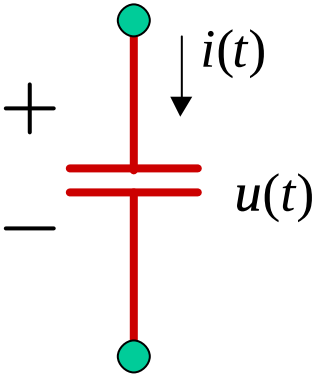
0.8 被動積分與微分器 ---RC電路的暫態分析

利用電容設計積分器與微分器



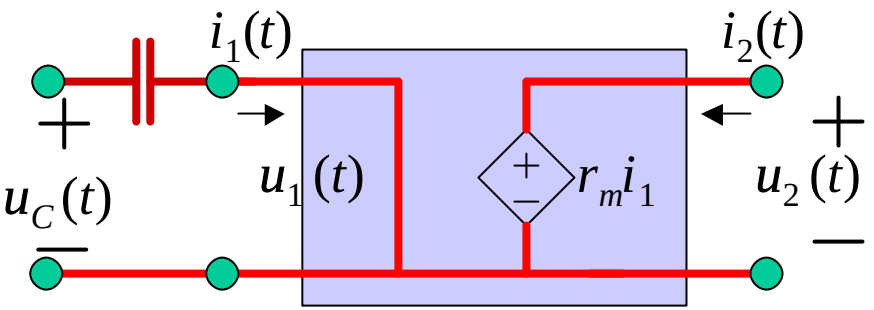
$$i = C\frac{du}{dt} \qquad u = \frac{1}{C}\int_{t_0}^{t} i\,dt + u(t_0)$$

