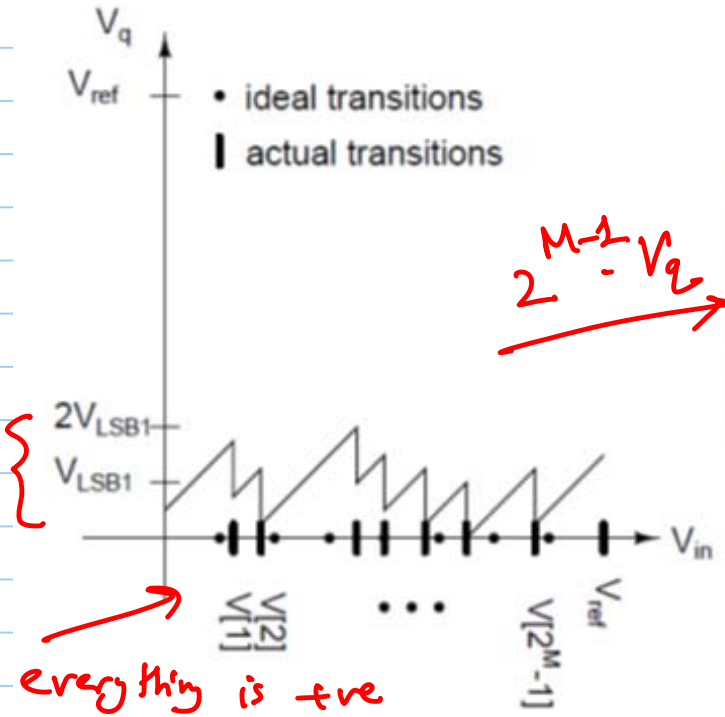
½ LSB₁ added to make residue V_2 positive

(1-bit redundancy)

