Generating System Equations from Linear Graphs

Graph Tree: A subgraph of a linear graph which:
- contains all nodes, and
- maximum number of branches, with no loops

Twigs - Branches in the tree.
Links - Other branches.

Primary Variables: - Twig across variables, &
- Link through variables.
Secondary Variables: - Twig through variables, &
- Link across variables.

Normal Tree: Add elements to Tree using this Priority:

High Priority:
1) Across Variable Sources
   - if an A. V. source cannot be added, the linear graph is wrong
2) A-Type Energy Storage Elements
   - an A-Type element that cannot be added is DEPENDENT
3) D-Type Dissipative Elements
4) T-Type Energy Storage Elements
   - an T-Type element that must be added is DEPENDENT

Low Priority:
5) Through Variable Sources
   - if an T. V. source must be added, the linear graph is wrong

State Variables
Number of State Variables = Number of Independent Energy Storage Elements = Number of A-Type Twigs & T-Type Links

State Variables: - across variables of A-Type Twigs, &
- through variables of T-Type Links

State Equation Formulation

Step 1: Generate a Normal Tree

Step 2: Identify:
- Primary Variables
- Secondary Variables
- System Order
- State Variables

Step 3: List the Elemental Equations for Primary Variables
   - Primary variable = \( f \) (Secondary variable).
   - List elemental equations of state variables first.

Step 4: Write Cut-Set equations for Secondary Through Variables.

Step 5: Write Tie-Set equations for Secondary Across Variables.

Step 6: Eliminate Secondary Variables using the Cut-Set & Tie-Set equations.

Step 7: Eliminate Non-State Variables from the state equations.