電力電子的基礎理論

Ten Fundamental Principles of Power Electronics

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2008年1月1日

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Ten Fundamental Principles of Power Electronics

William E. Newell: Ten Cornerstones of Power Electronics

William E. Newell and John W. Mottor Jr., **Introduction to Solid State Power Electronics**, Youngwood: Westinghouse Electric Corporation, 1977.

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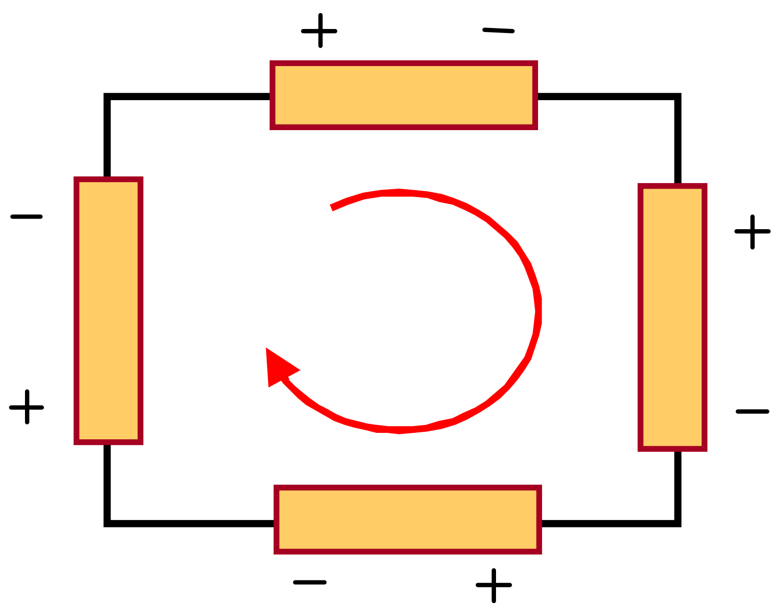
Ten Fundamental Principles of Power Electronics

1. Kirchhoff's Voltage Law
2. Kirchhoff's Current Law
3. Ohm's Law $V=iR$
4. $i=Cdv/dt$
5. $v=Ldi/dt$
6. Average voltage across an inductor over a full cycle in steady-state is zero.
7. Average current through a capacitor over a full cycle in steady-state is zero.
8. Average Value and Root-Mean-Square
9. Instantaneous Power and Average Power
10. Harmonic Analysis of PWM Waveforms

1 Kirchhoff's Voltage Law

The oriented sum of all voltages (efforts) around any closed loop is zero.



