EE220 Circuits 1

Oct. 23, 2019

Lecture 16

$$10^{11} \cdot \frac{1}{6} \cdot \left(\frac{1}{2}\right)^2 \cdot (10^{-6})^2$$

$$10^{11} \cdot 10^{-12} \cdot \frac{1}{6} \cdot \frac{1}{4}$$

$$\frac{1}{10} \cdot \frac{1}{6} \cdot \frac{1}{4}$$

$$= \frac{1}{240} = 4.16\,mV$$

$$i_c(t) = \frac{0.5\,\mu A}{1.5\,\mu A} \cdot t = \frac{1}{3} t$$

$$v_c(t) = \frac{1}{10\,pF} \int_0^t \frac{1}{3} t\, dt = 10^{11} \cdot \frac{1}{6} t^2 \Big|_0^t$$

$t = 0$, $v_c(t) = 0$

$$v_c(t) = 10^{11} \cdot \frac{1}{6} \cdot t^2$$

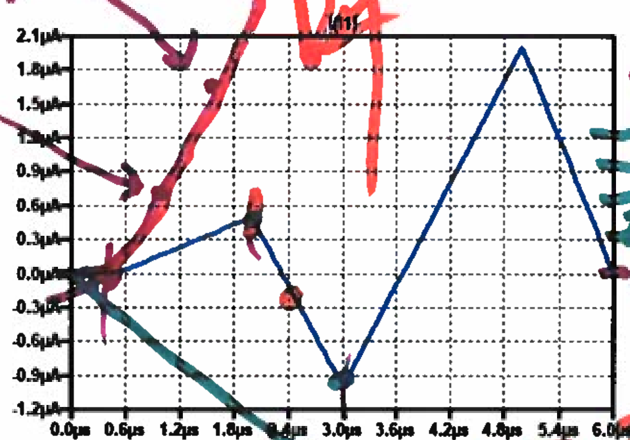
$t = \frac{1}{24}$, $v_c(1/24) = 4.16\,mV$

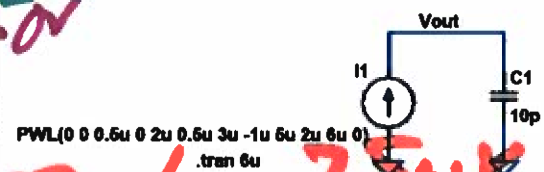
$t = 1\,\mu A$, $v_c(t) = \frac{1}{60} = 16.6\,mV$

H.W. #14 EE 220 Fall 2019

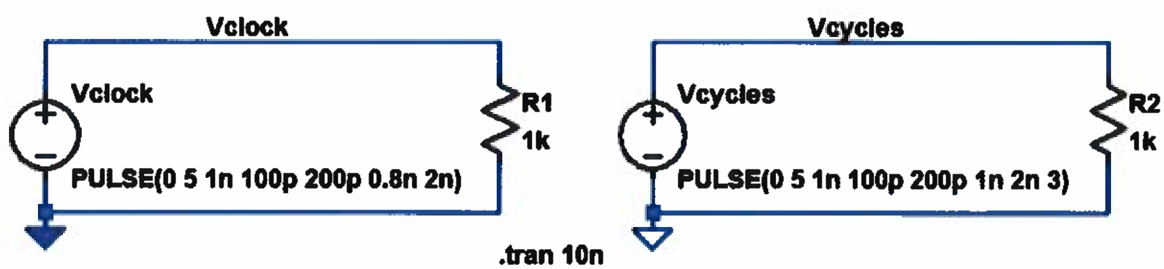
Show your work for credit!

1. Suppose a 0.4 uF capacitor is charged to 1 V. How much charge is stored on the capacitor? (1 point)
2. The following current is used to charge a 10 pF capacitor. Sketch the voltage across the capacitor and the charge stored on the capacitor against time (show your hand calculations, no hand calculations, no credit). Verify your answer with LTspice. Note that the current seen in this figure can be generated using the piece-wise linear (PWL) source, see example below (make sure you understand how to use a PWL source). (4 points)





3. Suppose that a constant current source, *I*, is used to *discharge* a capacitor, *C*. What will the voltage across the capacitor look like? Why? Provide an example using LTspice to support your answer. (3 points)
4. Repeat problem 3 if the constant current source is *charging* the capacitor. (2 points)
5. In your own words explain what each of the parameters mean in the following pulse statements. (2 points)