電壓訊號的微分為電流訊號

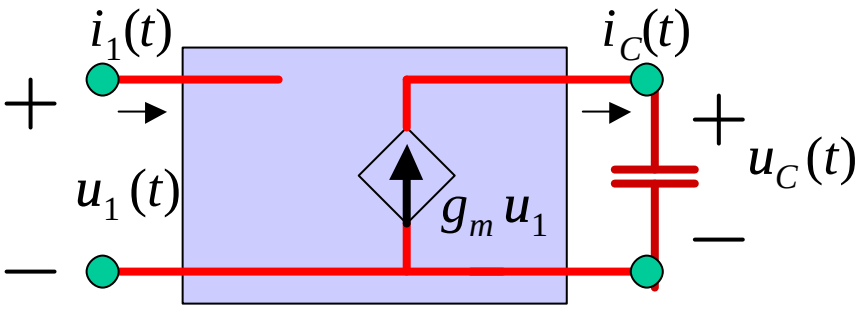
若希望微分的輸出為電壓訊號，必須加上一電流到電壓的轉換電路CCVS。

電流訊號的積分為電壓訊號

若希望積分的輸入為電壓訊號，必須加上一電壓到電流的轉換電路VCCS。

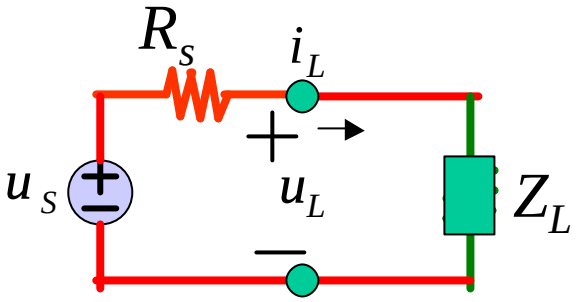


微分器



積分器

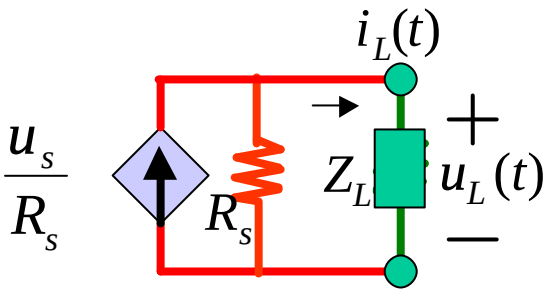
最簡易的VCCS與CCVS

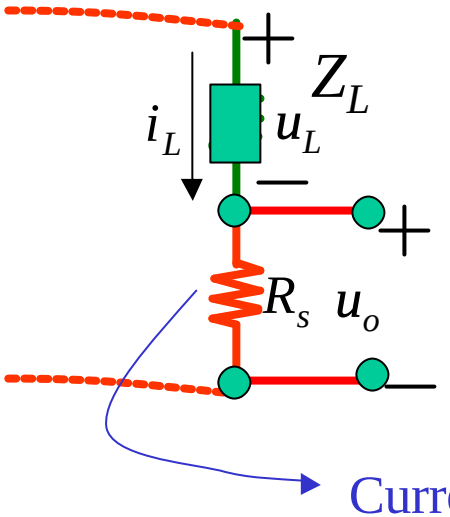


只要$|u_L| << |u_S|$，**或**$|Z_L| << R_s$，$i_L \approx \dfrac{u_s}{R_s}$

可用作VCCS

等效電路為

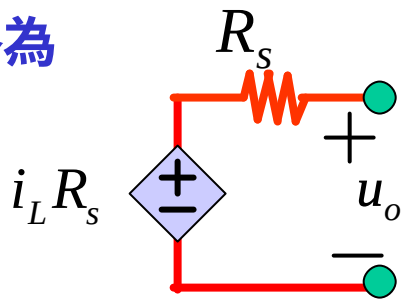




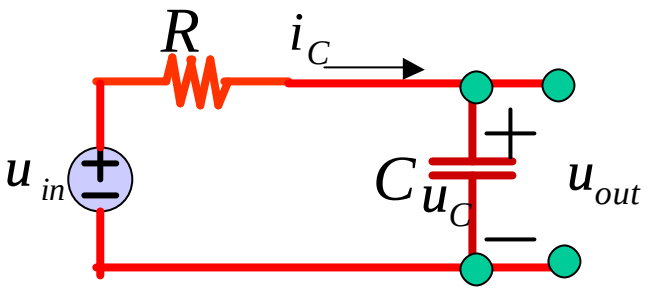
只要$|u_L >> |u_o|$，**或**$|Z_L| >> R_s$，$u_o = i_L R_s$

可用作CCVS

等效電路為



被動積分器



$$u_{out} = \frac{1}{C}\int_{t_0}^{t} i_C dt + u_C(t_0)$$

$$= \frac{1}{C}\int_{t_0}^{t} \frac{u_{in} - u_{out}}{R} dt + u_C(t_0)$$

$$u_{out} \approx \frac{1}{RC}\int_{t_0}^{t} u_{in} dt + \text{const.}$$

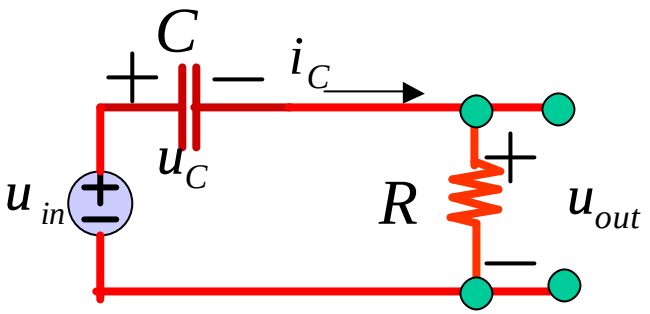
條件：

$$|u_{in}| >> |u_{out}|$$

$$wRC >> 1$$

$$|u_{out}| \approx \left|\frac{1}{RC}\int_{t_0}^{t} u_{in} dt\right| \sim \left|\frac{u_{in}}{wRC}\right| << |u_{in}|$$

