EECS 42 – Introduction to Electronics for Computer Science

Spring 2003 — **Prof. A. R. Neureuther**
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Course Web Site http://www-inst.EECS.Berkeley.EDU/~ee42/

Midterm #1 March 5th, 2003

Closed Book, Closed Notes
Write on the Exam paper

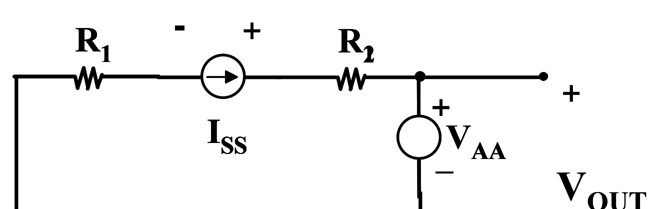
Print Your Name:_____Solution_______

Sign Your Name:_____________________

Show your work so that the method as well as the answer can be graded for correctness and completeness. Correct answers alone are only worth 70% of full credit.

Problem	Possible	Score
I	28	
II	22	
III	25	
IV	25	
Total	100	

I (28 Points) Basic Circuit Analysis



$V_{AA} = 2V$ $I_{ss} = 1$ mA

$R_1 = 1k\Omega$ $R_2 = 2k\Omega$ $R_3 = 3k\Omega$

a) (7 points) Find R_{TH}.

> Iss = 0 => R1 and R2 disconnected
> RTH = R3

b) (7 points) Find V_{OC}.

> VOC = Iss R3 + Vaa = 1 mA 3kΩ = 2+3 = 5V

c) (7 points) Find the power delivered to the circuit by V_{AA}.

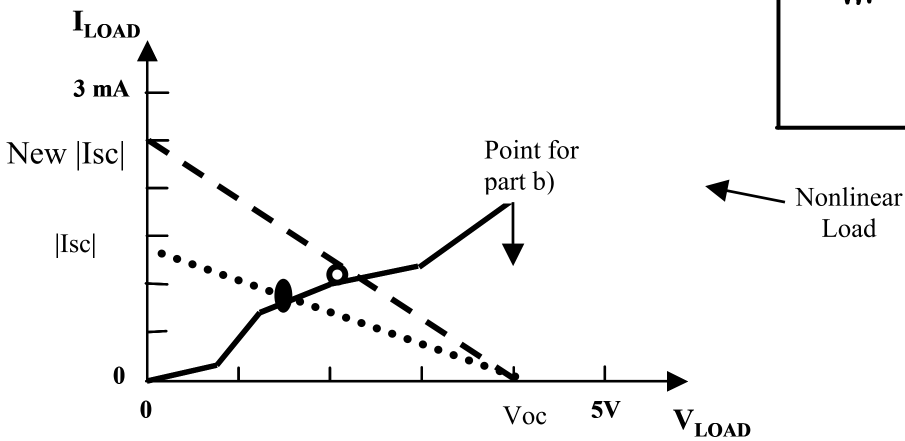
> Power = - Iss Vaa = - 1mA 2V = -2 mW
> Note Vaa abosorbs power from the circuit.

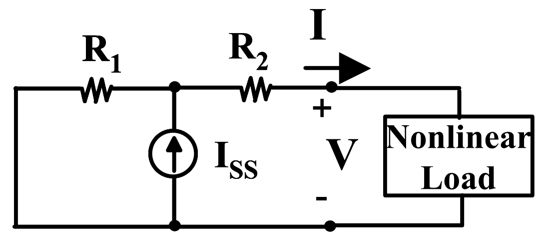
d) (7 points) Find the voltage on the current source I_{SS} in the direction shown on the diagram.

> Use a loop equation
> Vss = IssR2 + Vaa + Iss R3 – Iss R1 = 2V + 2V + 3V –1V = 6V

II (22 Points) Load Lines

A linear circuit is connected to a nonlinear load.





R_1 = 1 kΩ R_2 = 2 kΩ
I_{SS} = 4 mA

a) (12 points) Find the combination of current I and voltage V that satisfies both the circuit and the load.

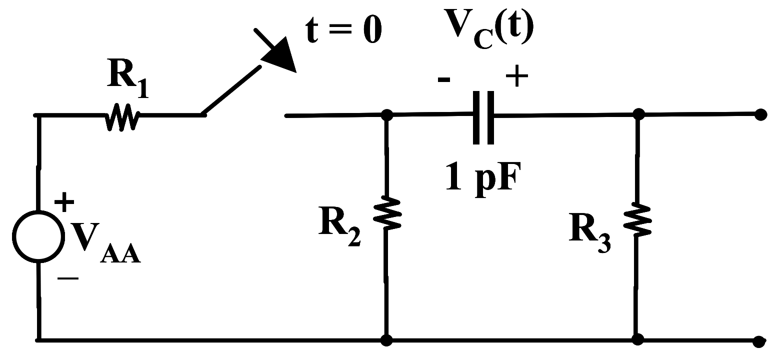
> Voc = Iss R1 = 1 mA 4kΩ = 4V
> |Isc| = [R1/(R1 + R2)] Iss = [1kΩ/(1 kΩ + 2kΩ)] 4 mA = 1.33 mA
> Draw line from (4V, 0 mA) through (0V, 1.33 mA)
> Intersection is about (1.5V, 0.8 mA)|

b) (10 points) Adjust R_2 so that the solution passes through the point indicated on the device curve.

> Voc is unaffected by R2 so still 4V.
> Draw a line from (4V, 0mA) through the given point which is approximately (2V, 1 mA) and hit V = 0 axis at about 2 mA.
> The new Rth = 4V/ 2mA = 2 kΩ
> This gives the new R2 = Rth – R1 = 2kΩ – 1kΩ = 1kΩ

III (25 Points) Transient

The switch in the circuit closes at t = 0. Just before switching the capacitor is charged to 2V.



$R_1 = 1k\Omega$ $R_2 = 2\ k\Omega$ $R_3 = 3\ k\Omega$
$V_{AA} = 5\ V$

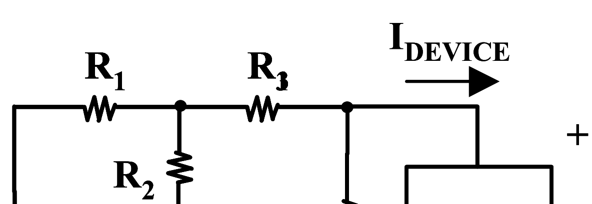
a) (18 points) Find the voltage on the capacitor $V_C(t)$ for t > 0.

Given Vinitial = Vc(o) = 2V
Find Vfinal as no current in C or R3 and R2 and R1 are voltage divider with voltage on C backward so
Voc(infinity) = -[R2/(R1 + R2) Vaa = -[2kΩ/(1kΩ + 2kΩ)] 5V = -3.33V
Capacitor sees Rth = R1||R2 + R3 = 3.67kΩ
τ = 1 pF 3.67kΩ = 3.67 ns
$Vc(t) = A + B\ e^{-t/\tau}$
A = Vfinal = -3.33V
B = 2V-A = 5.33V
$Vc(t) = -3.33 + 5.33e^{-t/3.67ns}$

b) (7 points) Find $dV_C(t)/dt$ just prior to the switch closing at t = 0.

i(t) = c dV/dt => d/V/dt = i(t)/C where current is into the + terminal
When Vc = 2V and the switch is open a current flows out of the positive terminal of C through R2 and R3 back to the negative terminal. This $i(0^-)$ = -Vc/(R2 + R3) = -2V/(2kΩ + 3kΩ) = -0.4mA.
DV/dt = -0.4 mA/ 1pF = -0.4 V/ns

IV (25 Points) Node Equations



a) (15 points) Assign labels to the nodes and write a complete set of node equations for determining the node voltages. (These equations should contain only the node voltages themselves, resistances, source strengths and the device current.)

R_1 = 1kΩ R_2 = 2 kΩ R_3 = 3 kΩ R_4 = 4 kΩ
V_{AA} = 5 V I_{SS} = 1 mA

Assign bottom terminal to ground.
Label top of R1 as node a.
Label top of node R4 as node b.

$$\frac{V_{AA} - V_a}{R_1} + I_{ss} + \frac{V_b - V_a}{R_3} = 0$$

$$\frac{V_a - V_b}{R_3} - \frac{V_b}{R_4} - I_{DEVICE} = 0$$

b) (10 points) Use **one** of your node equations from above to find the voltage on I_{SS} when the voltage on the device is 2V. (Hint: Substitute the device voltage to break the equations apart to avoid excessive algebra).

Use top equation and plug in Vb = 2V.

$$\frac{5V - V_a}{1k\Omega} + 1mA + \frac{2V - V_a}{3k\Omega} = 0$$

$$V_a\left(\frac{1}{1k\Omega} + \frac{1}{3k\Omega}\right) = 5mA + 1mA + 0.67mA = 6.67mA$$

$$V_a = [6.67mA)/(0.75k\Omega)] = 5V$$

$$Vss = Iss \cdot R2 + V_a = 1mA \cdot 2k\Omega + 5V = 7V$$