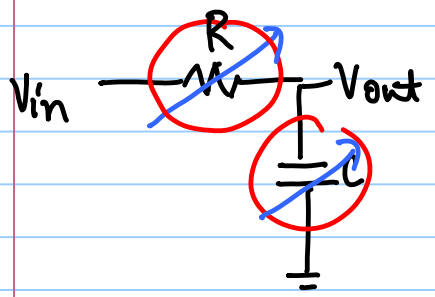
Note Title 15-04-2019

Lecture # 43

Switched Capacitor Circuits.



R, C: PVT variations.

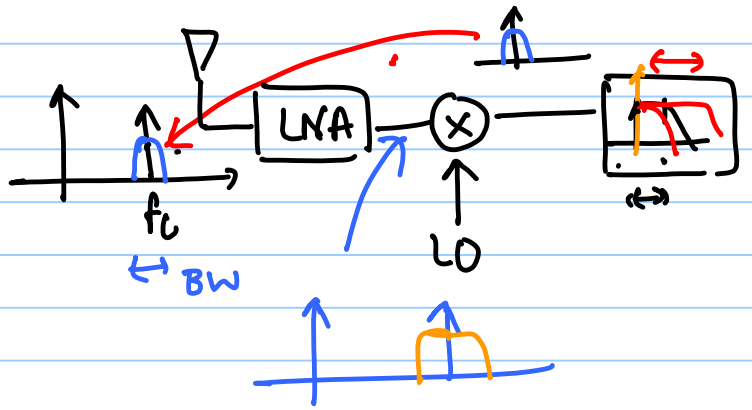
$$\frac{V_{out}}{V_{in}} = \frac{1}{1+sRC}$$

$$\omega_{-3dB} = \frac{1}{RC} = \frac{1}{R_{nom}C_{nom}}$$

200 kHz – 20 MHz.

