Homework for week 14

1. Textbook Reading:

- Chapter 15 Introduction to the Laplace Transform.
- Chapter 16 Applications of the Laplace Transform

2. Reference-Tan's textbook(谭老师教材)

- Chapter 14 （第 14 章 状态方程）
- Chapter 15 （第 15 章 非线性电阻电路）

3. Problem-solving:

Problem 1:

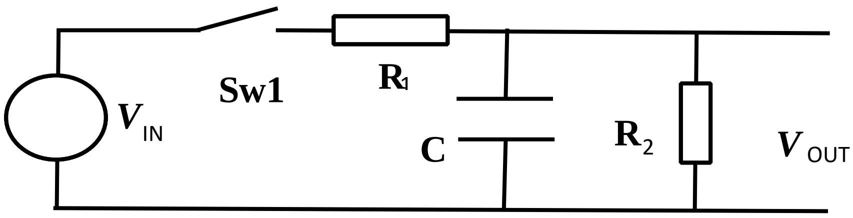
(a) The figure below shows a network where V_{IN} charges C with time constant τ_{C} when Sw1 is closed. If it were closed for ever, V_{OUT} would tend to V_{MAX}. When Sw1 is open, C discharges with time constant τ_{D}.

(i) Write an algebraic expression for τ_{D}.

(ii) Suppose that Sw1 is closed until V_{OUT} reaches a voltage V_{X}. Sw1 is then opened. Write an algebraic expression for V_{OUT} from this time onwards. Sketch a graph of V_{OUT} against time, marking V_{X}.

(iii) C is initially discharged, then Sw1 is closed. Sketch a graph of V_{OUT} against time, marking V_{MAX}. Give algebraic expressions for V_{MAX} and V_{OUT}.

(iv) Derive an algebraic expression for τ_{C}.



(b) This circuit is used to sample V_{IN}, which varies. Sw1 is closed briefly to take each sample. This happens once per second: Sw1 is closed for 1 ms then open for the next 999 ms. It is required that V_{OUT} rises to at least 99% of V_{MAX} while Sw1 is closed, and that V_{OUT} falls to no more than 1% of V_{MAX} while Sw1 is open. C is chosen to be 1 nF.

(i) Why do you think the 99% requirement was made?

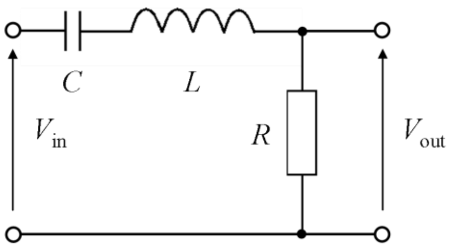
(ii) Why do you think the 1% requirement was made?

(iii) What must R_1 be to fulfil the 99% requirement? You may assume that R_2 is so much larger than R_1 that R_2 may be ignored.

Problem 2:

The circuit shown in Figure below has the following frequency transfer function:

$$H(\omega) = \frac{V_{\text{out}}}{V_{\text{in}}} = \frac{1}{1 + j\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)Q}$$

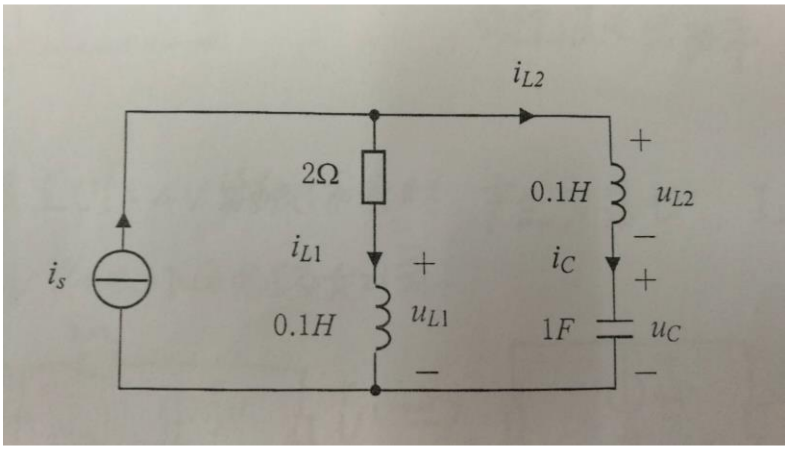


Passive filter circuit

By considering $H(\omega)$ at low frequencies, high frequencies and at $\omega = \omega_0$, justify that the circuit constitutes a band-pass filter. Write down expressions for Q and ω_0 in terms of R, C and L.

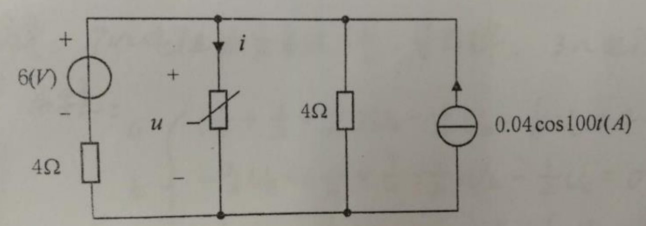
Problem 3:

Derive the State-Equation (in matrix form) of the circuit below.



Problem 4:

图示电路中，已知非线性电阻的伏安特性为 $u = i^2$ ($i>0$)。求 u 和 i 的值。



Following Problems are from Tan's textbook (谭老师教材).

Problem 5:

***Page* 397**: 14-4

Problem 6:

***Page* 398**: 14-6

Problem 7:

***Page* 413**: 15-2

Problem 8:

***Page* 415**: 15-7