

Lecture S7 Muddiest Points

General Comments

A lot of students were baffled by the idea of a Thevenin equivalent circuit. Please re-read the notes on this topic. Perhaps the easiest way to think about a Thevenin (or Norton) equivalent circuit is that it is a circuit model of a circuit, which models the behavior of the circuit at its terminals, but not in the individual elements.

Responses to Muddiest-Part-of-the-Lecture Cards

(38 cards)

1. **General confusion about Thevenin equivalent circuits. (10 students)** Comments ranged from the succinct, *Huh?*, to the more informative *What's the physical significance of Thevenin and Norton values?* Several folks asked for more examples. There will be at least one on the problem set this week.

Let me say again what I said in class: If you look into a resistive circuit at its terminals, the behavior will be pretty simple. In particular, you can describe the behavior by any two of three parameters: The Thevenin voltage (or open-circuit voltage); the Norton current (or short-circuit current); and the Thevenin (or Norton) resistance. On a plot of voltage versus current at the terminals, these three parameters correspond to the y -axis intercept, the x -axis intercept, and the slope of the straight line that describes the v versus i behavior of the circuit.

Why is this useful? Because it allows one to characterize what may be a fairly complicated circuit by just two parameters.

2. **Can you go through how the "short circuit" bit works for Norton? (1) What is I_N and how do you compute it?** If you look at the plot of v vs. i for a typical circuit, we identified V_T as the voltage for zero current, R_T is the slope, and $-I_N$ is the current for zero voltage, i.e., the x -axis intercept. So one way, in principle, to find I_N is to short the terminals of the circuit and measure the resulting current.
3. **Equations and pictures mean nothing to me ... is there a text I can look at? (1)** Hmmmm ... won't a textbook have equations and pictures? Please look at the notes. You could look at a book such as Bose and Stevens, "Introductory Network Theory."
4. **To [solve the node equations], should we use Cramer's rule or use G^{-1} ? (1)** I used G^{-1} to make a point. For small systems, you are probably better off using Cramer's rule.
5. **Given a loop [circuit?], what inputs do we need to calculate R_T and V_T ? (1)** You can solve the circuit for two different boundary conditions (say, short circuit and open circuit), or apply a current source (I_{test}) and determine the voltage as a function of the current.

6. *v and V_T ?? (1)* What does this mean?
7. *On the board you had the Thevenin circuit, with nothing attached to the terminals. Is $v = V_T$ in this situation? If yes, then in the PRS question [for the circuit with nothing attached to the terminals], does $v = V_T \neq 10 \text{ V}$? (1)* Yes, and yes. The open circuit voltage is V_T .
8. *In the PRS question, I was having trouble understanding how to find V_T . Do we ignore the terminals? (1)* That's right. To find V_T , you find the open-circuit voltage, that is, the voltage with nothing connected to the terminals.
9. *Still confused about the concept question. (1)* Please see the notes, which have a very similar problem.
10. *In the PRS question, why do the resistances add? (1)* When we calculated V_T , we found the current around the loop, so that we could find the voltage across the 10Ω resistor. In that situation, the resistors are in series, so their values add when we find the total resistance in the loop. To see this, just write the loop equation (using the loop method) for this problem.
11. *How do you find V_T , R_T , and I_N ? (3) I still don't get how to evaluate a circuit and compare it to a Thevenin circuit.* The most reliable way is to apply a test current, I_{test} , to the terminals, and find v as a function of I_{test} . In general, it will have the form

$$v = a + bI_{\text{test}} \quad (7)$$

for some constants a and b . Once you find a and b , you know V_T and R_T , since $a = V_T$, and $b = R_T$. From this, calculate $I_N = V_T/R_T$.

12. *I still do not know how to identify a short circuit current or a Thevenin resistance. What do I choose when I look at the circuit? (1)* See previous question.
13. *What do you mean by a "short circuit." (1)* A short circuit is what results when you put a conductor (a wire) across two nodes (in this case, the terminals).
14. *For the PRS question, how did you get the current in the loop to be 0.5 A? (1)* Use the loop method. The total resistance in the loop is 20Ω . The voltage source has strength 10 V . So the loop current is 0.5 A .
15. *How to use the Norton current? (1)* You can use the Thevenin circuit or the Norton circuit to analyze or characterize a more complicated circuit. In essence, a Norton (or Thevenin) circuit is model for a more complicated circuit.
16. *No mud. (9)* Apparently, this was a "muddy" lecture, as there were only 9 "no mud" cards. However, there was this: *I have read about Thevenin voltage in high school, in 8.022, and out of a thick electronics book. But never have I received an explanation as good as yours!* Glad to hear it.

There was also this: *Systems Problems should not be due the day after a Yankees / Red Sox game.* Perhaps. Just be glad that there are Yankees / Red Sox games.