Circuit Analysis and Transient Responses
by Aidan Chin & Aidan Carey
11/14/2023

Introduce and define concept (transient analysis)

Inductor- an inductor is a circuit component that temporarily stores energy in a surrounding magnetic field, they are often used with capacitors and resistors to make more complicated electrical components. Inductor
Capacitor- a capacitor is a circuit component that stores energy between 2 conductive plates, separated by a non conductive layer, they are often used with inductors and resistors to form more complicated electrical components. Capacitor
Resistor- resistors are a circuit component that resists the flow of current, they are often used with inductors and capacitors to make more complicated electrical components. Resistors
RC Circuit- A circuit that has a resistor and capacitor wired together. This specific type of circuit has countless uses, 2 common ones are; timing circuits and filtering out unwanted frequencies in a circuit. RC Circuits
RL Circuit- A circuit that has a resistor and inductor wired together. This type of circuit is frequently used in filters, oscillators, and damping systems. RL Circuits
RLC Circuit- A circuit that has a resistor, inductor, and capacitor wired together. This type of circuit is useful for voltage magnification, current magnification, and frequency filters. RLC Circuits
Steady state- this is the behavior of a circuit when the behavior is constant/unchanging. Steady State and Transient Response
transient conditions- by definition, the opposite of steady state, it is when the behavior of the circuit is changing, usually trends back towards the steady state. Steady State and Transient Response
transient response- This describes the behavior that a circuit will follow in the time it takes to return to steady state in response to an external input/disturbance. Transient Response
Transient analysis- this is the calculation of a circuit's transient response in a time frame as defined by the user. transient analysis

Differential equations- regarding Circuit analysis, differential equations introduce the time domain, and are useful to describe a circuit's behavior over time. Differential Equations in Circuit Analysis

Square wave- a square wave is a wave that has abrupt changes to max and minimum voltage. This wave is very significant because it is very good at representing 1 and 0, making the foundation of modern computers. Square Wave

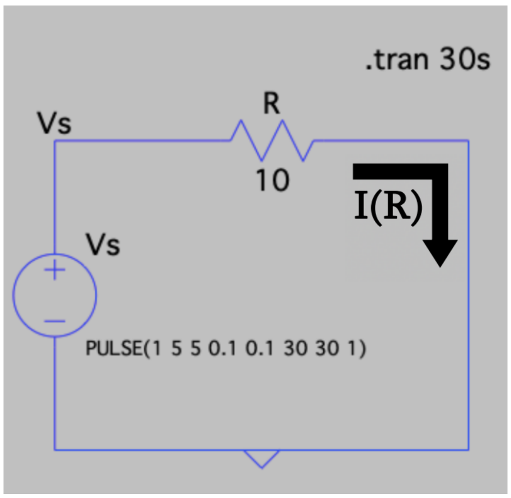
Rise time and fall time- the rise and fall time is the time it takes for a wave to rise to max voltage/fall to minimum voltage, in an ideal square wave, the rise and fall time is 0. Rise and Fall Time

Motivation for experiment

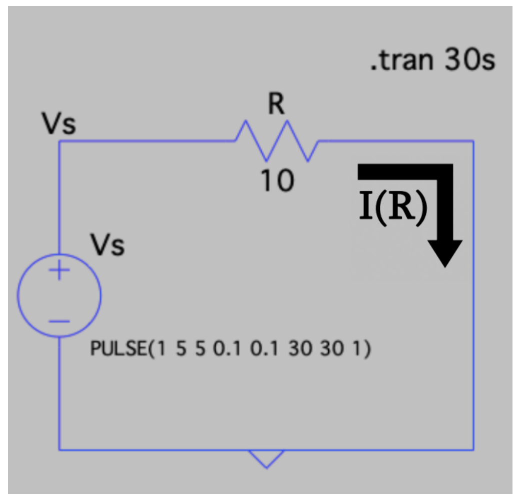
Our motivation for this lab is to deepen our understanding of R, RC, RL, and RLC circuit's transient response. It teaches us how to observe and analyze voltage and current behavior for inductors and capacitors when a circuit's state changes. Another goal is to increase our familiarity with LTSpice, a popular tool for circuit simulations so we can use this new understanding of R, RC, RL, and RLC circuits. We are also interested in applying the concepts that we have learned in lecture, and cement this knowledge in our minds.

