MATHEMATICAL QUESTIONS

Question 1

Find the equivalent resistance of the ladder network in Fig. 1.

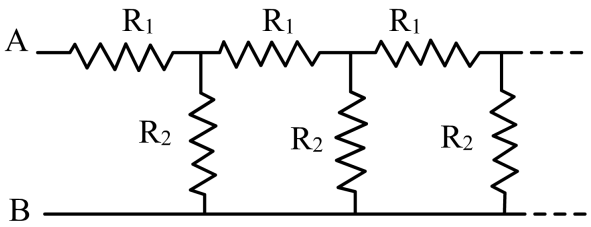

Figure 1: Ladder resistor network.

Question 2

How are Δ and T resistor networks in Fig. 2 equivalent?

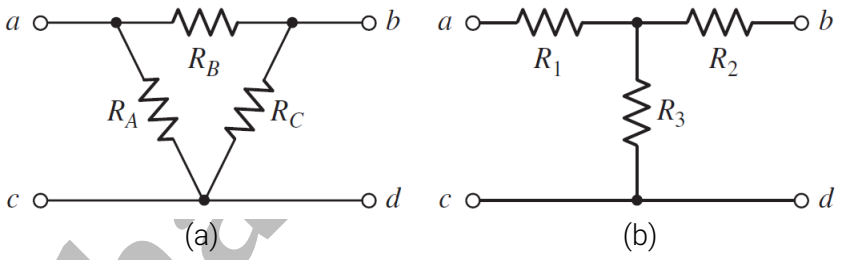

Figure 2: Two well-known equivalent resistor circuits. (a) Δ network. (b) T network.

Question 3

Consider the characteristic curves of the two NTI inductors shown in Fig. 3.

Question 3 continued on next page...

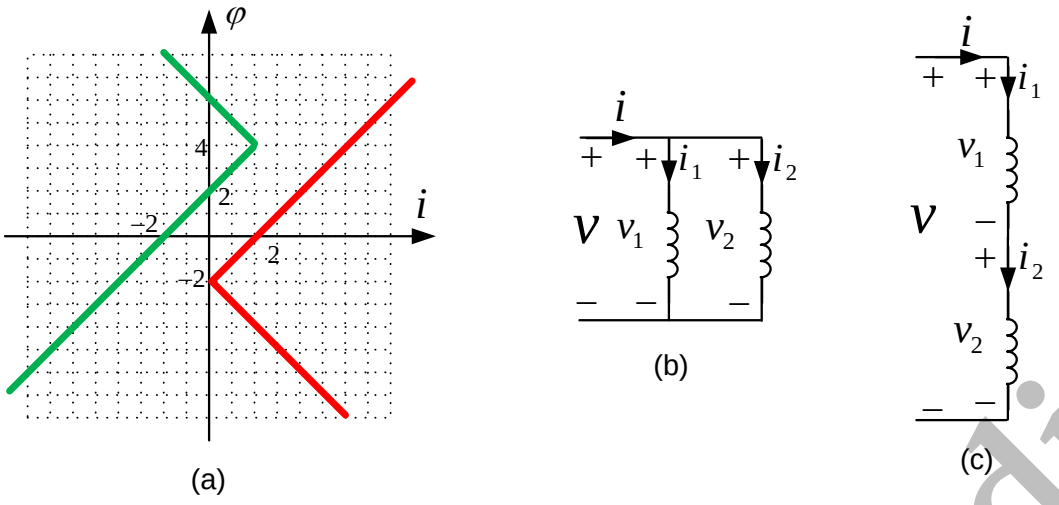

Figure 3: (a) Characteristic curves of two NTI inductors. (b) parallel connection. (c) series connection.

(a) Plot the characteristic curve of the parallel connection of the two inductors. Assume that the initial conditions are zero.

(b) Plot the characteristic curve of the series connection of the two inductors. Assume that the initial conditions are zero.

Question 4

Consider the diode circuit shown in Fig. 4.

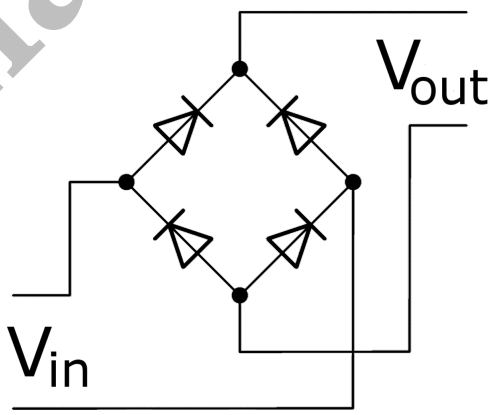

Figure 4: Full diode bridge rectifier.

Question 4 continued on next page...

(a) Plot the input-output characteristic curve, i.e., V_{out} versus V_{in}.

(b) Assume that $V_{in} = A\cos(\omega t + \theta)$. Plot V_{out} versus time t.

(c) How can this circuit be used as a rectifier?

Question 5

Two LTI capacitors and two LTI inductors are respectively going to be connected in parallel and series at $t = 0$, as shown in Fig. 5.

