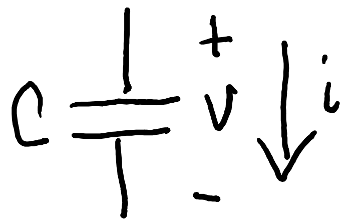
Capacitors

$Q = CV$



$i(t) = \frac{dQ}{dt} = C\frac{dv(t)}{dt}$

$i(t) = C\frac{dv(t)}{dt} \rightarrow$ Can't Cha

OPEN CIRCL

$$v(t_1) = \frac{1}{C}\int_{-\infty}^{t_1} i(t)\,dt = \frac{1}{C}\int_{t_0}^{t_1} i(t)\,dt + \underbrace{\frac{1}{C}\int_{-\infty}^{t_0} i(t)\,dt}$$

$$= \frac{1}{C}\int_{t_0}^{t_1} i(t)\,dt + v(t_0)$$

$$p = v(t)\left[C\frac{dv(t)}{dt}\right]$$

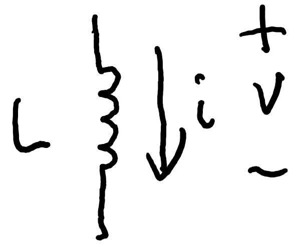
$$W_E = \int_{-\infty}^{t} p(\tau)\,d\tau$$

$$= C\int_{-\infty}^{t}\frac{dv(\tau)}{\cancel{d\tau}}v(\tau)\,\cancel{d\tau} = C\int_{v(-\infty)}^{v(t)} v(\tau)\,dv = \frac{Cv^2(\tau)}{2}\Bigg|_{v(-\infty)}^{v(t)}$$

Assume v disch

$\boxed{W_E = \frac{1}{2}}$

Inductors



$$v(t) = L\frac{di(t)}{dt}$$

$$i(t_1) = \frac{1}{L}\int_{-\infty}^{t_1} v(t)\,dt = \frac{1}{L}\int_{t_0}^{t_1} v(t)\,dt + \frac{1}{L}\int_{-\infty}^{t_0} v(t)\,dt$$

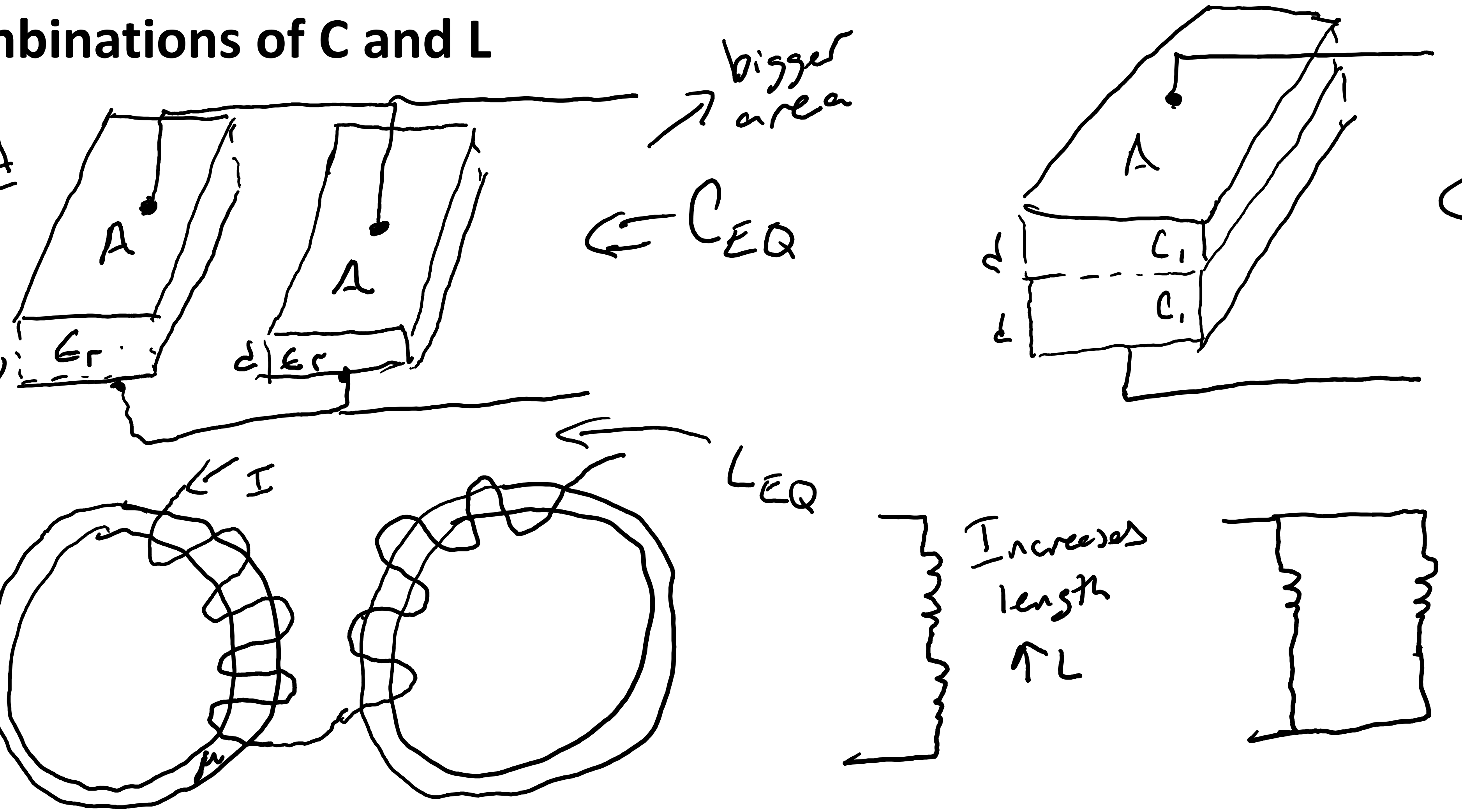
$$= \frac{1}{L}\int_{t_0}^{t_1} v(t)\,dt + i(t_0)$$

