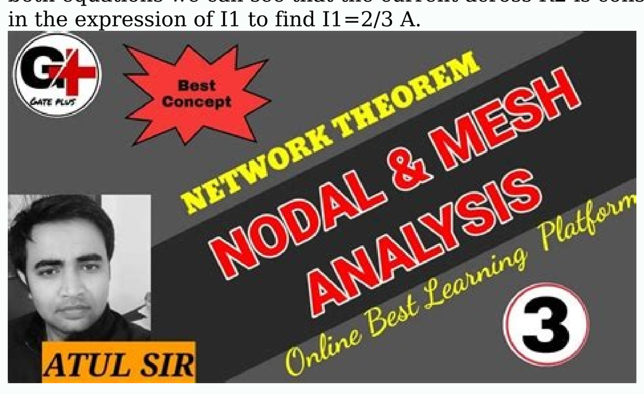
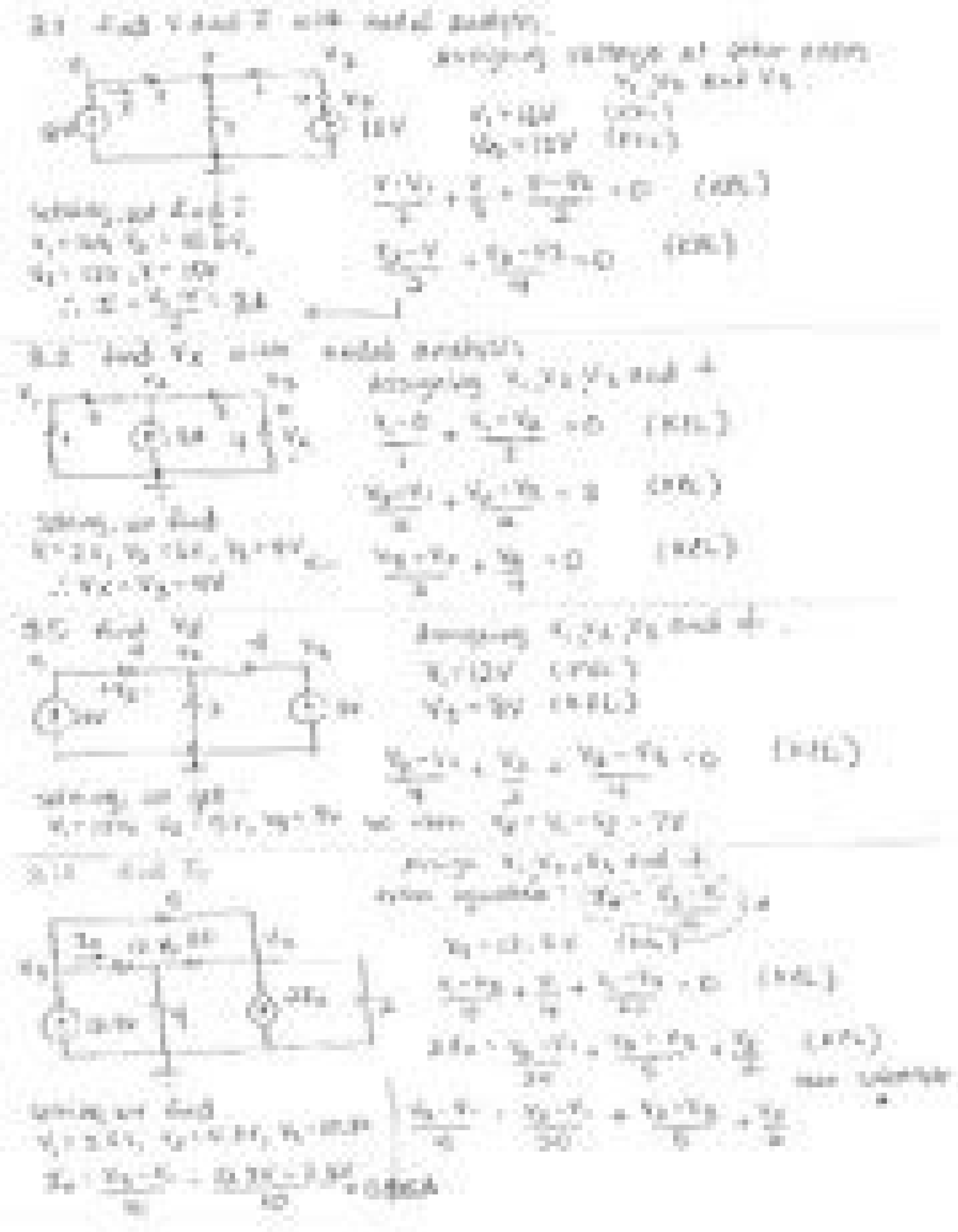
What is the difference between mesh and nodal analysis

