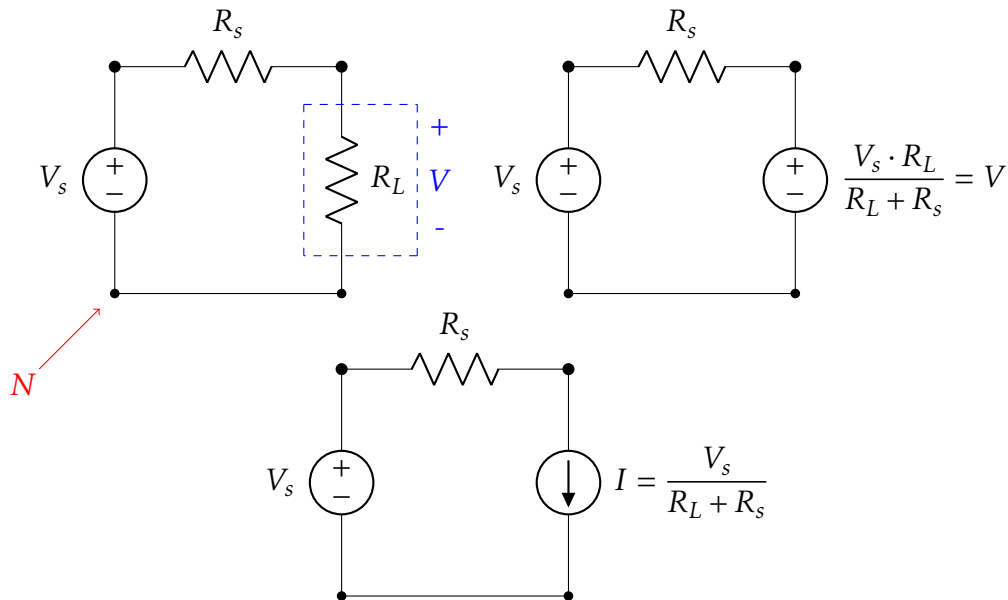


## Lecture 18: Proof of Thevenin's theorem

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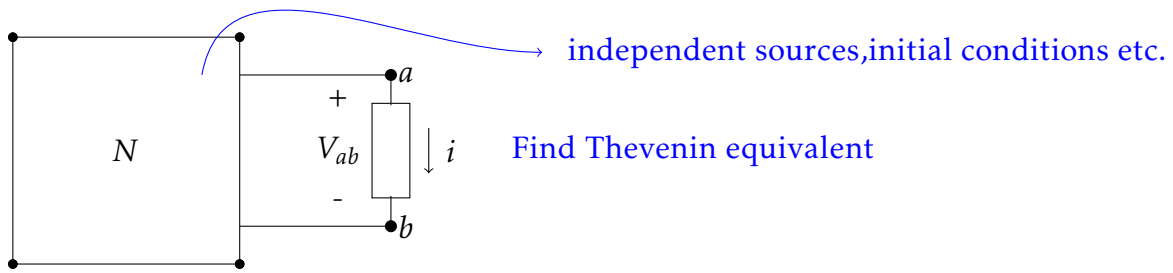
**Substitution Theorem:**

If  $R_L$  is replaced with a voltage source equal in value to the voltage across  $R_L$  in the original network, the other responses (current) remains the same. Equivalently, you can replace  $R_L$  with a current source equal in value to the current through  $R_L$  in the original network. The voltage across  $R_L =$  voltage across the current source in the modified network.

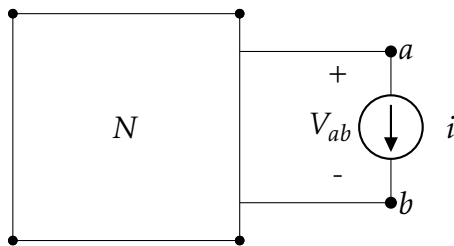
In general, solve for voltages, current in  $N$ . Assume we are doing nodal analysis and the solution to the node voltages are  $\{V_1, V_2, \dots, V_k\}$ ; pick any branch and replace it with a voltage source with value equal to the actual branch voltage. For eg., if we have an impedance between node  $i$  and the reference node, replace it with a voltage source of value  $V_i$ . This is called as **modified network**. Solutions to  $N$  and modified network are identical. This is obvious: Since  $V_i$  is the actual solution obtained using nodal analysis, the currents in all other branches are unaffected. Hence the current through the voltage source in the modified network also remains the same. Caution: If replacement by a voltage source, gives two voltage sources in parallel, one cannot do this.

**Proof of Thevenin's theorem**

$N$  is a network containing independent sources, initial conditions. We wish to replace it by its Thevenin equivalent across terminals  $a$  and  $b$ .

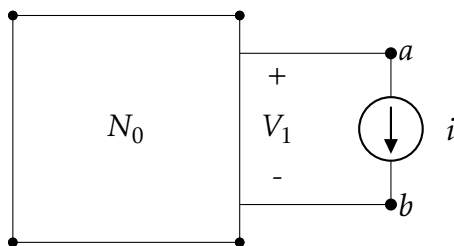


Find Thevenin equivalent



Use superposition to find solution  $V_{ab}$

First, use substitution theorem and replace the load by a current source whose value is the current through the load ( $i$ ). For this modified network, it is possible to find the solution using superposition. Set  $i = 0$ ; (open circuit across terminals  $a$  and  $b$ ). Activate one source at a time and find voltage across  $a$  &  $b$  i.e.  $V_{oc}$ . Set all sources in  $N$  to zero and activate  $i$ ; We get the following circuit.

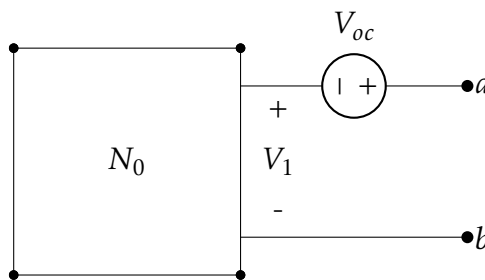


Let the solution be  $V_1$

Network  $N_0$  has no initial condition & no sources (short voltage sources and open current sources)

By Superposition, total solution is  $V_{ab} = V_{oc} + V_1$

For any arbitrary current source connected to terminals  $a$  and  $b$ , the solution of ' $N$ ' can be written as sum of  $V_{oc}$  and the solution to the relaxed network  $N_0$  i.e.



Thevenin equivalent circuit

Note that  $N_0$  can be replaced by the driving point impedance as seen from terminals  $a$  and  $b$ .