ECE 614 Advanced Analog

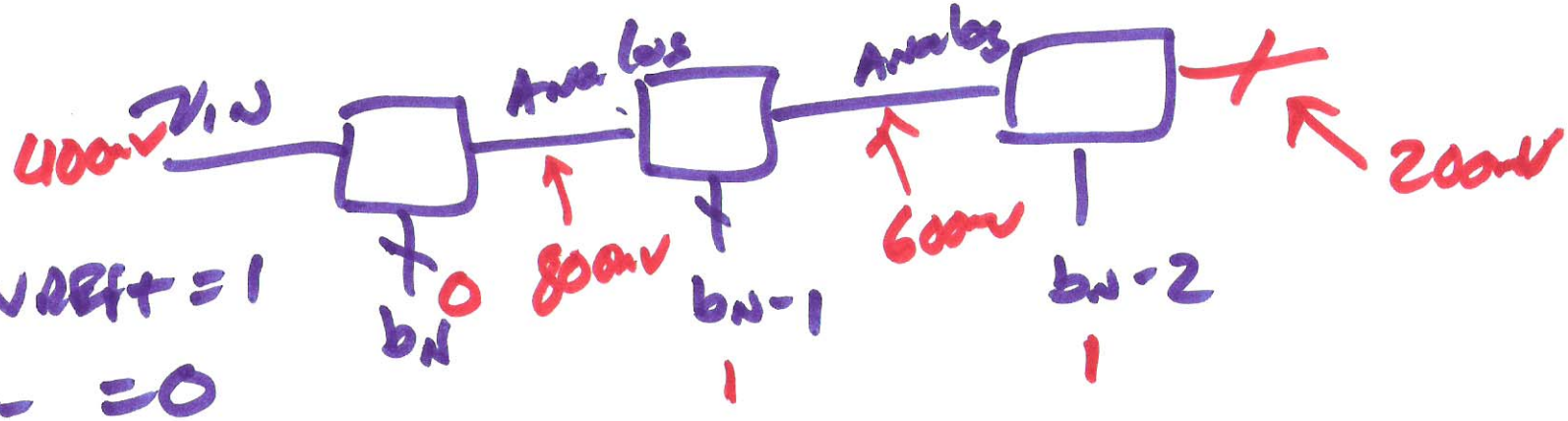
BOISE STATE UNIVERSITY

Lecture 23 NOV. 15, 2011

IS $V_{IN} > V_{cm}$ yes subtract V_{cm}

no subtract 0

then multiply by 2.



