F2018

Q4

i) $C + C + 2C + 4C = 8C = 2^3 C$

$= 2^k C$

$2^k C$ series with C_b

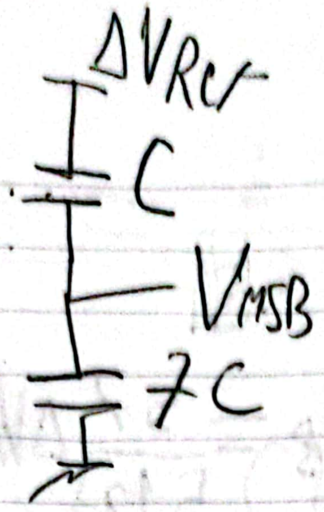
so for $C_{eq} = \dfrac{\cancel{2^k C}\, C_b}{2^k C + C_b} = \cancel{C}$

$2^k C_b = C_b + 2^k C$

$C_b [2^k - 1] = 2^k C$

$$\boxed{C_b = \frac{2^k}{2^k - 1} C}$$

b)

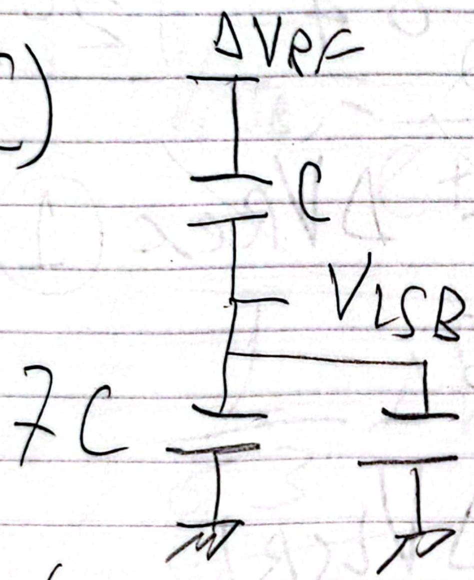


$$V_{MSB} = \Delta V_{Ref} \frac{C}{7C+C}$$

$$= \Delta V_{Ref} \frac{\cancel{C}}{8\cancel{C}}$$

$$= \frac{1}{2^3} V_{Ref}$$

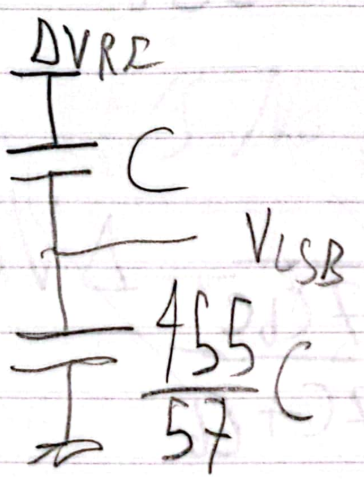
C)



$$C_b = \frac{8}{7} C$$

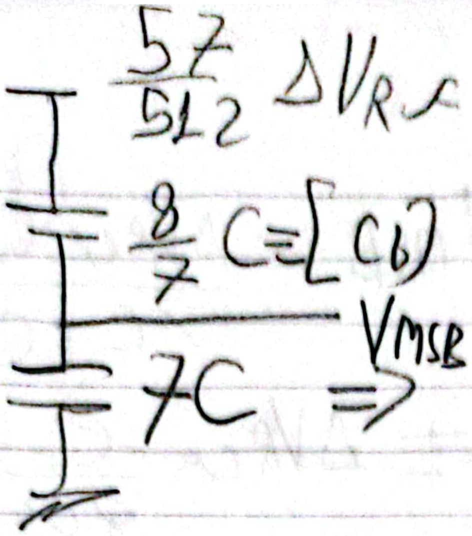
$$\frac{56}{57} C = \left[\frac{C_b \times 7C}{C_b + 7C} \right]$$

↓



$$\Rightarrow V_{LSB} = \frac{\cancel{C}}{\cancel{C}\left[1 + \frac{455}{57}\right]} \Delta V_{Ref}$$

$$\text{So: } V_{LSB} = \frac{57}{512} \Delta V_{Ref}$$



$$\Rightarrow V_{MSB} = \frac{57}{512}\Delta V_{Ref}\frac{\frac{8}{7}C}{7C+\frac{8}{7}C}$$

$$= \frac{\Delta V_{Ref}}{64} = \boxed{\frac{\Delta V_{Ref}}{2^6}}$$

d) $$\Delta V_{MSB} = \frac{C}{7C + \frac{C_b 7C}{7C + C_b}}\Delta V_{Ref} \quad (1)$$

$$\Delta V_{MSB,LSB} = \frac{C_b}{C_b + C_{MSB}}\Delta V_{LSBb}$$

$$= \frac{C_b}{C_b + 7C}\cdot\frac{C}{7C + \frac{7C_bC}{7C + C_b}}\Delta V_{Ref} \quad (2)$$

$$(2)/(1) = \frac{\Delta V_{MSB,LSB}}{\Delta V_{MSB}} = \frac{C_b}{C_b + 7C}$$

$$\frac{C_b}{C_b+7C} = \frac{1}{2^3}$$

$$2^3 C_b = C_b + 7C$$

$$\cancel{7} C_b = \cancel{7} C \Rightarrow \boxed{C_b = C}$$

e) $\Delta V_{MSB} = \frac{\cancel{C}}{\cancel{C}+7\cancel{C}} \cdot \frac{\cancel{C}}{7C + \frac{7\cancel{C^2}}{\cancel{C}(7+1)}} \Delta V_{Ref}$

