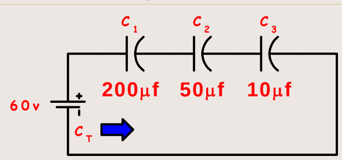
FE Review

RC and RL Analysis

1

Series Capacitors
Treat like parallel resistors



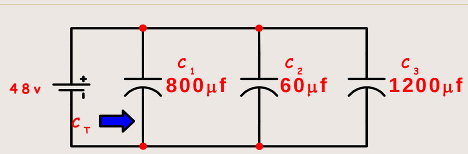
$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C_T} = \frac{1}{200\mu f} + \frac{1}{50\mu f} + \frac{1}{10\mu f} = 125k$$

$$\boxed{C_T = 8\mu f}$$

2

Parallel Capacitors
Treat like series resistors

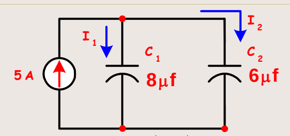


$$C_T = C_1 + C_2 + C_3$$

$$= 800\mu f + 60\mu f + 1200\mu f = \boxed{2.06mf}$$

3

Capacitor Current Divider (Like a resistor voltage divider)



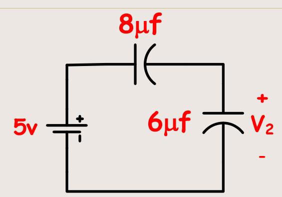
$$I_1 = \frac{IC_1}{C_1 + C_2} = \frac{5A(8\mu f)}{8\mu f + 6\mu f} = \boxed{2.857A}$$

$$I_2 = \frac{IC_2}{C_1 + C_2} = \frac{5A(6\mu f)}{8\mu f + 6\mu f} = \boxed{2.143A}$$

The two currents together MUST add up to 5 amps (Naturally) (taking roundoff error into account)

4

Capacitor voltage divider (Like a resistor current divider)



$$V_2 = \frac{5vC_1}{C_1 + C_2} = \frac{5v(8\mu f)}{8\mu f + 6\mu f} = \frac{40v}{14} = \boxed{2.857v}$$

5

Inductors

Treat inductors just like resistors. This includes the inductive voltage and current divider equations.

6

First Order Fundamentals

$$v(t) = v(\infty) + \left[v(0^{+}) - v(\infty)\right] e^{-t/\tau}$$

Final Value (steady state value)

Initial Value

time constant

7

Initial and Final Values

To start with, let's consider a switch. In analyzing the switch, we will consider two extremes:

- ♦ The instant a switch is closed (the **Initial Value**), and
- ♦ the **steady state value** (a long time has passed since the switch closed) (The **Final Value**).

8

When you have a circuit in which you are working out the initial values,

- An **uncharged capacitor** acts as a **short circuit**. **(It opposes a change in voltage)**
- A **un-fluxed inductor** acts as an **open circuit**. **(It opposes a change in current)**.

9

Extending this idea to the device with an Initial charge, we get:

$V_C(0+) = V_o \Leftarrow$ a voltage source!

$i_L(0+) = I_o \Leftarrow$ a current source!

10

Final Conditions

$i_c(t \Rightarrow \infty) = 0$ Capacitor current $\Rightarrow 0$ [open]

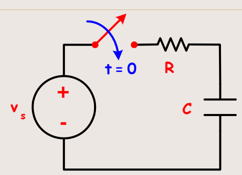
$v_L(t \Rightarrow \infty) = 0$ Inductor voltage $\Rightarrow 0$ [short]

another way to write these values would be:

$i_c(\infty) = 0$ and $v_L(\infty) = 0$

11

RC circuit – Charge Phase



$$\tau = RC$$

12

$y = V_C(t)$

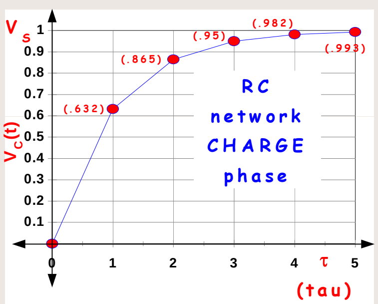
$$V_c(t) = V_c(\infty) + \left[V_c(0^+) - V_c(\infty)\right] e^{-t/\tau}$$

$y(0^+) = V_C(0^+) = 0v$ } determined
$y(\infty) = V_C(\infty) = V_S$ } earlier

$$V_c(t) = V_S + [0v - V_S]\, e^{-t/RC}$$

$$V_C(t) = V_S\left(1 - e^{-t/RC}\right)$$

13



14

RC Circuit – Discharge Phase

Discharge phase - Voltage

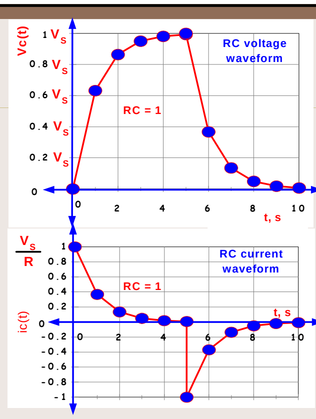
$$V_c(t) = V_c(\infty) + \left[V_c(0^+) - V_c(\infty)\right] e^{-t/\tau}$$

$V_C(0^+) = V_S \quad V_C(\infty) = 0v$

Note that it is assumed here that the capacitor had time to completely charge to V_s.

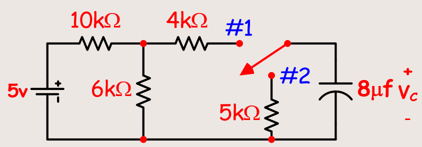
$$V_c(t) = 0v + [V_S - 0v]\, e^{-t/RC} \Rightarrow V_C(t) = V_S e^{-t/RC}$$

15



16

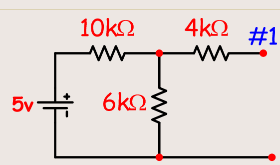
Example

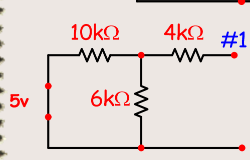


At time t = 0 the switch goes to position #1.
The initial charge on the capacitor is 0 volts.
Show the charge graph of the capacitor voltage.

17

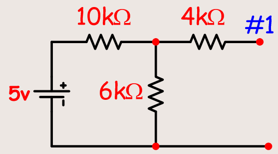
Step 1: Remove the load (the capacitor) and the Discharge Resistor and determine the Thevenin Ckt.





R_{Th} = 10kΩ || 6kΩ + 4kΩ
= 3.75kΩ + 4kΩ
= 7.75kΩ

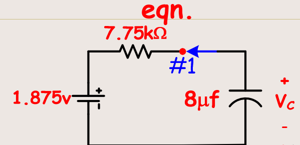
18



$$V_{Th} = \frac{5v(6k\Omega)}{10k\Omega + 6k\Omega} = 1.875v$$

19

Place the Cap onto the Thevenin circuit and then calculate the charge eqn.



$$V_c(t) = V_c(\infty) + \left[V_c(0^+) - V_c(\infty)\right]e^{-t/\tau}$$

$$\tau = RC = 7.75k\Omega(8\mu f) = 62ms$$

$$V_c(0^+) = 0v \quad V_c(\infty) = 1.875v$$

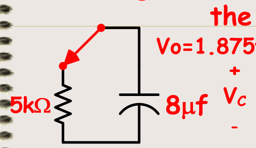
$$V_c(t) = 1.875v + [0v - 1.875v]e^{-t/62ms}$$

$$= 1.875 - 1.875e^{-t/62ms}$$

$$= 1.875\left(1 - e^{-t/62ms}\right)$$

20

Now place the cap with the discharge resistor and recalculate the eqn.



$$V_c(t) = V_c(\infty) + \left[V_c(0^+) - V_c(\infty)\right]e^{-t/\tau}$$

$$\tau = RC = 5k\Omega(8\mu f) = 40ms$$

$$V_c(0^+) = 1.875v \quad V_c(\infty) = 0v$$

$$V_c(t) = 0v + [1.875v - 0v]e^{-t/\tau}$$

$$V_c(t) = 1.875ve^{-t/40ms}$$

21