Step number one has already been done in the circuit where the mesh currents are labeled with the red loop symbols. As step number 2 suggests, we apply KVL for each mesh of the circuit: Equation 1: -V1+I1×(R1+R2)-I2×R2=0 Equation 2: V2-I1×R2+I2×(R2+R3)=0 In our case, both mesh currents I1 and I2 are present across the resistor R2, in both equations we can see that the current across R2 is considered as the algebraic sum of I1 and I2. In the following, we replace the parameters by their value, first of all, we express I1 as a function of I2 thanks to the first equation: We substitute this term in Equation 2, which after redistributing the terms, leads to find I2=-1/3 A. We put this value in the expression of I1 to find I1=2/3 A.



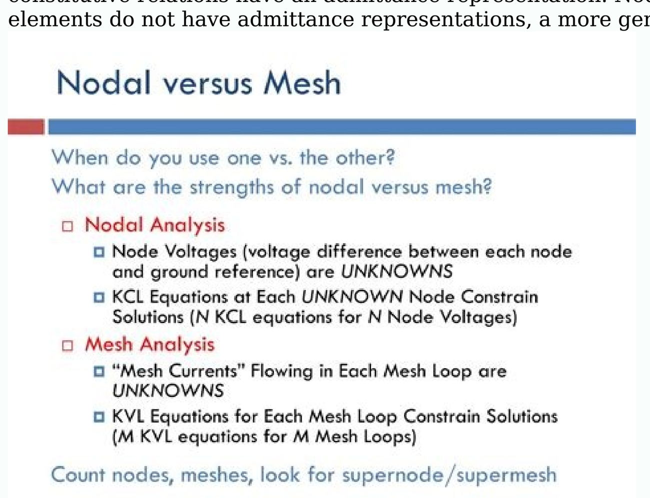
Finally, we can give the required current I to drive the circuit I=I1-I2=1 A. Conclusion We have presented in this tutorial two methods based on the Kirchoff's Circuit Laws called the Nodal Voltage Analysis (NVA) and the Mesh Current Analysis (MCA). These methods are more efficient to analyze circuits because they lead to the solution faster than KCL by reducing the amount of mathematics involved.



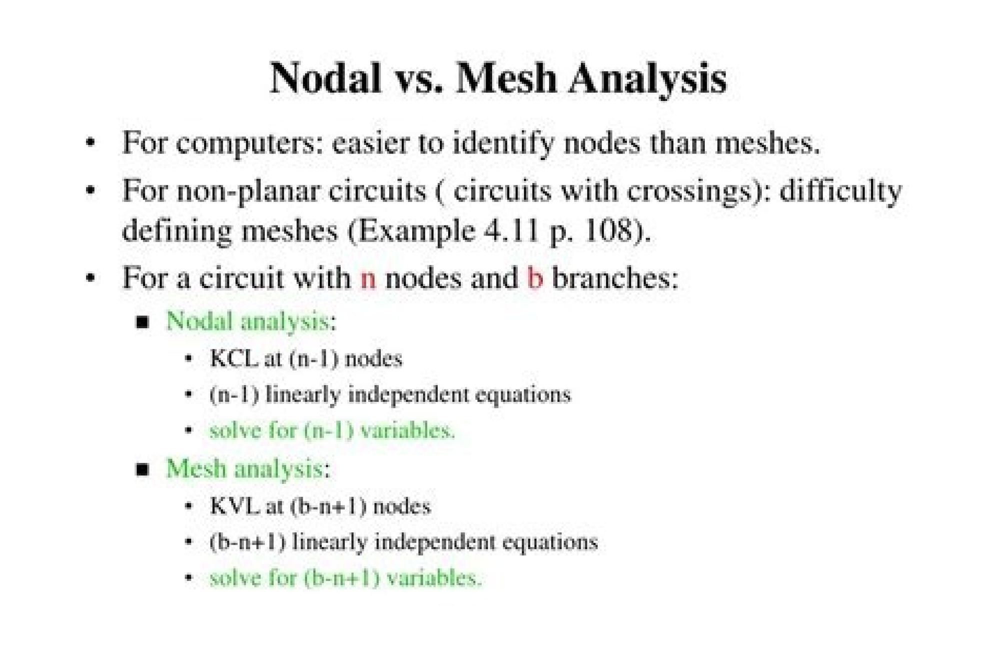
Each analysis consists of a series of steps to perform, the methods are presented separately at the beginning of their respective section. Examples are also given in order to show how to analyze resistive circuits with these two methods. We can note that for reactive circuits with inductors and capacitors, the NVA or MCA analysis leads to a differential equation or a system of differential equations to be solved.