$V_{DD} = V_{REF+} = 1$

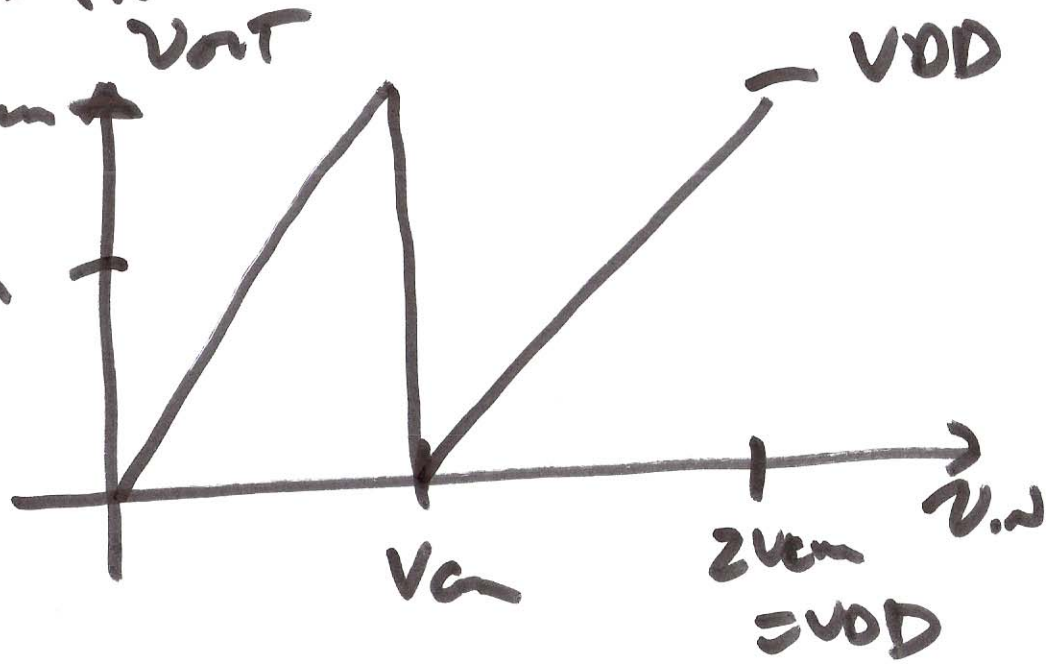
$V_{REF-} = 0$

$V_{cm} = \frac{V_{DD}}{2} = \frac{1}{2} V$

$$V_{out}\Big|_{stage} = 2\left(V_{in} + \bar{b}\cdot 0 - b\cdot V_{cm}\right)$$

$b \rightarrow$ output of the comparator

→ Single-ended V_{out}



$0 \leq V_{in} \leq V_{cm}$

2)

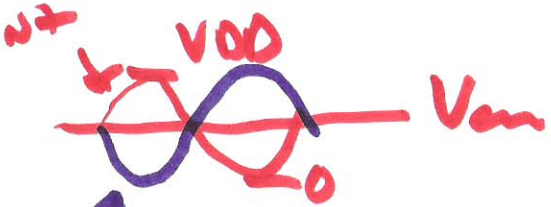
$$v_{OUT} = v_{OUT+} - v_{OUT-} =$$

Eq. (30.56)

$$\bar{b} \cdot V_m + 2\left(\overbrace{v_{IN+} - v_{IN-}}^{v_{IN}} + \bar{b} \cdot 0 - \bar{b} \cdot V_m\right)$$

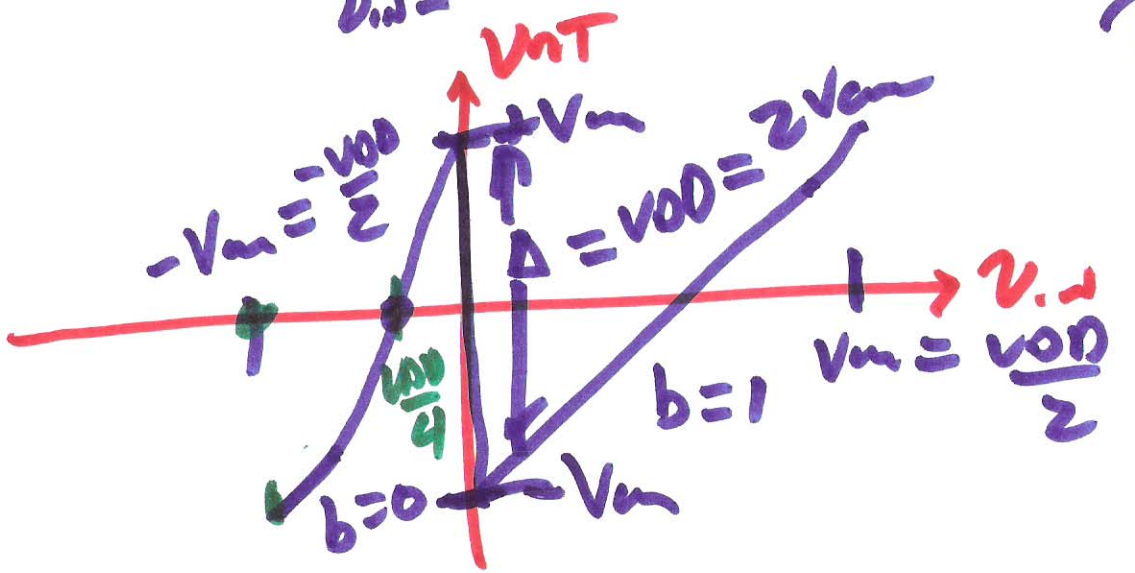
$$+b \cdot V_m$$

$$= V_m$$



$v_{IN} > 0$ subtract V_m

$v_{IN} < 0$ sub nothing



3)

$$V_{OUT+} - V_{OUT-} = 2\left(V_{IN+} - V_{IN-} + \bar{b}\cdot 0 - b\cdot V_{cm}\right)$$

$$+\bar{b}\cdot V_{cm} + b\cdot V_{cm}$$

$$V_{OUT+} - V_{OUT-} = 2\left(V_{IN+} - V_{IN-} + \bar{b}\cdot 0 + \bar{b}\cdot \frac{V_{cm}}{2} - bV_{cm} + b\cdot \frac{V_{cm}}{2}\right)$$

