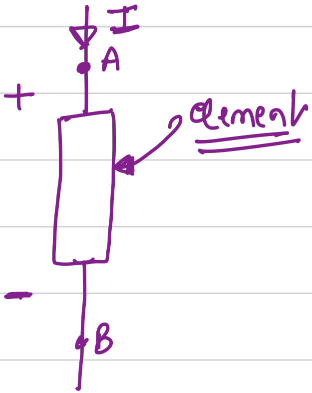
# Lecture 4

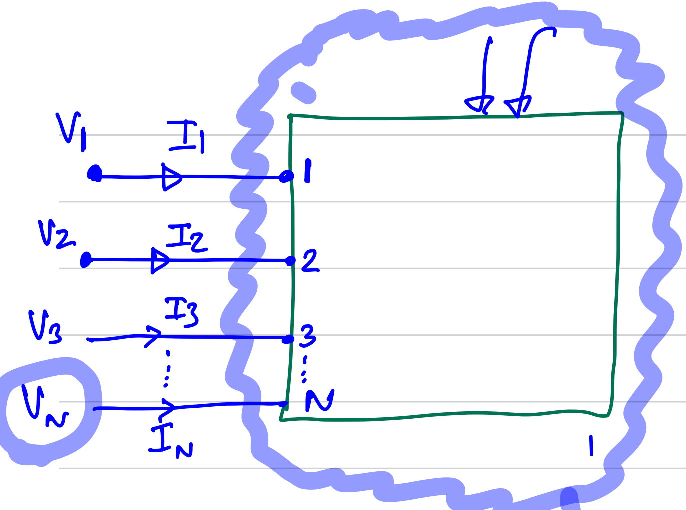



$P = VI = V(t)I(t) \rightarrow p(t)$

$P > 0$ "absorbing"

$P < 0$ "delivering power" Watts.

