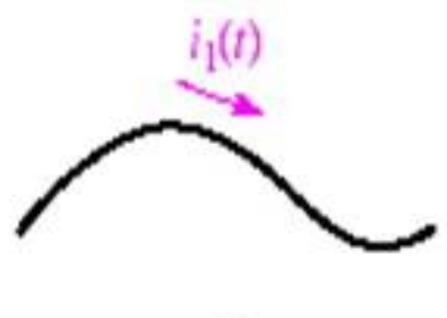
Chapter 1-9 REVIEW

Chapter 1 Basic Components and Electric Circuits

符号和数值缺一不可！



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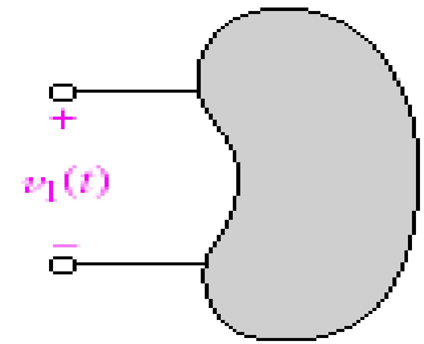
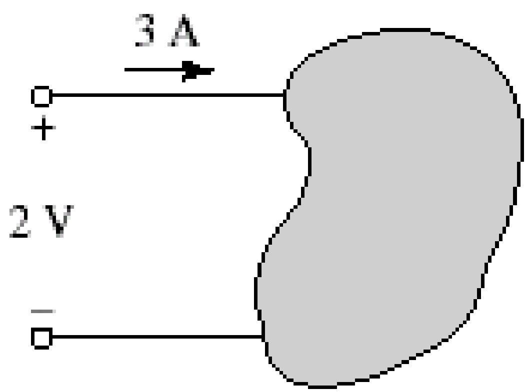


(c)

passive sign convention

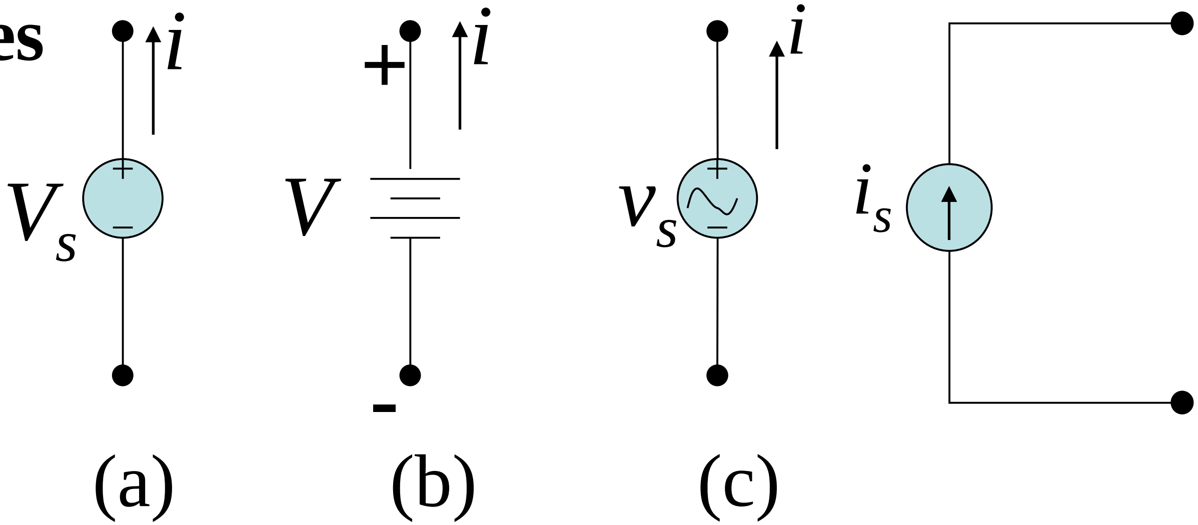
关联参考方向



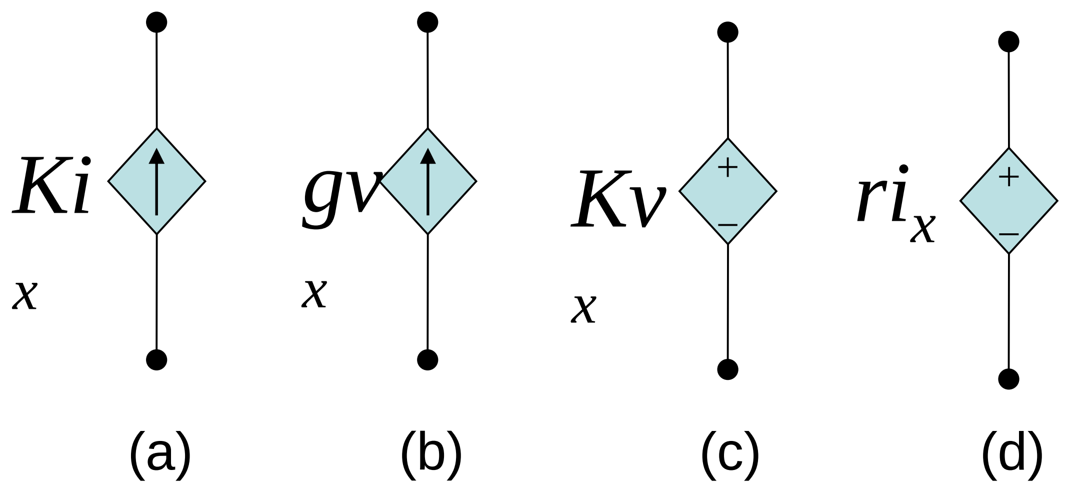
The reference current is defined consistent with passive sign convention（与关联参考方向一致）, which assumes that the element is **absorbing power**.