$-\frac{VDD}{4} - \frac{V_{cm}}{2} + V_{cm}/2$

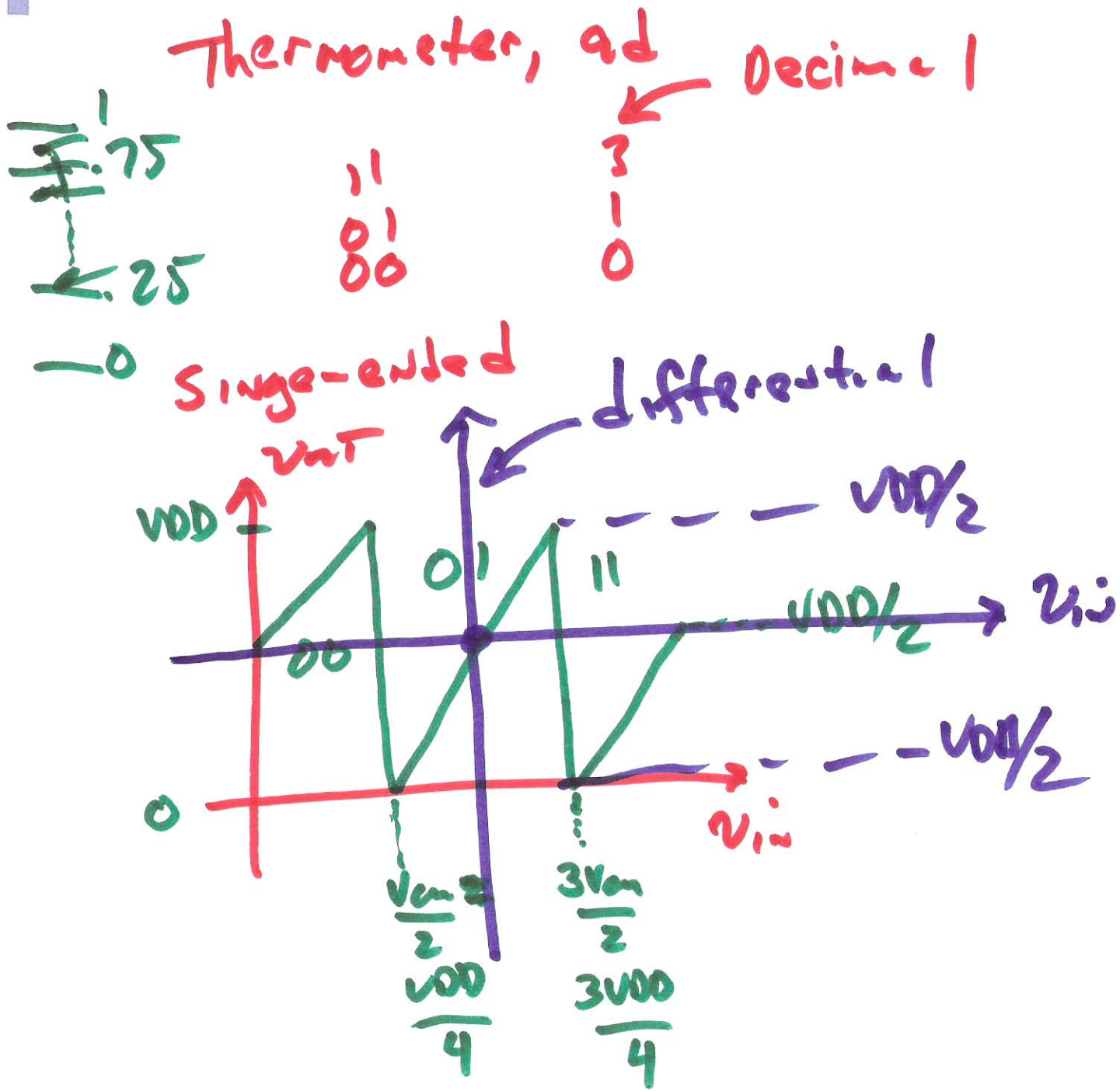
$-V_{cm}$

$$\underbrace{V_{OUT+} - V_{OUT-}}_{V_{OUT}} = 2\left(\underbrace{V_{IN+} - V_{IN-}}_{V_{in}} + \bar{b}\cdot\frac{V_{cm}}{2} - b\cdot\frac{V_{cm}}{2}\right)$$

$+$

$$.2 \quad -\frac{V_{cm}}{2} = -V_{in}$$

4)