$$E = \int_{t_1}^{t_2} p(t)\,dt \text{ Joules}$$




surface

$$P = \sum_{k=1}^{N} V_k I_k \qquad \text{"p"}$$

$$P = V_1 I_1 + V_2 I_2 + \dots V_N I_N$$

$$I_1 + I_2 + \dots I_N = 0$$

$$I_N = -(I_1 + I_2 + \dots I_{N-1})$$

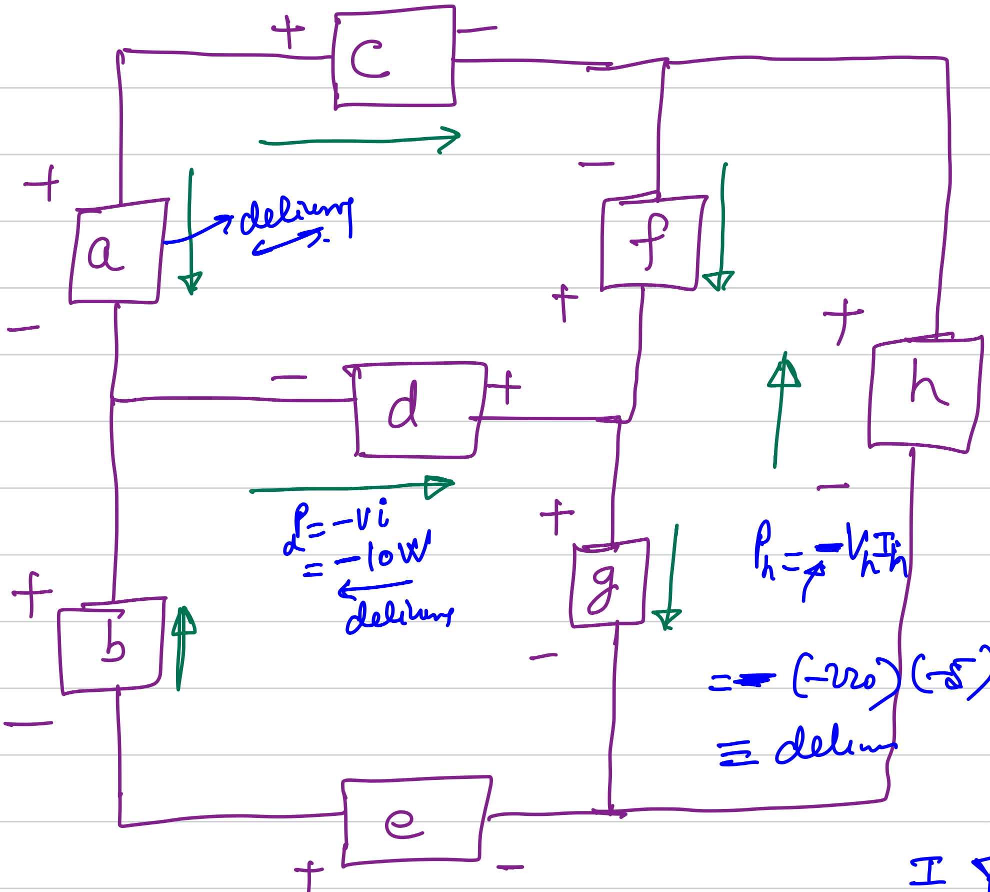
$$V_{AB} = (V_A - V_B)$$

$$V_{BA} = -V_{AB}$$

$$P = V_1 I_1 + V_2 I_2 + \dots + V_N(-I_1 - I_2 \dots - I_{N-1})$$

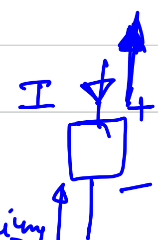
$$P = (V_1 - V_N) I_1 + (V_2 - V_N) I_2 + \dots (V_{N-1} - V_N) I_{N-1}$$

$$P = V_{1N} I_1 + V_{2N} I_2 + \dots V_{N-1\,N} I_{N-1}$$




| | V | I |
|---|---|---|
| a | 120 | −10 |
| b | 120 | 9 |
| c | 10 | 10 |
| d | 10 | 1 |
| e | −10 | −9 |
| f | −100 | −5 |
| g | 120 | 4 |
| h | −220 | −5 |