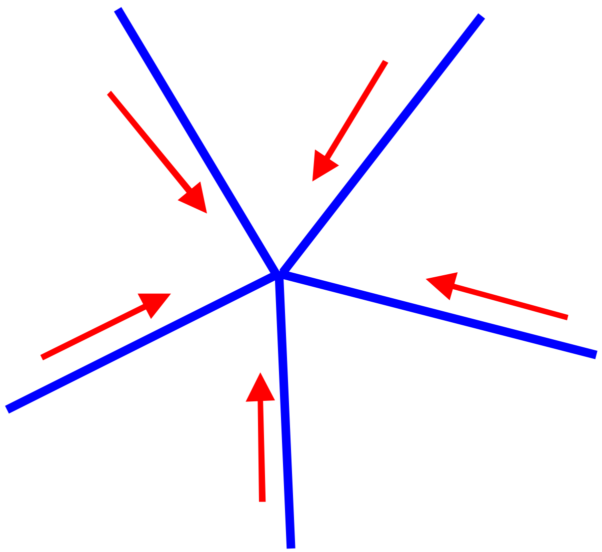
$$\sum_{i=1}^{N} v_i(t) = 0$$

Note : In Assumption of Lumped Circuit

Kirchhoff's Current Law

2 Kirchhoff’s Current Law

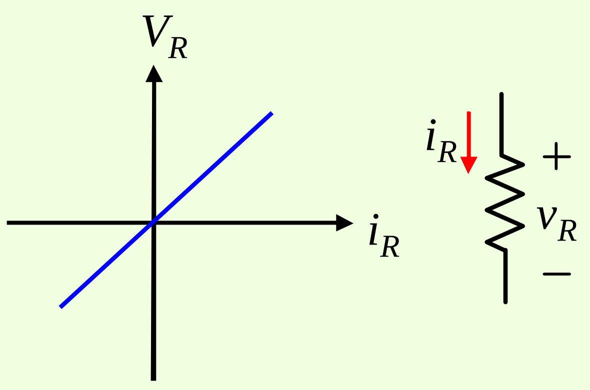
The sum of all currents (flow) entering a node is zero.



$$\sum_{i=1}^{N} I_i(t) = 0$$

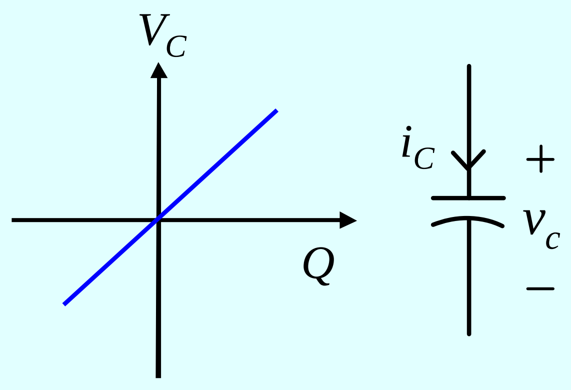
Note : In Assumption of Lumped Circuit

3-5 Resistor, Capacitor, and Inductor



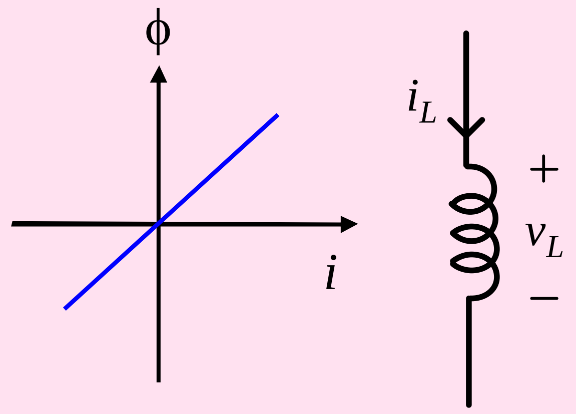
(a)

$$V = RI$$



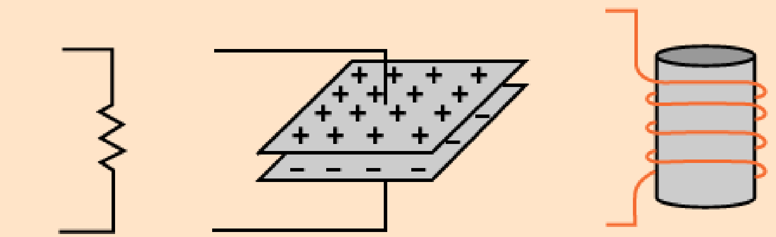
(b)

$$V = \frac{1}{C}Q$$



(c)