Voltage and Current Sources

Independent Sources

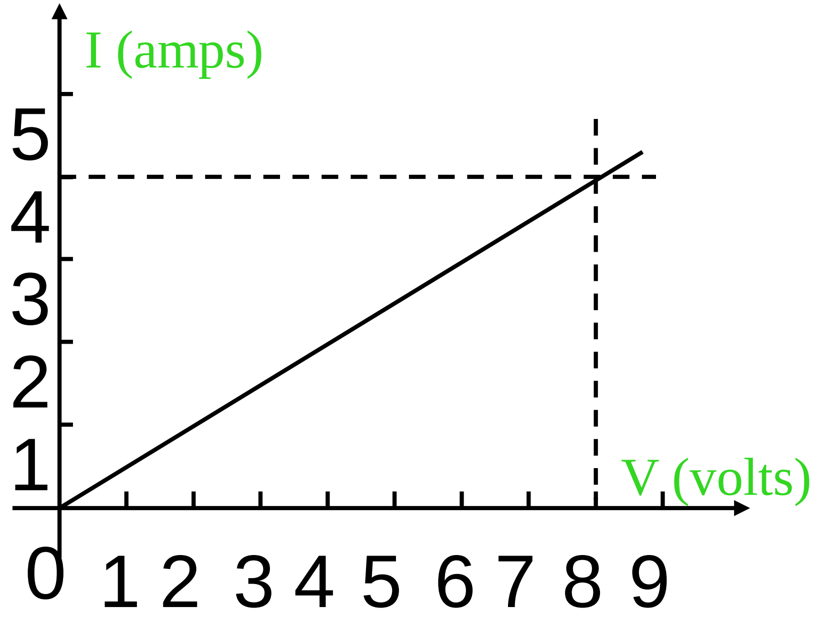


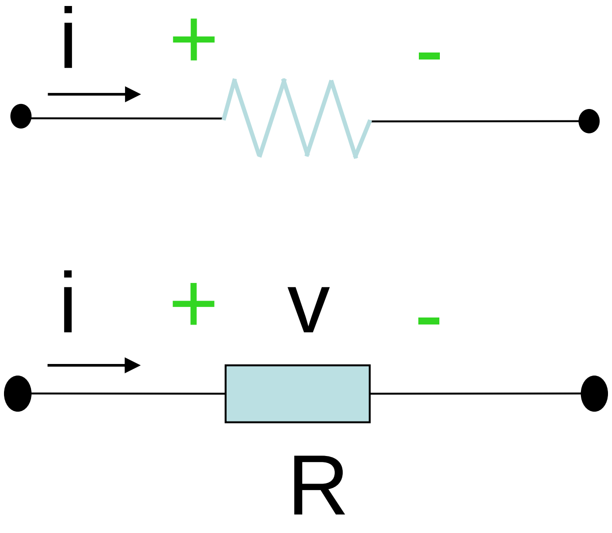
Dependent Sources



Ohm’s Law

$$v = iR \qquad p = vi = i^2R = v^2/R$$





Circuit symbol for the resistor

Chapter 2 Voltage and Current Laws

- **Ability to employ Kirchhoff's current law (KCL)**

$$\sum_{n=1}^{N} i_n = 0 \qquad i_1 + i_2 + i_3 + \Lambda + i_N = 0$$

the N current arrows are either all directed toward the node in question, or are all directed away from it.

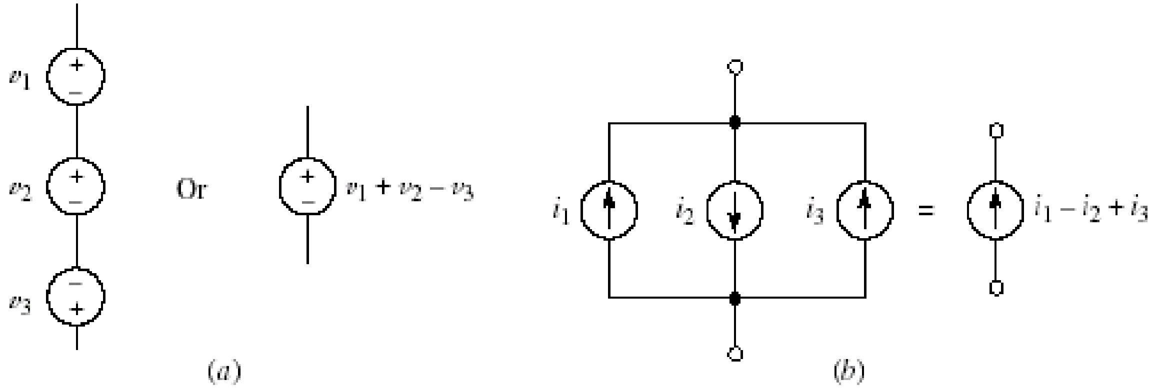
- **Ability to employ Kirchhoff's voltage law (KVL)**

$$\sum_{n=1}^{N} v_n = 0 \qquad v_1 + v_2 + v_3 + \Lambda + v_N = 0$$

the algebraic sum of the voltages across the individual elements around any closed path must be zero.

Chapter 2 Voltage and Current Laws

- Simplify series and parallel connected sources. (电源的串并联简化)



- Reduce series and parallel resistor combinations（电阻的串并联简化）

$$R_{eq} = R_1 + R_2 + R_3 + \Lambda + R_N$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \Lambda + \frac{1}{R_N}$$

- Intuitive understanding of voltage and current division

（理解对分压/分流的概念）

Chapter 3 Basic Nodal and Mesh Analysis

Implementation of nodal analysis(结点法)

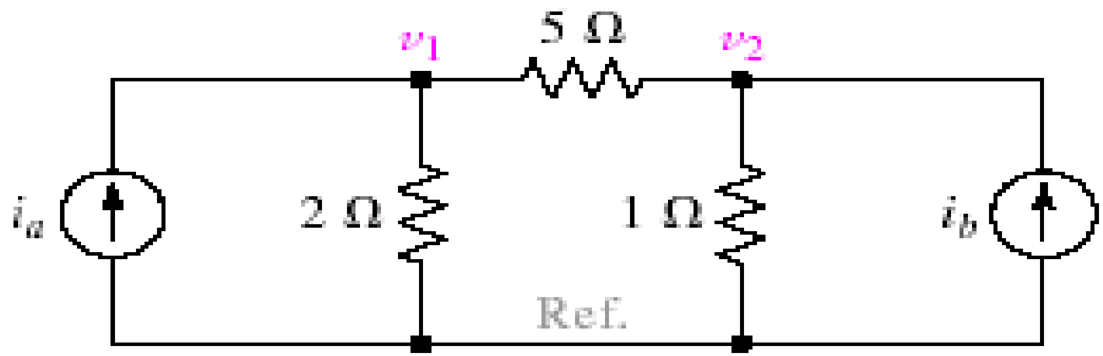
- Choose one of the nodes as a reference node. Then **label** the node voltage v_1, v_2, …, v_{N-1}, remembering that each is understood to be measured with respect to the reference node.
- If the circuit contains only current sources, apply **KCL** at each nonreference node.
- If the circuit contains voltages sources, form a supernode about each one, and then proceed to apply KCL at all nonreference nodes and supernodes.