被動微分器



$$u_{out} = i_C R = RC\frac{du_C}{dt} = RC\frac{d(u_{in} - u_{out})}{dt}$$

$$u_{out} \approx RC\frac{du_{in}}{dt}$$

條件：

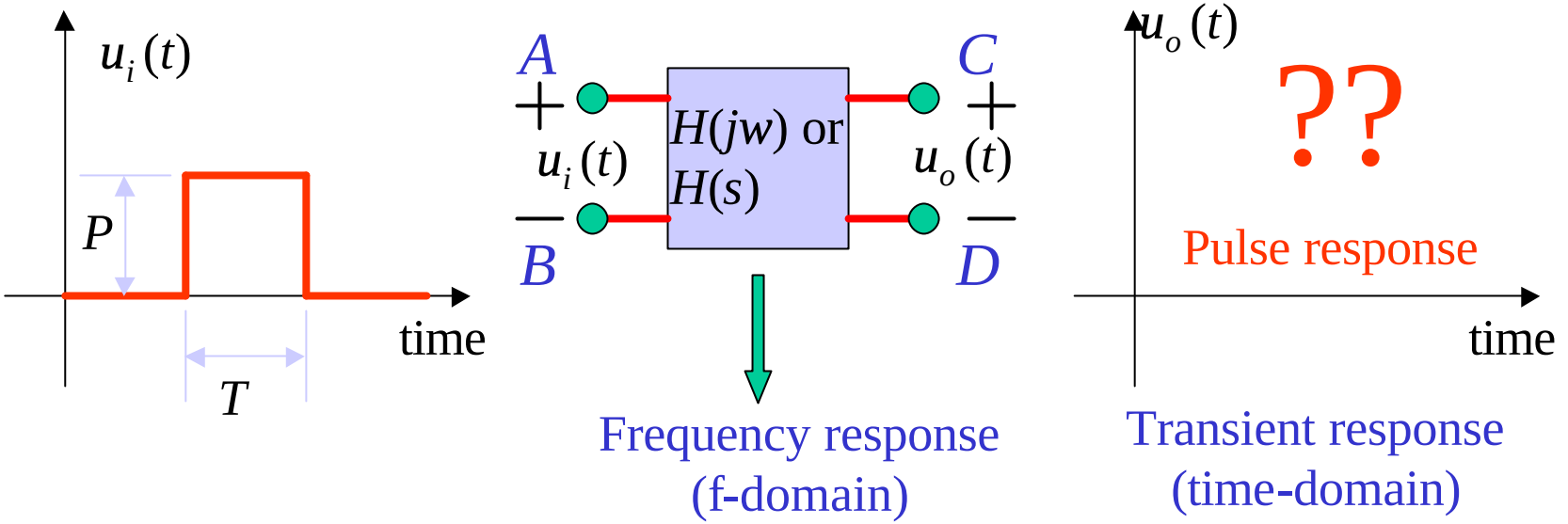
$$|u_{in}| >> |u_{out}|$$

$$wRC << 1$$

$$|u_{out}| \approx \left|RC\frac{du_{in}}{dt}\right| \sim |wRCu_{in}| << |u_{in}|$$

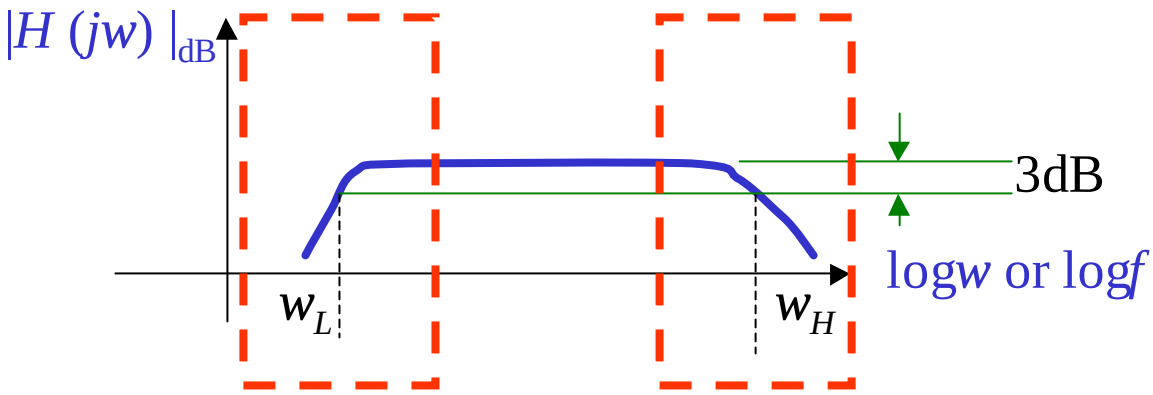
脈衝響應（Pulse Response)

