02/15/03 **3 Corrections (Capacitor Values)**

# EECS 42 – Introduction to Electronics for Computer Science


**Spring 2003,** **Prof. A. R. Neureuther**

**Dept. EECS, 510 Cory** **neureuth@eecs.berkeley.edu 642-4590**

**UC Berkeley** **Office Hours (Tentative M, Tu, W, (Th), F 11**

**Course Web Site** **http://www-inst.eecs.berkeley.edu/~ee42/**


# Problem Set # 4 Due 2:30 PM Feb 19th, 240 Cory

**Reading:** Week #4 Section 8.1 Schwarz and Oldham, Viewgraphs in HANDOUT_RC available on the web. Week #5 Feb. 17th is a UC Holiday, Feb 19th Node Eq.

**4.1 Sketch/Trend.** Consider the circuit in Fig. P4.1. At t = 0, the capacitor voltage $V_C$ = 1V.

a) Find $V_{OUT}$ as t goes to infinity.
b) Evaluate the time constant RC in ns.
c) Evaluate the initial slope $dV/dt = (1/C)\,(V_{FINAL}-V_{INITIAL})/R$
d) Draw axes for $V_{OUT}(t)$ vs t where t goes from 0 to 20 ns. Draw horizontal lines for $V_{INITIAL}$ and $V_{INITIAL}$. Draw a slanted line with the slope found in part c).
e) Sketch $V_{OUT}(t)$ on the graph.
f) What one-by-one fractional changes (i.e. doubling or reduction by half) of the individual parameters C, $V_{FINAL}-V_{INITIAL}$ and R will cause the slope to double?

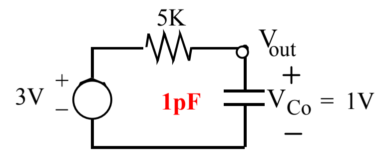


Fig. P4.1

**4.2 General Exponential Form**. Use the circuit in Fig. P4.1 and values from Problem 4.1.

a) Assume that $V_{OUT}(t)$ is an known function and find an equation for the current through the resistor in terms of $V_{OUT}(t)$.
b) Assume that $V_{OUT}(t)$ is an known function and find an equation for the current through the capacitor in terms of the time derivative of $V_{OUT}(t)$.
c) Equate a) and b) to obtain a differential equation for $V_{OUT}(t)$.
d) Substitute $V_{OUT}(t) = A + B\,e^{-(t/\tau)}$ and carry out the derivatives.
e) Group the equations into constant terms and terms times $e^{-(t/\tau)}$. Set these two groups of terms equal to zero to get two equations. Which two of the three parameters A, B and τ do they determine?
f) Use the initial value to determine the third parameter.

These values are the same as in Problem 4.1

$I_{SS}$ = 1mA, $R_1$ = 1kΩ, $R_2$ = 2kΩ, $R_3$ = 3 kΩ

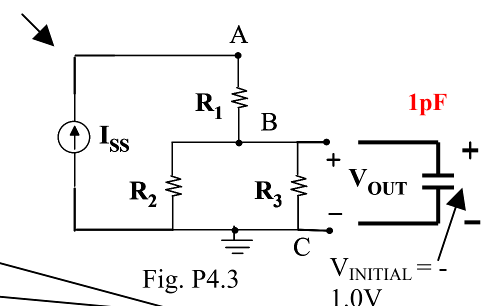


Fig. P4.3

**4.3 Nonzero levels and resistors**. A capacitor is precharged to –1.0 volts and connected at t=0 to the circuit in Fig. P4.3. This makes $V_{OUT}(0)$ = -1V.

a) Find the voltage on the capacitor as t goes to infinity.
b) Determine theThevenin resistance seen by the capacitor by setting $I_{SS}$ = 0.
c) Find $I_{OUT}$ and $dV_{OUT}/dt$ at t =0.
d) Assume $V_{OUT}(t) = A + B\,e^{-(t/\tau)}$ and use th initial condition and a) and b) to find A, B, and τ.

**4.4 Pulse shape.** In the circuit in Fig. P4.4 the switch has been in the upward position connecting to $R_U$ for a long time. At t =0 the switch changes such that it is connected to $R_D$.

a) Find $V_{OUT}(t)$ as t goes to infinity and the RC time constant.
b) Find $V_{OUT}(t)$ for t >0.
c) Determine the fraction of a time constant and the actual time that it takes for $V_{OUT}(t)$ to reach 2.5V.
d) Find $V_{OUT}$(t = 1.5 ns).
e) Assume the switch returns to the upward position a t = 1.5 ns and determine $V_{OUT}(t)$ for t > 1.5 ns. (Be aware that there is a different time constant going upward.)

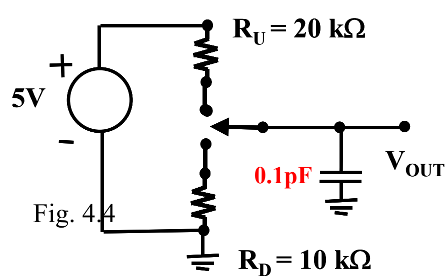


Fig. 4.4

Brain teaser for fun for good students: determine the time at which $V_{OUT}(t)$ reach 4 V on its way back upward!