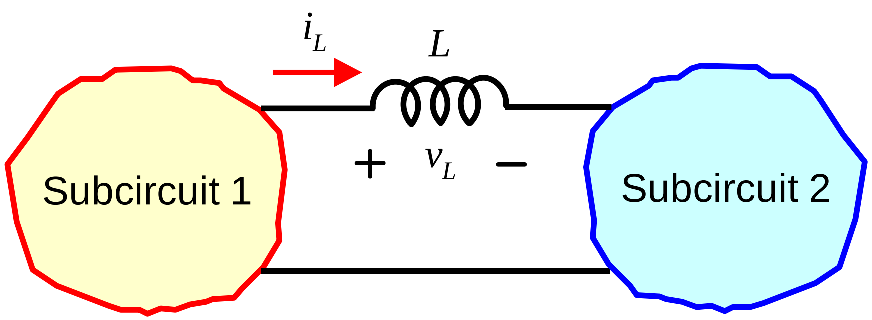
$$\lambda = LI$$



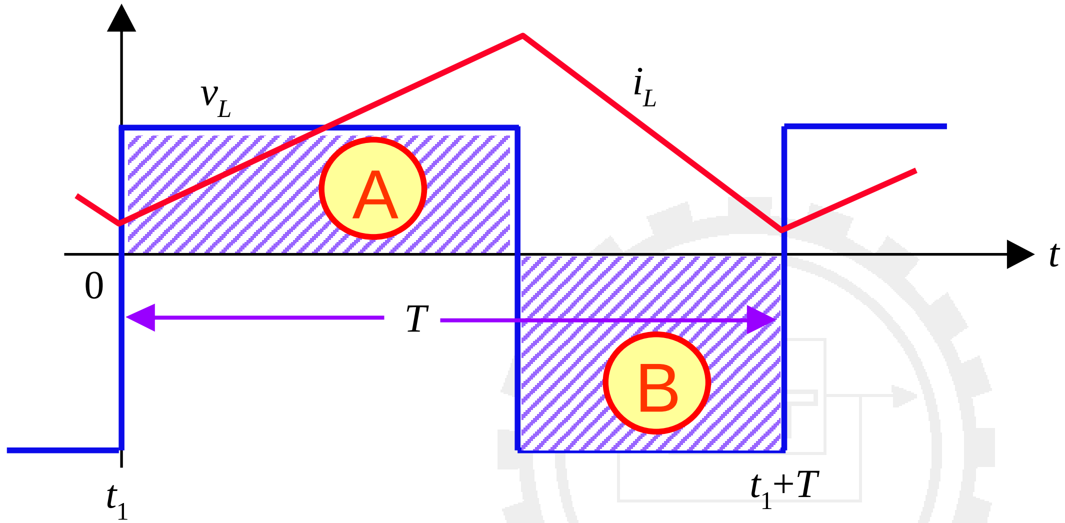
- **R – A Representation of Loss**
- **C – A Representation of Electric Field**
- **L – A Representation of Magnetic Field**

Flux Balance Principle

Average voltage across an inductor over a full cycle in steady-state is zero.



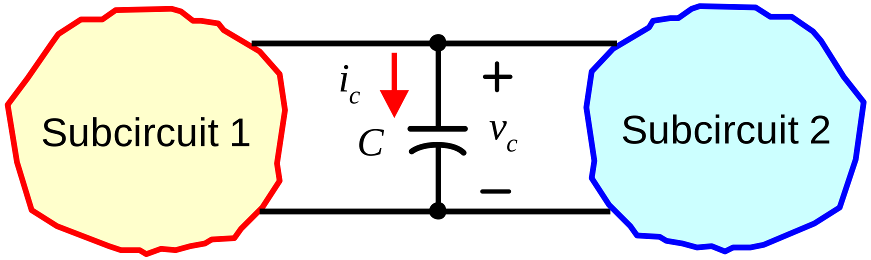
(a)