---方波測試



為何使用方波來測試？？

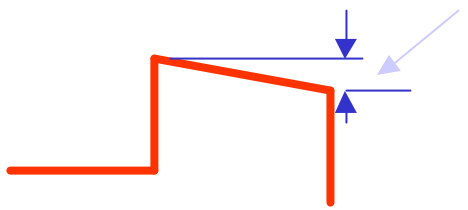
方波訊號包括了快速變化的部分，含有高頻的訊息；也包括維持不動的部分，含有低頻的訊息。輸入方波到系統中，觀察輸出重現的程度，即可得到系統的頻率特性。



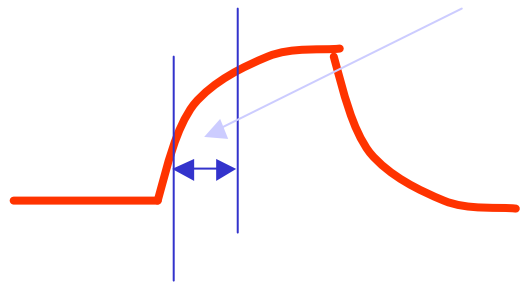
此部分行為和一個高通率波器類似，其脈衝響應也和高通率波器類似

此部分行為和一個低通率波器類似，其脈衝響應也和低通率波器類似

w_L ⟺ Fractional sag

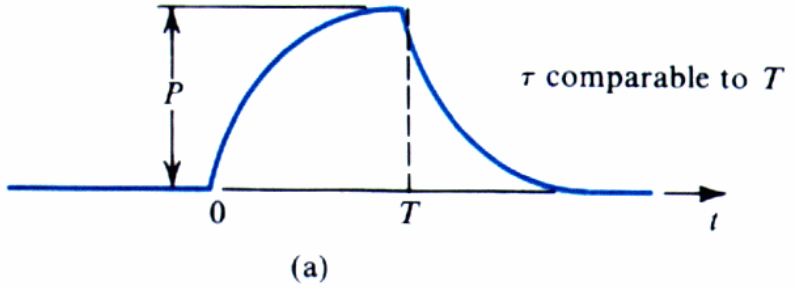


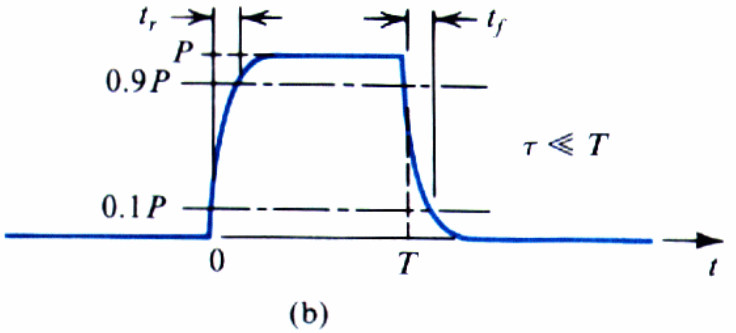
w_H ⟺ Rise time t_r

