

ECE 2300

Electronics Circuits
and
Electronics Devices Laboratory

Gregg Chapman

Laboratory 2

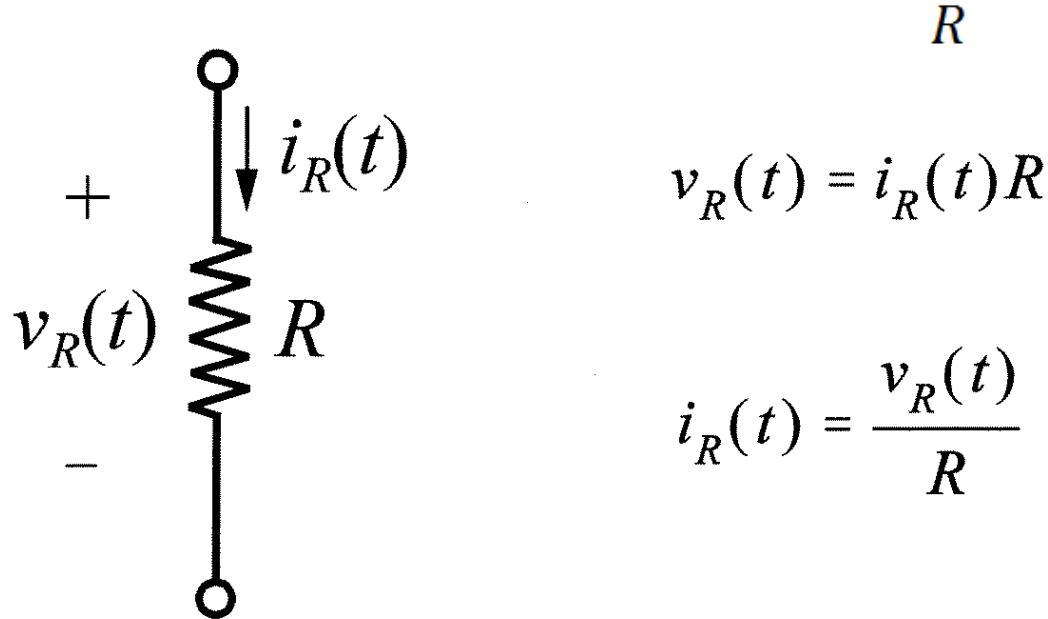
Passive Filters – Transient Response

Background

- Capacitors and Inductors
 - Laplace Notation
- Time Constants
 - Step Response

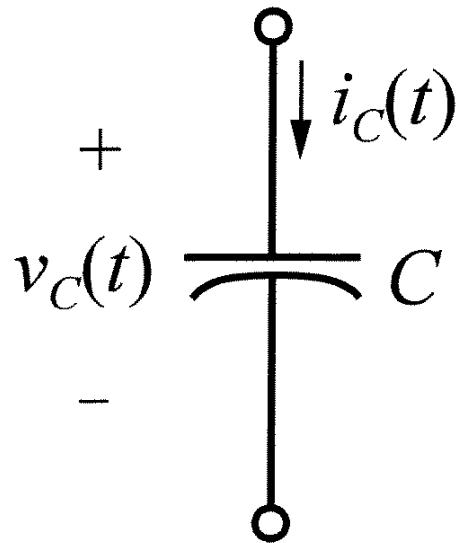
Resistors

Resistor



Capacitors

Capacitor



$$\frac{1}{sC}$$

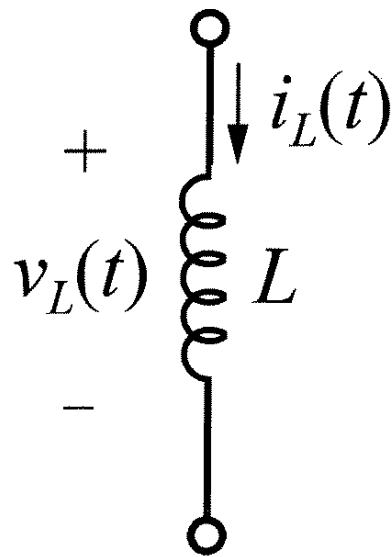
$$v_C(t) = \frac{1}{C} \int_{t_o}^t i_C(t) dt + v_C(t_o)$$