↳ to tolerate $|DNL| < \frac{V_{LSB_1}}{2}$ errors in A/D_1

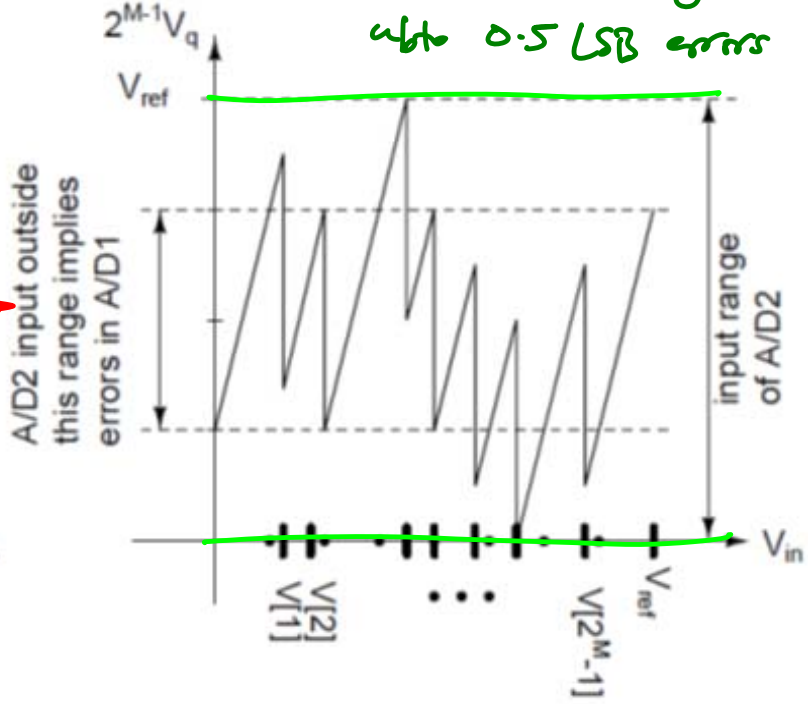
Ideal A/D2 with 1-bit redundancy





everything is +ve

$2^{M-1} \cdot V_q$



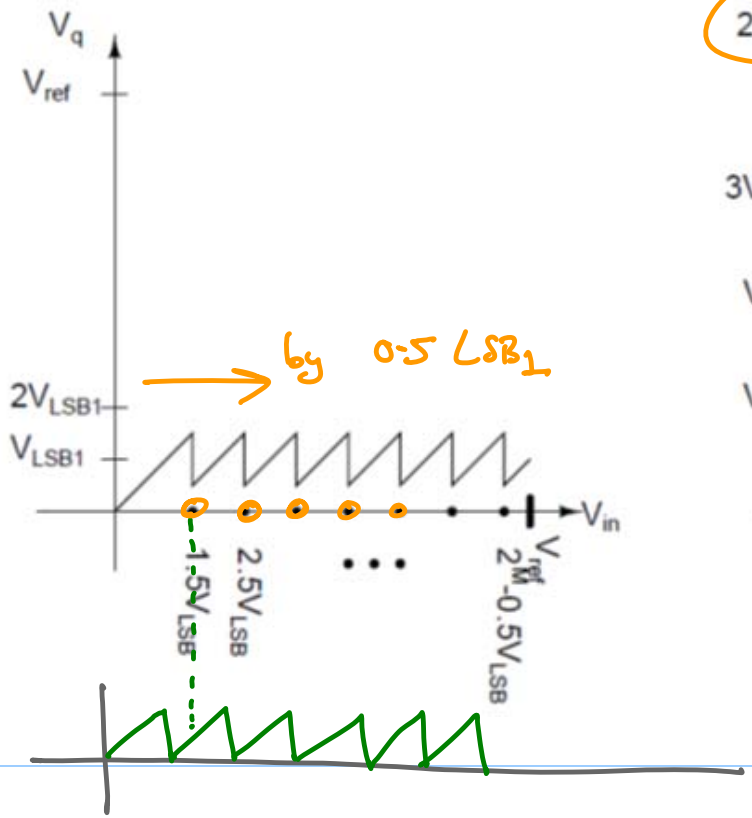
* No overload of A/D_2 for upto 0.5 LSB errors in A/D_1

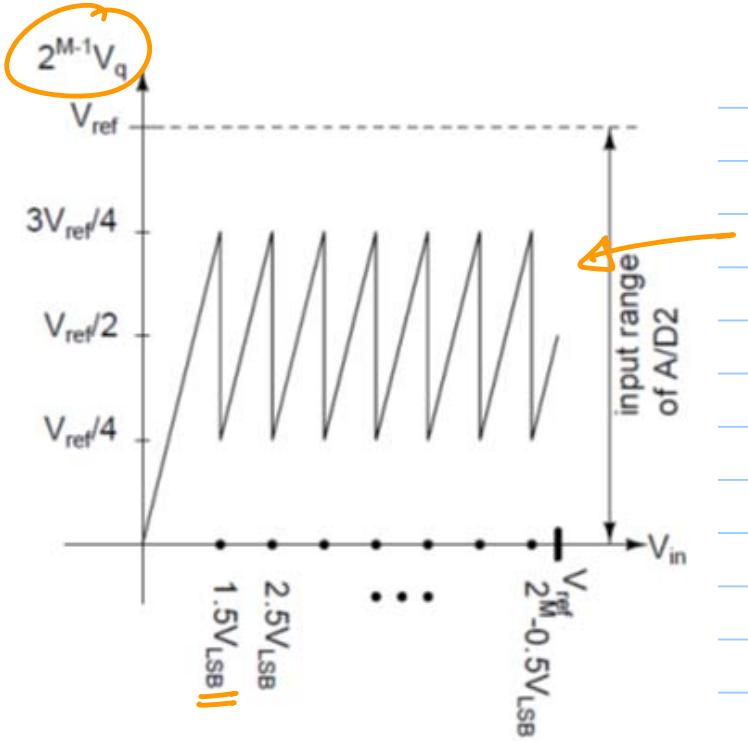
✓ This architecture can correct 1 LSB error in the coarse A/D_1