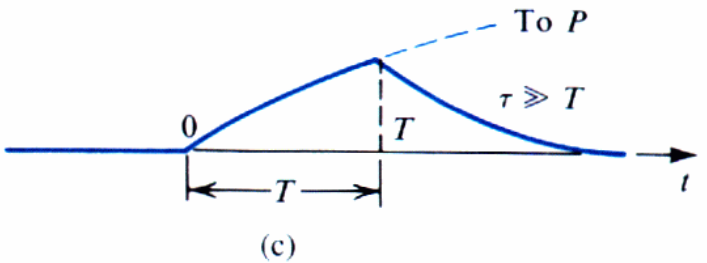


脈衝響應與STC網路之RC時間常數的關係

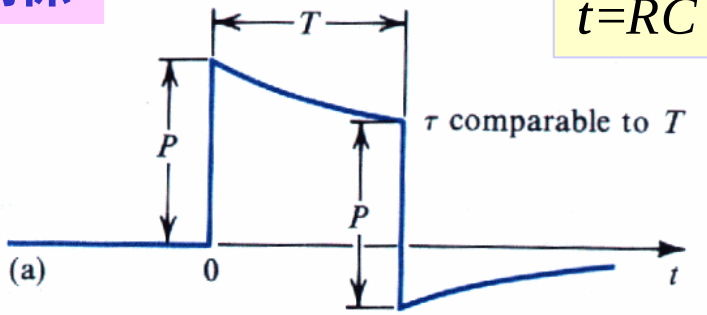
$t=RC$

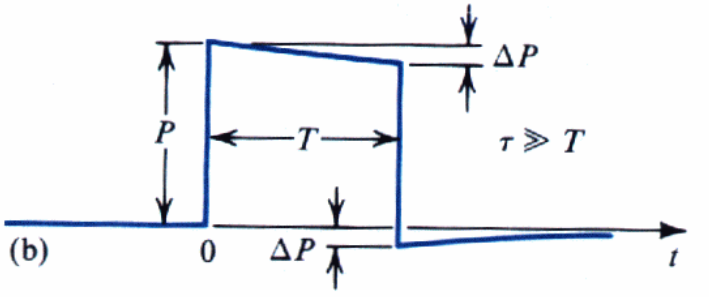


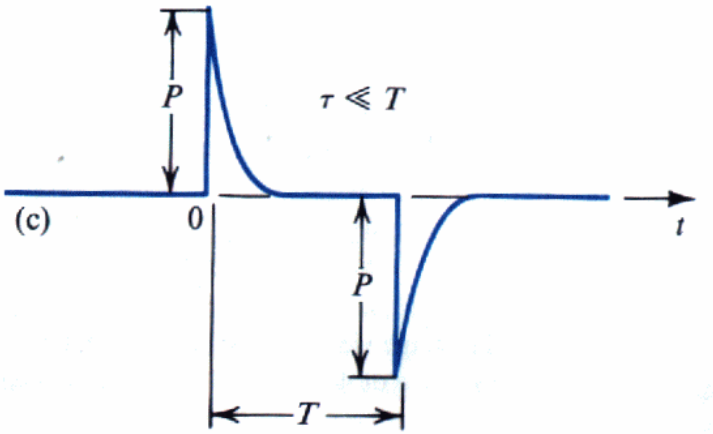




Low-pass STC network

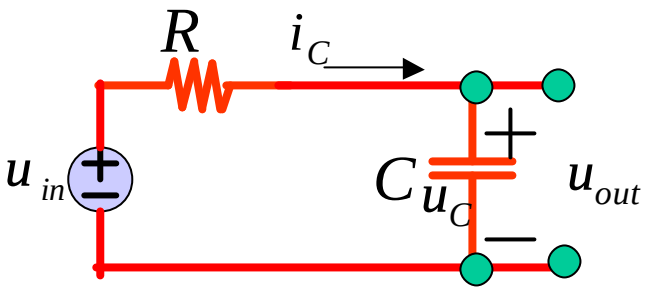


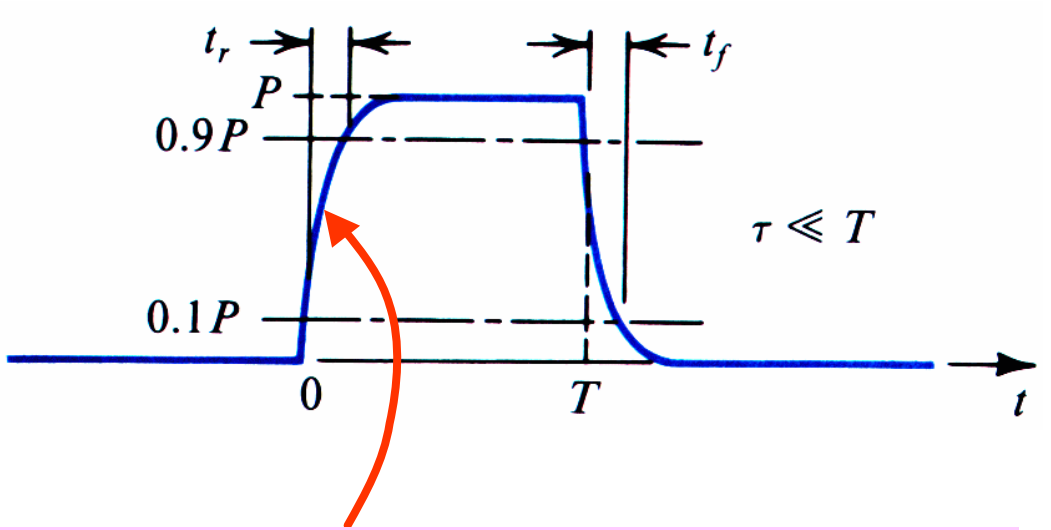




High-pass STC network

w_H與Rise time t_r



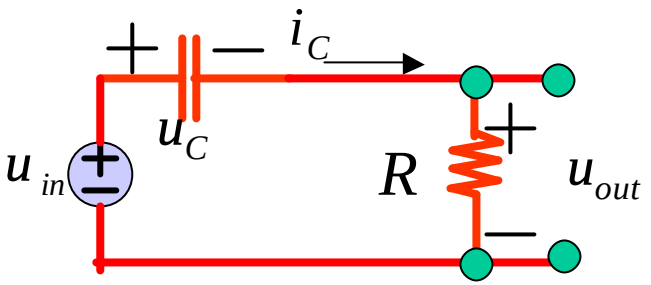


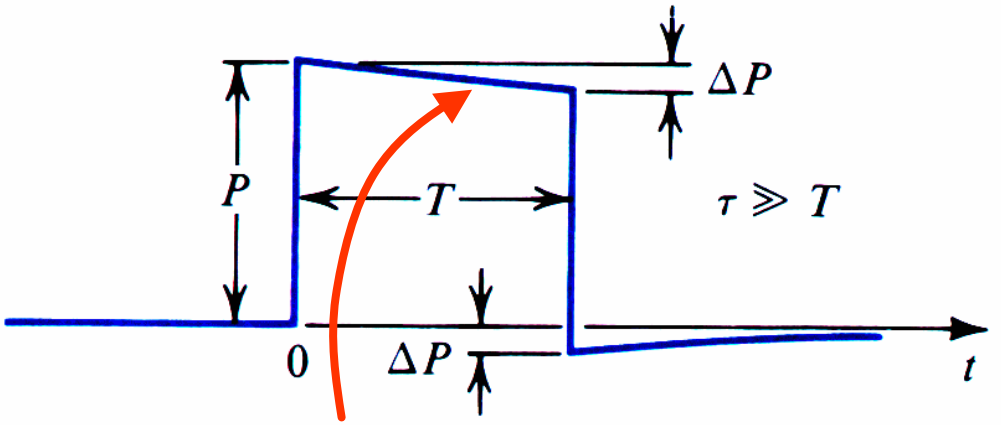
$$u_{out}(t) = P(1-e^{-t/t}) = P(1-e^{-w_H t})$$

$$t_r = \frac{2.2}{w_H} = \frac{0.35}{f_H} = 2.2RC$$

高頻限制（or有限頻寬）↔輸出變化需要時間（不能太快）

w_L與Fractional sag





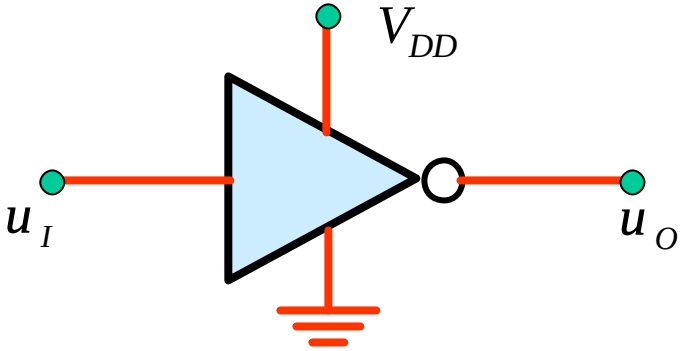
$$u_{out}(t) = Pe^{-t/t} = Pe^{-w_L t}$$

$$\text{fractional sag} = \frac{\Delta P}{P} = 1 - e^{-w_L T} \qquad \text{if } w_L T << 1$$