$P_a = +vi$
$= 120 \times (-10)$
$= -120W$ delivery




$P = +vi$
$= -vi$

$V = iR$

# Resistor

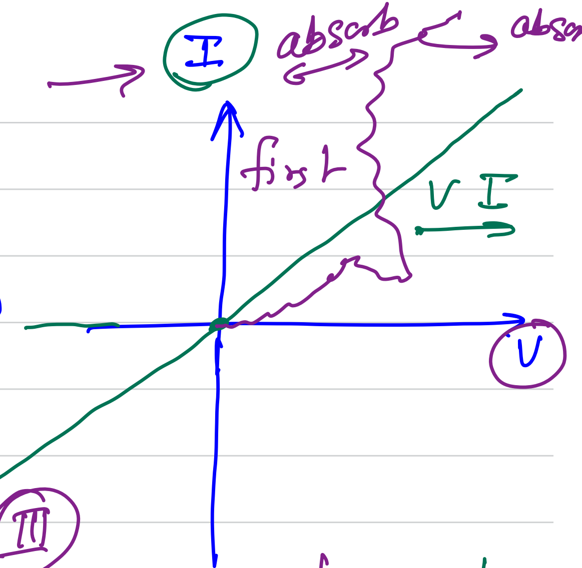
$\boxed{P = VI}$

$= i^2 R$

$= \frac{v^2}{R} \rightarrow -ve$

$p(t) = V(t)\, I(t)$

$= I^2(t) R,\ \frac{v^2(t)}{R}$



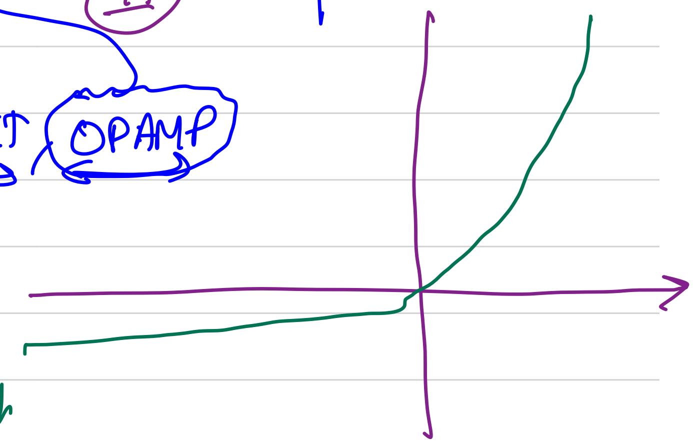

$R$ $\quad -R$ $\quad$ III

BJT, MOSFET $\quad$ OPAMP

R, L, C $\quad$ diode

$E = \int p(t)\,dt = \int_{t_1}^{t_2} \frac{V^2(t)}{R}\,dt$

$= \frac{V^2}{R} \int_{t_1}^{t_2} dt$



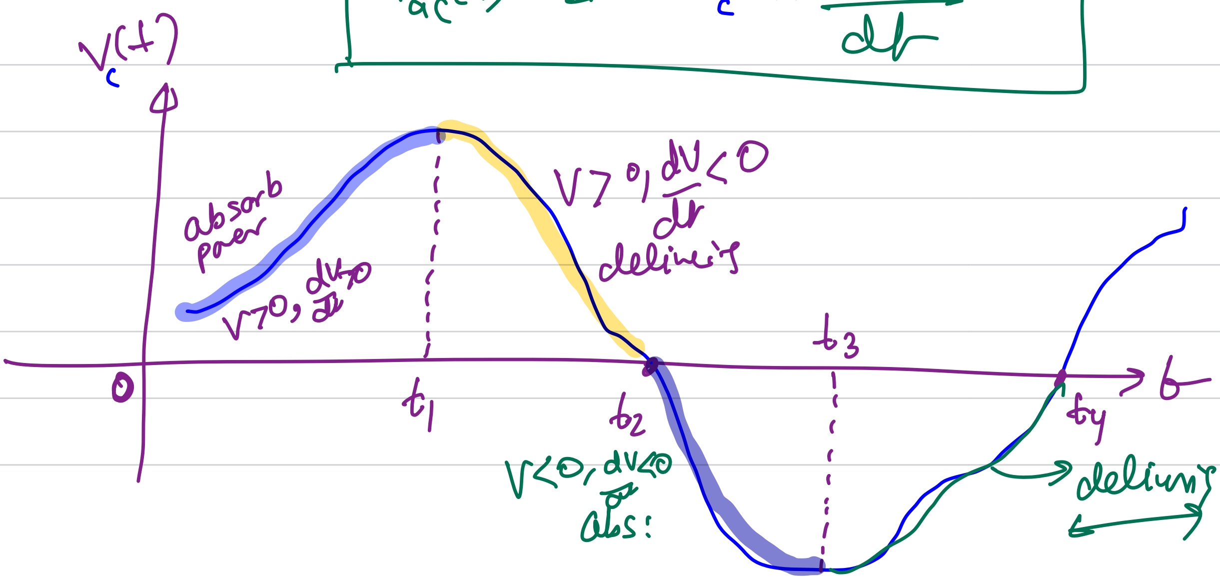
# Capacitors

$P_{dc} = VI$