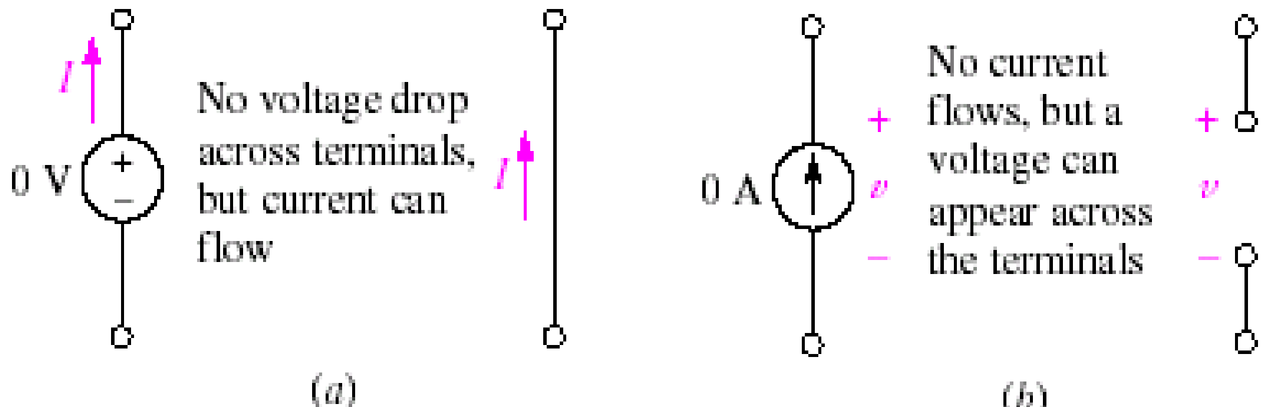
Implementation of mesh analysis(网孔法)

- First make certain that the network is a planar network. **Assign a clockwise** mesh current in each mesh: i_1, i_2, …, i_M.
- If the circuit contains only voltage sources, apply **KVL** around each mesh.
- If the circuit contains current sources, create a supermesh for each one that is common to two meshes, and then apply KVL around each mesh and supermesh.

Chapter 4 Useful Circuit Analysis Techniques

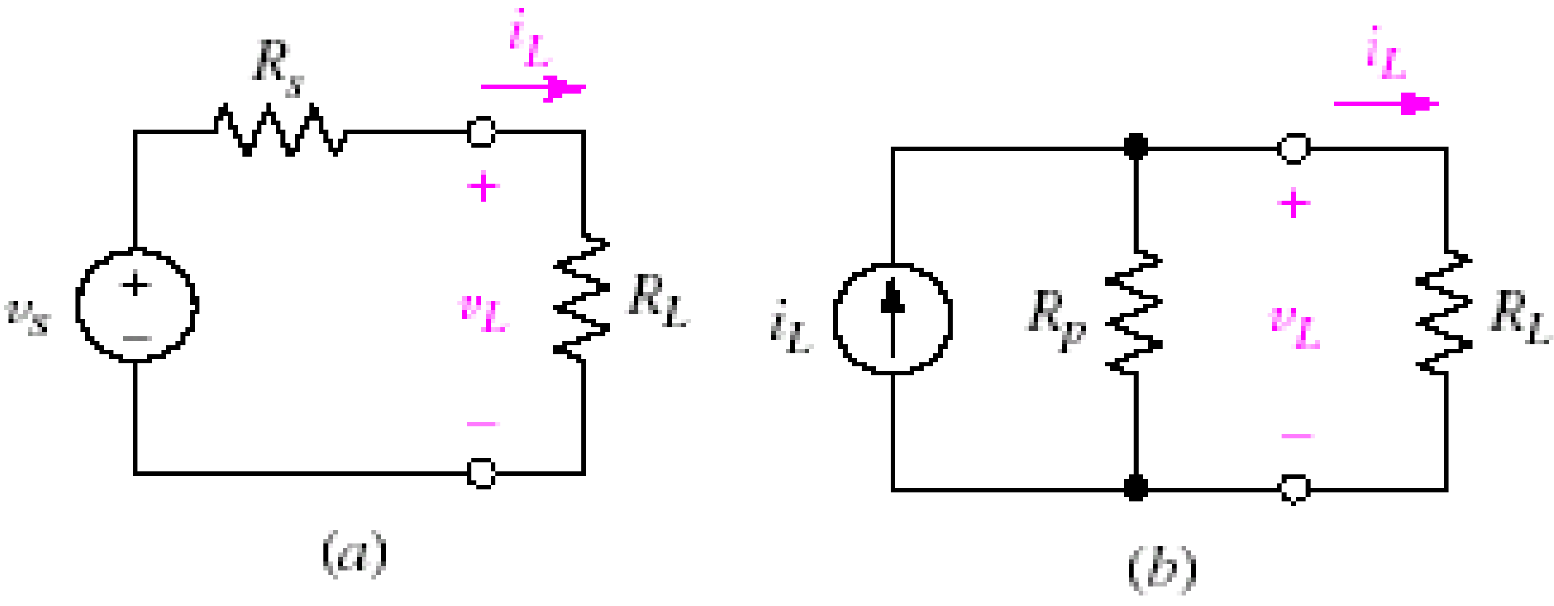
- Use superposition principle 叠加原理 to analyzed circuit





Remove power principle除源原则

- Use source transformations 电源变换 to reduce the complexity of a circuit.