6. Suppose you are doing a sim where you need a clock signal operating at 1 MHz that oscillates between 0 V and 5 V. Assume the duty cycle of the clock is 50% (the clock signal is high [= 5 V] the same amount of time that the clock is low [= 0V]). Assume the rising and falling edges are 10 ns. Show how to implement this clock signal in LTspice. (2 points)

$t = 1.5\mu s$, $v_c(\cdot) = 10^{11} \cdot \frac{1}{6} \cdot \left(\frac{3}{2}\right)^2 \cdot 10^{-12}$

$= \frac{1}{10} \cdot \frac{1}{6} \cdot \frac{9}{4}$

$= \frac{9}{240} = 9 \cdot 4.16$

$\approx 37 mV$

$v_c(t) = 10^{11} \cdot \frac{1}{6} t^2$

$v_c(t) = 10^{11} \cdot \frac{1}{6}\left(t - \frac{1}{2}\mu s\right)^2 + 0$

$\frac{1}{2}\mu s \leq t \leq 1.5\mu s$

3)

$$i_c(t) = \frac{-1.5\mu A}{1\mu s} \cdot t$$

$$v_c(t) = 10^{+11} \int_0^t -\frac{3}{2} t \cdot dt$$

$$= 10^{11} \cdot \left(-\frac{3}{2}\right) \cdot \frac{1}{2} t^2 \Big|_0^t$$

$$= 10^{11} \left(-\frac{3}{4}\right) t^2$$

$t = 1\mu s$

$$v_c(t) = 10^{11} \cdot \left(-\frac{3}{4}\right) 10^{-12}$$

$$= -\frac{3}{40} = -.75w$$

$t = \frac{1}{2}\mu s$, $v_c = 10^{11} \cdot 10^{-12} \left(-\frac{3}{4}\right)\left(\frac{1}{2}\right)^2$

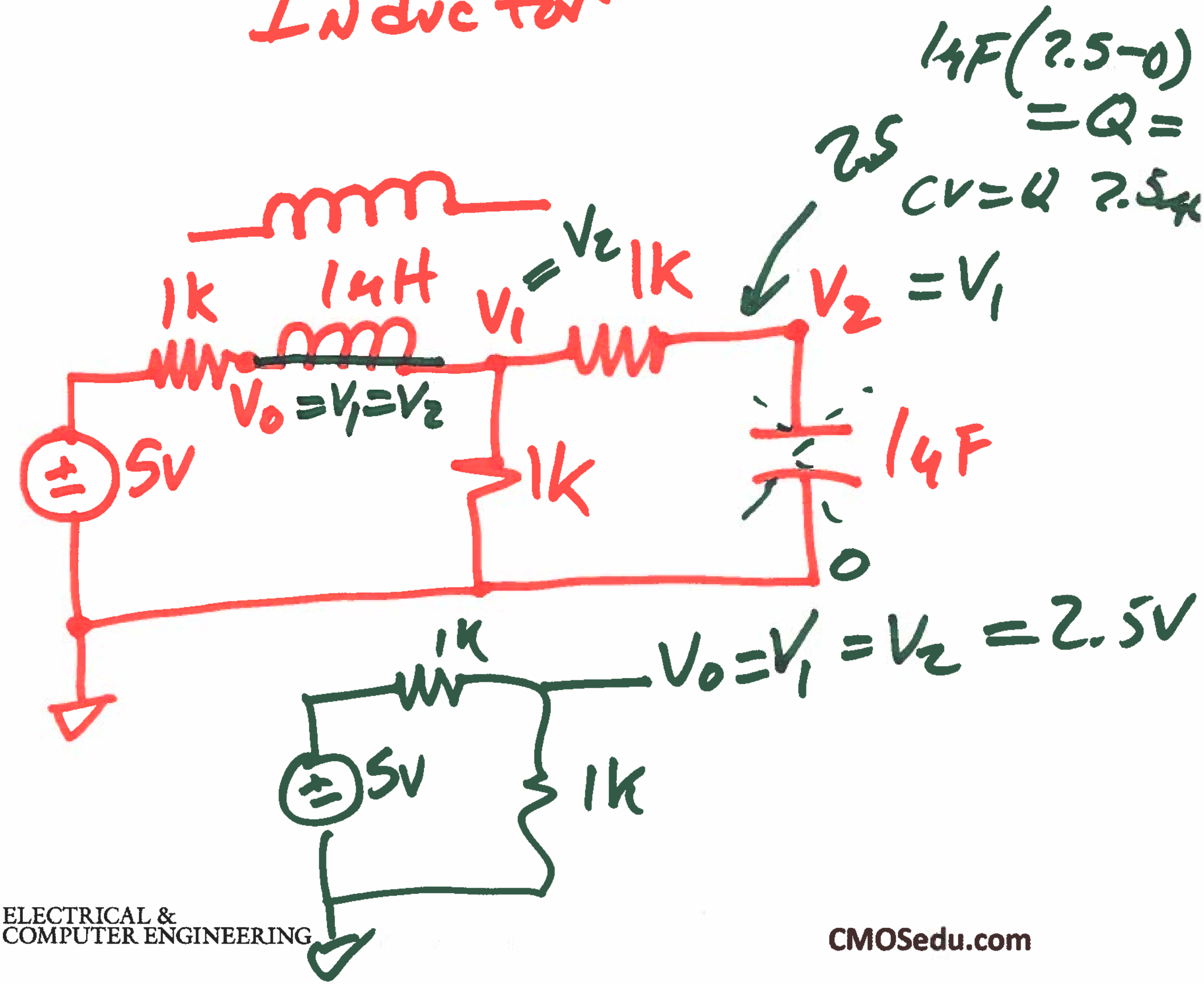
$$= -\frac{1}{10} \cdot \frac{3}{16} = -18.75w$$

UNLV ELECTRICAL & COMPUTER ENGINEERING

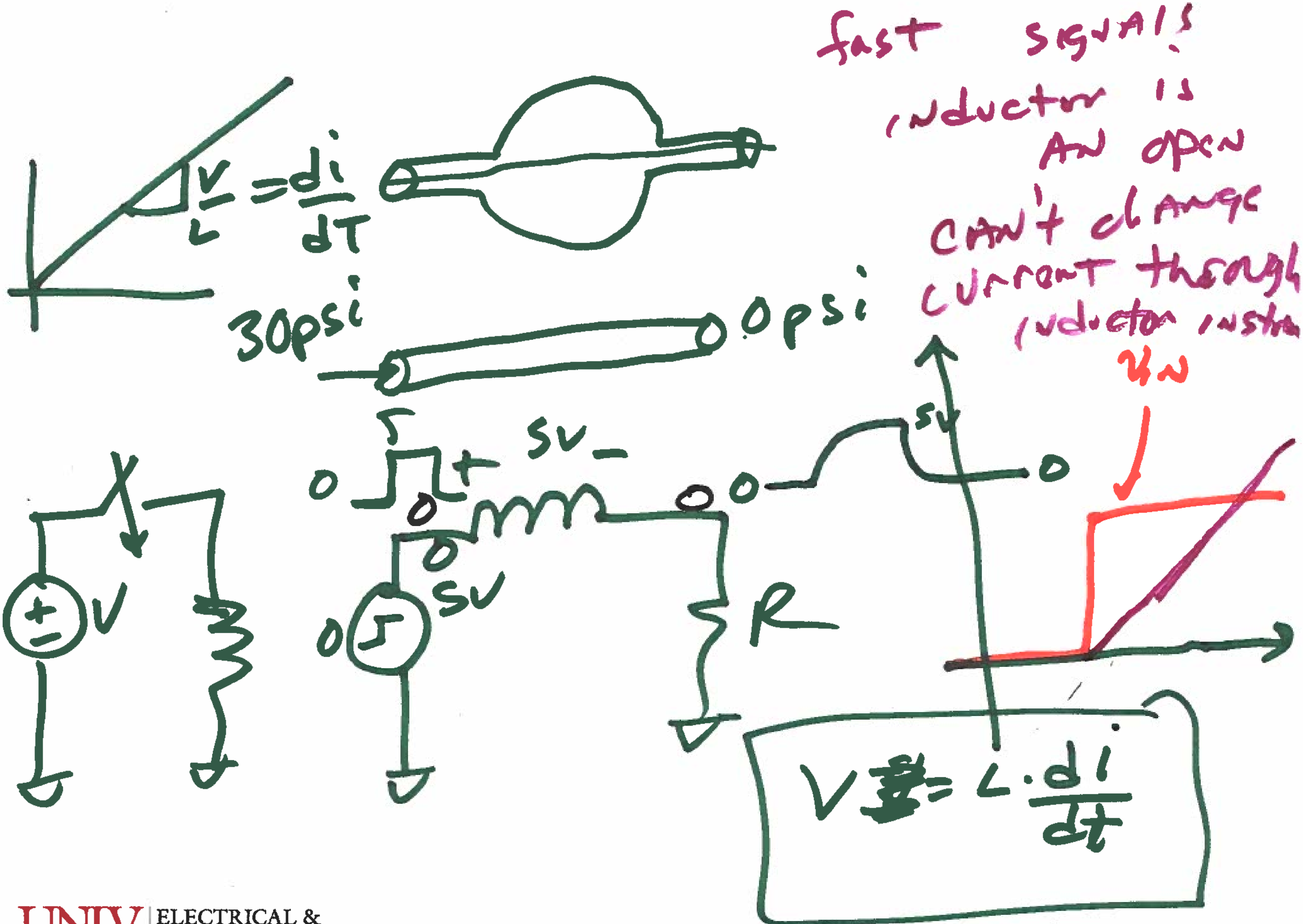
CMOSedu.com

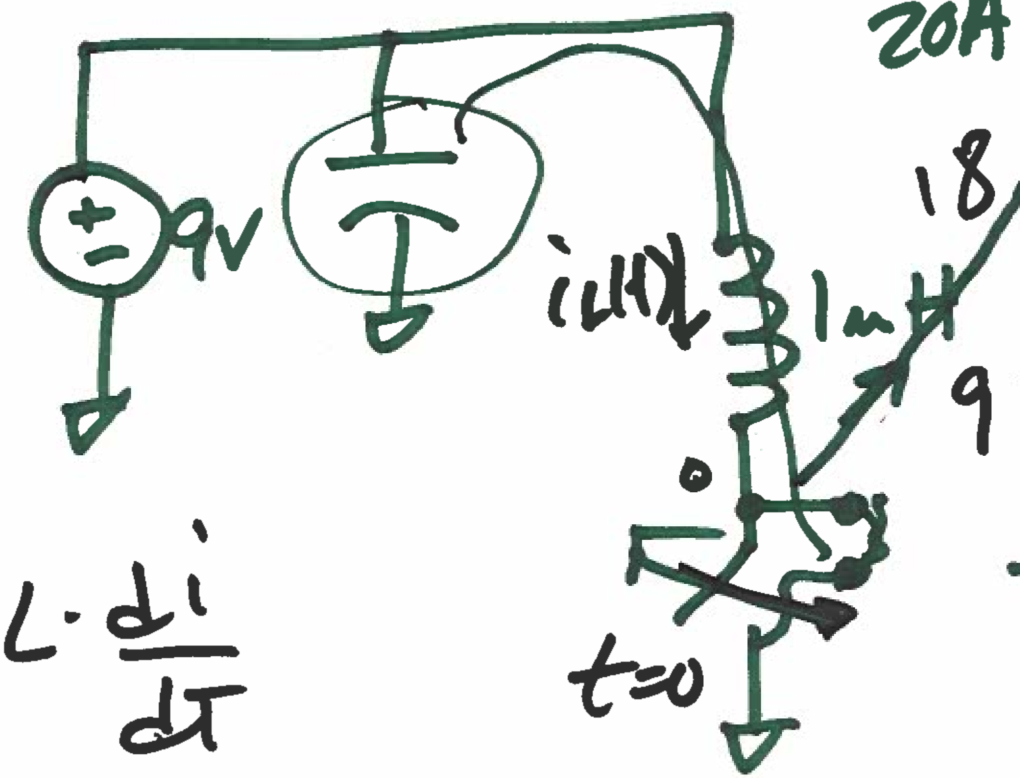
4)