$P_{ac}(t) = V(t)\, I(t)$

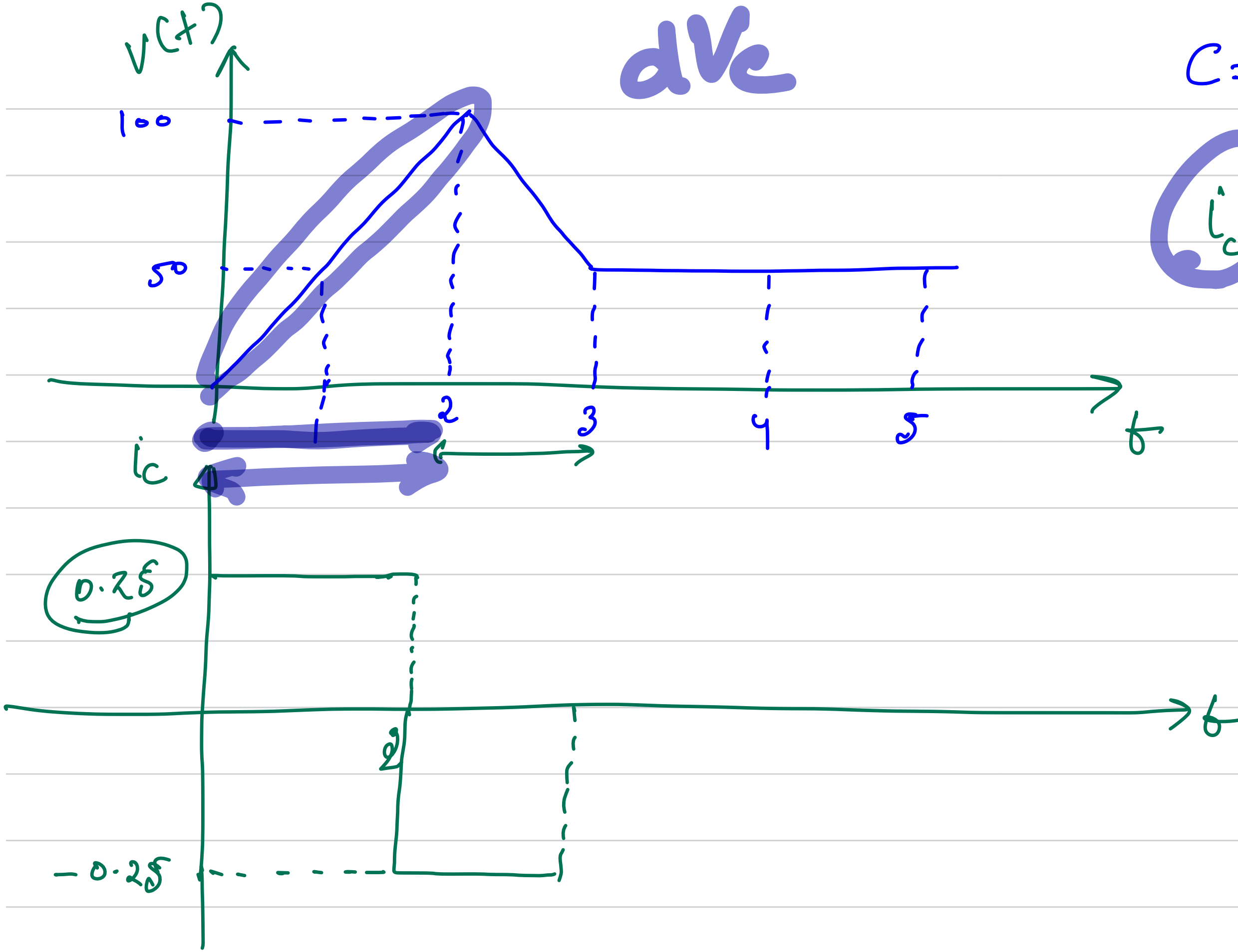
$I(t) = C \dfrac{dV(t)}{dt}$

$$\boxed{P_{ac}(t) = C\, V_c(t) \frac{d V_c(t)}{dt}}$$



$C = 5mF$

$$i_c = C\frac{dV_c}{dt} = \frac{100 \times 5mF}{2}$$

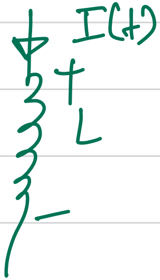


$$E_{cap} = \int_{t_0}^{t_1} p(t)\,dt = \int_{t_0}^{t_1} V_c(t)\, I_c(t)\,dt$$

$$= C\int_{t_0}^{t_1} V_c(t)\,\frac{dV_c(t)}{dt}\cdot dt = C\int_{t_0}^{t_1} V_c(t)\,dV_c(t)$$

$$E_{cap} = \frac{C}{2}\,V_c^2(t)\Big|_{t_0}^{t_1} = \frac{C}{2}\left[V_c^2(t_1) - V_c^2(t_0)\right]$$

Inductor.