$$i_C(t) = C \frac{dv_C(t)}{dt}$$

$$S = j\omega$$

Inductors

Inductor

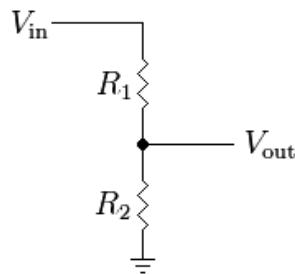


sL

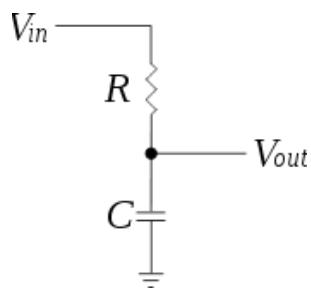
$$v_L(t) = L \frac{di_L(t)}{dt}$$

$$i_L(t) = \frac{1}{L} \int_{t_o}^t v_L(t) dt + i_L(t_o)$$

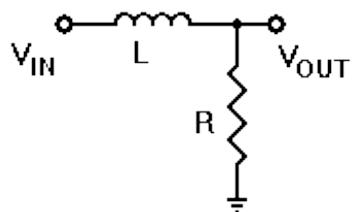
Laplace Notation



$$V_{out} = V_{in} \frac{R_2}{R_1 + R_2} \quad R$$



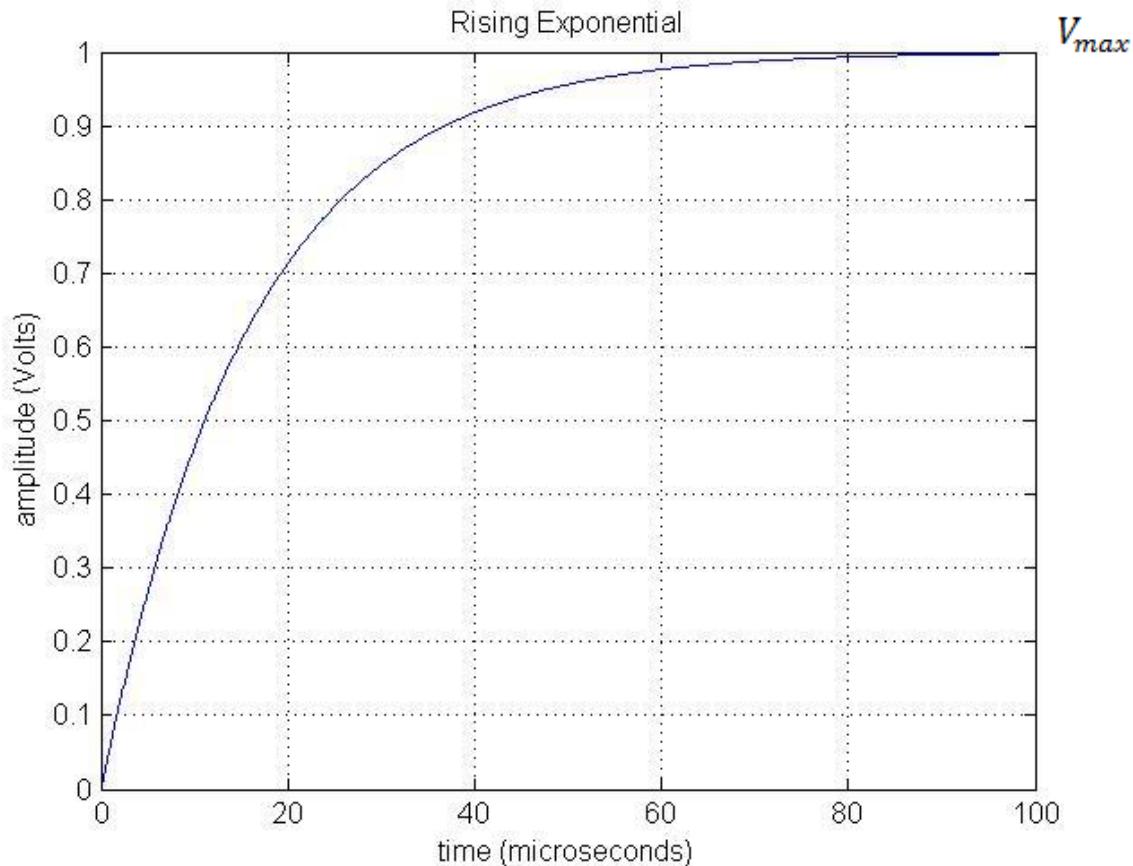
$$V_{out} = V_{in} \frac{1/sC}{R + 1/sC} \quad \frac{1}{sC}$$



$$V_{out} = V_{in} \frac{R}{R + sL} \quad sL$$

Rising Exponential

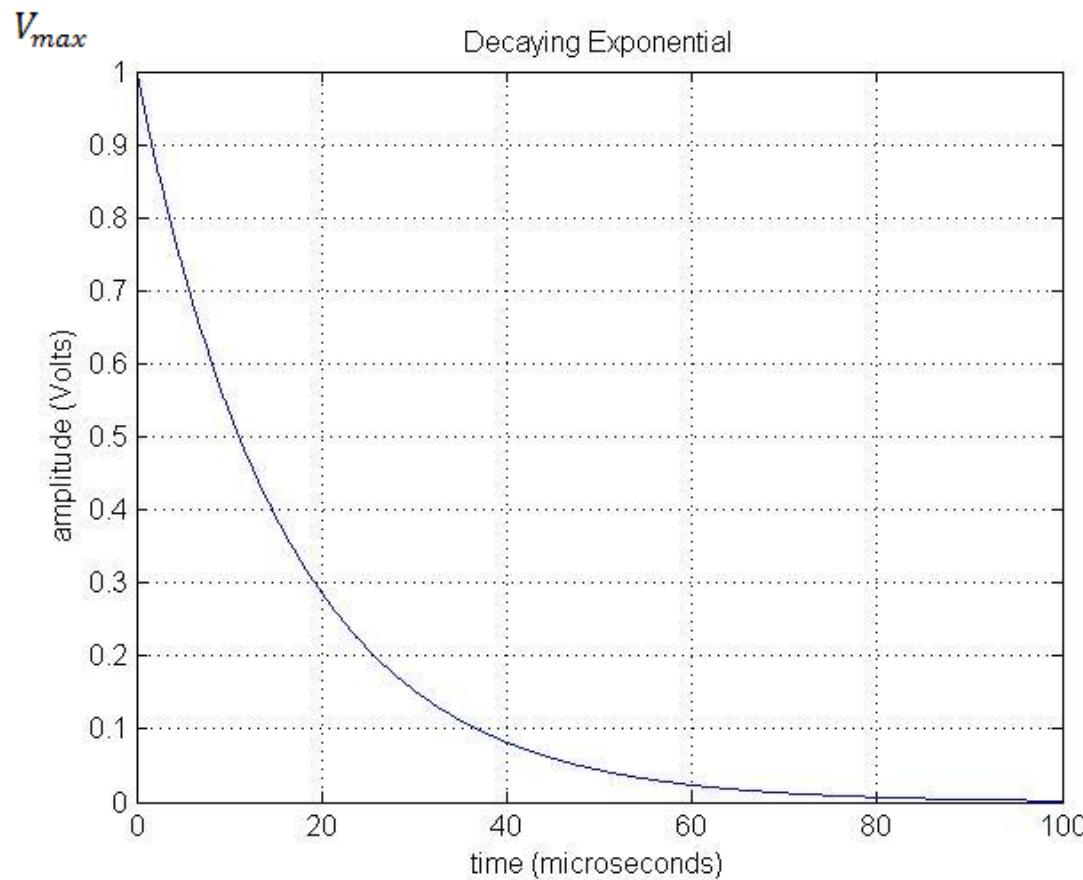
$$V(t) = V_{max} * (1 - e^{-t/\tau})$$



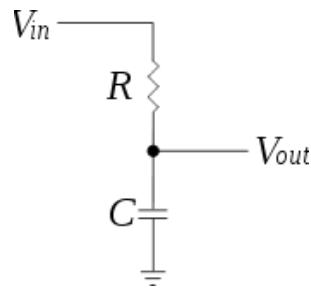
Screencast: 3:33

Decaying Exponential

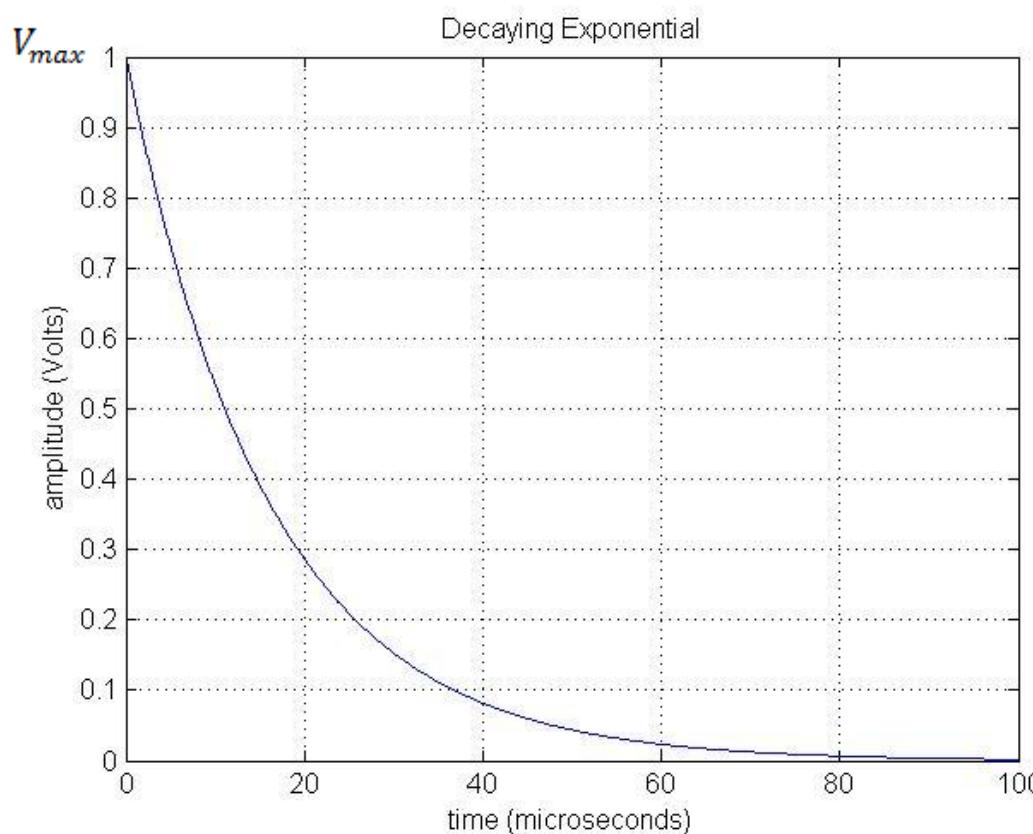
$$V(t) = V_{max} * e^{-t/\tau}$$



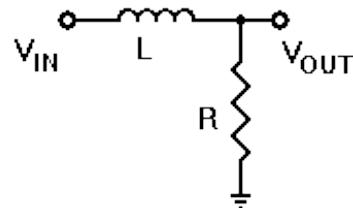