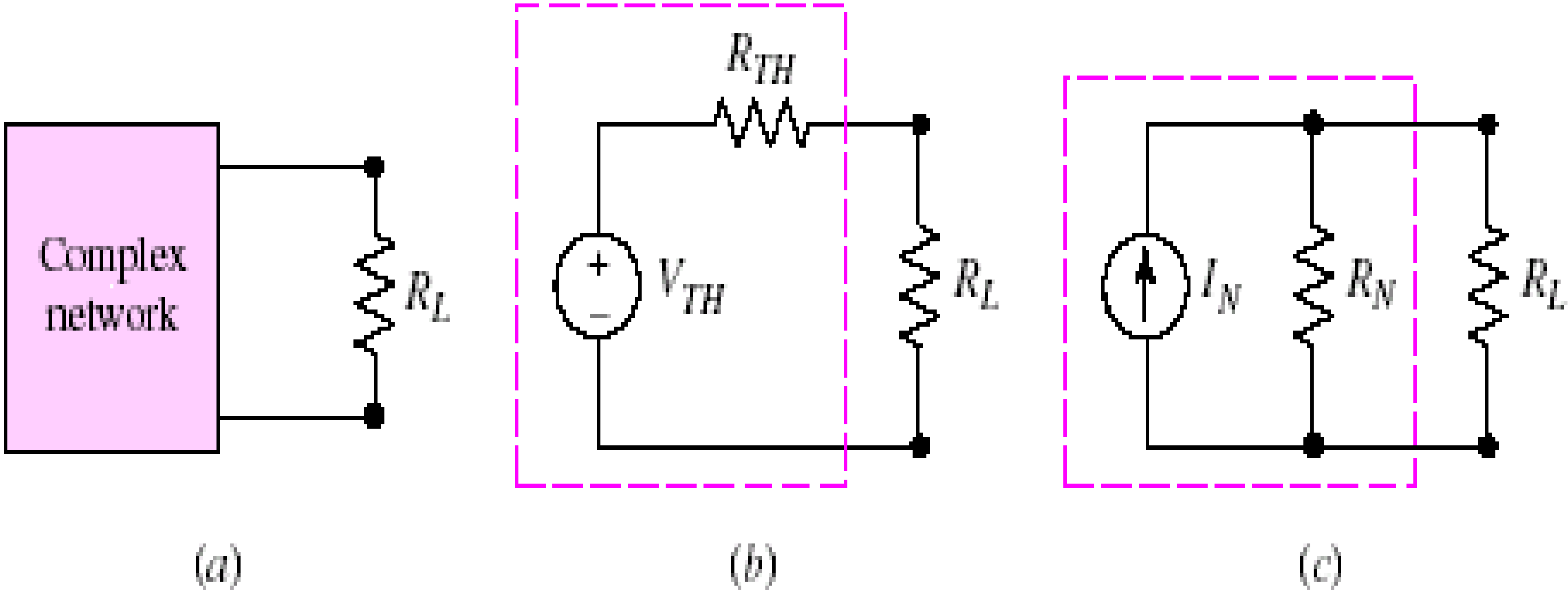


$$R_s = R_p \qquad v_s = R_p\, i_s = R_s\, i_s$$

A few parting comments:

- When performing a source transformation, remember that the **head of the current source arrow** corresponds to the “+” **terminal of the voltage source**.[注意变换前后电源方向]
- If the voltage or current associated with a particular resistor is used in a controlling variable for a dependent source, or is the desired response of a circuit, the resistor should not be included in source transformations. [受控源控制量和待求量不要被变没了！]
- In using source transformations, one common goal is to end up with either all current sources or all voltage sources in the final circuit whenever possible. [为方便计算，可全部变为同一种电源]
- Repeated source transformations can be used to simplify a circuit by allowing resistors and sources to be combined.[用电源等效变换化简电路过程中，可结合电阻、电源串并联组合的方法]

- Determine the Thévenin and Norton equivalent Circuits 戴维宁和诺顿等效网络 of any network

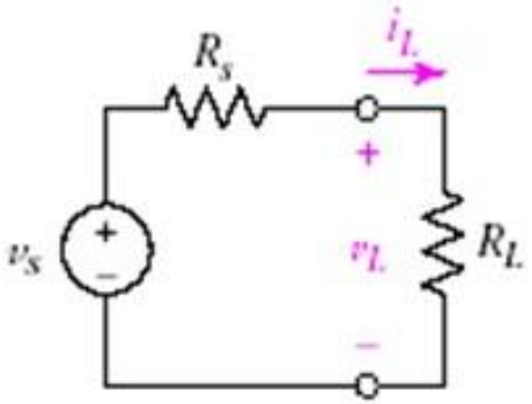


(a) A complex network including a load resistor R_L. (b) A Thévenin equivalent network connected to the load resistor R_L. (c) A Norton equivalent network connected to the load resistor R_L.

$$v_{oc} = R_{TH} i_{sc}$$

- Compute the load resistance that will result in maximum power transfer.计算产生最大功率传输的负载电阻

$$p_L = i_L^2 R_L = \frac{v_s^2 R_L}{(R_s + R_L)^2}$$



maximum

$$\boxed{R_s = R_L}$$

Chapter 5 Capacitors and Inductors

$$i = C\frac{dv}{dt}$$

$$v = L\frac{di}{dt}$$

where *v* and *i* satisfy the conventions for a passive element

Inductors in Series

$$L_{eq} = \left(L_1 + L_2 + \Lambda + L_N\right)$$

Capacitors in Series

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

Inductors in Parallel

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

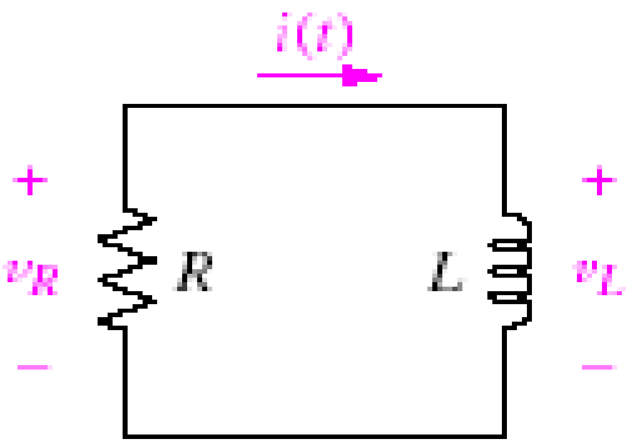
Capacitors in Parallel

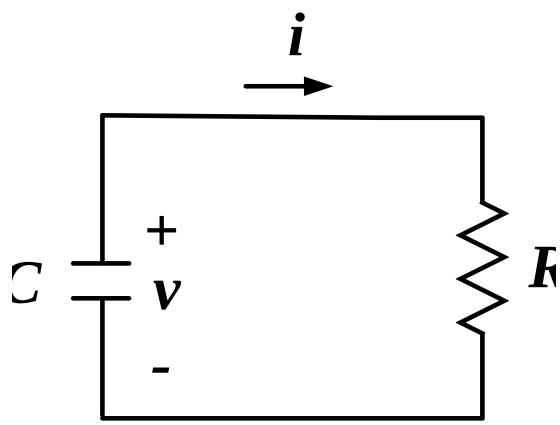
$$C_{eq} = C_1 + C_2 + \Lambda + C_N$$

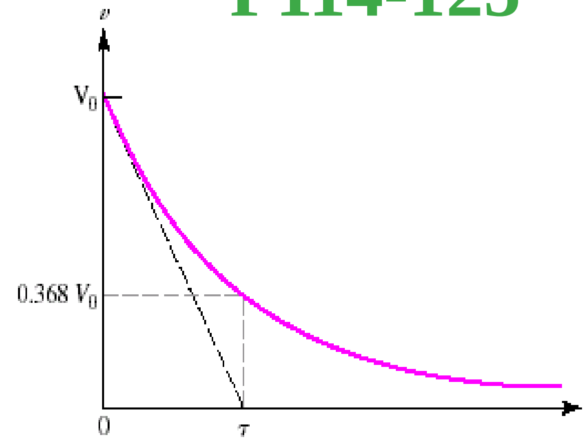
Chapter 6 Basic RL and RC Circuits

- A circuit reduced to a single equivalent inductance *L* and a single equivalent resistance *R* will have a natural response given by $i(t) = I_0 e^{-t/\tau}$, where $\tau = L/R$ is the circuit time constant.
- A circuit reduced to a single equivalent capacitance *C* and a single equivalent resistance *R* will have a natural response given by $v(t) = V_0 e^{-t/\tau}$, where $\tau = RC$ is the circuit time constant.