Thermometer, ad
Decimal
1
.75
.25
0
11
01
00
3
1
0
Single-ended
differential
v_{out}
VDD
VDD/2
01
11
00
VDD/2
v_{in}
-VDD/2
0
v_{in}
$\frac{V_{dm}}{2}$
$\frac{VDD}{4}$
$\frac{3V_{dm}}{2}$
$\frac{3VDD}{4}$

5)

$$V_{OUT} = 2 \cdot \left(V_{IN} - \bar{a}\bar{b} \cdot 0 - \bar{a}b \cdot V_{cm} - ab \cdot 2V_{cm} \right) + V_{cm}$$

$$V_{OUT} = 2 \cdot \left(V_{IN} + \bar{a}\bar{b} \cdot \frac{V_{cm}}{2} - \bar{a}b \cdot \frac{V_{cm}}{2} - ab \cdot \frac{3V_{cm}}{2} \right)$$

Single-ended

	a b
$0 \le V_{IN} \le \frac{V_{cm}}{2}$	0 0
$\frac{V_{cm}}{2} \le V_{IN} \le \frac{3V_{cm}}{2}$	0 1
	1 1

$$\frac{3V_{cm}}{2} \le V_{IN}$$

b)

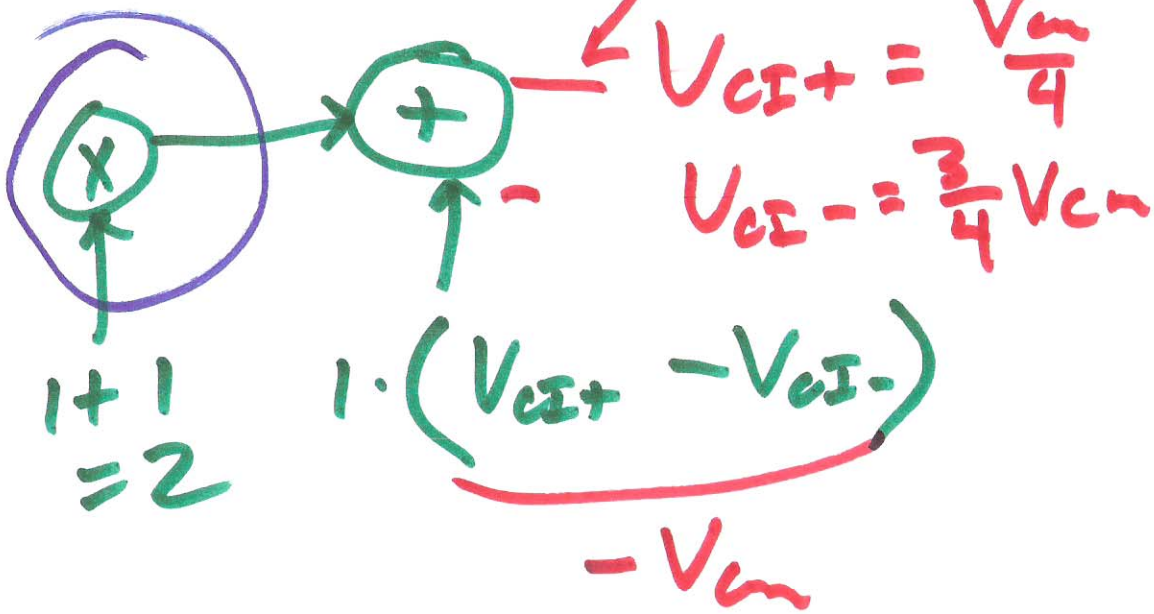
differential

$v_{out+} - v_{out-} = 2 \cdot (v_{id+} - v_{id-} + \bar{a}\bar{b} \cdot V_{cm} - \bar{a}b \cdot 0 - ab \cdot V_{cm})$

