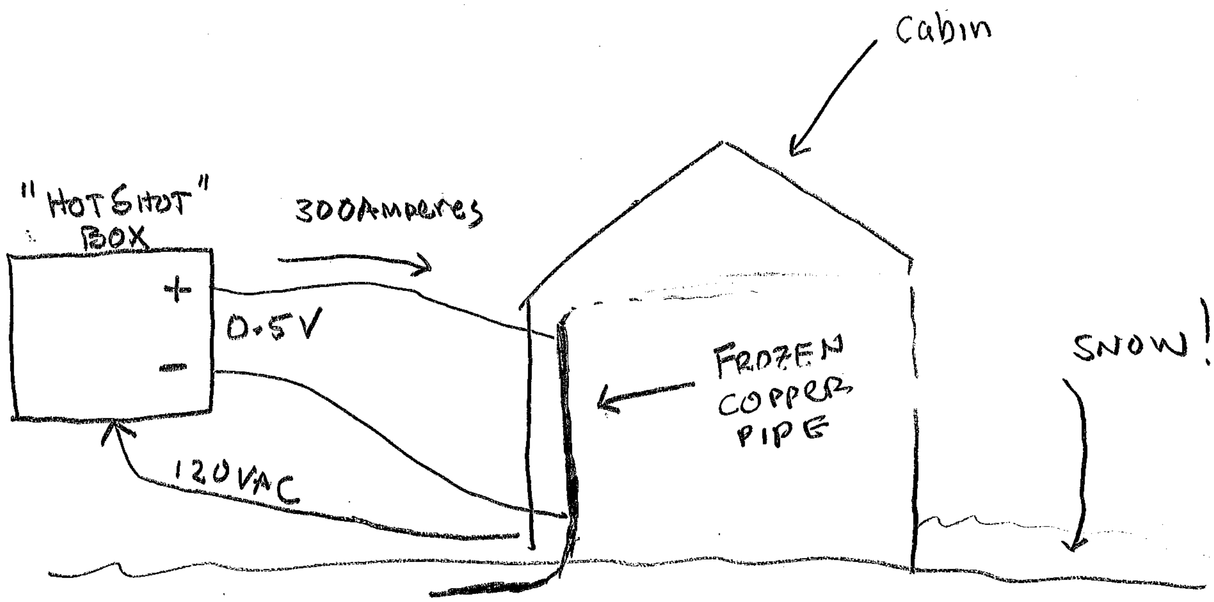
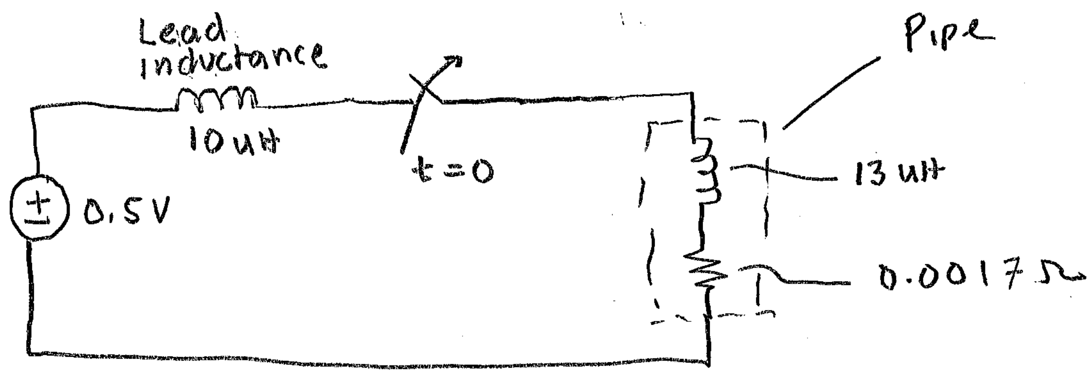
LECTURE #1



- If you don't drain the pipes in the winter, they Freeze.
- The "Hot Shot" box delivers Direct current (DC) at 0.5V
- The high current causes resistive heating in the frozen pipe and melts the ice.
- How does the Hot Shot box convert 120 VAC (from wall outlet) to 0.5V at 300 A?
- Why were there big sparks happening when the plumber disconnected the machine to the pipes?

Make a model



With the switch closed,

$$i(0^-) = \frac{0.5\,V}{0.0017\,\Omega} = 294\ A$$

$I^2R = 294^2 \times 0.0017$
$= 147\,W$ in pipe

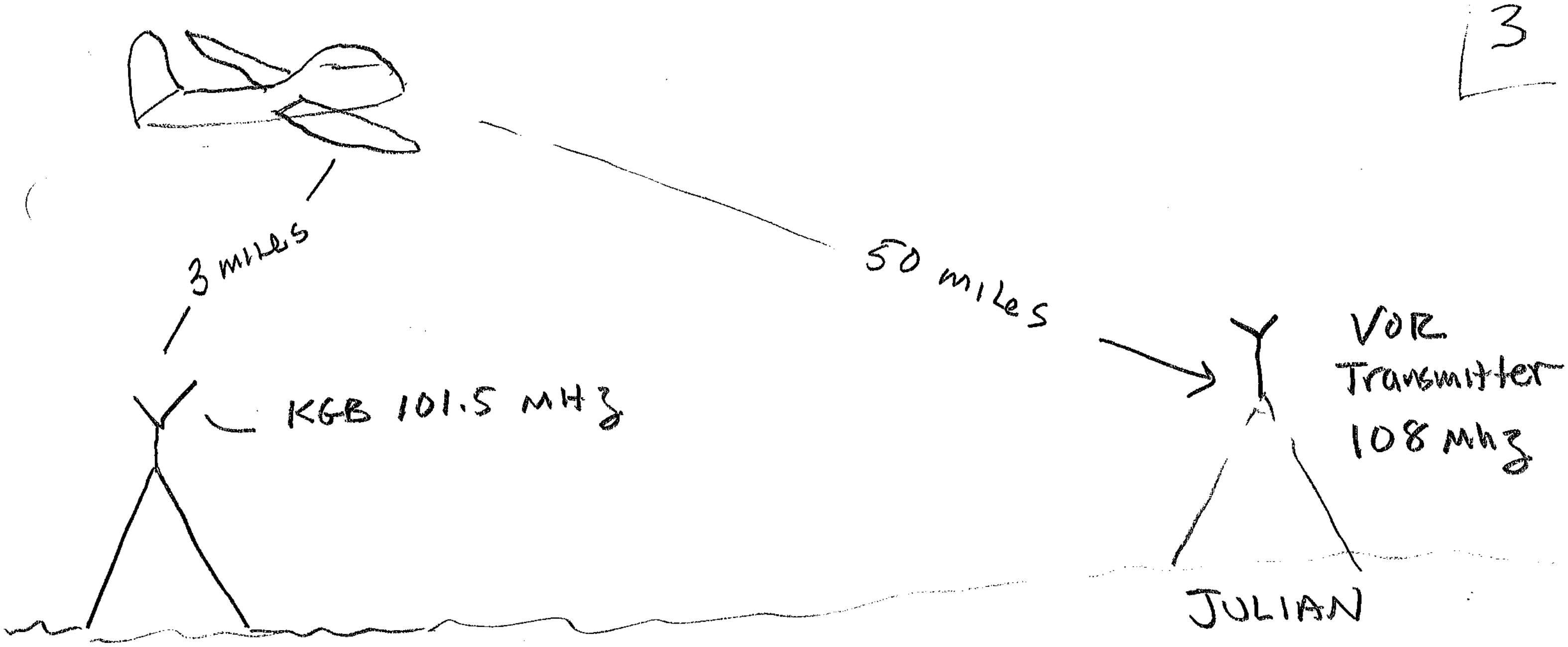
We know $V_L = L\dfrac{di}{dt}$

Opening switch causes current to stop immediately.
or

$$V_L = L\frac{di}{dt} = L \times -\infty = -\infty$$

The high voltage across the inductors causes sparks even though the source voltage was only 0.5 VDC!

- The same idea is used to make a spark in the spark plugs in your car.
- The same idea is responsible for injury and death when jump starting cars incorrectly.

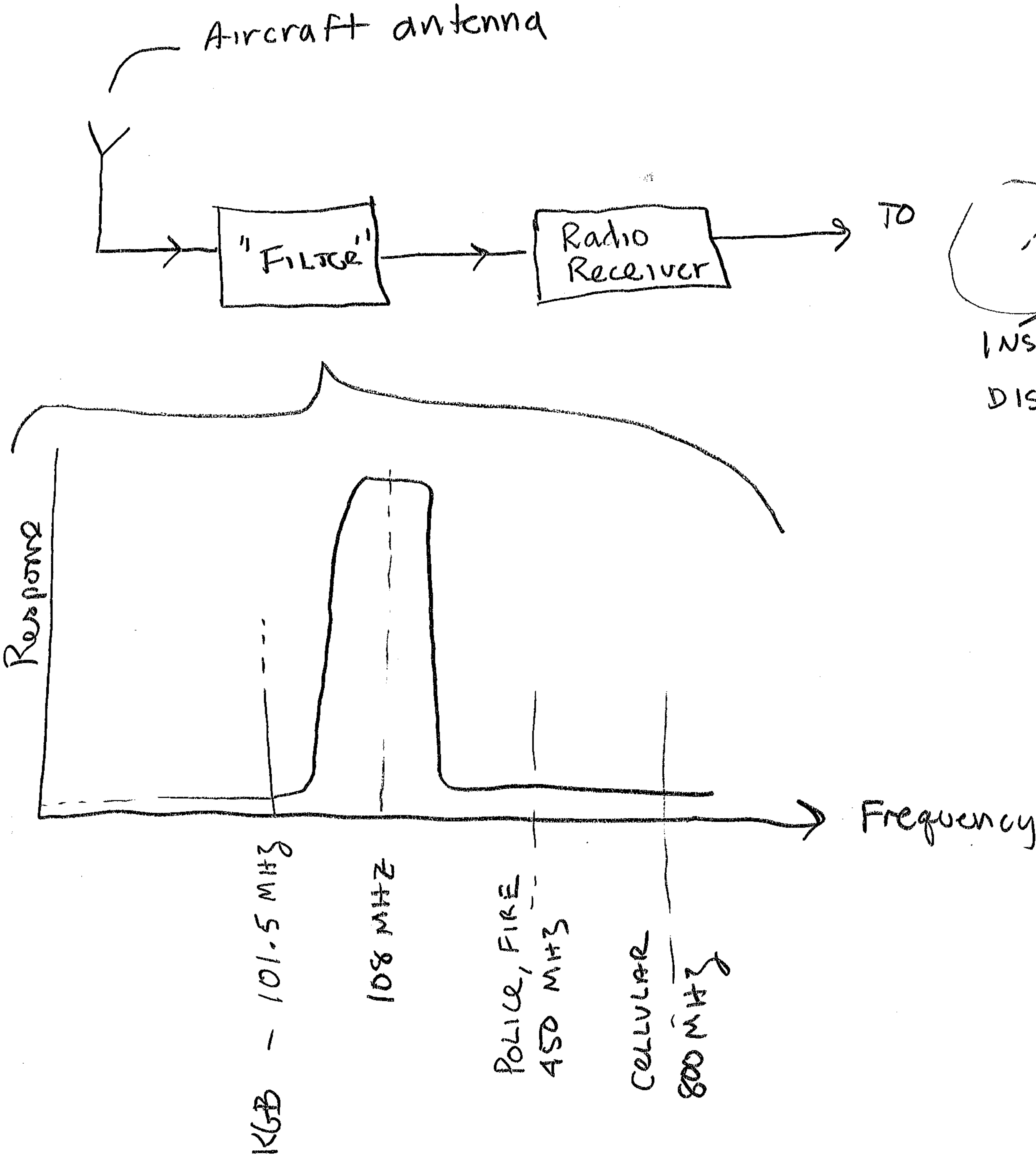


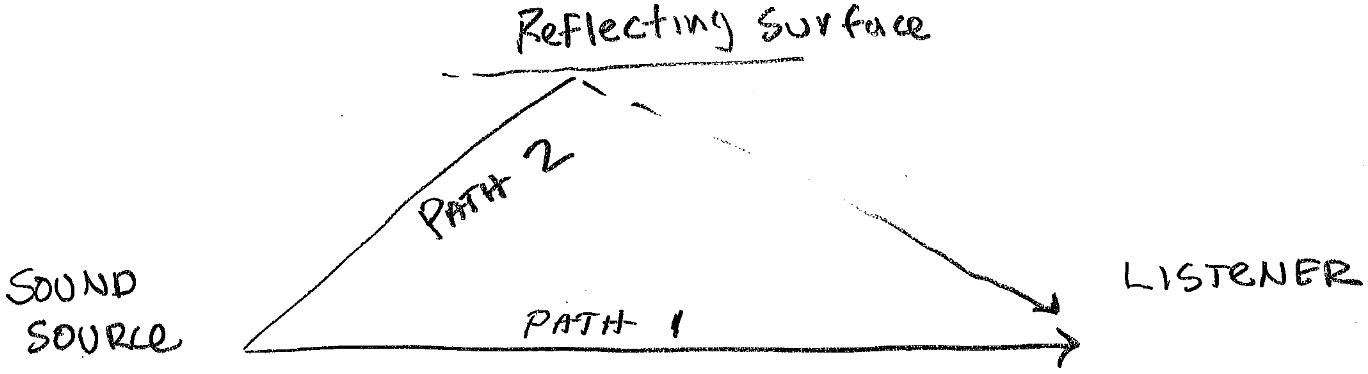
Signal strength is proportional to $\frac{K_p}{d^2}$

$$\frac{\text{Power from KGB}}{\text{Power from Vor}} = \frac{K_p/3^2}{K_p/50^2} = \frac{50^2}{3^2} = 278$$

This is the difference between the horn playing and a conversation

So how can the aircraft "hear" the VOR station?


Aircraft antenna
"FILTER"
Radio Receiver
TO
INSTRUMENT DISPLAY
Response
Frequency
KGB – 101.5 MHz
108 MHZ
POLICE, FIRE 450 MHz
CELLULAR 800 MHz



Path 1: Listener hears $A\cos(2\pi f t)$

Path 2: Listener hears $A\cos(2\pi f(t+T))$

Where T is the time difference between the two paths.

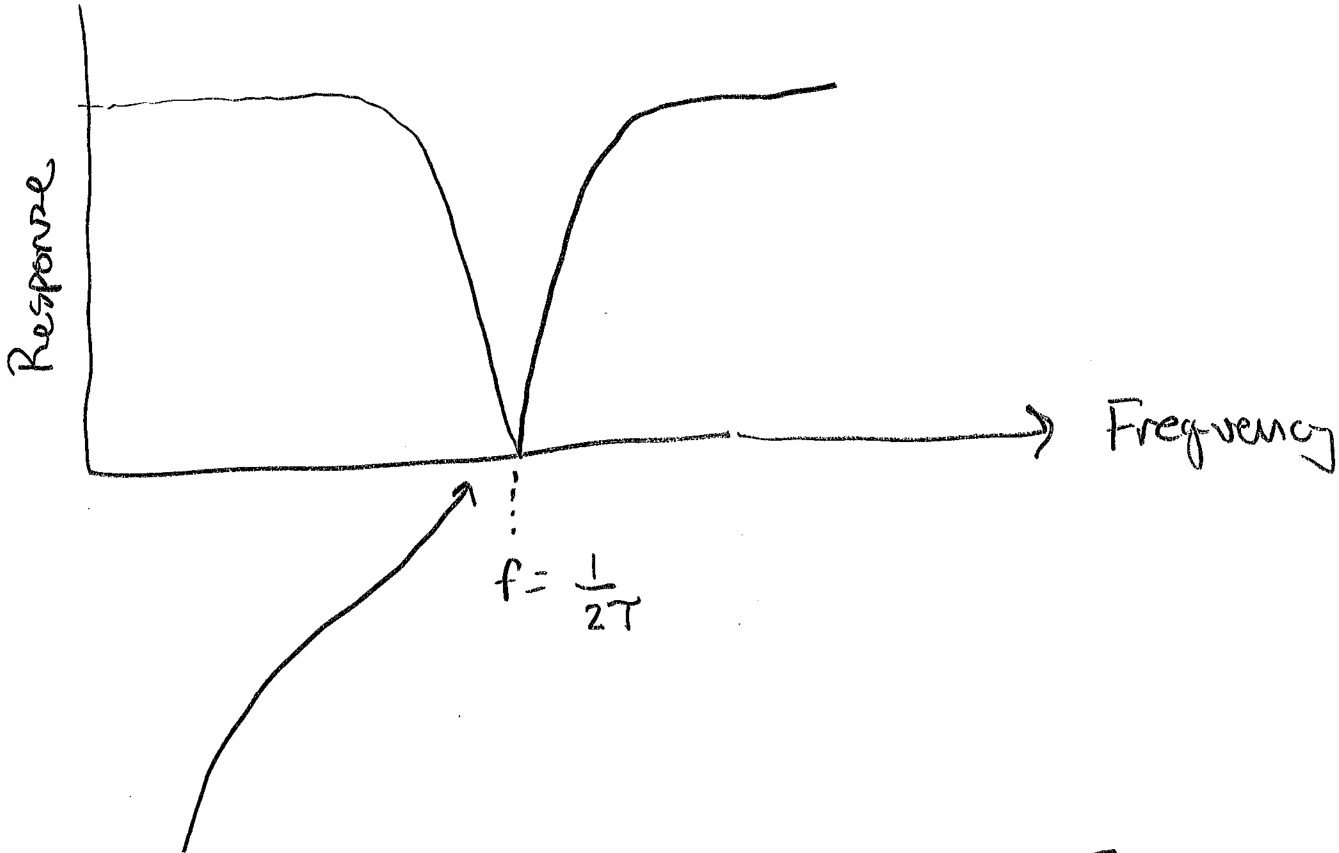
Path 1 plus Path 2

$$s(t) = A\left(\cos(2\pi f t) + \underbrace{\cos(2\pi f(t+T))}_{\cos(2\pi f t + 2\pi f T)}\right)$$

Say $T = \frac{1}{2f}$ or $f = \frac{1}{2T}$

$$\cos(2\pi f t + \pi) = -\cos(2\pi f t)$$

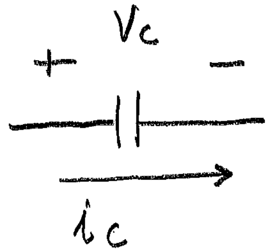
$$s(t) = A\left(\cos(2\pi f t) - \cos(2\pi f t)\right) = 0$$



What if someone plays this note?

In EE 310 we will use Laplace transforms to analyze and solve <u>much</u> more complex and interesting systems.

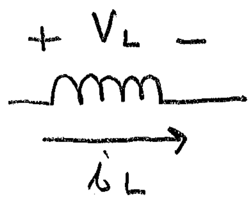
Lecture #1 INITIAL AND FINAL CONDITIONS



$$i_c = C\frac{dv}{dt}$$

"stores energy in electric field"

"Passive Sign Convention" see Fig 6.3 and 6.23 in text



$$V_L = L\frac{di}{dt}$$

"stores energy in magnetic field"

In Chapters 8 and 16 we will analyze behavior

- We will start with the circuit at steady state → voltages and currents not changing with time.

- We will suddenly change the circuit topology by changing a switch or applying a voltage.

- We will observe voltages and currents immediately after the switch changes

- We'll get thuds (drop a bean bag) and boings (drop a piece of copper pipe)

Capacitors and inductors store energy

Energy in capacitor $= \frac{1}{2} C V^2$ Joules

Energy in inductor $= \frac{1}{2} L I^2$ Joules

Power $= W = \frac{\text{Joules}}{\text{sec}} \longrightarrow$ rate of energy transfer

Can I instantly change the energy in an inductor or capacitor?

Terminology

$v(0^-)$ or $i(0^-) \rightarrow$ current or voltage immediatly before switch is changed.

$v(0^+)$ or $i(0^+) \longrightarrow$ current or voltage immediatly after switch is changed.

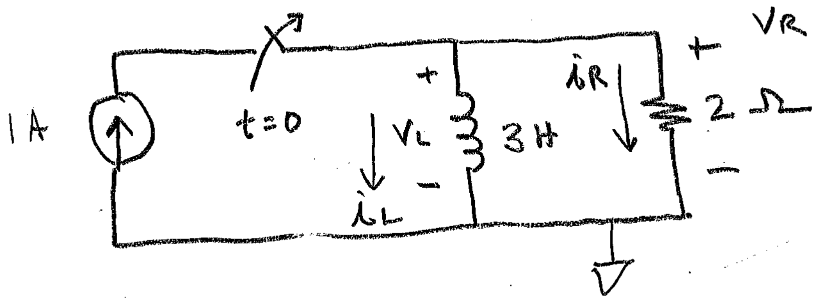
$v(\infty)$ or $i(\infty) \rightarrow$ Current or voltage after all transients have subsided

The Rules

"Verbal"	Equation	
Inductor current cannot change instantaneously"	$i_L(0^+) = i_L(0^-)$	1
Capacitor voltage cannot change instantaneously	$V_C(0^+) = V_C(0^-)$	2
Inductor voltage can change instantaneously	$V_L = L \dfrac{di}{dt}$	3
Capacitor current can change instantaneously	$i_C = C \dfrac{dv}{dt}$	4
At steady state $\dfrac{di}{dt} = 0$ so inductor voltage is zero	$V_L(\infty) = 0$	5
At steady state $\dfrac{dv}{dt} = 0$ so $i_C = 0$	$I_C(\infty) = 0$	6

Example

The switch has been "closed for a long time"
It opens at $t = 0$.
Compute $\frac{di_L}{dt}(0^+)$ and $V_L(\infty)$



$i_L(0^-) =$

$V_L(0^-) =$

$V_R(0^-) =$

When switch opens $i_L(0^+) = i_L(0^-)$ So $i_R(0^+) = -1\,A$

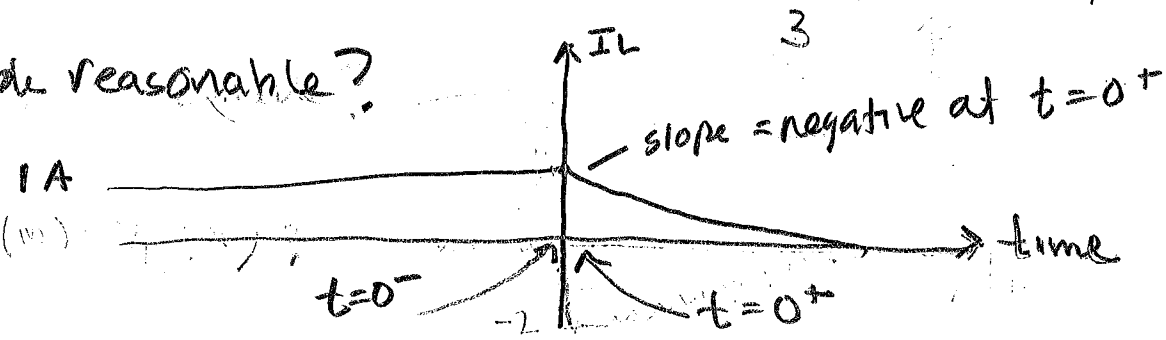
$V_R(0^+) = -2\,V$

Therefore $V_L(0^+) = -2\,V$

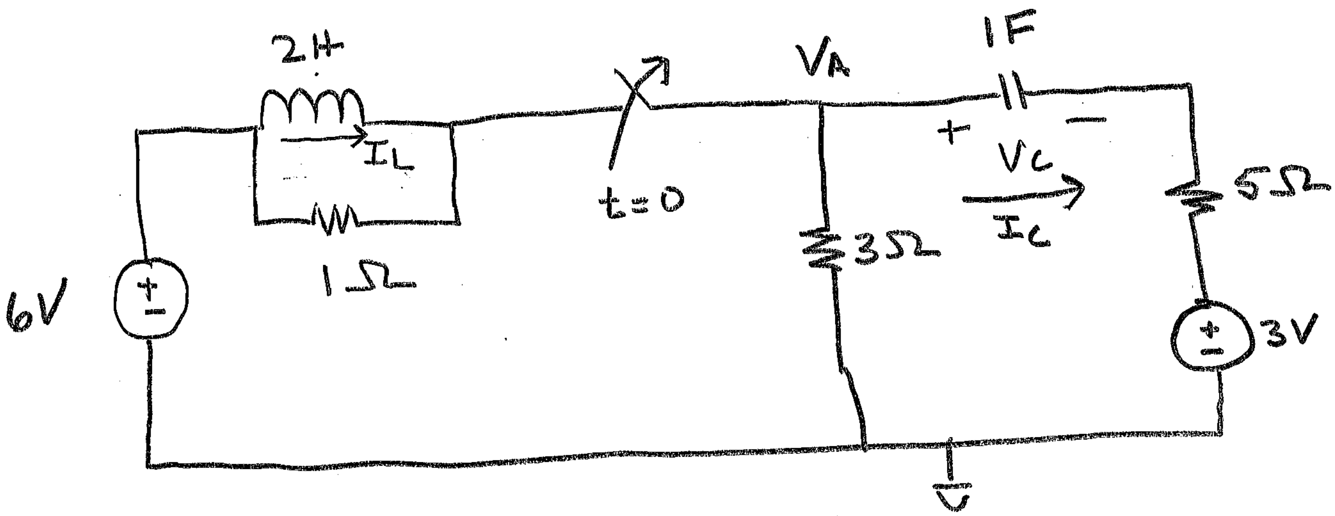
Since $V_L = L\frac{di_L}{dt}$, $\frac{di_L}{dt}(0^+) = \frac{V_L(0^+)}{L}$

$= -\frac{2}{3} = -0.6\bar{6}\,A/s$

Does the sign look reasonable?



Example



$\underline{I_L(0^-)} = \frac{6V}{3\Omega} = 2A$

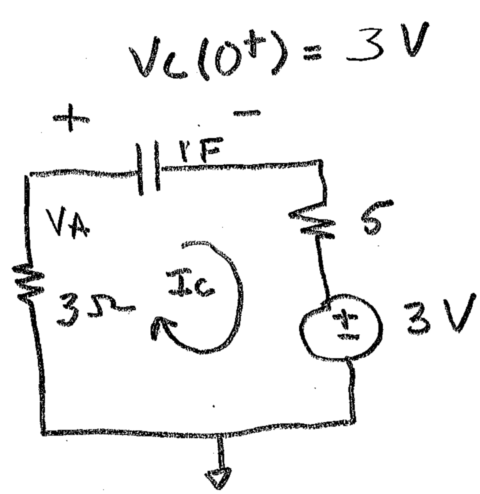
$\underline{V_A(0^-)} = 6V$

$\underline{V_C(0^-)} = 6 - 3 = 3V$

$\underline{I_L(0^+)} = I_L(0^-) = 2A$

$\underline{V_C(0^+)} = V_C(0^-) = 3V$

$\underline{I_C(0^+)}$



KVL

$3I_C + 3 + 5I_C + 3 = 0$

$8I_C + 6 = 0$

$I_C = \frac{-6}{8} = -0.75A$

so $I_C(0^+) = -0.75A$

Example - CONT

$V_A(t=0^+)$

$V_A(0^+) = -I_c(0^+) \times 3\Omega = 0.75 \times 3 = 2.25V$

$dV_c/dT(0^+)$

$i = C\, dv/dt$ so $dv = \frac{i}{c} = -\frac{0.75}{1} = -0.75\, V/s$