P114-125







- Calculation of the total response of *RL* and *RC* circuits

complete response =forced response +natural response

The forced response is thus obtained by inspection of the final circuit.

用分析电路的方法得到强迫相应（稳态解）

The form of the natural response (also referred to as the transient response) depends only on the component values and the way they are wired together.

自由响应与原件性质参数和连接关系有关

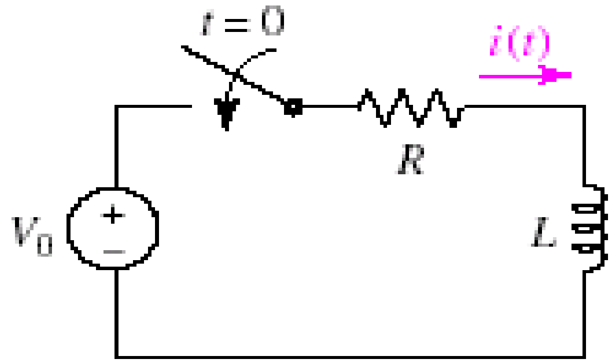
$$i = i_n + i_f$$

$$i_n = Ae^{-Rt/L}$$

$$i_f = V_0 / R$$

$$i = Ae^{-Rt/L} + V_0 / R$$

$$0 = A + V_0 / R$$



$$i = (1 - e^{-Rt/L})V_0 / R$$

P132-135

$$f(t) = f(\infty) + Ae^{-t/\tau} \qquad f(0^+) = f(\infty) + \mathrm{A}$$

$$f(t) = f(\infty) + [f(0^+) - f(\infty)]e^{-t/\tau}$$

total response = final value + (initial value – final value) $e^{-t/\tau}$

Chapter 7 Sinusoidal Steady-State Analysis

- If two sine waves (or two cosine waves) both have positive magnitudes and the same frequency, it is possible to determine which waveform is **leading** and which is **lagging** by comparing their phase angles.
  判断两个正弦信号的相位关系。

  $$v(t) = V_m \sin(\omega t + \theta)$$

- The forced response of a linear circuit to a sinusoidal voltage or current source can always be written as a single sinusoid having the same frequency as the sinusoidal source.
  线性电路中正弦激励的稳态响应（强迫响应）是同频率的正弦信号。

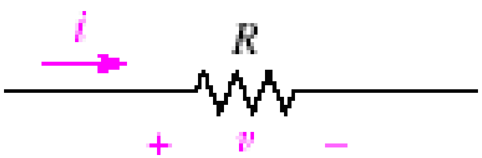
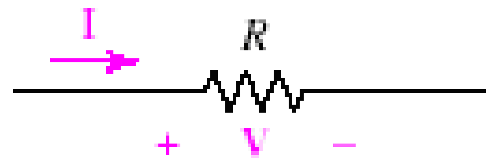
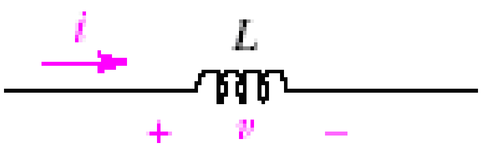
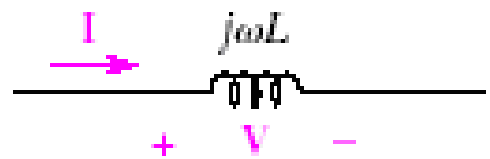
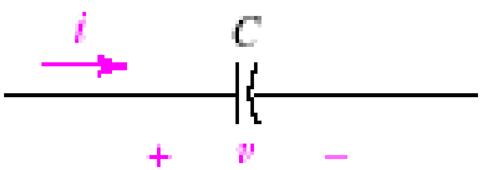
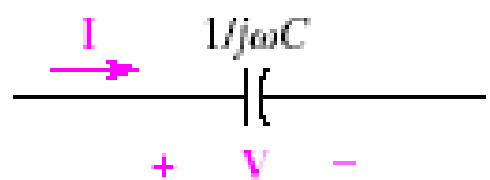
- A phasor transform may be performed on any sinusoidal function. A phasor has both a magnitude and a phase angle; the frequency is understood to be that of the sinusoidal source driving the circuit.
向量法在正弦信号中的应用。

$$i(t) = I_m \cos(\omega t + \phi) \longrightarrow \dot{I} = I_m \angle \phi$$

Phasor Diagrams 向量图法

- When transforming a time-domain circuit into the corresponding frequency-domain circuit, resistors, capacitors, and inductors are replaced by impedances (or, occasionally by admittances).
用向量法将时域电路转为频域电路时，电子、电容、电感都要转换为阻抗（或导纳）。

- The impedance of a resistor is simply its resistance.
- The impedance of a capacitor is $1/j\omega C$.
- The impedance of a inductor is $j\ \omega\ L$.

Time domain		Frequency domain	
	$v = Ri$	$\mathbf{V} = R\mathbf{I}$	
	$v = L\dfrac{di}{dt}$	$\mathbf{V} = j\omega L\mathbf{I}$	
	$v = \dfrac{1}{C}\int i\,dt$	$\mathbf{V} = \dfrac{1}{j\omega C}\mathbf{I}$	

- Impedance combine both in series and in parallel combinations in the same manner as resistors.

  阻抗(导纳)的串并联计算

  P162-166 7.7 Impedance

  P166-167 7.8 Admittance

- All analysis techniques previously used on resistive circuits apply to circuits with capacitors and/or inductors once all elements are replaced by their frequency-domain equivalents.

  频域电路（用向量法描述的电路）计算方法

  P167-169 7.9 Nodal and Mesh Analysis

Chapter 8 AC Circuit Power Analysis

- Defining the **average power 平均功率** supplied by a sinusoidal source.（P183-188）

$$v(t) = V_m \cos(\omega t + \theta)$$

$$i(t) = I_m \cos(\omega t + \phi)$$

$$P = \frac{1}{2} V_m I_m \cos(\theta - \phi)$$

- Average Power Absorbed by an **Ideal Resistor**

$$P_R = \frac{1}{2} V_m I_m \cos 0 = \frac{1}{2} V_m I_m$$

$$P_R = \frac{1}{2} I_m^2 R$$

$$P_R = \frac{V_m^2}{2R}$$

- Average Power Absorbed by **Purely Reactive Elements**

$$P_R = \frac{1}{2} V_m I_m \cos 90^\circ = 0$$

- Calculating the **rms** 均方根/有效值 value of a time-varying waveform.