Please follow and like us: Sign Up Now &Daily Live Classes250+ Test seriesStudy Material & PDFQuizzes With Detailed Analytics+ More BenefitsGet Free Access Now No matter how many nodes you have, when doing nodal analysis, you describe the currents going into and out of each node. As you walk through each node, you'll end up with 1 linearly independent equation that describes all of the current going into and out of it. In nodal analysis, everything that goes into a node must come out of it. When you finally get to the last node in your analysis, it should become obvious that none of the inputs or outputs to that node may be tweaked to your liking. Every single input (or output) to this node already has some other node determining how much current flows into or out of it. That last node can't be linearly independent because it's dependent upon all of the other nodes. You can think of this like water pipes where voltage sources are pumps, and resistors are narrow parts of the circuit. In a circuit (i.e. closed loop), electrons can never escape from the system, they always just go in loops. The same thing would occur in a network of tubes with pumps pushing water around them with constrictions. At any joint where 3 or more tubes connect, what flows into the joint will be equal to what flows out of the joint. If you're accounting/measuring how much goes into and out of every joint, when you get to the last one, you'll realize that you don't need to measure the amount going into and out of that joint or node because you've already accounted for it because you assume that your pipes aren't leaking and you're not adding any water to the network of pipes. That's basically all that that statement is saying. Since it's a closed loop system, you can't add or remove electrons, so the last node can't be linearly independent.

It's dependent upon all of the other nodes. Kirchhoff's current law is the basis of nodal analysis. In electric circuits analysis, nodal analysis, node-voltage analysis, or the branch current method is a method of determining the voltage (potential difference) between "nodes" (points where elements or branches connect) in an electrical circuit in terms of the branch currents. In analyzing a circuit using Kirchhoff's circuit laws, one can either do nodal analysis using Kirchhoff's current law (KCL) or mesh analysis using Kirchhoff's voltage law (KVL). Nodal analysis writes an equation at each electrical node, requiring that the branch currents incident at a node must sum to zero. The branch currents are written in terms of the circuit node voltages. As a consequence, each branch constitutive relation must give current as a function of voltage; an admittance representation. For instance, for a resistor, Ibranch = Vbranch * G, where G (=1/R) is the admittance (conductance) of the resistor. Nodal analysis is possible when all the circuit elements' branch constitutive relations have an admittance representation. Nodal analysis produces a compact set of equations for the network, which can be solved by hand if small, or can be quickly solved using linear algebra by computer. Because of the compact system of equations, many circuit simulation programs (e.g., SPICE) use nodal analysis as a basis. When elements do not have admittance representations, a more general extension of nodal analysis, modified nodal analysis, can be used.



Procedure Note all connected wire segments in the circuit. These are the nodes of nodal analysis. Select one node as the ground reference.

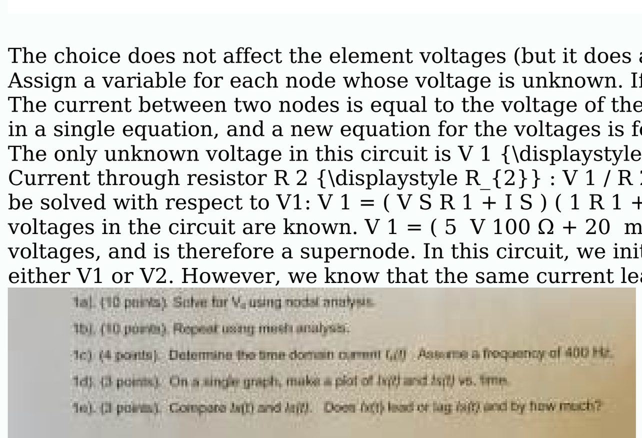


The choice does not affect the element voltages (but it does affect the nodal voltages) and is just a matter of convention. Choosing the node with the most connections can simplify the analysis. For a circuit of N nodes the number of nodal equations is N−1.