R Circuit

t < 5s (steady state)



t > 5s (transient)



Voltage

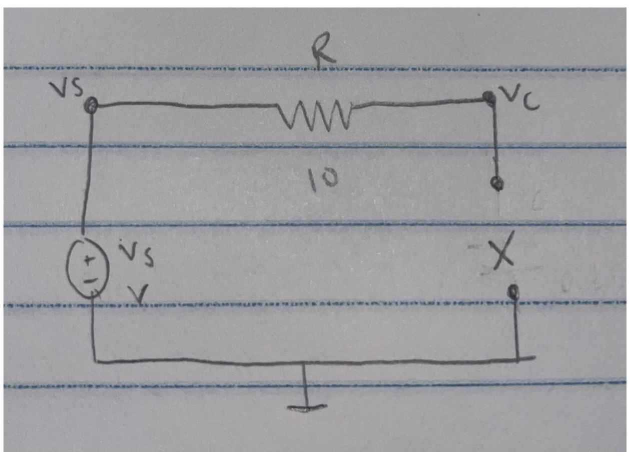
Current

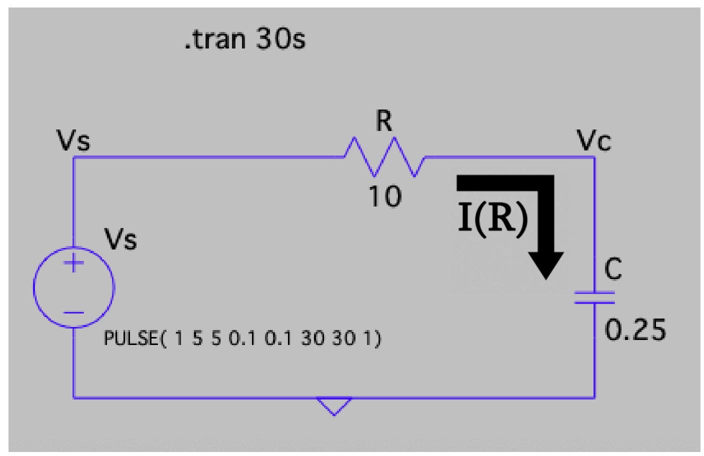
V(vs) @ T=0
1 Volt
V(vs) @ T=10
5 Volts
I(R) @ T=0
100 MilliAmps
I(R) @ T=10
500 MilliAmps

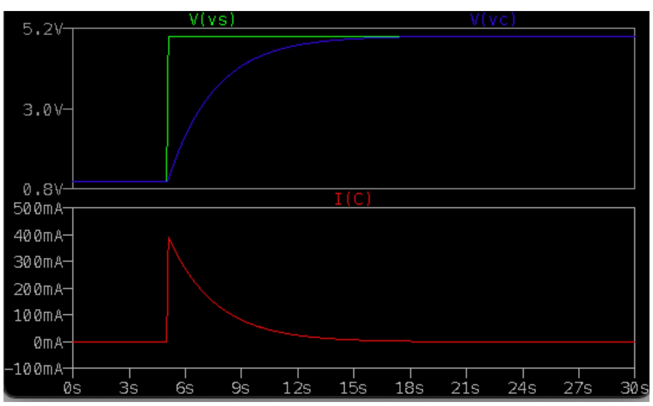
RC Circuit

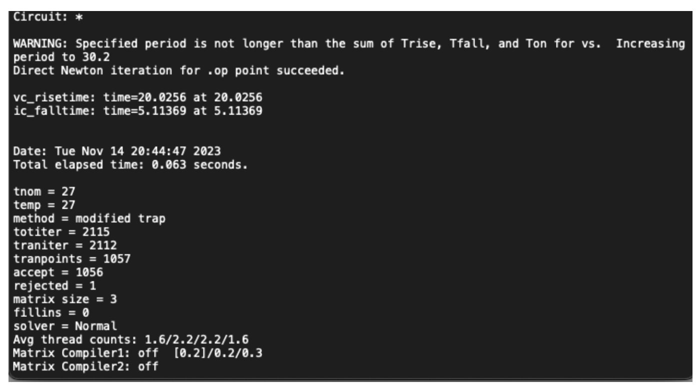
t < 5s (steady state)

t > 5s (transient)