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

root-mean-square

Use of RMS values to compute average power. P192-193

$$I_{eff} = I_m / \sqrt{2}$$

$$P = \frac{1}{2} I_m^2 R \Rightarrow P = I_{eff}^2 R$$

$$V_{eff} = V_m / \sqrt{2}$$

$$P = \frac{V_m^2}{2} R \Rightarrow P = \frac{V_{eff}^2}{R}$$

$$P = V_{eff} I_{eff} \cos(\theta - \phi)$$

- Apparent Power and Power Factor 视在功率和功率因数(P194)

$$v = V_m \cos(\omega t + \theta) \qquad i = I_m \cos(\omega t + \phi)$$

$$P = \frac{1}{2} V_m I_m \cos(\theta - \phi) \qquad P = V_{eff} I_{eff} \cos(\theta - \phi)$$

$$\text{PF} = \frac{\text{average power}}{\text{apparent power}} = \frac{P}{V_{off} I_{off}} = 0\sim1$$

- Identifying the **power factor** 功率因数 of a given load, and learning means of improving it. (P195-196)

PF=0.5

A load having an input impedance with a phase angle of either 60° or - 60° .

an inductive load

A lagging PF

a capacitive load

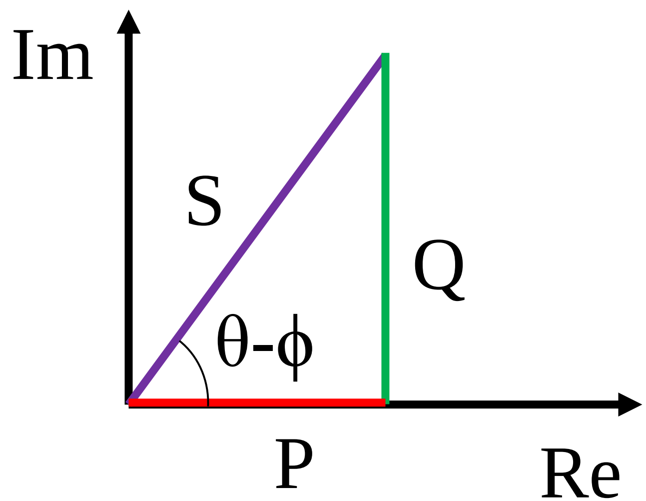
A leading PF

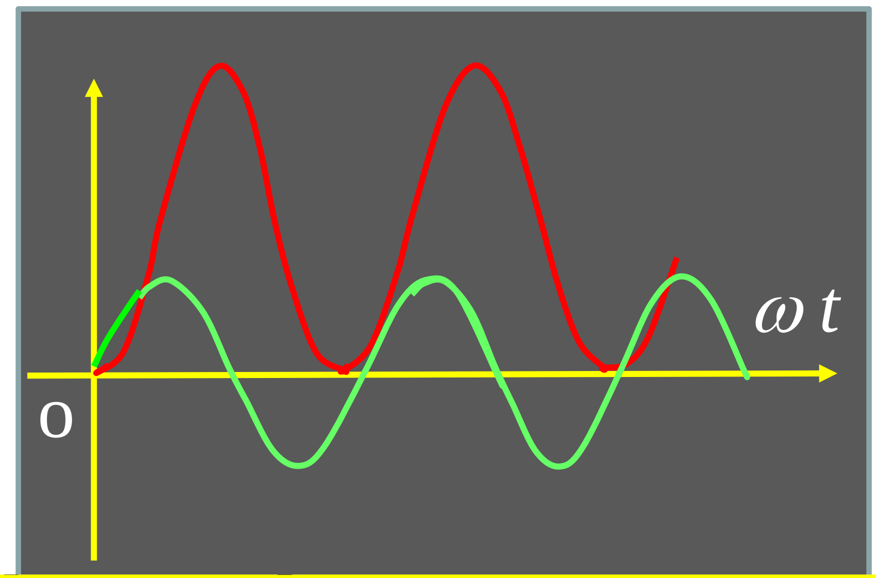
- Using complex power to identify **average** 有功功率 **and reactive power** 无功功率.

The complex power is defined as S=P+jQ, or $S=V_{eff}I^{*}_{eff}$. It is measured in units of volt-amperes (VA).

$$S = V_{eff} I_{eff}^{*} = P + jQ$$

$$Q = V_{eff} I_{eff} \sin(\theta - \phi)$$





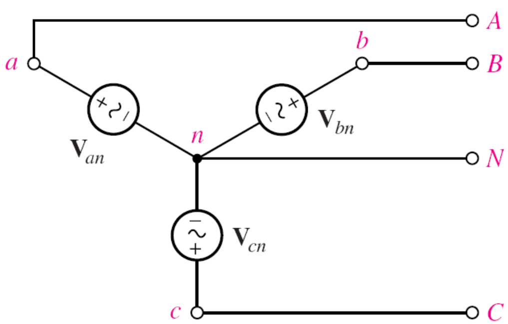
$$p(t) = \frac{1}{2} V_m I_m \cos(\theta - \phi)(1 + \cos(2\omega t + 2\theta)) + \frac{1}{2} V_m I_m \sin(2\omega t + 2\theta)\sin(\theta - \phi)$$

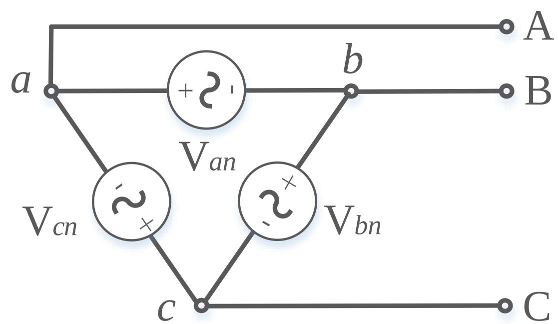
Comparison of Power Terminology P199

Term	Symbol	Unit	Description
Instantaneous power	p(t)	w	p(t)=v(t)i(t). It is the value of the Power at a specific instant in time. It is not the product of the voltage and current phasors.
Average power	P	w	In the sinusoidal steady state, P= ½ $V_m I_m \cos(\theta-\phi)$, where θ is the voltage phase angle, and ϕ is the phase angle of the current. Reactances do not contribute to P.
Effective or RMS value	V_{rms} or I_{rms}	V or A	Defined as $I_{eff} = \sqrt{\frac{1}{T}\int_0^T i^2 dt}$; if i(t) is sinusoidal, then $I_{eff} = I_m / \sqrt{2}$
Apparent power	$\lvert S \rvert$	VA	$\lvert S \rvert = V_{eff} I_{eff}$, and is the maximum value the average power can be; $P = \lvert S \rvert$ only for purely resistive loads.
Power factor	PF(or λ or cosφ)	None	Ratio of the average dissipated power to the apparent power. The PF is unity for a purely resistive load, and zero for a purely reactive load.
Reactive power	Q	VAR	A means of measuring the energy flow rate to and from reactive loads.
Complex power	S	VA	A convenient complex quantity that contains both the average power P and the reactive power Q:S=P+jQ