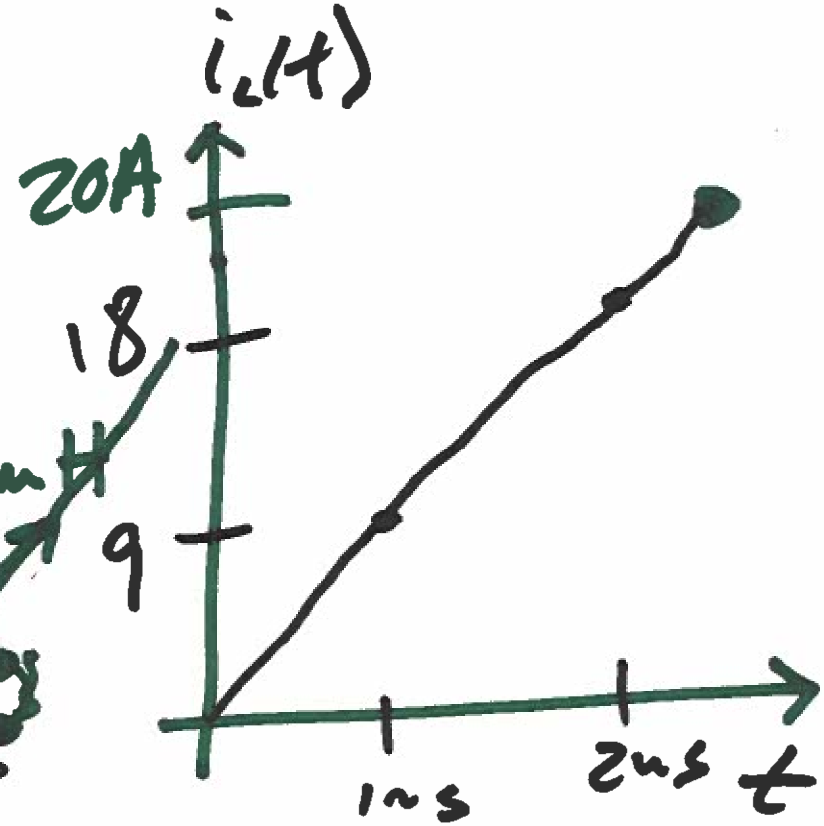
Inductor



1μF(2.5−0)
= Q =
2.5
CV=Q 2.5μC
1k
1μH
V1 = V2
1K
V2 = V1
V0 = V1 = V2
5V
1K
1μF
0
V0 = V1 = V2 = 2.5V
1K
5V
1K


fast signals
inductor is an open
can't change current through inductor instantly
V/L = di/dT
30psi
0psi
5V
5V
0
R
V
V = L·di/dt