ω

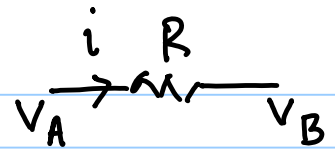
RF Tx & Rx



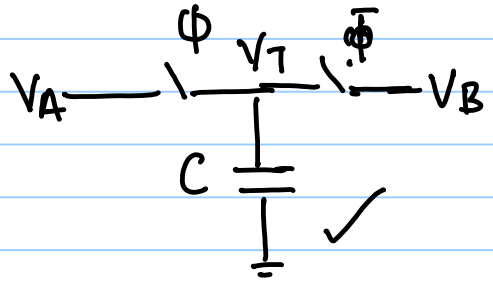
GSM
WiFi
LTE
5G

GSM → TX / RX

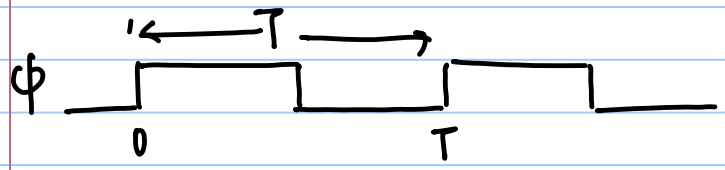
TX / RX



$$i = \frac{V_A - V_B}{R} \checkmark \Rightarrow R = \frac{V_A - V_B}{i_{avg}}$$



$\checkmark$



ϕ is high: $V_T = V_A$

$q(T/2) = C V_A$

ϕ is low: $V_T = V_B$

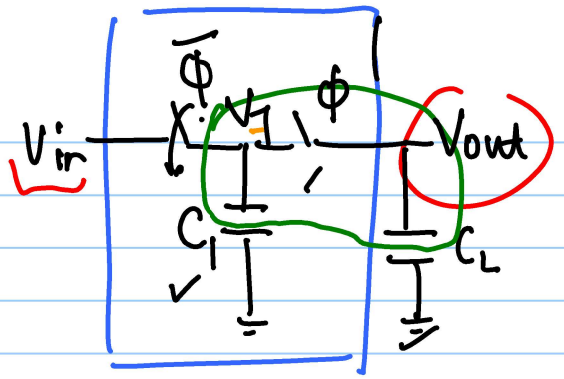
$q(T) = C V_B$

$$i_{avg} = \frac{C(V_A - V_B)\checkmark}{T\checkmark}$$

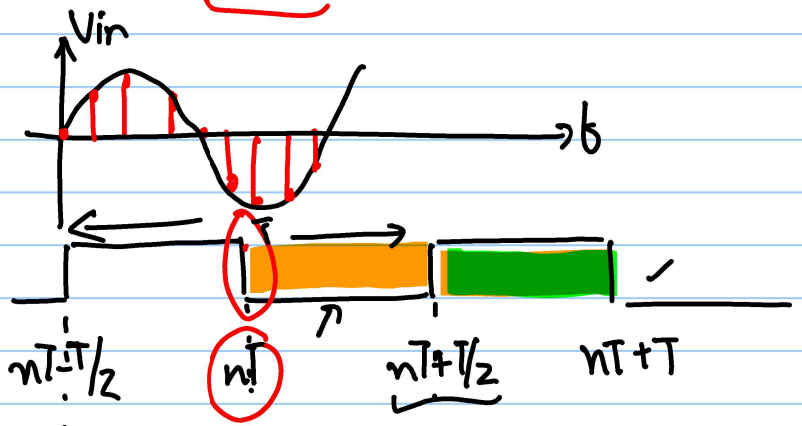
$$= \frac{V_A - V_B}{(T/C)}\checkmark = \frac{V_A - V_B}{R}$$

$\checkmark$

$$\Rightarrow \boxed{R = T/C = \frac{1}{C f_s}}$$



$$R \approx \frac{1}{f_s C_1}$$



$$\omega_{-3dB} = \frac{1}{RC} = \frac{f_s C_1}{C_L} = f_s \cdot \left(\frac{C_1}{C_L}\right)$$

$$\frac{V_{out}}{V_{in}} = \frac{1}{1+sRC} = \frac{1}{1+j\omega RC}$$

→ Bandwidth tuning with clock frequency.

→ Bandwidth $\propto \frac{C_A}{C_B}$

Φ is low: $V_T(nT+T/2) = V_{in}(nT+T/2)$

$V_{out}(nT+T/2) = V_{out}(nT)$

$$q_1(nT+T/2) = C_1 V_T(nT+T/2) = C_1 V_{in}(nT+T/2)$$

$$q_2(nT+T/2) = C_L V_{out}(nT+T/2) = C_L V_{out}(nT)$$

ϕ is high:

$$C_1 V_{in}(nT+T/2) + C_L V_{out}(nT) = (C_1+C_L) V_{out}(nT+T)$$

$$V_{out}(nT+T) = \frac{C_1}{C_1+C_L} V_{in}(nT+T/2) + \frac{C_L}{C_1+C_L} V_{out}(nT)$$

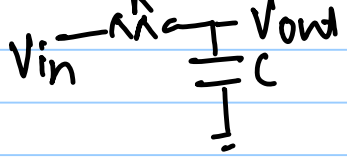
z

$$z\, V_{out}(z) = \frac{C_1}{C_1+C_L} V_{in}(z) + \frac{C_L}{C_1+C_L} V_{out}(z)$$

$z = e^{j\omega T}$

$$\frac{V_{out}(z)}{V_{in}(z)} = \frac{\frac{C_1}{C_1+C_L}}{\left(z - \frac{C_L}{C_1+C_L}\right)}$$

$$= \frac{C_1/(C_1+C_L)}{\left(1 - \frac{C_L}{C_1+C_L}\right) + j\omega T}$$



$$V_{out}(t) =$$

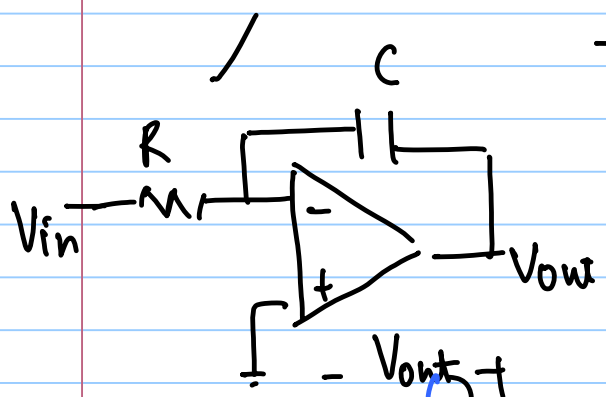
$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{1}{1+sRC}$$