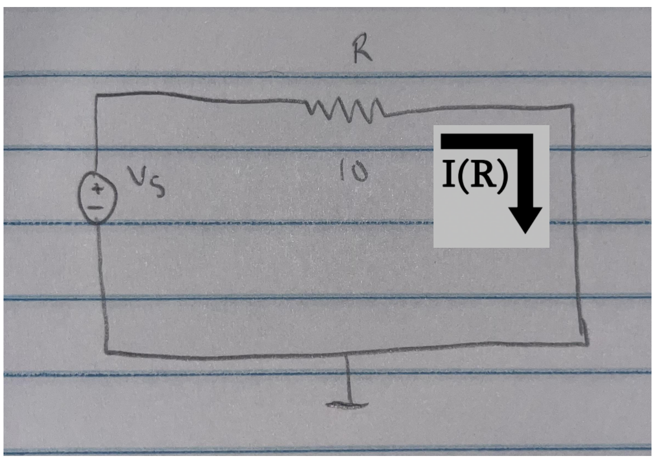
```
Circuit: *

WARNING: Specified period is not longer than the sum of Trise, Tfall, and Ton for vs.  Increasing
period to 30.2
Direct Newton iteration for .op point succeeded.

vc_risetime: time=20.0256 at 20.0256
ic_falltime: time=5.11369 at 5.11369


Date: Tue Nov 14 20:44:47 2023
Total elapsed time: 0.063 seconds.

tnom = 27
temp = 27
method = modified trap
totiter = 2115
traniter = 2112
tranpoints = 1057
accept = 1056
rejected = 1
matrix size = 3
fillins = 0
solver = Normal
Avg thread counts: 1.6/2.2/2.2/1.6
Matrix Compiler1: off  [0.2]/0.2/0.3
Matrix Compiler2: off
```

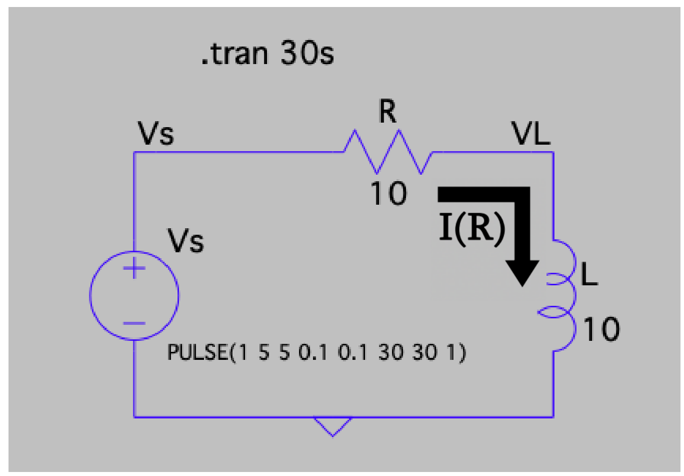
Vc(5-) = 1V
Vc(0+) = 5V

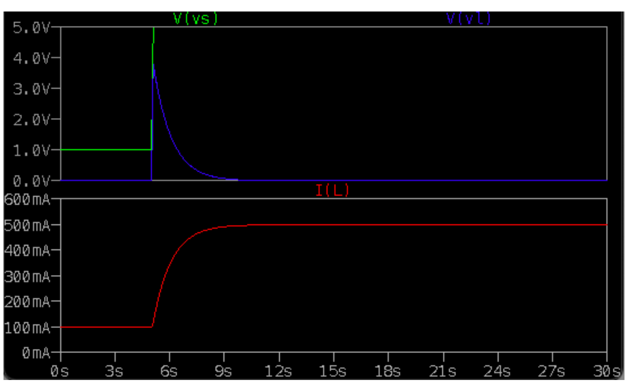
RL Circuit

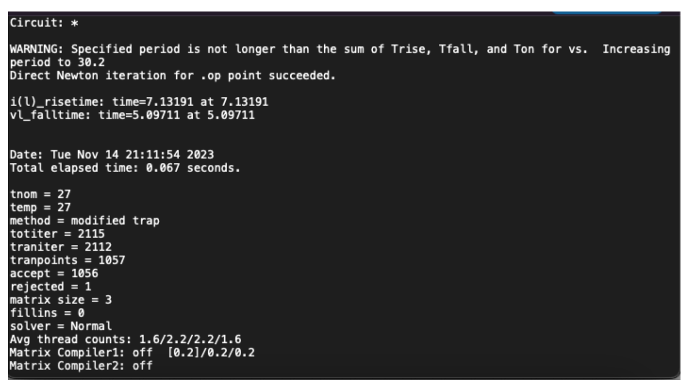
t < 5s (steady state)

t > 5s (transient)