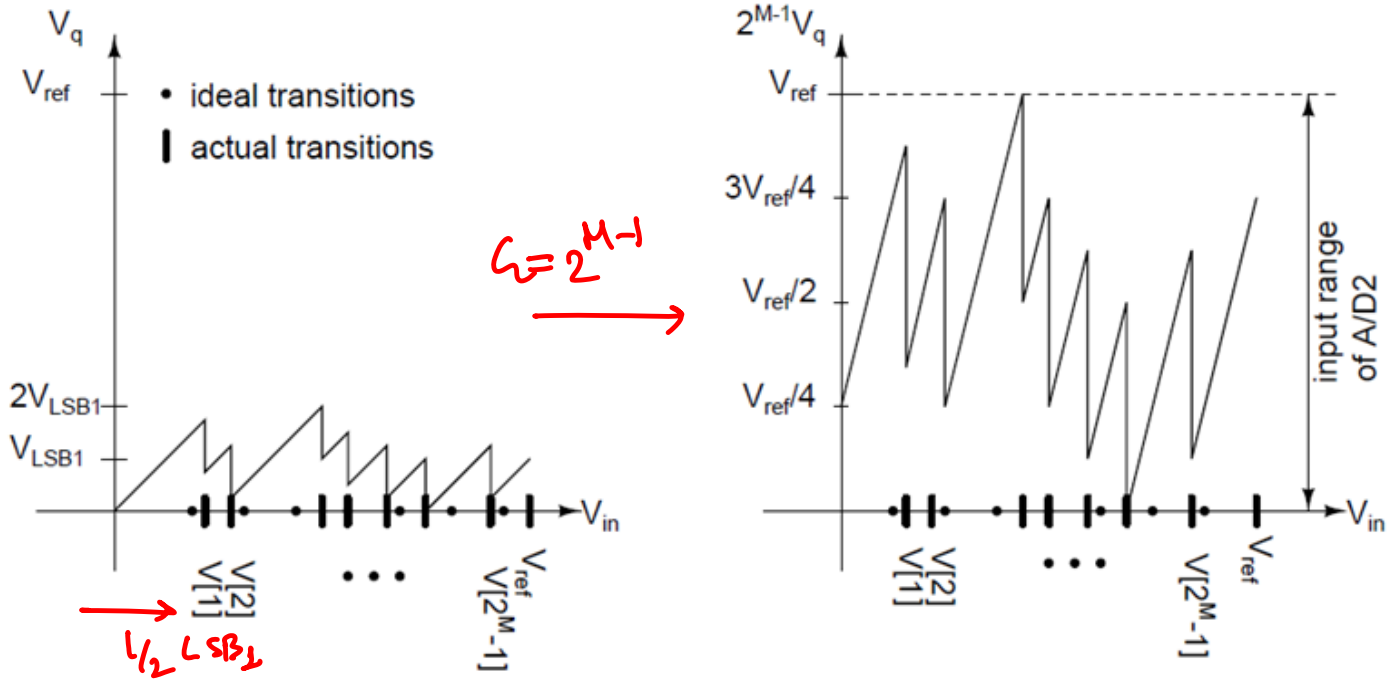
(-) Issue: Accurate analog addition of 0.5 LSB_1 is difficult in practice.

* Try some other idea to keep V_L +ve and within the input range of A/D_2

↳ Lets try and shift the transitions of A/D_1 to the right by $\frac{V_{ref}}{2^{M+1}}$ $(=0.5\ LSB_1)$ to keep V_L positive.


V_q
V_{ref}
$2V_{LSB1}$
V_{LSB1}
V_{in}
1.5V_{LSB}
2.5V_{LSB}
V_{ref} 2^M-0.5V_{LSB}


$2^{M-1}V_q$
V_{ref}
3V_{ref}/4
V_{ref}/2
V_{ref}/4
input range of A/D2
V_{in}
1.5V_{LSB}
2.5V_{LSB}
V_{ref} 2^M-0.5V_{LSB}


V_q
V_{ref}
ideal transitions
actual transitions
$2V_{LSB1}$
V_{LSB1}
V_{in}
V[2]
V[1]
V_{ref}
V[2^M-1]
1/2 LSB1
$G = 2^{M-1}$
$2^{M-1}V_q$
V_{ref}
$3V_{ref}/4$
$V_{ref}/2$
$V_{ref}/4$
input range of A/D2
V_{in}
V[2]
V[1]
V[2^M-1]
V_{ref}