$$\Delta V_{MSB} = \boxed{\frac{1}{63} \Delta V_{Ref}}$$

No, It's NoT NoN-linearity error

final 2019/2020

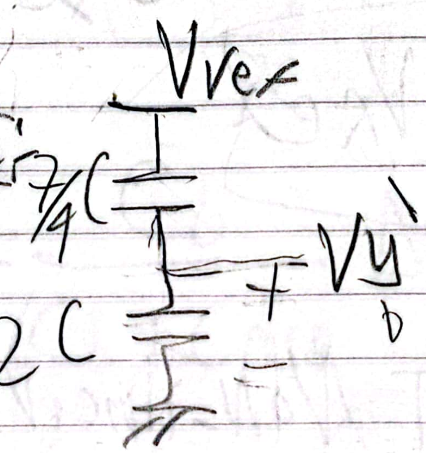
Q2

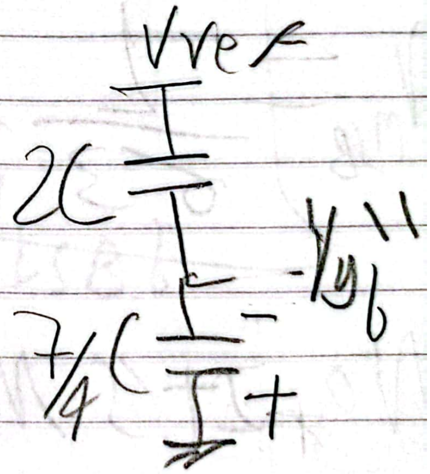
a)

Scnt linear error, as it doesn't depend on the input

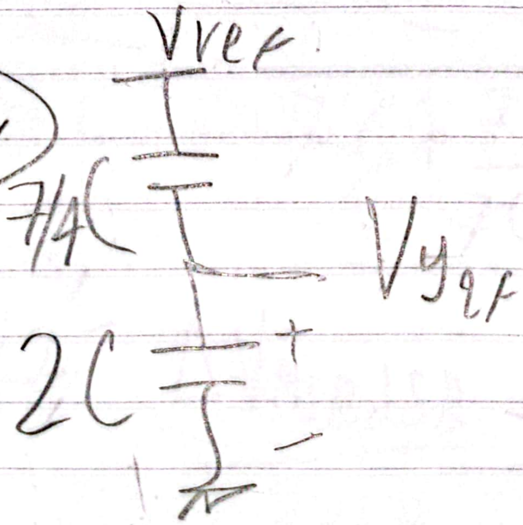
Scht NoN-linear error, depends on input

b) before





after



$$\Delta V_y = -V_{ref} \cdot \frac{2\cancel{C}}{\frac{7}{4}\cancel{C}+2\cancel{C}} = -\frac{8}{15} V_{ref}$$

c) $V_y = V_{in} - \frac{8}{15} V_{ref}$

$V_{in} \geq 0{,}5\, V_{ref} \Rightarrow$

$V_y \geq 0{,}5\, V_{ref} - \frac{8}{15} V_{ref}$

$V_y \geq \frac{-1}{30} V_{ref} \quad \therefore V_{th} \leq \frac{-1}{30} V_{ref}$

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d) $V_{in} = 0,\ V_{ref} = 1{,}5\,V$

(i) $\Delta V_x = -\Delta V_{ref} \dfrac{\cancel{C}}{\cancel{C}\left(1+2+\frac{3}{4}\right)}$

$= \frac{-4}{15} \times \frac{3}{2} = \boxed{-0{,}4V}$

$\Delta V_y = \Delta V_x \frac{C}{4C} = \boxed{-0{,}1V}$

(ii) $\Delta V_{x_{S1}} = 2\,\Delta V_{x_{S0}} = -0{,}8V$

$$\boxed{\Delta V_{y_{S1}} = \frac{1}{4}\Delta V_{x_{S1}} = -0{,}2V}$$

(iii) $\Delta V_{y_{S2}} = \dfrac{C}{3C + \frac{3\cancel{C}^2}{4\cancel{C}}}(-V_{ref})$

$= \boxed{-\frac{6}{7}V}$

(e)

(i) $\Delta V_x = \dfrac{-V_{ref}\;C}{\frac{25}{4}C + C} = -\dfrac{4}{29}V_{ref}$

$\Delta V_y = \dfrac{\Delta V_x}{4} = -\dfrac{1}{29}V_{ref} = -0{,}078V$

ii) $\Delta V_{y_{S1}} = 2\,\Delta V_{y_{S0}} = -0{,}156\;V$

iii) $\Delta V_y = -V_{ref} \dfrac{C}{3C + \dfrac{4C^2}{5C}} = \boxed{-0{,}394V}$

f)

i) $\Delta V_x = -V_{ref} \cdot \dfrac{C}{3C + \dfrac{4C^2}{5C}} = \boxed{-0{,}394V}$

$\Delta V_y = V_y = \dfrac{C}{5C} \Delta V_x = \boxed{-0{,}0788V}$

ii)

$\Delta V_x = 2 \Delta V_{x_{50}} = -0{,}788V$

$\Delta V_y = 2 V_{y_{50}} = -0{,}1576V$

iii) $\Delta V_y = -V_{ref} \dfrac{C}{4C + \dfrac{3C^2}{4C}} = -0{,}315V$

g) V_x, as $\Delta V_x > \Delta V_y$ more sensitive

$D_{NL_x} = -\left(\dfrac{-0{,}1 + 0{,}078}{-0{,}1}\right) = \boxed{0{,}22 LSB}$

$$D_{nL} = -\left(\frac{-0{,}2+0{,}0788}{-0{,}2}\right)$$

$$= \boxed{0{,}212\ LSB}$$