ELEC 341 – Graded Assignments

Assignment A1
White-Box Systems

10 Marks

Learning Objectives

Modeling White Box Systems
Circuit Analysis
Impulse / Natural Response
Practical Impulse Response
Envelope Approximation
Step Response
Settle Time

Matlab
- inv()
- tf()
- minreal()
- lsim()
- impulse()
- step()
- plot()

When you design a circuit from scratch, you know exactly what's inside and can identify the system analytically. This is called a "White Box" system.

Q1 2 mark(s) CCT Analysis

Use circuit analysis to compute the transfer function **Vout/Vin** of the **Voltage Amplifier** circuit.
After assigning Q1.G, use **minreal()** to cancel any common factors.

- Q1.G (V/V) LTI

The circuit is nothing but a 2-stage amplifier. If you have difficulty analyzing it, review standard op-amp circuits. Most op-amp circuits are either an amplifier or weighted sum.

*If you round the coefficients, poles or zeros, of a transfer function, the error compounds. If you do not carry at least 3 significant digits, your error could compound quite a bit. But there is **no good reason** to round digits in the first place. Your MAT file isn't going to be any cleaner, just less accurate.*

Q2 2 mark(s) Impulse & Envelope

Plot the **Step** response. Scale the input by Vin to simulate the voltage source.
Find the **EXPONENTIAL** envelope from the Inverse Laplace Xform, or estimate it by trial & error.
Your envelope should have the form FV ± K exp(-A*T), where FV is the final value.

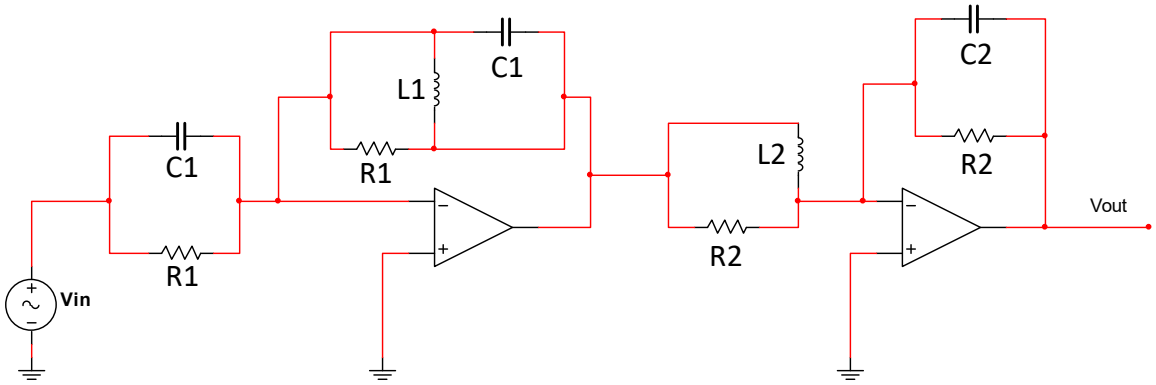
- Q2.K (V) Scalar
- Q2.A (s^-1) Scalar

Voltage Amplifier Circuit

$Vin = \#G\ (V)$

$R1 = 10 \times \#A\ (\Omega)$
$L1 = \#B\ (mH)$
$C1 = \#C\ (\mu F)$

$R2 = 10 \times \#D\ (\Omega)$
$L2 = \#E\ (mH)$
$C2 = \#F\ (\mu F)$



In Matlab, you can use impulse() to find a natural response, but in practice its an impossible input function because it is infinitely large. But you can approximate it. Just remember a fundamental property of the impulse function is the area under the curve is 1.

*Pay attention to **PHYSICAL UNITS**. An answer that is 1000x too big or too small is **WRONG**.*

Q3 1 mark(s) Approximate Impulse

Plot the **Impulse** response of Q1.G.

Generate a signal that starts high Vh at Th=0, goes low Vl=0 at Tl, and stays low for the length of the signal in Q2. This signal **APPROXIMATES** an impulse when Vh is large and Tl is small.

Use **lsim()** to apply the signal to the Voltage Amplifier and plot the response on the same figure.

Tl should be the **LARGEST** value that satisfies the following requirements:

The actual and approximate impulse responses are approximately equivalent when Tl = Q3.Tl

The actual and approximate impulse responses are noticeably different when Tl = 5 x Q3.Tl

- Q3.Tl (s) Scalar
- Q3.Vh (KV) Scalar

The function you developed is POSSIBLE, but is it PRACTICAL ???

Why or why not ??? What's the difference ???

What was the point of maximizing Tl ???

What would you do if you really did need to do this in practice ???

What could be easier than a circuit with only current sources because you can turn to your old friend, Nodal Analysis ???

*Now that you've got a new friend, Matlab, it's time to meet another new friend, Matrix-Method. To prove what a loyal friend it is, try to solve this problem **by inspection**.*

Q4 2 mark(s) CCT Analysis

Compute the transfer function **Iout/Iin** of the **Shunt** circuit.
Use **minreal()** to cancel any common factors.

- Q4.G (pure) LTI

Q5 2 mark(s) Step & Envelope

Plot the **STEP** response.
Find the **EXPONENTIAL** envelope from the Inverse Laplace Xform, or estimate it by trial & error.
Your envelope should have the form FV ± K exp(-A*T), where FV is the final value.

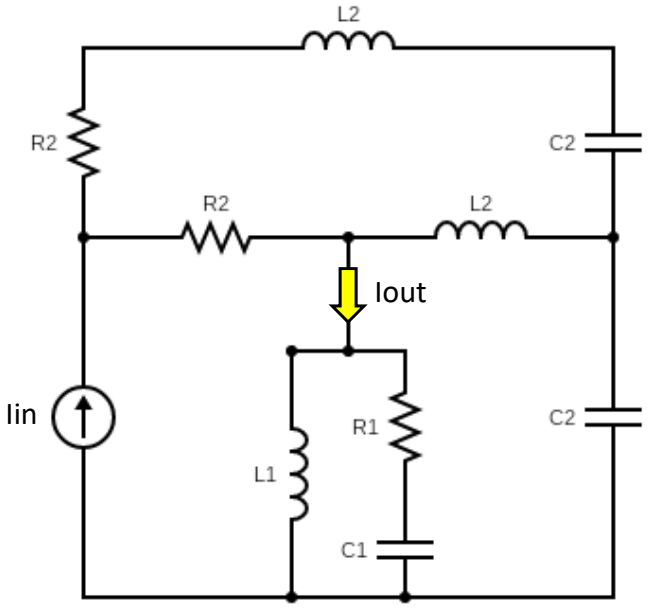
- Q5.K (A) Scalar
- Q5.A (s^-1) Scalar

***COW**: Check your initial and final values **by inspection** of the circuit.*
If they do not agree, your transfer function isn't right.

Shunt Circuit

$Iin = \#H\ (A)$

All other component values are the same as in the Voltage Amplifier Circuit



Settle time is the time it takes for a response to settle to within 2% of its final value.
***COW**: Pay attention to **PHYSICAL UNITS**.*
*An answer that is 1000x too big or too small is **WRONG**.*

Q6 1 mark(s) Settle Time

For your Q5 Step Response, estimate settle time Ts.

- Q6.Ts (ms) Scalar

What is the settle time for your Impulse response ???
Is it even possible to find the settle time of your Impulse response ???