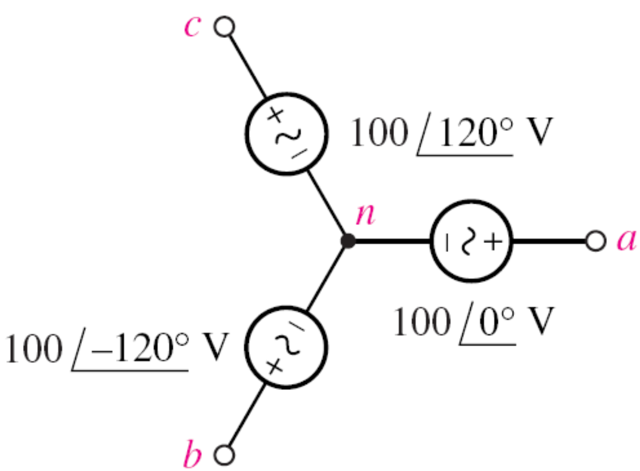
Chapter 9 Polyphase Circuits

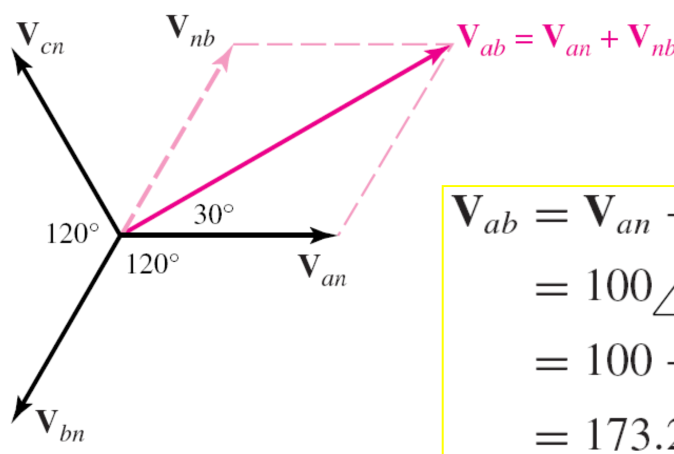
- Three phase sources can be either Y or Δ connected.
- In a balanced three-phase system, each phase voltage has the same magnitude, but is 120° out of phase with the other two.





$$\mathbf{V}_{an} = 100\angle 0^\circ \text{ V}$$
$$\mathbf{V}_{bn} = 100\angle -120^\circ \text{ V}$$
$$\mathbf{V}_{cn} = 100\angle -240^\circ \text{ V}$$





(P209-211)

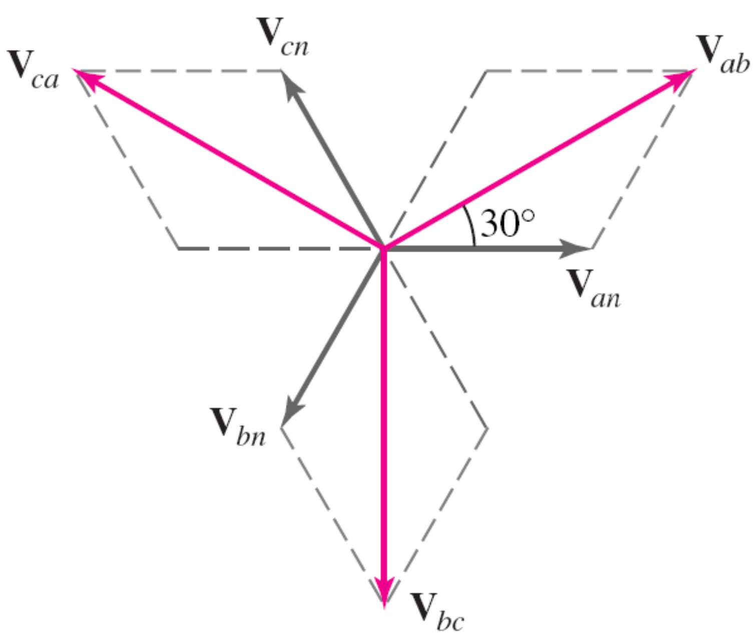
$$\begin{aligned}\mathbf{V}_{ab} &= \mathbf{V}_{an} + \mathbf{V}_{nb} = \mathbf{V}_{an} - \mathbf{V}_{bn} \\ &= 100\angle 0^\circ - 100\angle -120^\circ \text{ V} \\ &= 100 - (-50 - j86.6) \text{ V} \\ &= 173.2\angle 30^\circ \text{ V}\end{aligned}$$

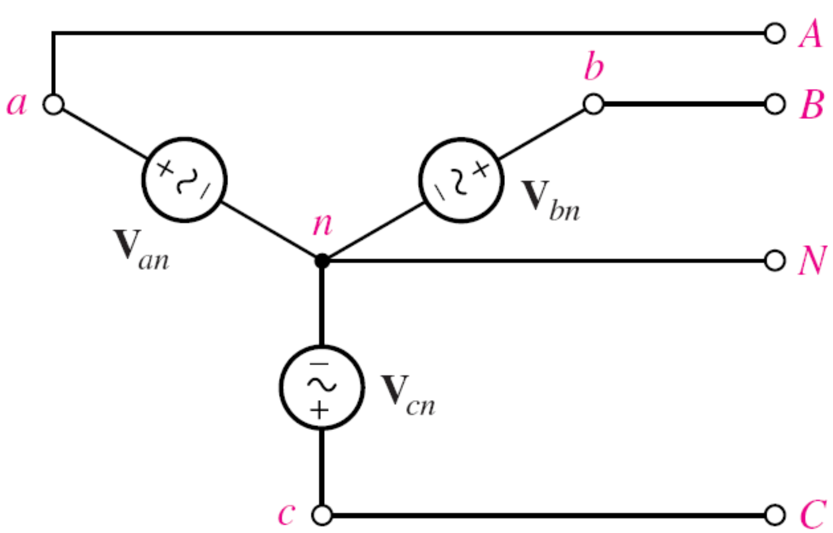
- These three voltages, each existing between one line and the neutral, are called **phase voltages相电压**. (P215)

$$\mathbf{V}_{an} = V_p \angle 0^\circ \qquad \mathbf{V}_{bn} = V_p \angle -120^\circ \qquad \mathbf{V}_{cn} = V_p \angle -240^\circ$$