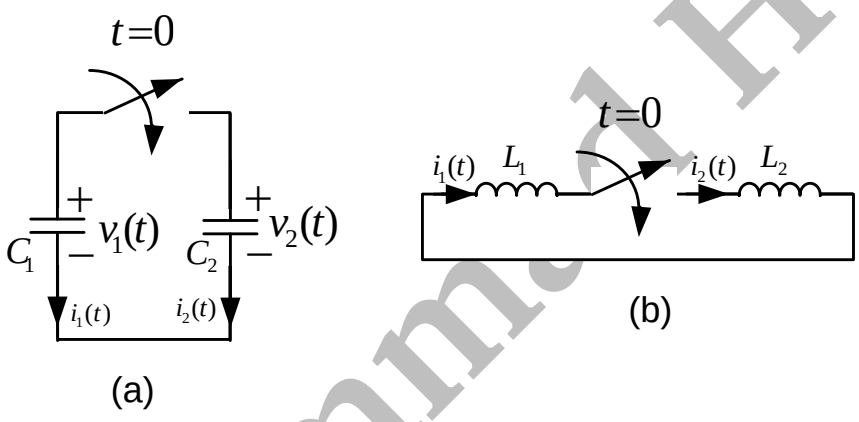

Figure 5: (a) Parallel connection of two LTI capacitors. (b) series connection of two LTI inductors.

(a) Calculate $\epsilon(0^-)$ and $\epsilon(0^+)$, the absolute electrical energy before and after connection, for the capacitors and show that $\epsilon(0^-) \geq \epsilon(0^+)$. Is the energy conserved? Provide enough explanation.

(b) Calculate $\epsilon(0^-)$ and $\epsilon(0^+)$, the absolute magnetic energy before and after connection, for the inductors and show that $\epsilon(0^-) \geq \epsilon(0^+)$. Is the energy conserved? Provide enough explanation.

Question 6

Design a resistive one-port with linear resistors, ideal diodes, and independent sources that has the iv characteristic shown in Fig. 6.

Question 6 continued on next page...

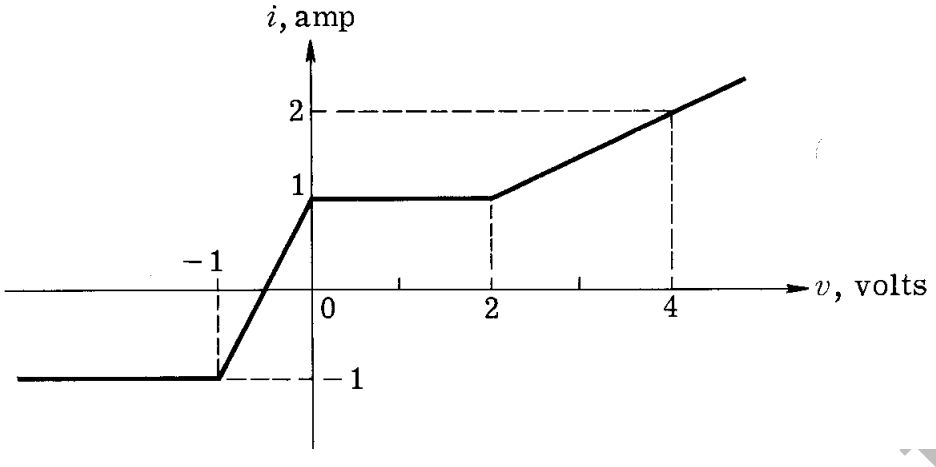

Figure 6: A desired iv characteristic curve.

SOFTWARE QUESTIONS

Question 7

Assume that the characteristic curve of a voltage-controlled NTI capacitor is described by $q = f(v)$. Write a MATLAB/Python function that receives the characteristic curve along with an arbitrary input voltage waveform and generates the corresponding output current waveform. Plot the current waveform for a few sample NTI capacitors.

BONUS QUESTIONS

Question 8

Consider the infinite grid of resistors shown in Fig. 7. All the resistors have a same resistance of R.

Question 8 continued on next page...

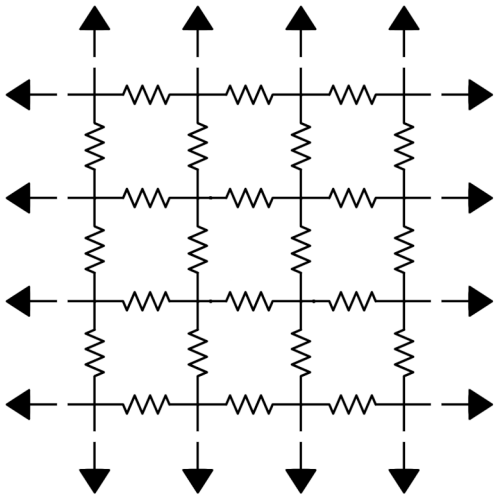

Figure 7: Infinite grid of resistors.

(a) Find the resistance between any two horizontal adjacent nodes $R_{0,1}$.

(b) Find the resistance between any two vertical adjacent nodes $R_{1,0}$.

(c) Find the resistance $R_{m,n}$ between two arbitrary nodes, which are m horizontal and n vertical steps away from each other. Note that this part may need complex mathematical calculations.

Question 9

Return your answers by filling the LaTeXtemplate of the assignment.

EXTRA QUESTIONS

Question 10

Feel free to solve the following questions from the book *"Basic Circuit Theory"* by C. Desoer and E. Kuh.

1. **Chapter 3, question 3.**
2. **Chapter 3, question 6.**

Question 10 continued on next page...

3. **Chapter 3, question 8.**
4. **Chapter 3, question 11.**
5. **Chapter 3, question 12.**
6. **Chapter 3, question 15.**
7. **Chapter 3, question 19.**
8. **Chapter 3, question 20.**