Handout for Circuits and Network Analysis

Fall 2025

These handouts serve as **compact, informal summaries** of grouped lecture topics from the course. Rather than offering detailed lecture-by-lecture notes, the material clusters related concepts into an approachable and streamlined format. These are intended to supplement, not replace, standard textbooks. For more thorough explanations, please consult the references listed below.

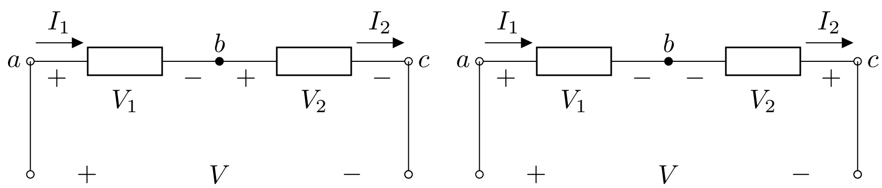
Note: These notes are prepared in an informal style and may contain typos or minor errors. If you notice any mistakes, please let me know so I can correct them in future versions.

References:

1. M. E. Van Valkenburg, *Network Analysis*, 3rd Edition, Prentice-Hall of India.
2. C. A. Desoer and E. S. Kuh, *Basic Circuit Theory*, McGraw-Hill.
3. W. H. Hayt Jr., J. E. Kemmerly, and S. M. Durbin, *Engineering Circuit Analysis*, 9th Edition, McGraw-Hill.
4. C. K. Alexander and M. N. O. Sadiku, *Fundamentals of Electric Circuits*, 7th Edition, McGraw-Hill.
5. A. S. Sedra and K. C. Smith, *Microelectronic Circuits*, 8th Edition, Oxford University Press.

Series and Parallel Connection of Circuit Elements

- Two circuit elements are said to be connected in series if they are connected end-to-end (i.e., they have a common node), such that the same current flows through both elements. A typical layout of series connected elements is shown Fig. 1. The voltage across the series combination of elements is the algebraic sum of the voltages across



(a) scenario 1 (b) scenario 2

Fig. 1: Series connection of circuit elements.

each element. It is important to pay attention to the polarity of the voltages when determining the voltage across the series combination. For example, in Fig. 1a, the voltage across the series combination is V can be computed as

$$V = -\int_c^a \mathbf{E}\cdot\mathbf{dl} = -\int_c^b \mathbf{E}\cdot\mathbf{dl} - \int_b^a \mathbf{E}\cdot\mathbf{dl} = V_2 + V_1 \tag{1}$$

On the other hand, in Fig. 1b, the voltage across the series combination is V can be computed as

$$V = -\int_c^a \mathbf{E}\cdot\mathbf{dl} = -\int_c^b \mathbf{E}\cdot\mathbf{dl} - \int_b^a \mathbf{E}\cdot\mathbf{dl} = -V_2 + V_1 \tag{2}$$

- Two circuit elements are in parallel if they are connected such that they share the same two nodes. This means that the voltage across the parallel combination is same, because the potential difference between two points (defined by the external work done per unit charge) is independent of the path taken. A typical layout of parallel connected elements is shown in Fig. 2. The current through the parallel combination of elements depends on whether the

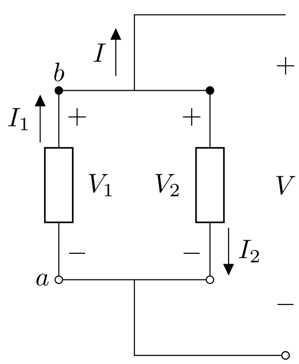


Fig. 2: Parallel connection of circuit elements.

combination is connected to an external circuit or not.

  - If the parallel combination is not connected to an external circuit ($I = 0$), the current through each element is same and so is the voltage across them. For the conventions shown in Fig. 2,the voltage across and the current through the inidividual elements can be expressed as

$$V_1 = V_2 = V \text{ and } I_1 = -I_2 \ \ \text{(note the current references)} \tag{3}$$

– On the other hand, if the parallel combination is not connected to an external circuit, the current I (see Fig. 2) is given by

$$I = I_1 - I_2 \ \ \text{(derived from KCL)} \tag{4}$$

Note that even in this case, the potential difference across the elements remains the same, i.e.,

$$V_1 = V_2 = V \tag{5}$$

A word of caution here! When we study AC circuits, the voltage across the algebraic sum of voltages across the parallel connected elements is equal to time-rate of change of magnetic flux associated with the loop. This can result in a situation where the voltages across the parallel connected elements are not equal, i.e., $V_1 \neq V_2$ (Luckily we are still dealing with DC circuits here!).

- Questions to ponder: What happens to the power consumed by elements connected in series or parallel? Does the choice of sign convention affect the actual power consumed/generated by the elements, or does it only change the way we express it?