$$z = e^{j\omega T} \simeq 1 + j\omega T$$

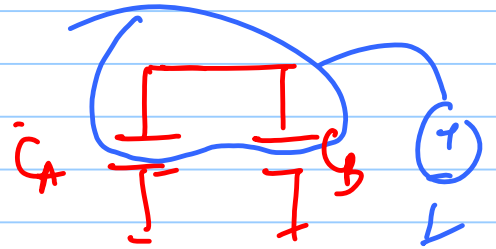
$(|\omega T| \ll)$

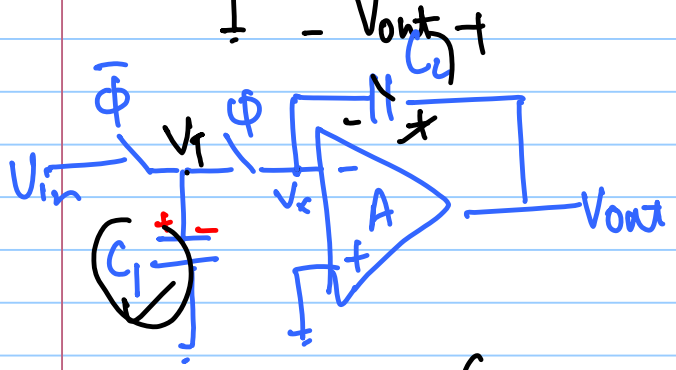
$$= \frac{C_1 \| (C_1 + C_2)}{\frac{C_1}{C_1 + C_2} + j\omega T} = \frac{1}{1 + j\omega T \frac{(C_1 + C_2)}{C_1}}$$

$$\frac{1}{1 + j\omega RC}$$



$$\frac{V_{out}}{V_{in}} = \frac{-1}{sRC}$$





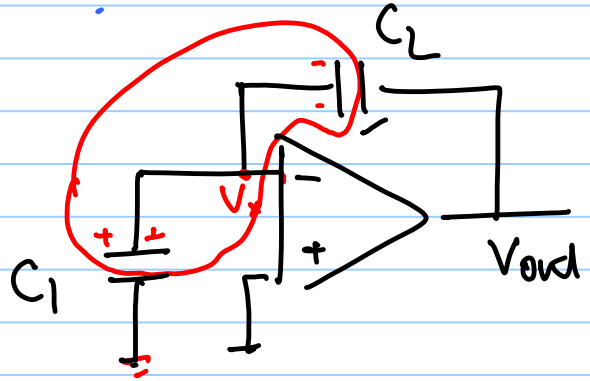
ϕ is low: $V_T(nT + T/2) = V_{in}(nT + T/2)$

$V_{out}(nT + T/2) = V_{out}(nT)$

ϕ is high:

$$C_1 V_{in}(nT + T/2) - C_2 V_{out}(nT) = -C_2 V_{out}(\overline{n+1}\,T)$$

$$V_{out}(\overline{n+1}\,T) = V_{out}(nT) - \frac{C_1}{C_2} V_{in}(nT)$$



$$z\,V_{out}(z) - V_{out}(z) = -\frac{C_1}{C_2} V_{in}(z)$$

$$\frac{V_{out}(z)}{V_{in}(z)} = -\frac{C_1}{C_2}\,\frac{1}{z-1} \approx -\frac{C_1}{C_2(j\omega T)} \qquad z = e^{j\omega T} \approx 1 + j\omega T$$

$$= -\frac{1}{j\omega C_2 (T/C_1)} = \frac{1}{j\omega C_1 \cdot R}$$

$$R = \frac{T}{C_1}$$