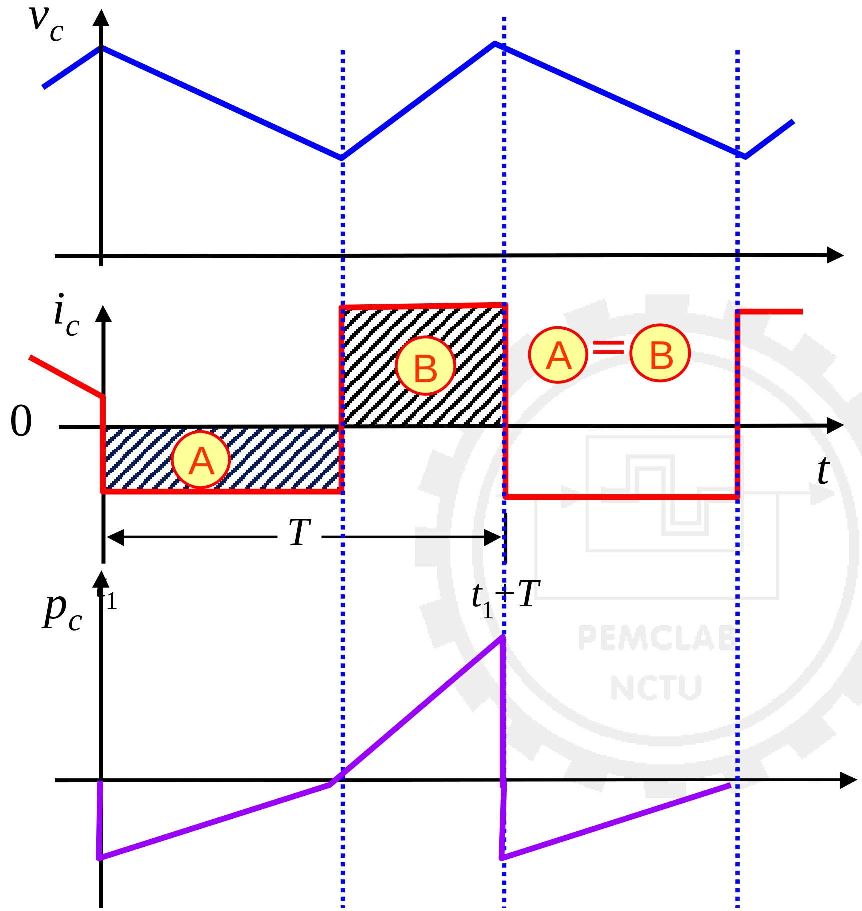


(b)

Charge Balance Principle

Average current through a capacitor over a full cycle in steady-state is zero.





Average Value and Root-Mean-Square (RMS) Value

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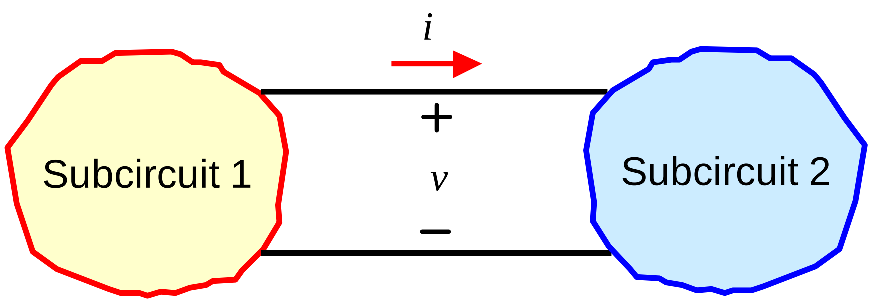


Instantaneous Power Flow Between Two Circuits

$$\text{Average Value} = [f(t)]_{AVE} = \frac{1}{T}\int_{t_0}^{t_0+T} f(t)dt$$

$$Root - Mean - Square = [f(t)]_{\mathrm{RMS}} = \sqrt{\frac{1}{\mathrm{T}}\int_{\mathrm{t}_0}^{\mathrm{t}_0+T} [f(t)]^2 \mathrm{dt}}$$