$$W_M = L\frac{i^2(t)}{2} = \frac{1}{2}Li^2$$

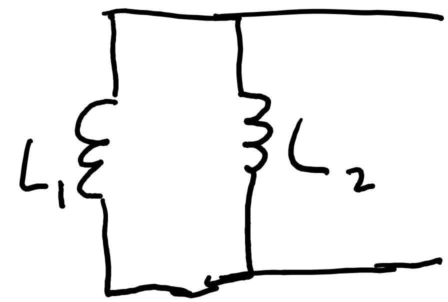
MAGNETIC

Combinations of C and L

$C = \frac{\varepsilon A}{d}$

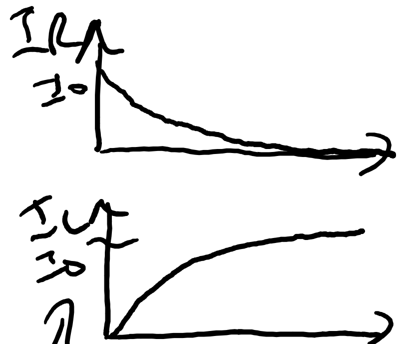


Combinations of C and L



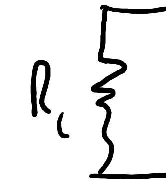
$$L_{EQ} = \frac{L_1 L_2}{L_1 + L_2}$$

$$\frac{1}{L_{EQ}} = \frac{1}{L_1} + \frac{1}{L_2}$$

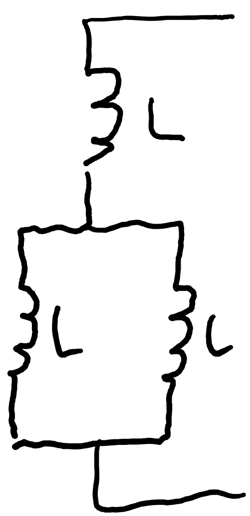


$R_1 \gg R_2$

$R_{EQ} = R_2$

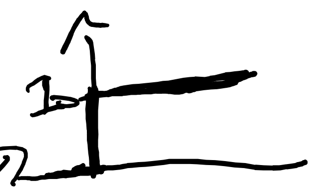


$j = \sqrt{-1}$

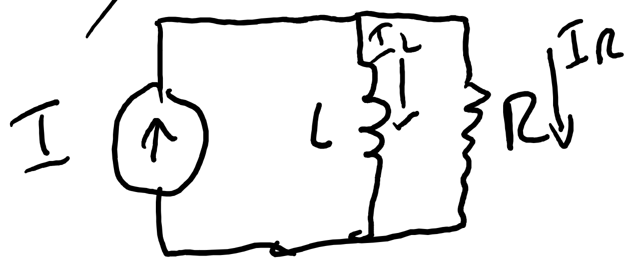


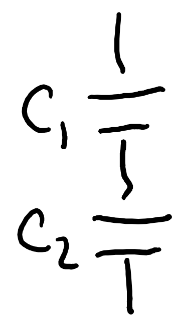
$$L_{EQ} = \frac{3}{2} L$$

$Z = j\omega L$



$$Z = \frac{1}{j\omega C}$$

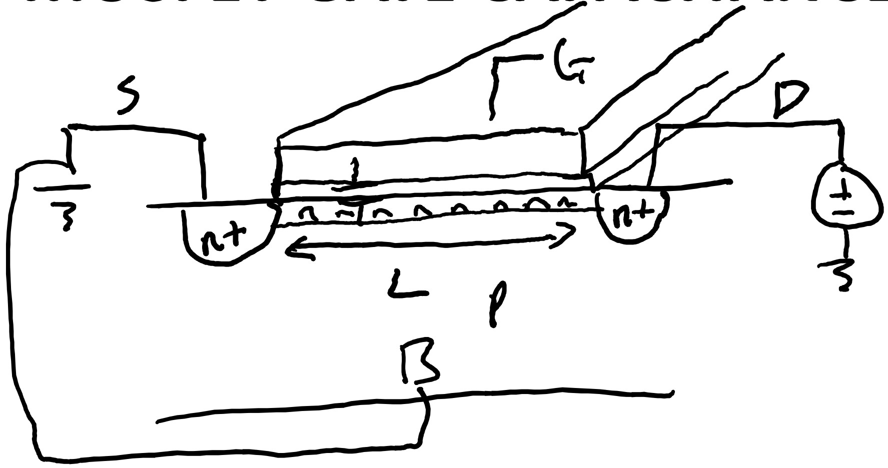




$C_1 \gg C_2$

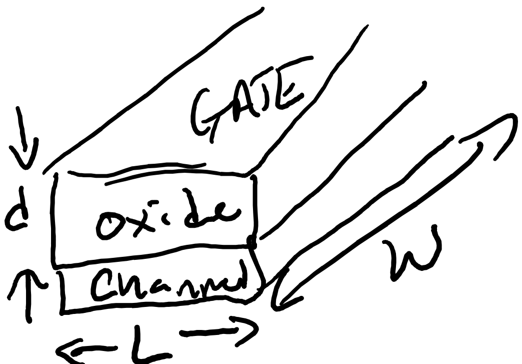
$C_{EQ} = C_2$

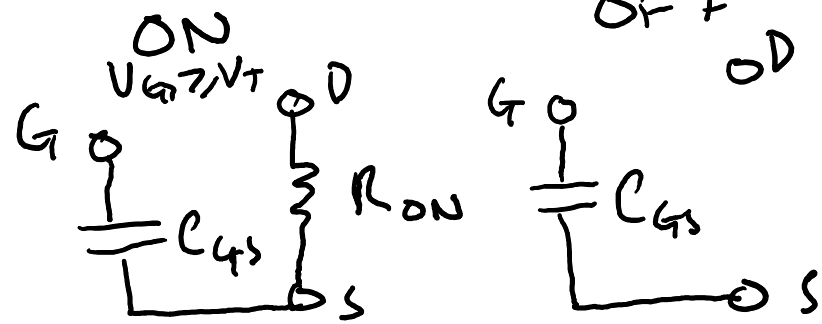
MOSFET GATE CAPACITANCE

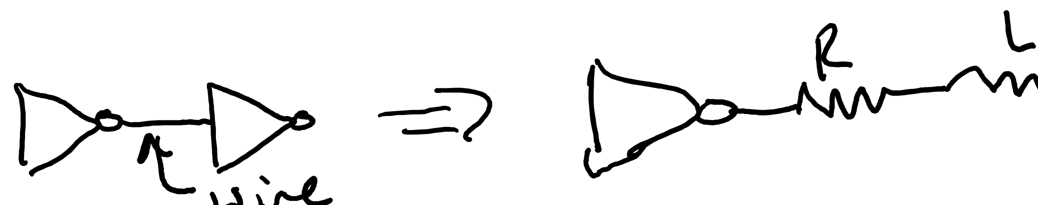


$$C_{GS} = \frac{\epsilon_{ox} L \cdot W}{d}$$

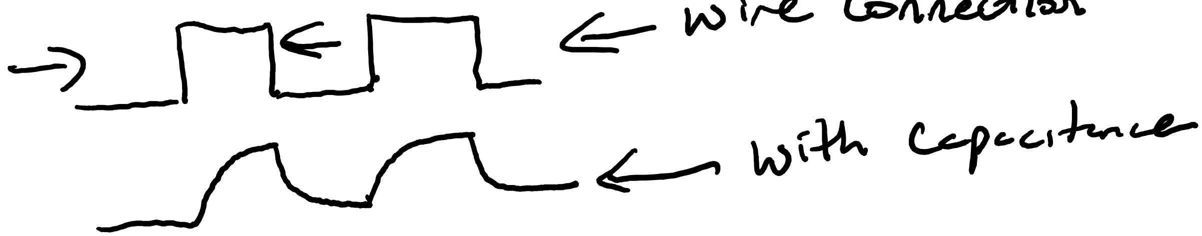
S - R



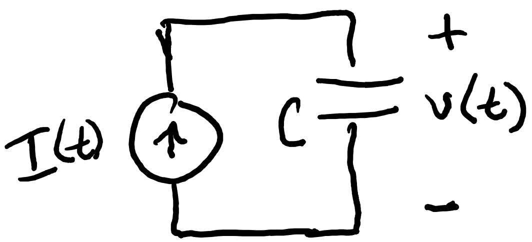




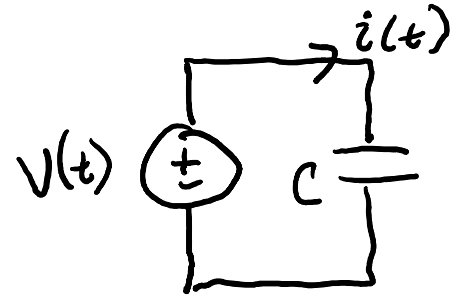
$$\boxed{i_G(t) = C_{GS} \frac{dV_{GS}(t)}{dt}}$$



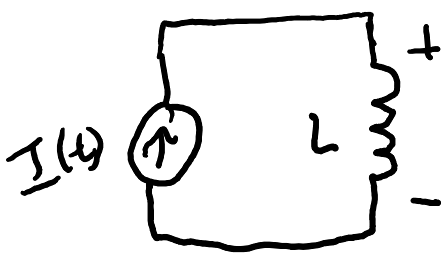
CAPACITOR & INDUCTOR RESPONSES



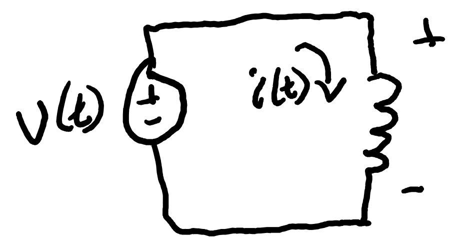
$$v(t) = \frac{1}{C}\int_0^t I(t)\,dt + V(t=0)$$



$$i(t) = C\frac{dV(t)}{dt}$$

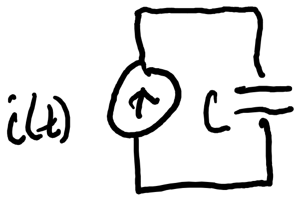


$$v(t) = L\frac{di(t)}{dt}$$



$$i(t) = \frac{1}{L}\int_0^t v(t)\,dt +$$

STEP INPUT

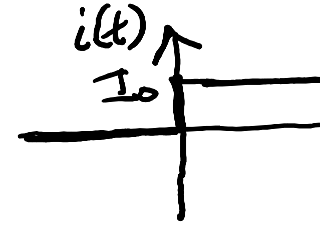


$$v(t) = \frac{1}{C}\int_0^t i(t)\,dt + V_0$$

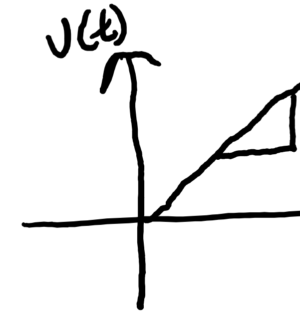
$$= \frac{1}{C}\int_0^t I_0\,dt + \cancel{V_0}^{=0}$$

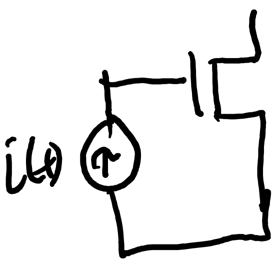
$$= \frac{I_0 t}{C}$$

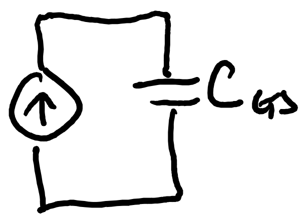
$$i(t) = \begin{cases} 0 & t \le 0 \\ I_0 & t > 0 \end{cases}$$



$$v(t) = \begin{cases} 0 & t \le 0 \\ \frac{I_0 t}{C} & t > 0 \end{cases}$$







V_{GS} $0 \rightarrow 5V$ in 10ns

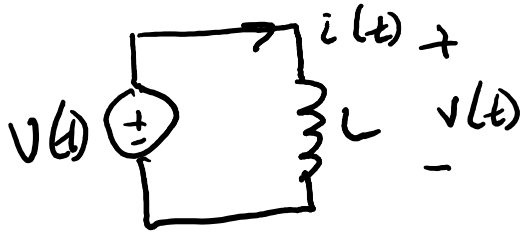
what current would be needed

$C_{GS} = 100\,fF = 100 \times 10^{-15} F$

$$v = \frac{I_0 t}{C} \Rightarrow I_0 = \frac{VC}{t} = \frac{5 \times 10\cancel{0} \times 10}{1\cancel{0} \times \cancel{10}}$$

$$\frac{\cancel{V}C}{\cancel{V}s}$$

VOLTAGE STEP FOR INDUCTOR

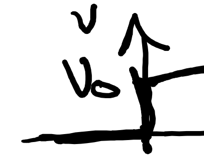


$$i(t) = \frac{1}{L}\int_0^t v(t)\,dt + I_0$$

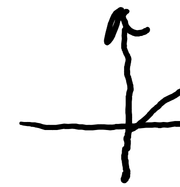
$$= \frac{1}{L}\int_0^t V_0\,dt + \cancel{I_0}^{\,0}$$

$$= \frac{V_0 t}{L}$$

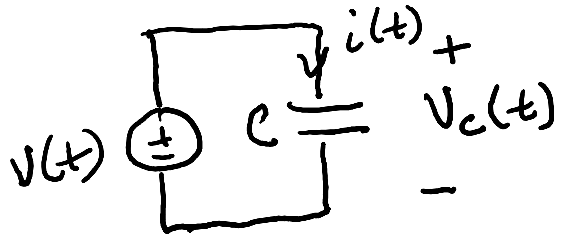
$$V(t) = \begin{cases} 0 & t \le 0 \\ V_0 & t > 0 \end{cases}$$

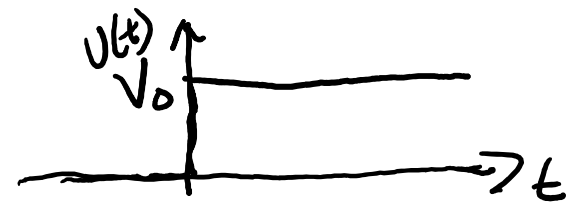


$$i(t) = \begin{cases} 0 & t \le 0 \\ \frac{V_0 t}{L} & t > 0 \end{cases}$$



UNIT STEP AND DELTA FUNCTIONS



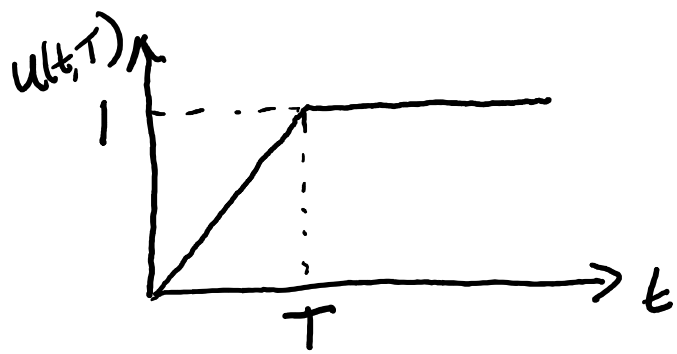


$$v(t) = \begin{cases} 0 & t \le 0 \\ V_0 & t > 0 \end{cases}$$

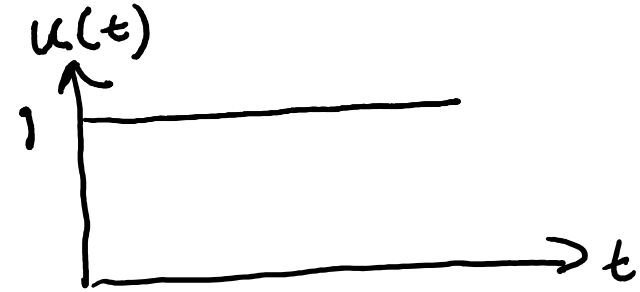
$i(t) = C\dfrac{dv(t)}{dt}$ what happens at $t = 0$?

DEFINE RAMPING UNIT STEP FUNCTION

$u(t,T)$ $t \rightarrow$ function of time; T is ramp duration

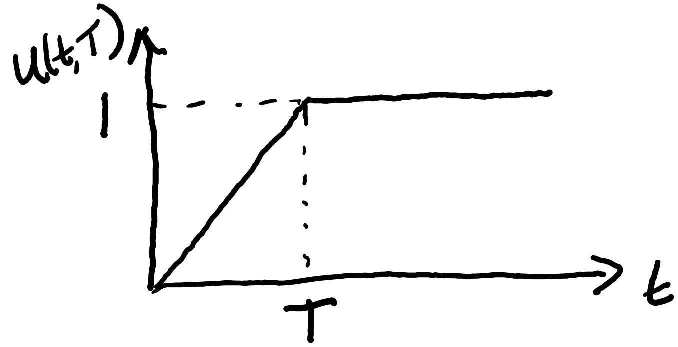


If $T \rightarrow 0$ $\Longrightarrow$

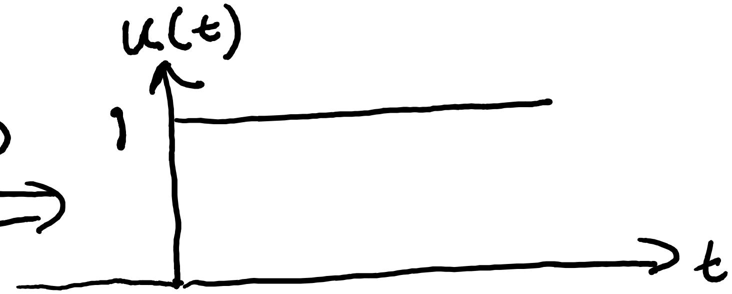


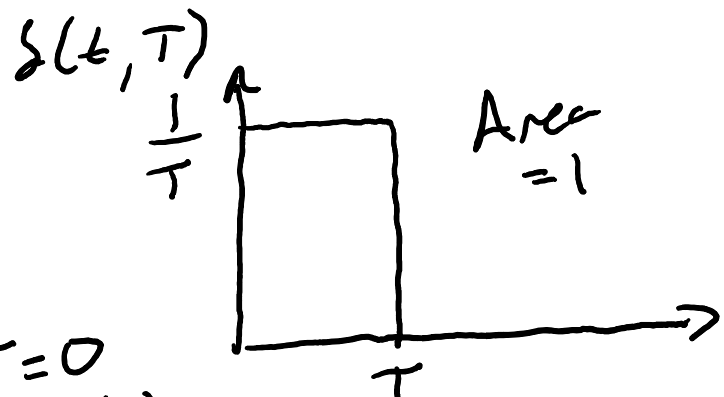
DEFINE RAMPING UNIT STEP FUNCTION

$u(t,T)$ $t \rightarrow$ function of time; T is ramp duration

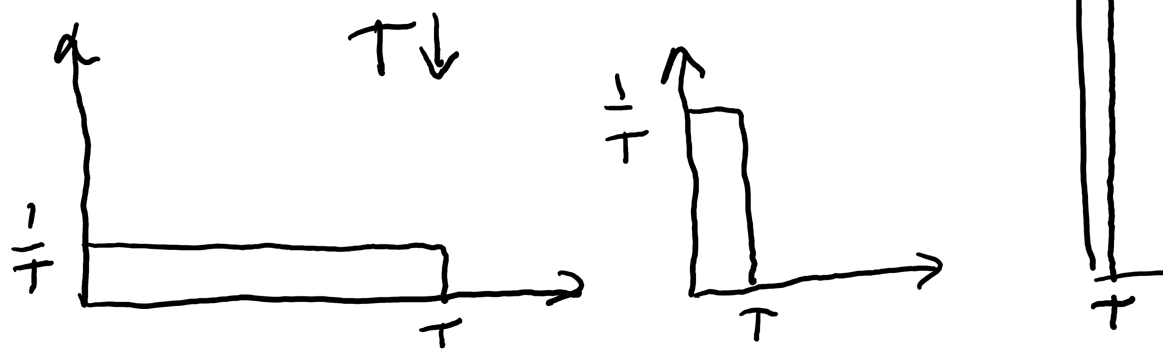


If $T \rightarrow 0$

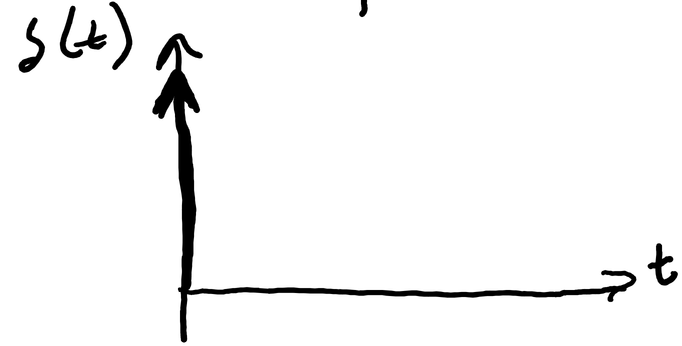




$T \downarrow$



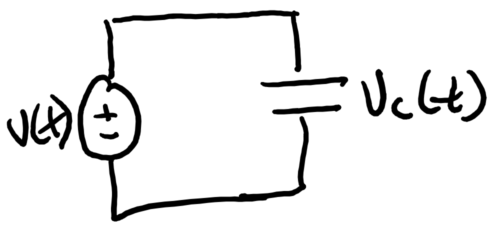
$T = 0$



$$\int_{-\infty}^{\infty} \delta(t)\,dt = 1 \qquad \int_{-\infty}^{t} \delta(t)\,dt = u(t) \Rightarrow \delta(t$$

BACK TO VOLTAGE STEP

$v(t) = V_0 u(t,T)$



$Q = CV$

$\frac{C}{V}$

$$i(t) = C\frac{dv}{dt}$$

$$= CV_0 \frac{du(t,T)}{dt}$$

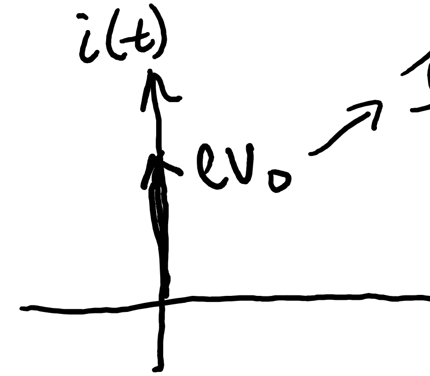
$$= CV_0 \delta(t,T)$$

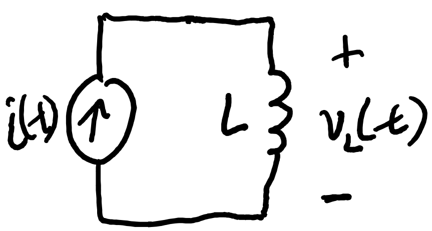
$$T = 0$$

$$i(t) = CV_0 \underbrace{\delta(t)}_{1/s}$$

$$\frac{C}{\cancel{V}} \cancel{V}$$

$\delta(t,T) = $





$$i(t) = I_0 u(t)$$

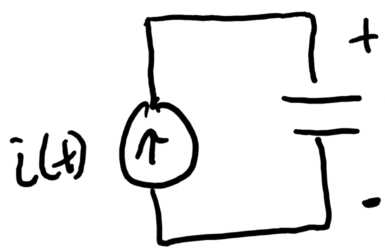
$$V_L(t) = L\frac{di}{dt} = L I_0 \frac{du(t)}{dt} = L I_0 \delta(t)$$

$u(t - t_1)$

IMPULSE INPUT

$$i(t) = Q\,\delta(t) \quad \left[\frac{\text{charge}}{\text{time}}\right]$$

$t > 0$



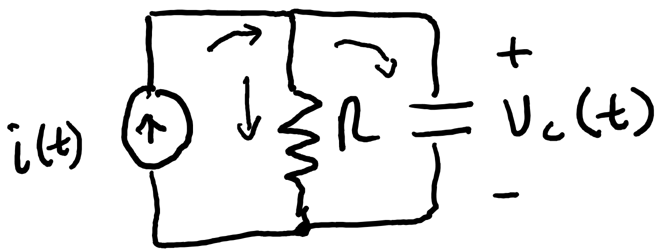
$$v(t) = \frac{1}{C}\int_{-\infty}^{t} i(t)\,dt = \frac{1}{C}\int_{-\infty}^{t} Q\,\delta(t)\,dt = \frac{Q}{C}\underbrace{\int_{-\infty}^{t} \delta(t)\,dt}_{1}$$