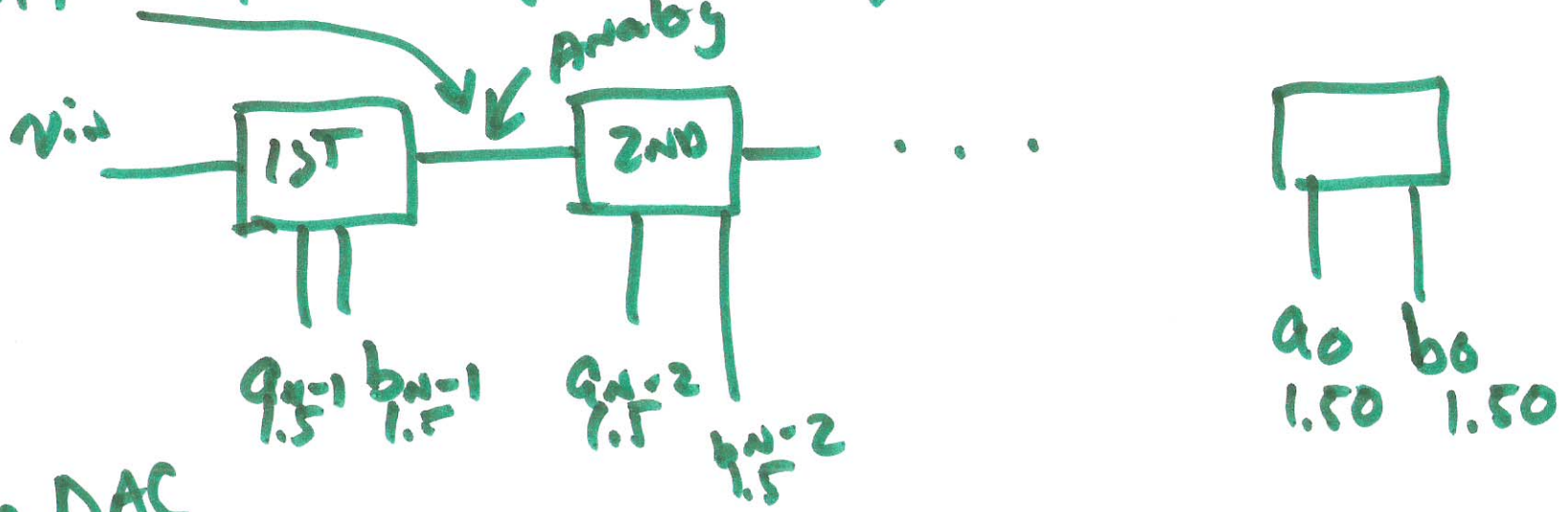
Add $2V_{cm}$ to add V_{cm}

Fig 30.40

$C_I = C_F$



$$V_{OUT+} - V_{OUT-} = 2\left(V_{IN+} - V_{IN-}\right) + \bar{a}\bar{b}\cdot 2V_{cm} - ab\cdot 2V_{cm}$$



for a DAC

$$V_{OUT} = b_{N-1}\cdot V_{cm} + b_{N-2}\cdot\frac{V_{cm}}{2} + b_{N-3}\frac{V_{cm}}{4}$$

Remember this

$$+ \ldots b_0 \frac{2V_{cm}}{2^N}$$

1 LSB

$\frac{V_{cm}}{2^{N-1}}$

$\frac{V_{DD}}{2^N}$

8)

$$V_{IN} = a_{1.5N-1}\,b_{1.5N-1} \cdot V_m + a_{1.5N-1}\,b_{1.5N-1} \cdot 2V_m - \frac{V_m}{2}$$

30.59

$$\frac{V_{OUT}}{2} = \frac{1}{2}\left(V_{IN} - \bar{a}\bar{b} \cdot 0 - \bar{a}b \cdot V_m - ab\,\frac{3V_m}{2} + \frac{V_m}{2}\right)$$

$$-\frac{V_m}{2} - \frac{V_m}{4} - \frac{V_m}{8} - \ldots = -V_m \cdot \frac{2^N - 1}{2^N}$$

$$= -V_m + \frac{1}{2}LSB + \frac{V_{REF-}}{2^N}$$

$$\frac{V_{cm}}{2^N} = \frac{\overbrace{\frac{V_{REF+} + V_{REF-}}{2}}^{V_{cm}}}{2^N} = \frac{V_{cm}}{2^{N+1}}$$

$$= \frac{V_{REF+} - V_{REF-}}{2^{N+1}} + \frac{2V_{REF-}}{2^{N+1}}$$

$$= \frac{1}{2}LSB + \frac{V_{REF-}}{2^N}$$

Addition, not an "OR"

$$V_{IN} = \left(\overline{a_{1.5N-1}}\, b_{1.5N-1} + a_{1.5N-2}\, b_{1.(N-2)}\right) \cdot V_{cm} +$$

MSB

$1\,000000$ — VDD

111111 — VDD - 1 LSB

100000 — V_{cm}

011111 — $V_{cm} - \frac{1}{2}$ LSB

00000 — 0V