Chapter 3

Node Analysis

无Voltage source (n nodes)

S1. Select a node as the reference node

S2 Assign node voltages $v_1, \cdots, v_{n-1}$ to the remaining nodes (nonreference)

S3 Apply KCL to each of the nonreference nodes.

无Voltage source 且只有 independent current source (n+1 nodes)

"Node Analysis by Inspection" —

对 n 个 nonreference nodes: 列 node-voltage matrix equations

$$\begin{bmatrix} G_{11} & G_{12} & \cdots & G_{1n} \\ G_{21} & \vdots & & \vdots \\ \vdots & & & \\ G_{n1} & G_{n2} & \cdots & G_{nn} \end{bmatrix} \begin{bmatrix} v_1 \\ \vdots \\ v_n \end{bmatrix} = \begin{bmatrix} i_1 \\ \vdots \\ i_n \end{bmatrix}$$

G_{kk}: Sum of the conductances connected to node k.

$G_{kj} = G_{jk}$: Negative of the sum of the conductances directly connecting nodes k & j

j, k 两者之间只连了该 conductance / current

i_k: Sum of all independent current sources directly connected to node k, 流入的记为正

$Gv = i$

conductance matrix, output vector, input vector.

有Voltage source (both dependent & independent)

Case 1: Voltage source 与 reference node 相连 --- 已知另一与之相连的 nonreference node 的电压.

Case 2: Voltage source 连在两个 nonreference nodes 间

S2 把这个voltage source、两个nodes 和与之直接相连的元件 视为一个 supernode, 对该supernode 列 KCL

S1 列: $v_k - v_j = v_{voltage\ source}$.

Mesh Analysis

⚠ 只适用于 planar circuit

无 Current Sources

S1 Assign mesh currents $i_1, \cdots, i_n$ to the n meshes (统一取顺时针)

S2 Apply KVL to each of the n meshes. (公共部分的电流 — $i_k - i_j$)

无Current Sources 且只有 independent voltage sources.

"Mesh Analysis by Inspection" —

列 mesh-current equations.

$$\begin{bmatrix} R_{11} & R_{12} & \cdots & R_{1N} \\ R_{21} & R_{22} & \cdots & R_{2N} \\ \vdots & \vdots & & \vdots \\ R_{N1} & R_{N2} & \cdots & R_{NN} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ \vdots \\ i_N \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_N \end{bmatrix}$$

R_{kk}: Sum of the resistances in mesh k

$R_{kj} = R_{jk}$ = Negative of the sum of the resistances in common with meshes k & j

v_k: Sum taken clockwise of all independent voltage sources in mesh k, with voltage rise taken as positive — 与KVL相反

有 Current Sources (both dependent & independent)

Case 1: A current source exists only in one mesh -- 已知该 mesh current i_k

Case 2: A current source exists between two meshes,

S1: 这两个mesh 电流满足: $i_k - i_j = i_{current\ source}$

S2: 把这两个mesh 去掉公共部分后所得的 视为一个 supermesh, 对该 supermesh 列 KVL

· Linear: Output linearly related to input. homogeneity & additivity

nonlinear element example: diode (二极管) "turn off"

$i_D = I_s(e^{qv_D/kT} - 1)$ I_s, q, k, T 量 value & meaning

解 nonlinear 题方法: 正常做, 只不过把欧姆定律换成之 (See C04 slide 9)

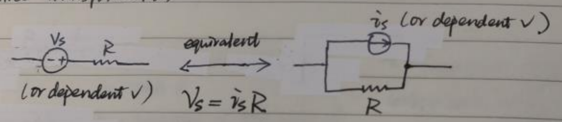
· Superposition principle: When a linear system is driven by more than one independent source, the total output = the sum of individual output.

Application:

⚠ remove INdependent sources, Leave dependent sources intact!

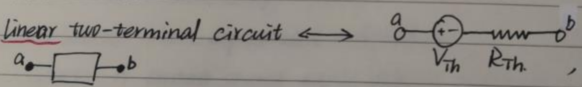
All but one "O" at a time. "◇"

· Source Transformation



Thevenin's Theorem

A linear two-terminal circuit ⟷



where V_{Th}: 开路时 V_{ab}

R_{Th}: = R_{eq} (with all independent sources off)

无dependent source: turn off sources, 看R_{eq} 横向

有dependent source: turn off independent sources, 外加电压源 v_0, 得电流 i_0. 那么 $R_{Th} = R_{eq} = \frac{v_0}{i_0}$

· R_{Th} can be negative -- implies that the circuit is supplying power.

· Power transfer

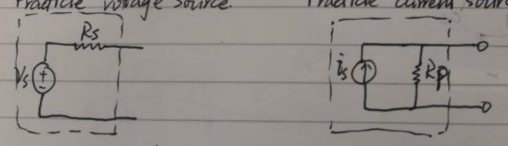
· two objectives { Large quantities (power utility systems) — major concern: Efficiency of transfer; Small amount (communication sys) — Power transfer

· $P = \left(\frac{V_{Th}}{R_{Th}+R_L}\right)^2 R_L \overset{max}{=} \frac{V_{Th}^2}{4R_{Th}}$

"L" for "load"   Thevenin's Theorem

· Source Modeling

Practical voltage source   Practical current source



R_s 越小越 ideal R_p 越大越 ideal

·unloaded source voltage/current

loading effect.