Assign a variable for each node whose voltage is unknown. If the voltage is already known, it is not necessary to assign a variable. For each unknown voltage, form an equation based on Kirchhoff's Current Law (i.e. add together all currents leaving from the node and mark the sum equal to zero).

The current between two nodes is equal to the voltage of the node where the current exits minus the voltage of the node where the current enters the node, both divided by the resistance between the two nodes. If there are voltage sources between two unknown voltages, join the two nodes as a supernode. The currents of the two nodes are combined in a single equation, and a new equation for the voltages is formed. Solve the system of simultaneous equations for each unknown voltage. Examples Basic case Basic example circuit with one unknown voltage, V1.

The only unknown voltage in this circuit is V 1 {\displaystyle V_{1}} . There are three connections to this node and consequently three currents to consider. The direction of the currents in calculations is chosen to be away from the node. Current through resistor R 1 {\displaystyle R_{1}} : (V 1 − V S) / R 1 {\displaystyle (V_{1}-V_{S})/R_{1}} Current through resistor R 2 {\displaystyle R_{2}} : V 1 / R 2 {\displaystyle V_{1}/R_{2}} Current through current source I S {\displaystyle I_{S}} : − I S {\displaystyle -I_{S}} With Kirchhoff's current law, we get: V 1 − V S R 1 + V 1 R 2 − I S = 0 {\displaystyle {\frac {V_{1}-V_{S}}{R_{1}}}+{\frac {V_{1}}{R_{2}}}-I_{S}=0} This equation can be solved with respect to V1: V 1 = (V S R 1 + I S) (1 R 1 + 1 R 2) {\displaystyle V_{1}={\frac {\left({\frac {V_{S}}{R_{1}}}+I_{S}\right)}{\left({\frac {1}{R_{1}}}+{\frac {1}{R_{2}}}\right)}}} Finally, the unknown voltage can be solved by substituting numerical values for the symbols. Any unknown currents are easy to calculate after all the voltages in the circuit are known. V 1 = (5 V 100 Ω + 20 mA) (1 100 Ω + 1 200 Ω) = 14 3 V {\displaystyle V_{1}={\frac {\left({\frac {5{\text{ V}}}{100\,\Omega }}+20{\text{ mA}}\right)}{\left({\frac {1}{100\,\Omega }}+{\frac {1}{200\,\Omega }}\right)}}={\frac {14}{3}}{\text{ V}}} Supernodes In this circuit, VA is between two unknown voltages, and is therefore a supernode. In this circuit, we initially have two unknown voltages, V1 and V2. The voltage at V3 is already known to be VB because the other terminal of the voltage source is at ground potential. The current going through voltage source VA cannot be directly calculated. Therefore, we cannot write the current equations for either V1 or V2. However, we know that the same current leaving node V2 must enter node V1. Even though the nodes cannot be individually solved, we know that the combined current of these two nodes is zero.