$$\boxed{E(t) = \int_{t_0}^{t} L\, I(t) \frac{dI(t)}{dt} \cdot dt}$$

$$V_L = L \frac{dI}{dt}$$

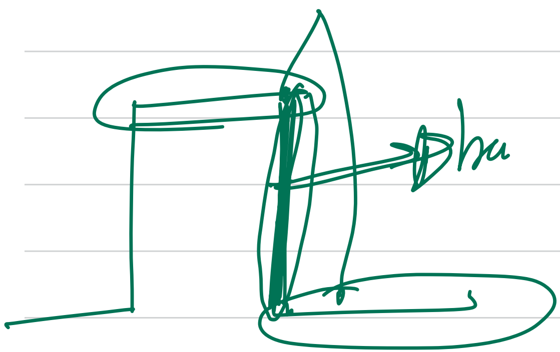
$$P = VI$$

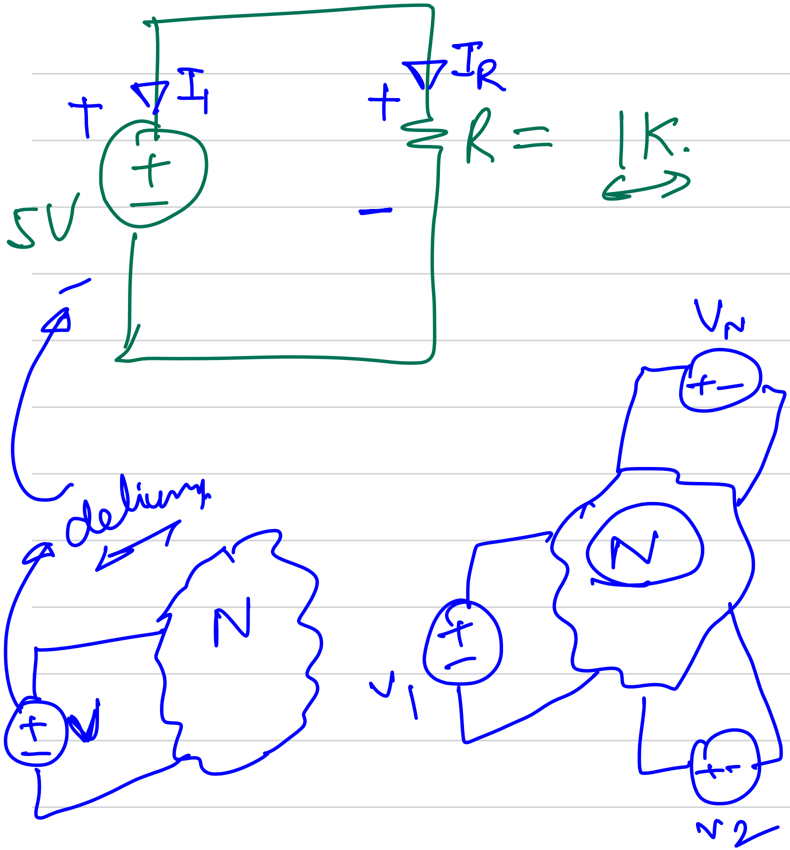
$$I(t) > 0, \quad \frac{dI(t)}{dt} > 0$$

abs power

$> 0$ $< 0$

Energy/Power for voltage source



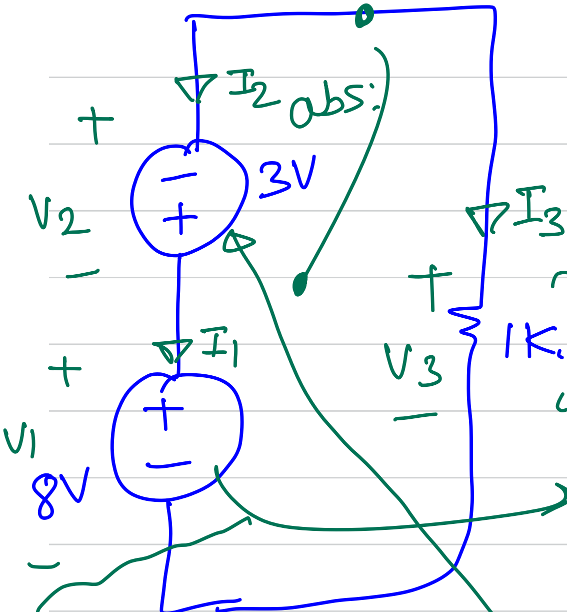

$$I_1 = -I_R$$

$$I_R = \frac{5}{1K} = 5mA$$

$$V_R = 5V$$

$$P_R = 5 \times 5 = 25mW$$

$$P_{5V} = -5m \times 5 = 25mW$$




$8-3=5V \quad I_1 = I_2 = -I_3$

KVL

$V_3 = 5V$

abs.

$P_{Resi} = \frac{5 \cdot 5}{1K} = 25mW$

delivery

power.

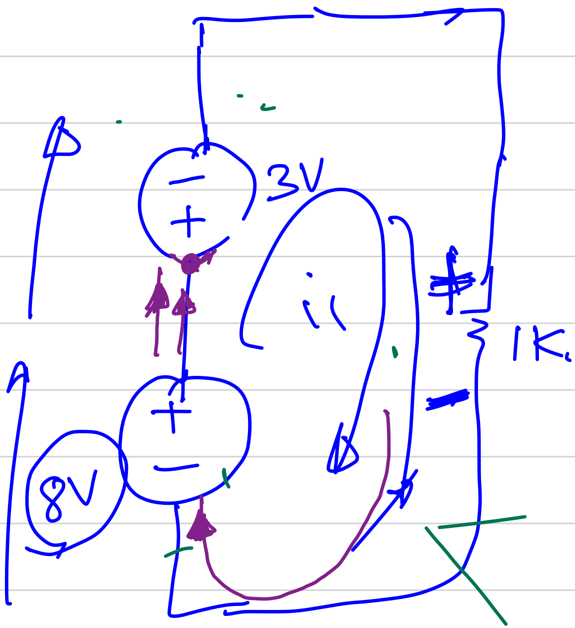
$P_{8V} = V_1 I_1$

delivery

$P_{8V} = -8 \times 5mA = -40mW$

$(V_2 = -3V)$

$P_{3V} = V_2 I_2 = (-3)(-5mA) = 15mW$




$$8-3-1k \times i = 0$$

$$i = 5mA$$

$$P = -vi = -$$

$$+vi = 3 \times 5$$

P abs: