Lecture S13 Muddiest Points

General Comments

In today's lecture, we began considering circuits with sources. We saw that the state-space equations for such a system generally have the form

$$\dot{x} = A\underline{x} + Bu \tag{32}$$

This is the *state equation*. In Lecture S14, we will look at the measurement equation, which will complete the description of the relationship between input and output.

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

(46 cards)

1. ***General confusion about the last PRS question. (5 students)*** I will try to post a discussion. I'm running behind updating the PRS questions.

2. ***For the PRS question, I got different signs than in your solution. I got***

$$-\frac{(u(t) - v_1(t))}{R} - C\frac{dv_1}{dt} + i_2 = 0 \tag{33}$$

   (1) I think that the only term you got wrong is the capacitor current. You drew it as up — it should be down, since the + sign is on top.

3. ***Given the eigenvalues, I can find eigenvectors. How do I find the eigenvalues?*** *(1)* Please see the reading assignment. The short answer is to solve

$$\det(sI - A) = 0 \tag{34}$$

4. ***When dealing with states, can you just focus on the states and ignore everything else in between...?*** *(1)* Not sure what you mean. The notes have a step-by-step procedure which you can follow.

5. ***Can you go over specific differences in calculating information about a capacitor vs. and inductor?*** *(1)* The question is vague enough that I'm not sure that I can answer it. Please see me at office hours or recitation.

6. ***Mud: how to solve 3×3 matrix to find eigenvalues.*** *(1)* There is an example on the homework this week. See me at office hours if you have trouble with it.

7. ***How do you vary the spread of the graph [of the transfer function of the bandpass filter]?*** *(1)* The frequency of the center of the pass band is set by L and C. For given L and C, the width of the pass band is controlled by the value of R.

8. ***For the PRS example in class, all the nodes were known. I don't know if I could do it if that weren't the case.*** *(1)* There are examples this week on the homework to give you practice.

9. **What do you mean by "state space"? (1)** The state space approach is what we are doing — describing the dynamics of systems by considering the differential equations for the states of the system.

10. **Not clear how [unreadable] works. (1)** Sorry, I couldn't read your question.

11. **How do you determine which way the current is going through a capacitor? (1)** I'm not sure I understand your question. If we label a capacitor with $+/-$, then we *measure* the current in a particular direction, that is, down if the $+$ is at the top.

12. **Good lecture. You mentioned that a bandpass filter doesn't block 100% of a signal at any frequency. Does this mean that they don't pass 100% of any signal? (1)** Thanks! No. In a bandpass filter, the filter can have a gain of 100% at the center frequency, but there is no frequency at which the gain is 0%.

13. **In the bandpass filter, what are the input and outputs? (1)** The input is the source strength, $u(t)$. The output is the voltage, $y(t)$.

14. **How do we find the frequency that will give the highest output / input ratio (in the bandpass filter)? (1)** I haven't given you enough tools yet to do that. In principle, you could just plot the "transfer function" (which I will explain in S14), and look for the maximum.

15. **How did you know to write**
$$\dot{x} = A\underline{x} + Bu \tag{35}$$

    (1) In any linear circuit, the rate of change of any capacitor voltage is proportional to the current through the capacitor. That current is in turn a linear combination of all the capacitor voltages and inductor currents, plus the voltage and current source strengths. Likewise, the rate of change of any inductor current is proportional to the voltage across the inductor. That voltage is in turn a linear combination of all the capacitor voltages and inductor currents, plus the voltage and current source strengths. So the rate of change of the states is a linear combination of the states and the sources. The equation above is the most general form of that result.

16. **More examples of finding i and v for circuits with inputs. (1)** We will do a little more of this in S14, recitation.

17. **When solving for the eigenvectors of a 2×2 matrix, can you always use a value of 1 for either of the variables and then solve for the other? (1)** No! For example, the matrix
$$A = \begin{bmatrix} 0 & 2 \\ 0 & 1 \end{bmatrix} \tag{36}$$

    has eigenvalues $s = 1$ and $s = 0$. For $s = 0$, the eigenvector is

$$\underline{v} = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \tag{37}$$

18. **In first PRS question, why is $v_1 = v_2$? (1)** The capacitor and inductor are in parallel — they share two nodes in common. Therefore, the voltage across the two are the same.

19. ***What is a bandpass filter, and how does it work? (1)*** We will take this up again in S14.

20. ***Is the frequency at which the bandpass filter gives outputs the resonant frequency of the circuit? When the circuit is resonant, does the current basically just [unreadable] between the capacitor and inductor? (1)*** Yes, the pass band is centered on the resonant frequency. At resonance, most of the current flow in the inductor also flows through the capacitor.

21. ***I did not understand the back substitution technique. (1)*** Please see the linear algebra primer (the first reading).

22. ***States are still unclear. (1)*** Understood. I'm not sure how to help, other than to ask that you see me in person.

23. ***How do you work with C and L? How else can they be represented in equations? (1)*** I'm afraid that I don't understand you question. Please ask me in recitation or office hours.

24. ***No mud. (19)*** Good!