$$p(t) = v(t)\, i(t)$$

$$P_{av} = \frac{1}{T}\int_0^T p(t)dt = \frac{1}{T}\int_0^T vidt$$

$$P_{av} = R\frac{1}{T}\int_0^T i^2 dt$$

$$P_{av} = RI_{RMS}^2$$

$$I_{RMS} = \sqrt{\frac{1}{T}\int_0^T i^2 \cdot dt}$$

Instantaneous Power and Average Power

$$\text{Instantaneous Power} = p(t) = v(t)i(t)$$

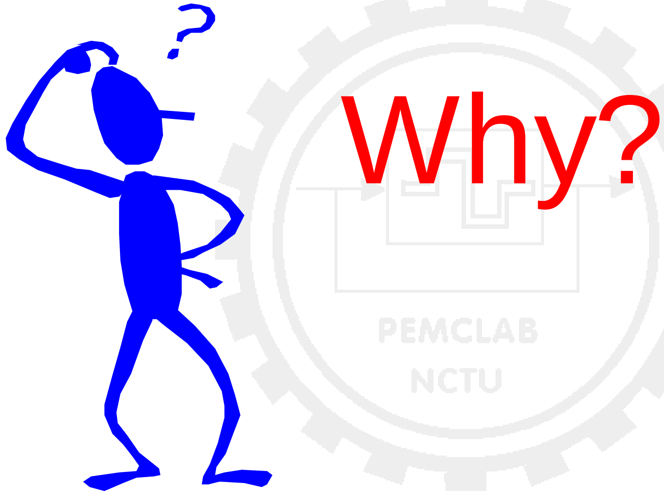
$$\text{Average Power} = P_{\text{AVG}} = \frac{1}{T}\int_{t_0}^{t_0+T} p(t)\,dt$$

$$\text{Average Voltage} = V_{\text{AVG}} = \frac{1}{T}\int_{t_0}^{t_0+T} v(t)\,dt$$

$$\text{Average Current} = I_{\text{AVG}} = \frac{1}{T}\int_{t_0}^{t_0+T} i(t)\,dt$$

In general, $P_{\text{AVG}} \neq V_{\text{AVG}} I_{\text{AVG}}$

Unless one of $v(t)$ or $i(t)$ is a constant value.



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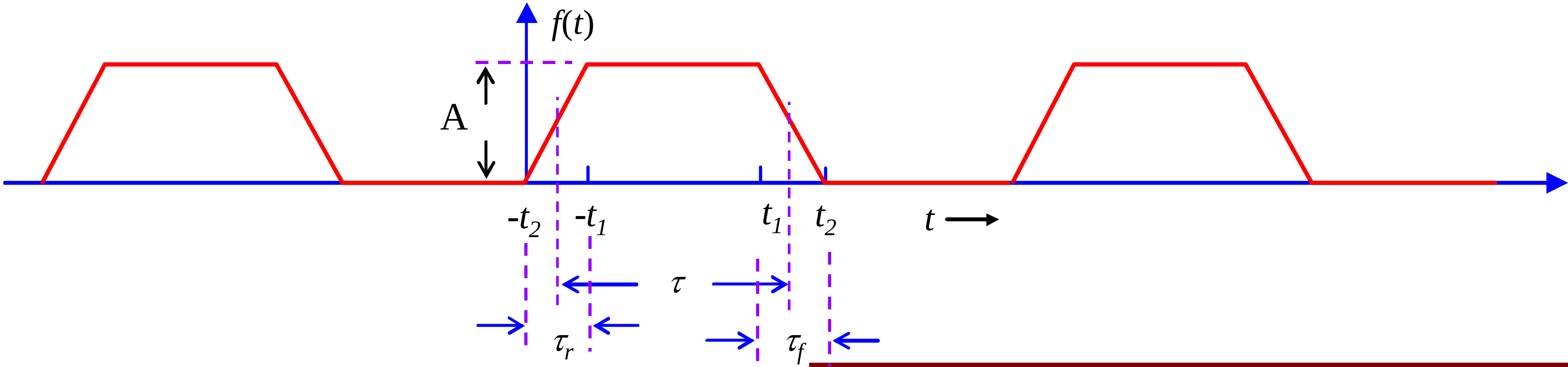
Harmonic Analysis of PWM Waveforms



if $\tau_r = \tau_f$ ➡

$$c_n = A\frac{\tau}{T}\sin c\left(n\omega_o\frac{\tau}{2}\right)\sin c\left(n\omega_o\frac{\tau_r}{2}\right)e^{-jn\omega_o\frac{\tau+\tau_r}{2}}$$