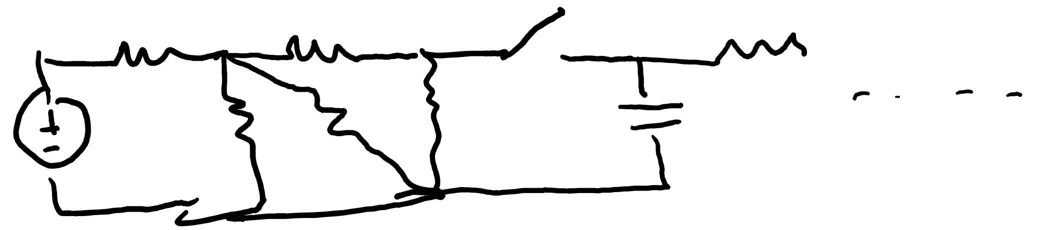
$$v(t) = \frac{Q}{C}u(t)$$

instantaneous voltage jump to $\frac{Q}{C}$ at

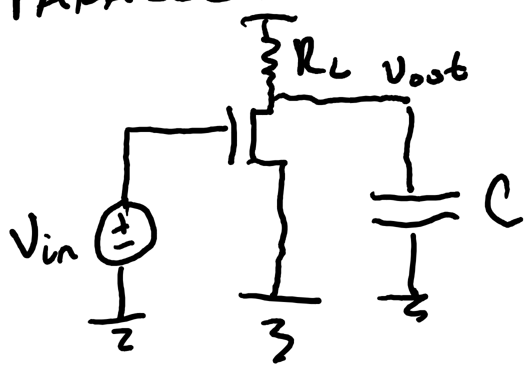
CHAP 10: FIRST ORDER TRANSIENTS

ONE ENERGY STORAGE ELEMENT → L, C





PARALLEL RC → SIMPLIFY COMPLICATED CKT INTO NORTON/

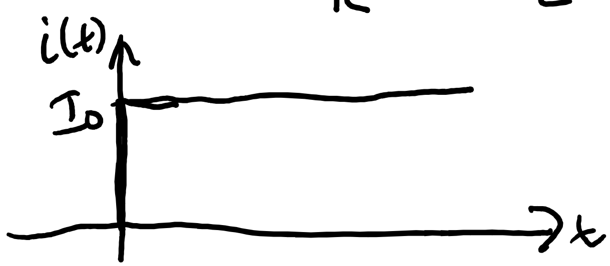


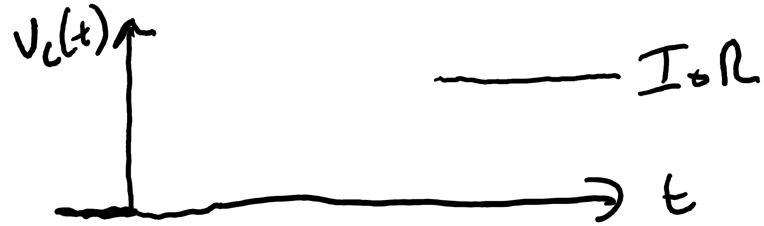
$A = \frac{V_{out}}{V_{in}}$

STEP INPUT → $i(t) = I_o u(t)$

$$i(t) = \frac{V_c}{R} + C\frac{dV_c}{dt} \Rightarrow \frac{dV_c}{dt} + \frac{V_c}{RC} = \frac{i(t)}{C}$$

Inhomogeneous Diff Equation





$$\frac{dv_c}{dt} + \frac{v_c}{RC} = \frac{i(t)}{C}$$

METHOD OF HOMOGENEOUS & PAR
SO

NATURAL RESPONSE → 1) FIND HOMOGEN SOLUTION

FORCED OR DRIVEN RESPONSE → 2) FIND PARTICULAR SOLUTION

3) TOTAL SOLUTION $= v_{cH} + v_{cP}$

① $$\frac{dv_{cH}}{dt} + \frac{v_{cH}}{RC} = 0$$

driving function set to zero

$$v_{cH} = Ae^{st}$$

$$\cancel{A}s\cancel{e^{st}} + \frac{\cancel{Ae^{st}}}{RC} = 0$$

$$s = -\frac{1}{RC}$$

RC = Time constant = τ