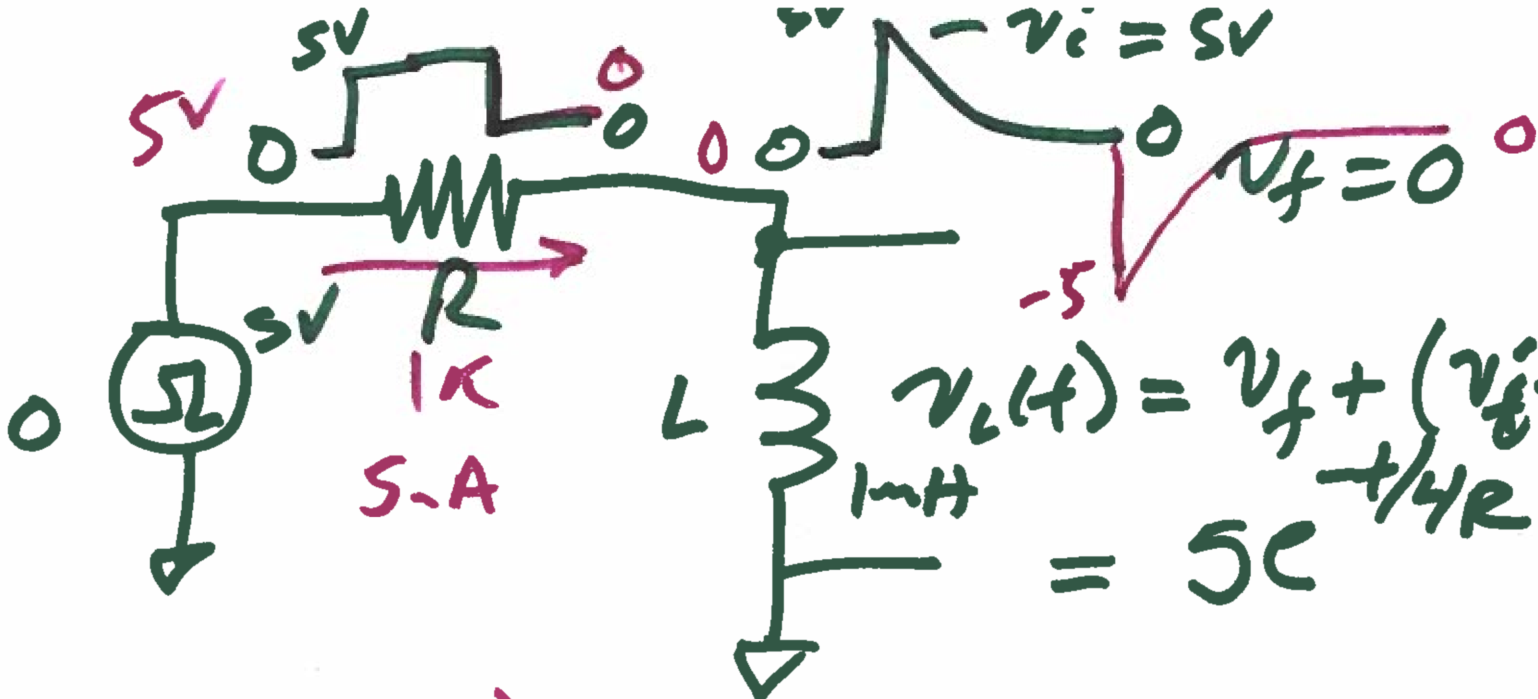




$$V = L \cdot \frac{di}{dT}$$

$$\frac{9V}{1mH} = \frac{9mA}{\mu s} = \frac{9A}{ms}$$

$$V = L \cdot \frac{di}{dt}$$

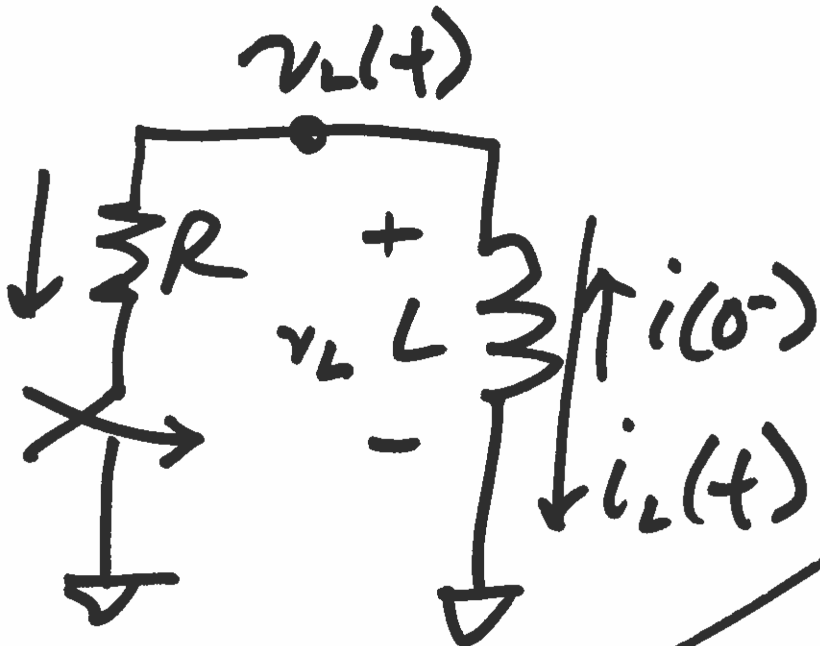


$$v_L(t) = v_f + (v_i - v_f)e^{-t/(L/R)}$$

$$= 5e^{-t/(L/R)}$$

$$\frac{0-(-5)}{1K} = 5\,mA$$

$$\tau = \frac{L}{R} = \frac{1mH}{1K} = 1\mu s$$



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

$$\frac{v_L(t)}{R} + i_L(t) = 0$$

$$\frac{L}{R}\frac{di_L}{dt} + i_L(t) = 0$$

$$-\frac{L}{R}\frac{di_L}{dt} = i_L$$

$$\int_{i(0^-)}^{i_L(t)} \frac{di_L}{i_L} = \int_0^t \left(-\frac{L}{R}\right)^{-1} \cdot dt$$

$$\ln \frac{i_L}{i(0^-)} = t/\left(-L/R\right)$$

$$i_L(t) = i(0^-)\, e^{-t/(L/R)}$$

$$v_L(t) = R \cdot i_L(t)$$