This combining of the two nodes is called the supernode technique, and it requires one additional equation: V1 = V2 + VA. The complete set of equations for this circuit is: { V 1 − V B R 1 + V 2 − V B R 2 + V 2 R 3 = 0 V 1 = V 2 + V A {\displaystyle {\begin{cases}{\frac {V_{1}-V_{\text{B}}}{R_{1}}}+{\frac {V_{2}-V_{\text{B}}}{R_{2}}}+{\frac {V_{2}}{R_{3}}}=0\\V_{1}=V_{2}+V_{\text{A}}\\\end{cases}}} By substituting V 2 = (R 1 + R 2) R 3 V B − R 2 R 3 V A (R 1 + R 2) R 3 + R 1 R 2 {\displaystyle V_{2}={\frac {(R_{1}+R_{2})R_{3}V_{\text{B}}-R_{2}R_{3}V_{\text{A}}}{(R_{1}+R_{2})R_{3}+R_{1}R_{2}}}} Matrix form for the node-voltage equation In general, for a circuit with N {\displaystyle N} nodes, the node-voltage equations obtained by nodal analysis can be written in a matrix form as derived in the following. For any node k {\displaystyle k} , KCL states ∑ j ≠ k G j k (v k − v j) = 0 {\textstyle \sum _{jeq k}G_{jk}(v_{k}-v_{j})=0} where G k j = G j k {\displaystyle G_{kj}=G_{jk}} is the negative of the sum of the conductances between nodes k {\displaystyle k} and j {\displaystyle j} , and v k {\displaystyle v_{k}} is the voltage of node k {\displaystyle k} . This implies 0 = ∑ j ≠ k G j k (v k − v j) = ∑ j ≠ k G j k v k − ∑ j ≠ k G j k v j = G k k v k − ∑ j ≠ k G j k v j {\textstyle 0=\sum _{jeq k}G_{jk}(v_{k}-v_{j})=\sum _{jeq k}G_{jk}v_{k}-\sum _{jeq k}G_{jk}v_{j}=G_{kk}v_{k}-\sum _{jeq k}G_{jk}v_{j}} where G k k {\displaystyle G_{kk}} is the sum of conductances connected to node k {\displaystyle k} . We note that the first term contributes linearly to the node k {\displaystyle k} via G k k {\displaystyle G_{kk}} , while the second term contributes linearly to each node j {\displaystyle j} connected to the node k {\displaystyle k} via G j k {\displaystyle G_{jk}} with a minus sign. If an independent current source/input i k {\displaystyle i_{k}} is also attached to node k {\displaystyle k} , the above expression is generalized to i k = G k k v k − ∑ j ≠ k G j k v j {\textstyle i_{k}=G_{kk}v_{k}-\sum _{jeq k}G_{jk}v_{j}} . It is readily shown that one can combine the above node-voltage equations for all N {\displaystyle N} nodes, and write them down in the following matrix form (G 11 G 12 ⋯ G 1 N G 21 G 22 ⋯ G 2 N ⋮ ⋮ ⋱ ⋮ G N 1 G N 2 ⋯ G N N) (v 1 v 2 ⋮ v N) = (i 1 i 2 ⋮ i N) {\displaystyle {\begin{pmatrix}G_{11}&G_{12}&\cdots &G_{1N}\\G_{21}&G_{22}&\cdots &G_{2N}\\\vdots &\vdots &\ddots &\vdots \\G_{N1}&G_{N2}&\cdots &G_{NN}\end{pmatrix}}{\begin{pmatrix}v_{1}\\v_{2}\\\vdots \\v_{N}\end{pmatrix}}={\begin{pmatrix}i_{1}\\i_{2}\\\vdots \\i_{N}\end{pmatrix}}} or simply G v = i . {\textstyle \mathbf {Gv} =\mathbf {i} .} The matrix G {\displaystyle \mathbf {G} } on the left hand side of the equation is singular since it satisfies G 1 = 0 {\displaystyle \mathbf {G1} =0} where 1 {\displaystyle \mathbf {1} } is an N × 1 {\displaystyle N\times 1} column matrix containing only 1s. This corresponds to the fact of current conservation, namely, ∑ k i k = 0 {\textstyle \sum _{k}i_{k}=0} , and the freedom to choose a reference node (ground). In practice, the voltage at the reference node is taken to be 0. Consider it is the last node, v N = 0 {\displaystyle v_{N}=0} . In this case, it is straightforward to verify that the resulting equations for the other N − 1 {\displaystyle N-1} nodes remain the same, and therefore one can simply discard the last column as well as the last line of the matrix equation. This procedure results in a (N − 1) × (N − 1) {\displaystyle (N-1)\times (N-1)} dimensional non-singular matrix equation with the definitions of all the elements stay unchanged. See also Mesh analysis Ybus matrix Topology (electrical circuits) Charge conservation Circuit diagram References P. Dimo Nodal Analysis of Power Systems Abacus Press Kent 1975 External links Wikiversity has learning resources about Nodal analysis Branch current method Online four-node problem solver Simple Nodal Analysis Example Retrieved from "