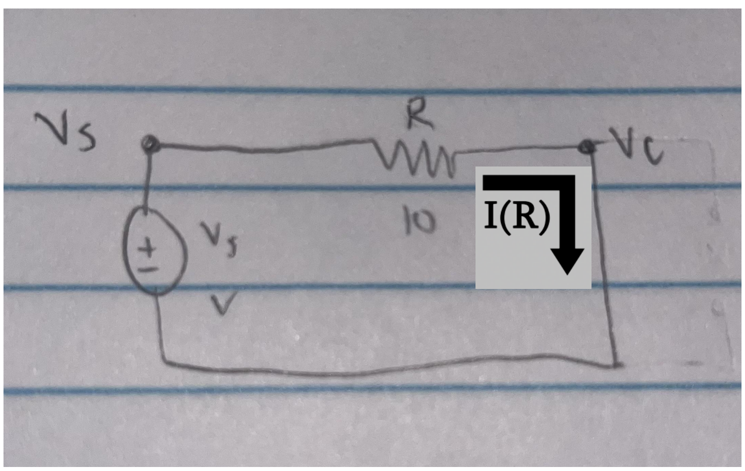


```
Circuit: *

WARNING: Specified period is not longer than the sum of Trise, Tfall, and Ton for vs.  Increasing
period to 30.2
Direct Newton iteration for .op point succeeded.

i(l)_risetime: time=7.13191 at 7.13191
vl_falltime: time=5.09711 at 5.09711


Date: Tue Nov 14 21:11:54 2023
Total elapsed time: 0.067 seconds.

tnom = 27
temp = 27
method = modified trap
totiter = 2115
traniter = 2112
tranpoints = 1057
accept = 1056
rejected = 1
matrix size = 3
fillins = 0
solver = Normal
Avg thread counts: 1.6/2.2/2.2/1.6
Matrix Compiler1: off  [0.2]/0.2/0.2
Matrix Compiler2: off
```