$$= 1 - [1 - w_L T + (w_L T)^2 - \cdots] \approx w_L T$$

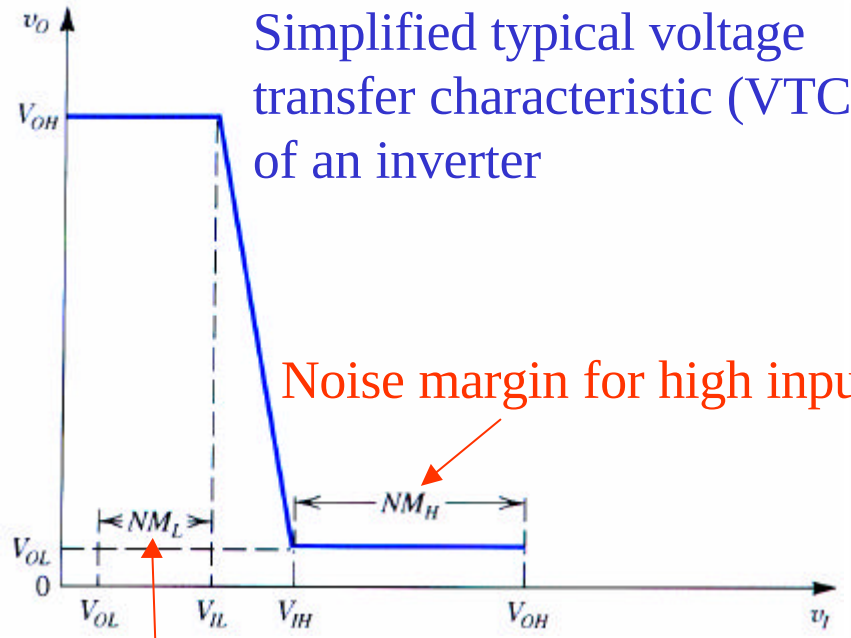
低頻限制（or直流不能通過）↔無法維持直流（or低頻）成分

數位邏輯閘之傳遞延遲時間(propagation delay)



Inverter **反相器（反閘）** NOT

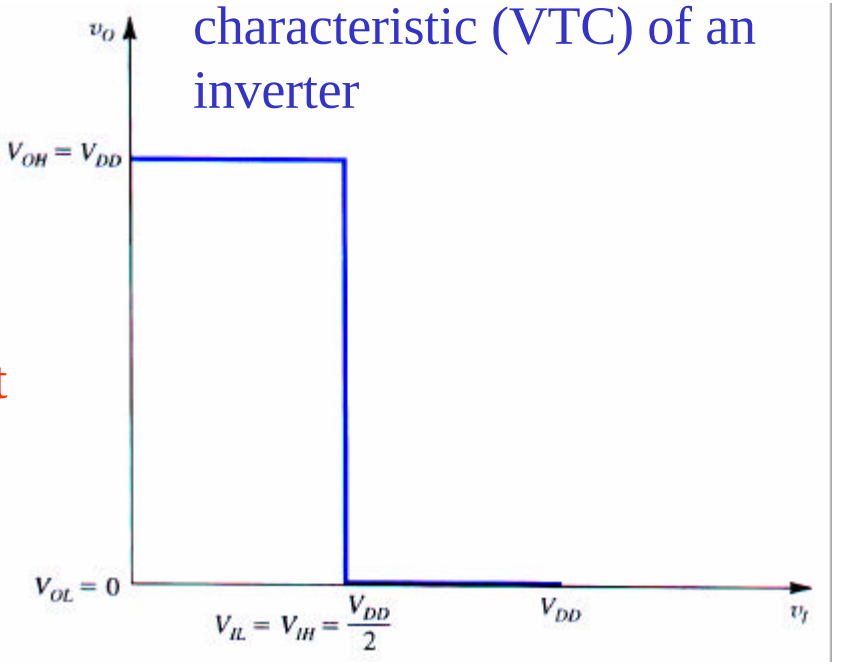
Simplified typical voltage transfer characteristic (VTC) of an inverter