Time Constant - RC



$$V(t) = V_{max} * e^{-t/RC} \quad \tau = RC$$

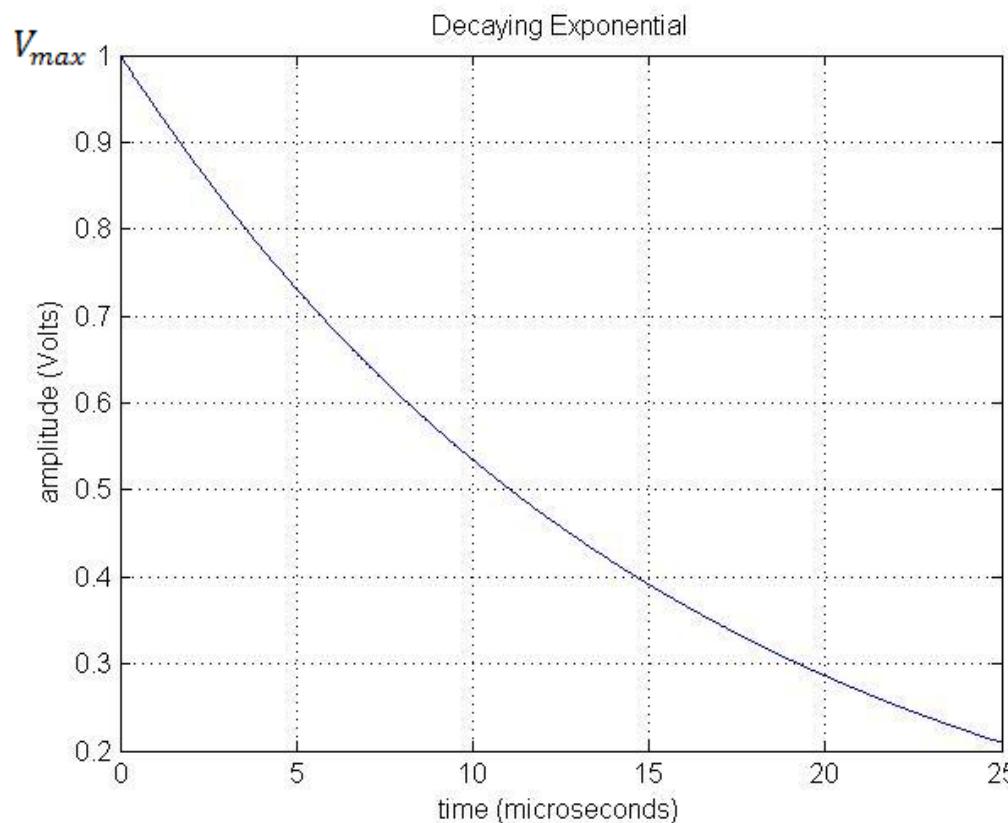


Time Constant - RL



$$V(t) = V_{max} * e^{-t \cdot R/L}$$

$$\tau = \frac{L}{R}$$



Lab Supplies

- Resistors
 - 1 each of: 316 Ohm
1.62 Kilo-Ohm (Kohm)
- Capacitor
 - 1 each of: 0.01 microFarad (μF) Ohm
- Inductor
 - 1 each of: 1 milliHenry (mH)

Capacitors

Capacitor Codes are in PICO-Farads

Code	Calculation	Value PicoFarads (pF)	Value MicroFarads (uF)
104	$10 \times 10^4 = 100,000$	100,000	0.1
103	$10 \times 10^3 = 10,000$	10,000	0.01
102	$10 \times 10^2 = 1,000$	1000	0.001
101	$10 \times 10^1 = 100$	100	0.0001
471	$47 \times 10^1 = 470$	470	0.00047

Giga (G) 10^9

Mega (M) 10^6

Kilo (K) 10^3

milli (m) 10^{-3}

micro (u) 10^{-6}

nano (n) 10^{-9}

pico (p) 10^{-12}

Inductors

Inductor Codes are in Micro-Henrys

Code	Calculation	Value microHenry (uH)	Value milliHenry (mH)
102	$10 \times 10^2 = 1000$	1000	1
103	$10 \times 10^3 = 10,000$	10,000	10
104	$10 \times 10^4 = 100,000$	100,000	100
474	$47 \times 10^4 = 470,000$	470,000	470
3R3	3.3	3.3	0.0033

Inductor codes may also use color code for numbers (same as resistors)

Test Set-up

- Breadboard
- Oscilloscope
- Function Generator
- BNC-to-Mini-grabber (2)
- BNC Cable
- BNC T-Adapter

Cabling



Test Set-up

- BNC T-Adapter on output of Function Generator
- BNC cable from T-Adapter to Channel 1 of the Oscilloscope
- BNC to Mini-clip from T-Adapter to input
- BNC to Mini-clip from Channel 2 of the Oscilloscope to the output

Remember: Black clips always go to GROUND

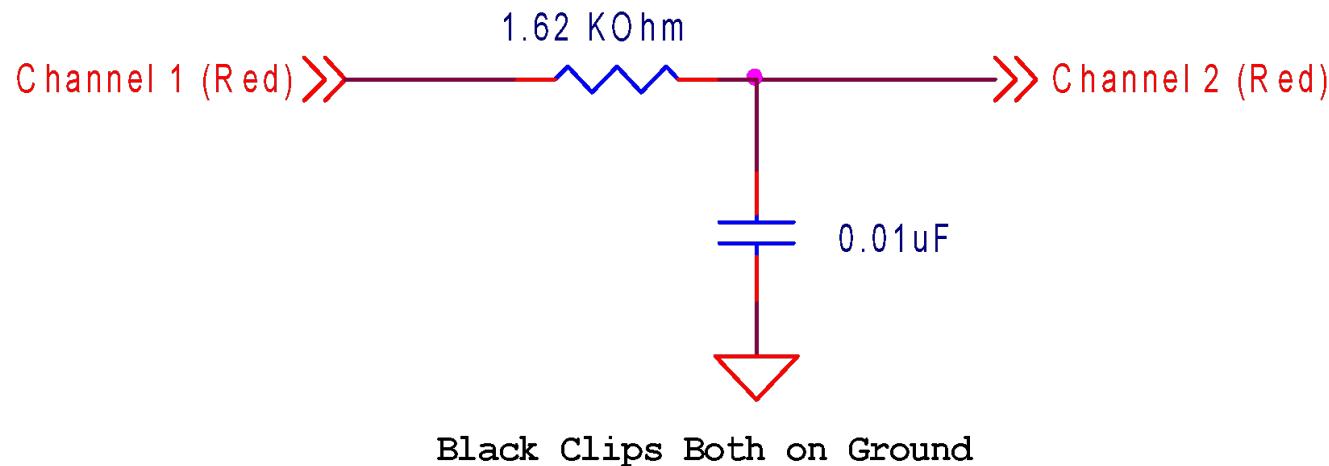
Function Generator Setup

- Square Wave
- 0 to 5 Volt Amplitude
 - 5 Volt peak-to-peak amplitude
 - 2.5 Volt offset
- $1000 \text{ Hz} = 1 \text{ KHz}$

Circuits

- Low Pass RC Filter
- High Pass RC Filter
- Low Pass RL Filter
- High Pass RL Filter

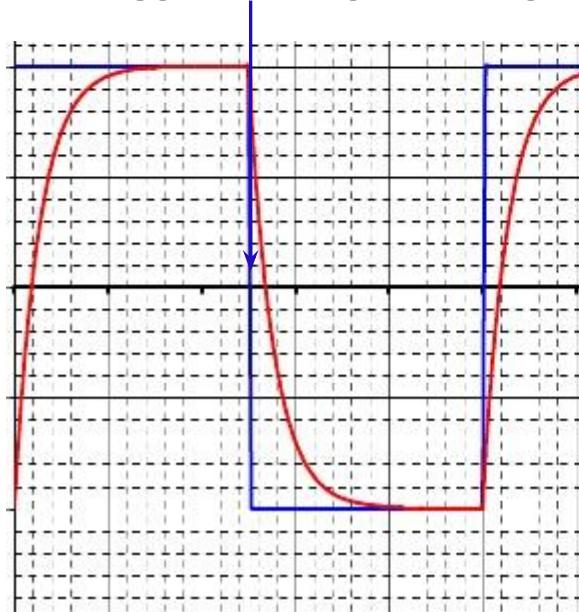
Low Pass RC Filter



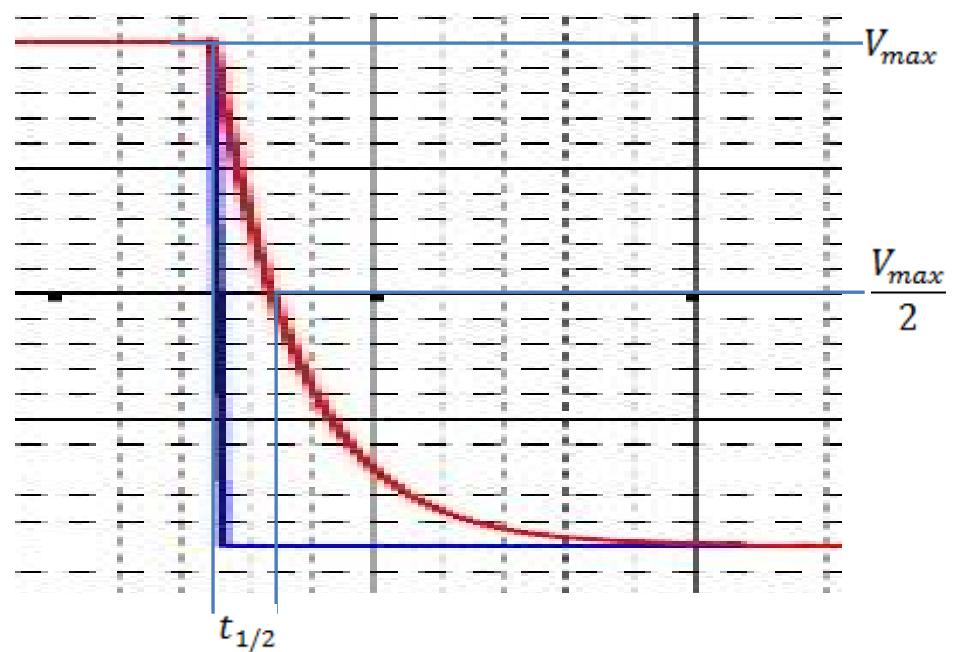
Measurements

Decay Time – Low Pass

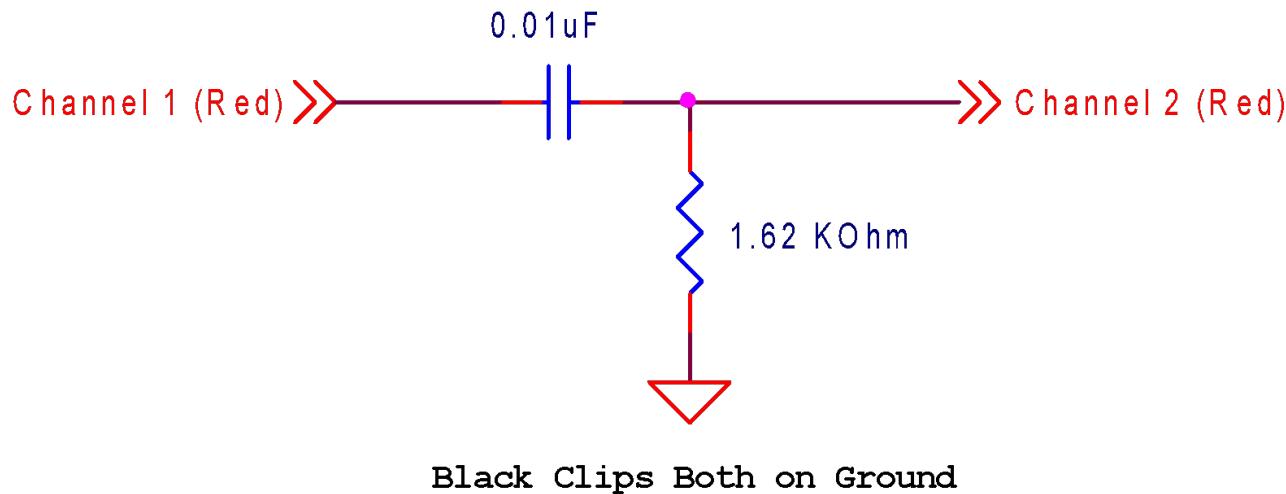
Trigger on Negative Edge



Expand Waveform

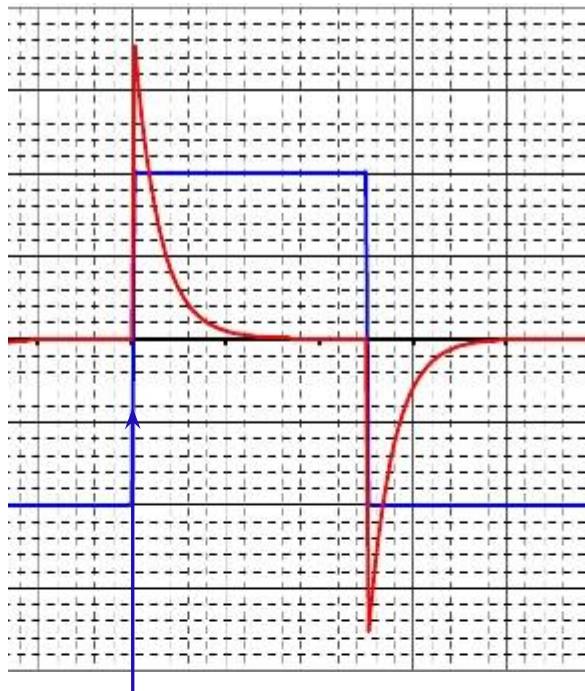


High Pass RC Filter

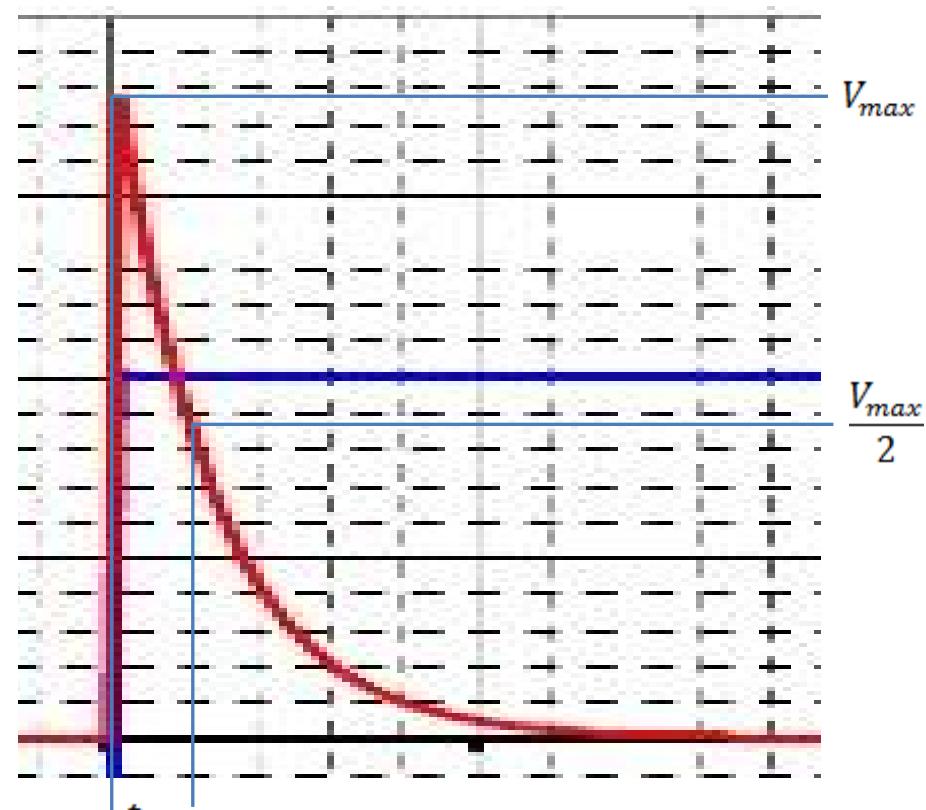


Measurements

Decay Time – High Pass:

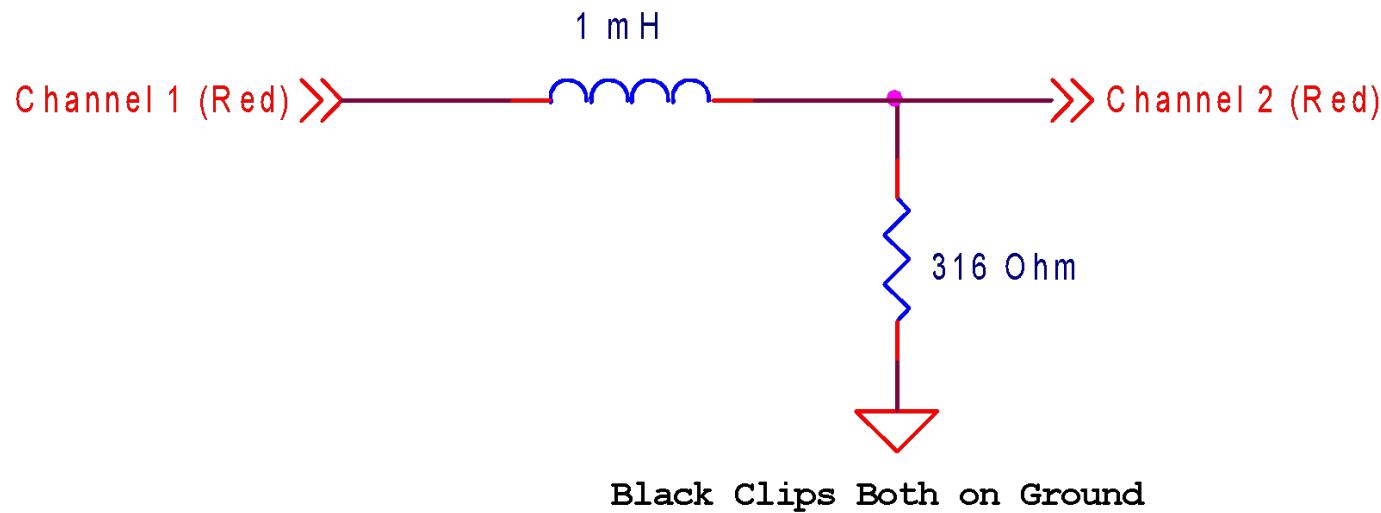


Trigger on Positive Edge

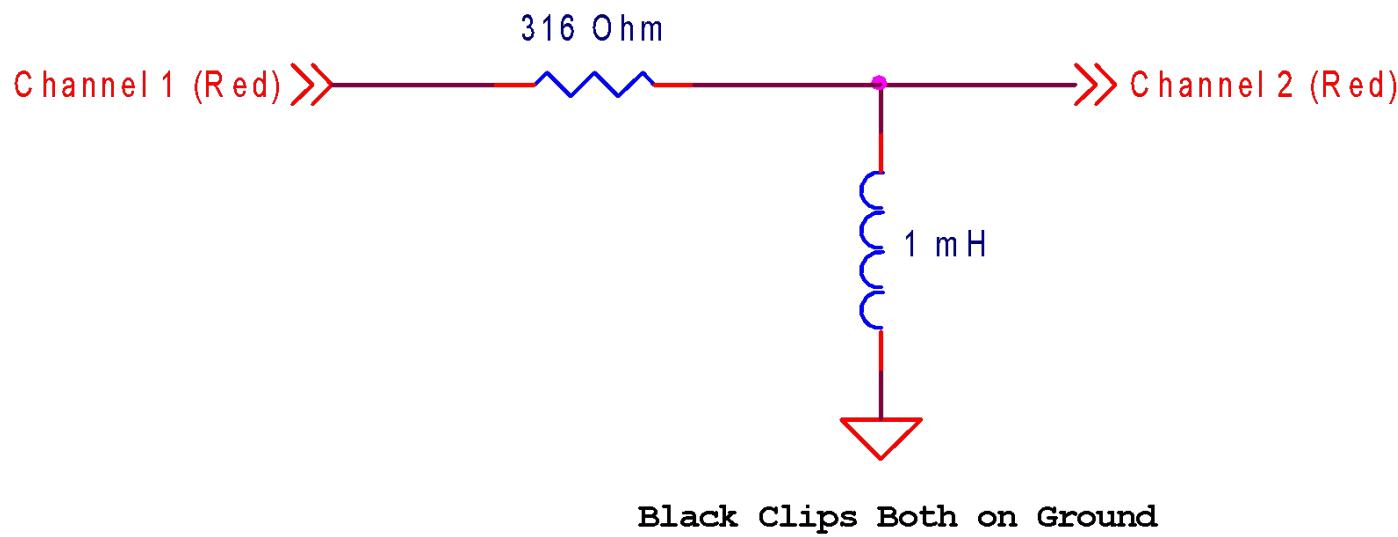


Expand Waveform

Low Pass RL Filter



High Pass RL Filter



Calculations

Measured Time Constant:

$$\tau = \frac{t_{1/2}}{\ln(2)}$$

Calculated Time Constant:

$$\tau = RC$$

Calculated Time Constant:

$$\tau = \frac{L}{R}$$

NOTE: Use Ohms, Farads and Henrys for calculations

Results

Laboratory 2

Circuit	Measured Decay Time ($t_{1/2}$)	Measured Time Constant	Calculated Time Constant	Percent Error
Low Pass RC Filter				
High Pass RC Filter				
Low Pass RL Filter				
High Pass RL Filter				