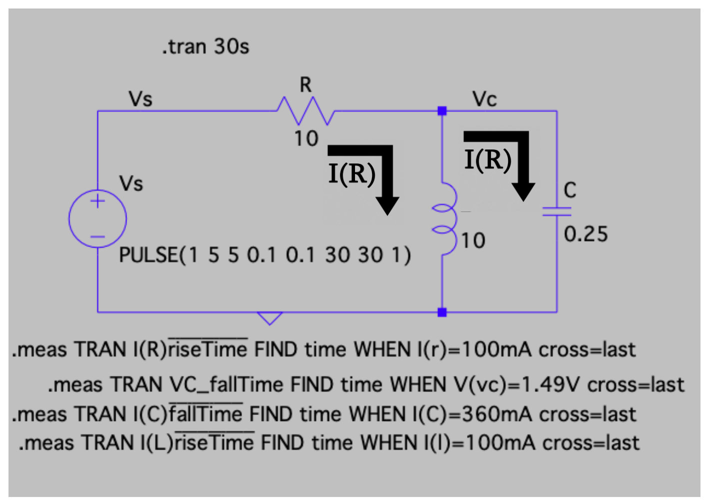
$IL(5^-) = 96mA$
$IL(0+) = 496mA$

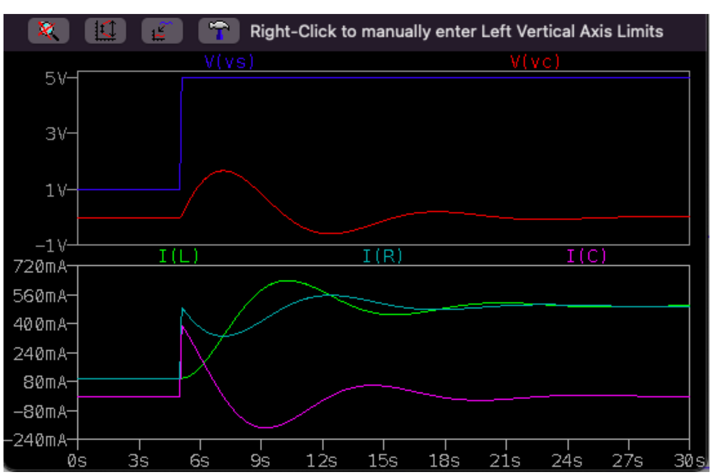
RLC Circuit

t < 5s (steady state)

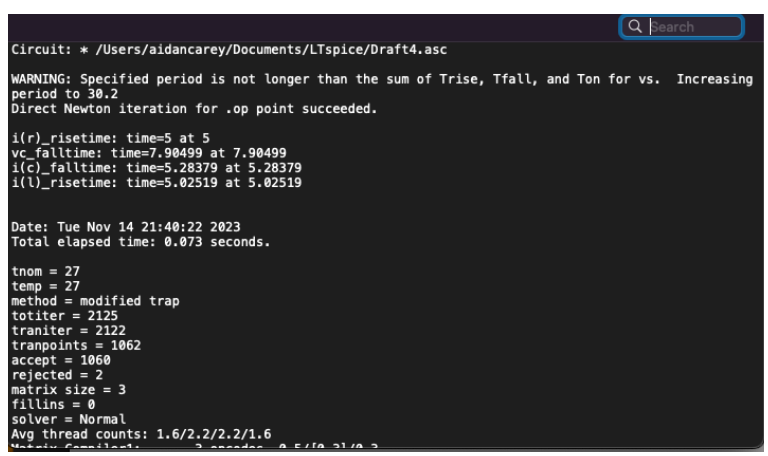


t > 5s (transient)





$IL(5^-) = 90mA$
$VC(5^-) = 0V$



```
Circuit: * /Users/aidancarey/Documents/LTspice/Draft4.asc

WARNING: Specified period is not longer than the sum of Trise, Tfall, and Ton for vs.  Increasing
period to 30.2
Direct Newton iteration for .op point succeeded.

i(r)_risetime: time=5 at 5
vc_falltime: time=7.90499 at 7.90499
i(c)_falltime: time=5.28379 at 5.28379
i(l)_risetime: time=5.02519 at 5.02519


Date: Tue Nov 14 21:40:22 2023
Total elapsed time: 0.073 seconds.

tnom = 27
temp = 27
method = modified trap
totiter = 2125
traniter = 2122
tranpoints = 1062
accept = 1060
rejected = 2
matrix size = 3
fillins = 0
solver = Normal
Avg thread counts: 1.6/2.2/2.2/1.6
```

Conclusion

In conclusion, this lab served its purpose. It deepened our understanding of transient responses in R, RC, RL and RLC circuits. We used LTSpice to analyze each circuit's behavior, including current and voltage and how it changes over time. In a simple R circuit we found that in the steady state the voltage to the resistor was 1 volt and the current across was 100 milliamps, when time equaled 10 seconds, we found that the voltage was 5 volts and the amperage was 500 milliamps, this is expected because the voltage and amperage increased by a factor of 5, which follows Ohm's Law. for the simple RC circuit, we found that the voltage going into the resistor was 1 volt at the steady state, $Vc(5^-)$, after the circuit reached its steady state, and before that in the initial condition of the transient state $Vc(0^-)$ the voltage was 5 volts. In the simple RL circuit, we found that the current going across transistor was 96 milliamps at the steady state, $IL(5^-)$, after the circuit reached its steady state, and before that in the initial condition of the transient state $IL(0^-)$ the current was 496 milliamps. Finally in the RLC circuit, we found that the voltage going into the resistor was 0 volts at the steady state $Vc(5^-)$, we also found that the current across the transistor was 90 milliamps at the steady state $Vc(5^-)$. In this lab we simulated the difference between each circuit, and showed how each component has its own unique behavior. We also showed how the characteristics of each component contribute to the overall behavior of the whole circuit. Not only did the lab show us how each component interacts with each other, it solidified our understanding of these types of circuits, at steady state and transient states.