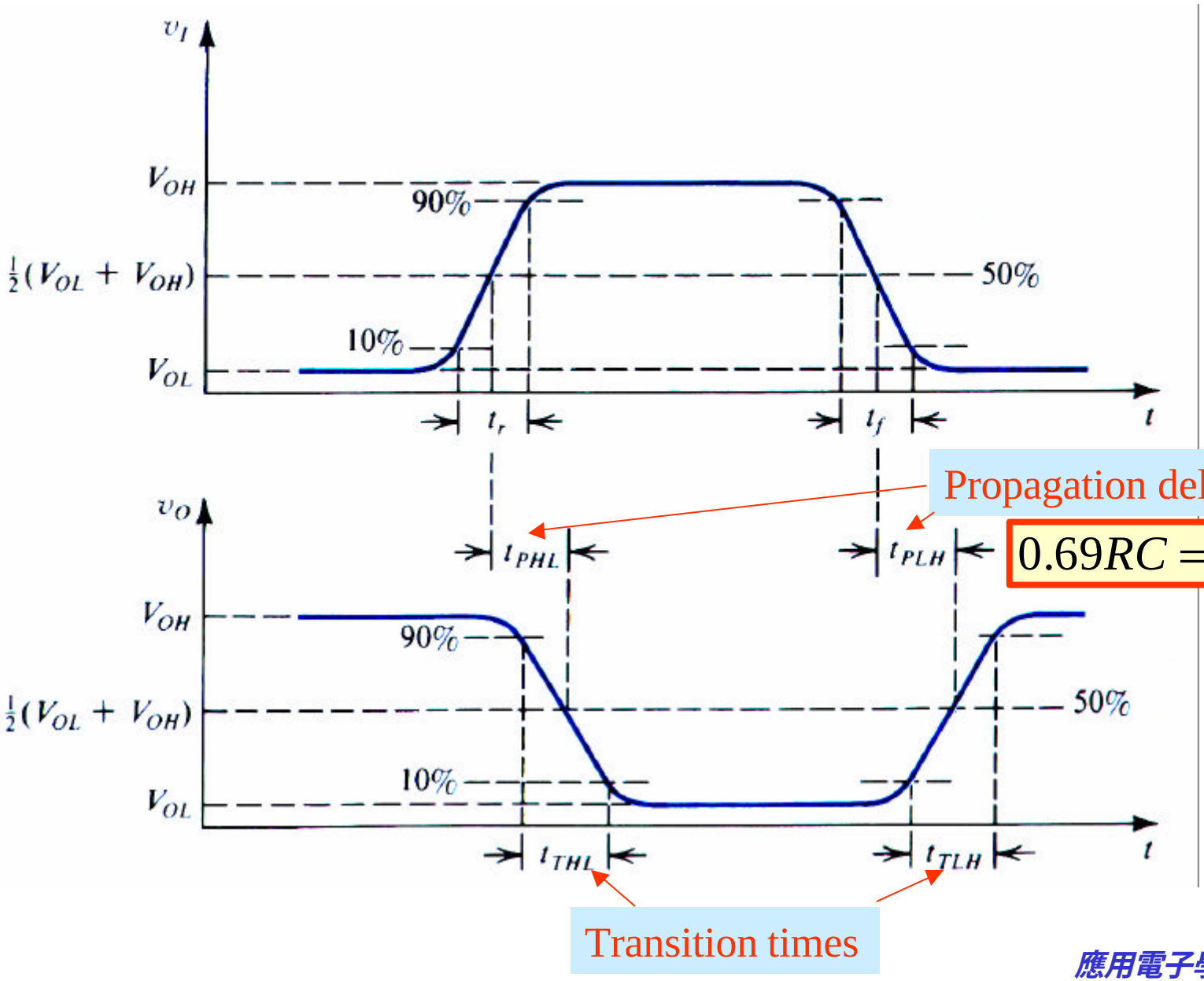


Noise margin for high input

Noise margin for low input

Ideal voltage transfer characteristic (VTC) of an inverter




v_I
V_{OH}
90%
$\frac{1}{2}(V_{OL} + V_{OH})$
50%
10%
V_{OL}
t_r
t_f
t
Propagation delays
t_{PHL}
t_{PLH}
$0.69RC = 0.69t$
v_O
V_{OH}
90%
$\frac{1}{2}(V_{OL} + V_{OH})$
50%
10%
V_{OL}
t_{THL}
t_{TLH}
t
Transition times