- These line-to-line voltages are often simply called the **line voltages** 线电压. (P216)

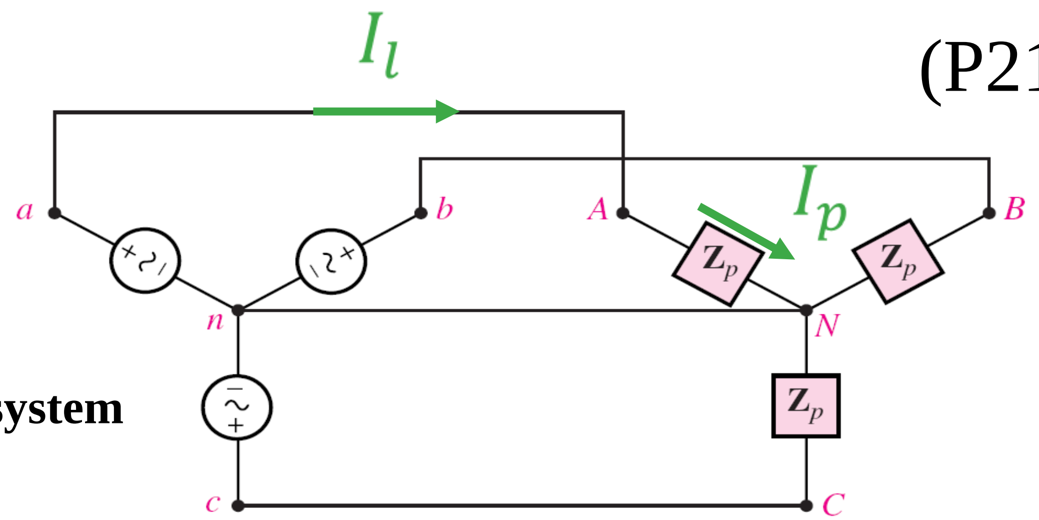
$$\mathbf{V}_{ab} = \sqrt{3} V_p \angle 30^\circ \qquad \mathbf{V}_{bc} = \sqrt{3} V_p \angle -90^\circ \qquad \mathbf{V}_{ca} = \sqrt{3} V_p \angle -210^\circ$$





- Loads in three-phase system may be either Y or Δ connected. In a Y-connected load, the line currents are equal to the phase currents.

(P217-220)



Y-Y connected system

$$\dot{V}_{AB} = \sqrt{3}\dot{V}_{AN}\angle 30^\circ$$

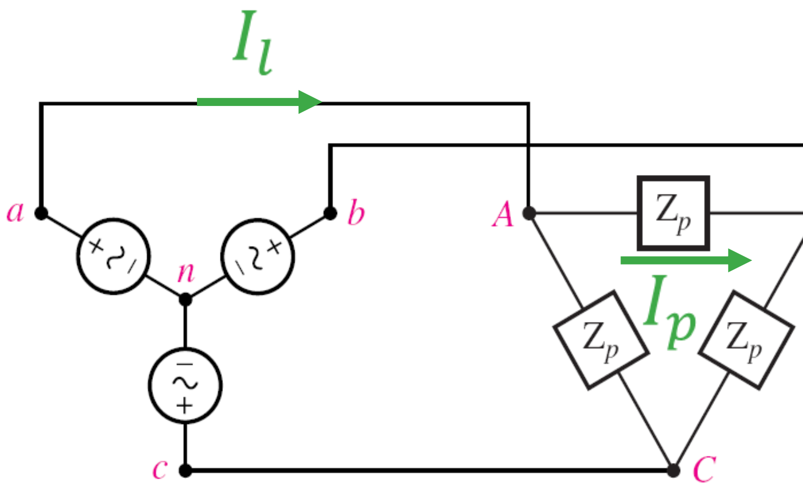
$$\dot{I}_{aA} = \dot{I}_{AN} = \dot{V}_{AN} / Z_p$$

$$|\dot{V}_{AB}| = |\dot{V}_{ab}| = \dot{V}_l \qquad |V_{AN}| = V_p \qquad |\dot{I}_{aA}| = I_l \qquad |\dot{I}_{AN}| = I_p$$

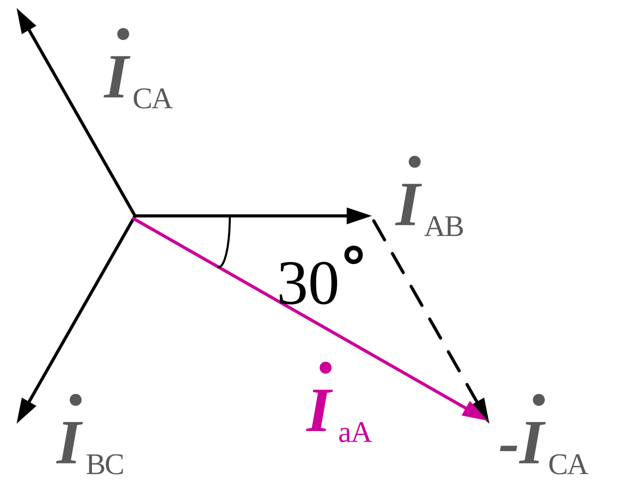
$$V_l = \sqrt{3}V_p \qquad I_l = I_p$$

$$P_\Sigma = 3P_p = 3V_p I_p \cos\theta_{Zp} = \sqrt{3}V_l I_l \cos\theta_{Zp}$$

• In a Δ-connected load, the line voltages are equal to the phase voltages.



Y-Δ connected system



$$\dot{V}_{AB} = \dot{V}_{ab}$$

$$\dot{I}_{aA} = \dot{I}_{AB} - \dot{I}_{CA} = \sqrt{3}\dot{I}_{AB}\angle -30°$$

$$|\dot{V}_{ab}| = V_l \qquad |\dot{V}_{AB}| = V_p$$

$$\dot{I}_{AB} = \dot{V}_{AB} / Z_p$$

$$V_l = V_p$$

$$|\dot{I}_{aA}| = I_l \qquad |\dot{I}_{AB}| = I_p \qquad I_l = \sqrt{3} I_p$$

$$P_\Sigma = 3P_p = 3V_p I_p \cos\theta_{Zp} = \sqrt{3} V_l I_l \cos\theta_{Zp}$$