Appendix A – Network Topology

(Originally written by Dr. D. Conner – Edited by Dr. A. Winchester)

A. Circuit Preparation Step 1: Replace all voltage sources by a "short circuit".
B. Data Collection Step 1: Count the number of nodes (N) in this network. A node, by definition, will be a connection of three or more elements.
C. Circuit Preparation Step 2: Using the circuit obtained in Circuit Preparation Step 1, replace all current sources by an "open circuit".
D. Data Collection Step 2: Count the number of branches (B) in this new network, called a "dead network" because all sources have been "turned off". A branch, by definition, will be an element or group of series elements connected between two nodes in this network.
E. Application of Data
    1. N-1 independent KCL equations written in terms of N-1 independent voltage unknowns will be required to solve the problem for all unknowns in the problem. These equations will be written using an approach called Node Analysis (which is a special case of Ambit or Cut-Set Analysis).
    2. B-N+1 independent KVL equations written in terms of B-N+1 independent current unknowns will be required to solve the problem for all unknowns in the problem. These equations will be written using an approach called Loop Analysis (or a more special case called Mesh Analysis).
F. The Writing of Equations – Use either Mesh Analysis or Node Analysis.

Chapter 3 – Nodal and Loop Analysis Techniques

(Originally written by Dr. D. Conner – Edited by Dr. A. Winchester)

A. Node Analysis
    1. The Setup
        i. Perform the steps described above in Network Topology to determine the number of "real nodes" (N) in the circuit and to identify their location in the original circuit.
        ii. Select one of these nodes in the original circuit and identify it as the reference or "ground" node.
        iii. Specify an unknown voltage between each of the remaining "real nodes", as identified in the original circuit, and the "ground node". (**Why?**

Because N-1 independent voltage unknowns are required, and this approach in assigning unknowns will provide a set of N-1 independent voltage unknowns.)

2. Determine the KCL equation associated with each identified node other than the "ground" node in the original circuit. (**Why?** Because N-1 independent KCL equations are required, and this set of equations will provide a set of N-1 independent KCL equations.) [**NOTE**: There will be TWO techniques presented in class: a "brute force technique" and an "inspection technique". During problem sessions, the Instructor will, in general, only use the "inspection technique". Use of the "brute force technique" will require a special request on the part of the student asking to have a problem worked.]
3. Solve the set of KCL equations produced by this technique for any required unknowns.

B. Mesh Analysis
    1. The Setup
        i. Perform the steps described above in Network Topology to determine the number of "real nodes" (N) and "real branches" (B) in the network.
        ii. Identify the meshes in the network. A mesh, by definition, is each interior "open space" in the final Network Topology network.
        iii. Specify a "circulating current" unknown within each mesh as it appears in the original circuit as identified in the final Network Topology network. (**Why?** Because B-N+1 independent current unknowns are required, and there are B-N+1 interior meshes which produces a set of B-N+1 independent current unknowns.)
        iv. For each current source in the original circuit, assign an arbitrary path of circulation in the original circuit.
    2. Determine the KVL equation associated with each "circulating current" unknown in the original circuit. (**Why?** Because we need B-N+1 independent KVL equations, and this set of equations will provide B-N+1 independent VL equations.) [**NOTE**: There will be TWO techniques presented in class: a "brute force technique" and an "inspection technique". During problem sessions, the Instructor will, in general, only use the "inspection technique". Use of the "brute force technique" will require a special request on the part of the student asking to have a problem worked.]
    3. Solve the set of KVL equations produced by this technique for any required unknowns.

C. Special Issues Associated with Node and Mesh Analysis
    1. Controlled Sources → Requires the introduction of a "Constraint Equation"
    2. Super Nodes → Implies "Source Pushing"
    3. Source Modeling for the Inspection Techniques → Requires

i. Conversion of voltage sources to a current source equivalent for **node analysis**, and
ii. Conversion of current sources to a voltage source equivalent for **mesh analysis**.