EECS 42 – Introduction to Electronics for Computer Science

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Midterm #1 October 3rd, 2001

Closed Book, Closed Notes
Write on the Exam paper

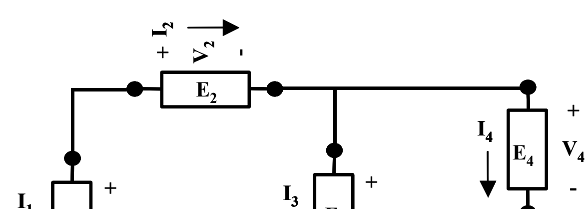
Print Your Name:___Solutions________

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	20	
II	20	
III	20	
IV	20	
V	20	
Total	100	

I (20 Points) Basic Circuit Analysis



$V_1 = 1V \quad V_2 = 2V \quad V_5 = -3V$

$I_1 = 1$ mA $\quad I_4 = 2$ mA

a) For the circuit shown find V_4.

Use KVL around outside of circuit.
-V1 + V2 +V4 +V5 = 0
-1V +2V +V4 –3V =0
V4 = 2V

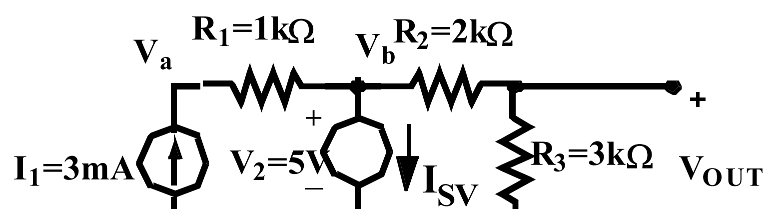
b) For the circuit shown find I_3.

KCL at top left node I2 = - I1
KCL at top right node I2 -I3 -I4 = 0
-1mA –I3 – 2mA = 0
I3 = -3mA

c) For the circuit shown find the power into E_2.

PAB = (IAB)(VAB) = (I2)(V2)
= (-1mA)(2V) = -2mW

II (20 Points) Equivalent Circuits and Analysis



a) For the circuit shown find the Thevinin equivalent circuit looking into the output.

Vb is fixed by V2
R3 and R2 divide this voltage
VOC = V2 (R3)/(R2+R3)
= 5V (3k)/(2k + 3k) = 3V

Find REQ by turning sources to zero
Current source = open; voltage source = short
Looking into the output see R3 in parallel with R2 due to short of V2.
REQ = (2k x 3k)/(2k + 3k) = 1.2k Ohms

b) For the circuit shown find the current through the voltage source (I_{SV}) when the output is shorted.

When the output is shorted R2 has V2 across it.
IOUT = V2/R2 = 5V/2k = 2.5 mA

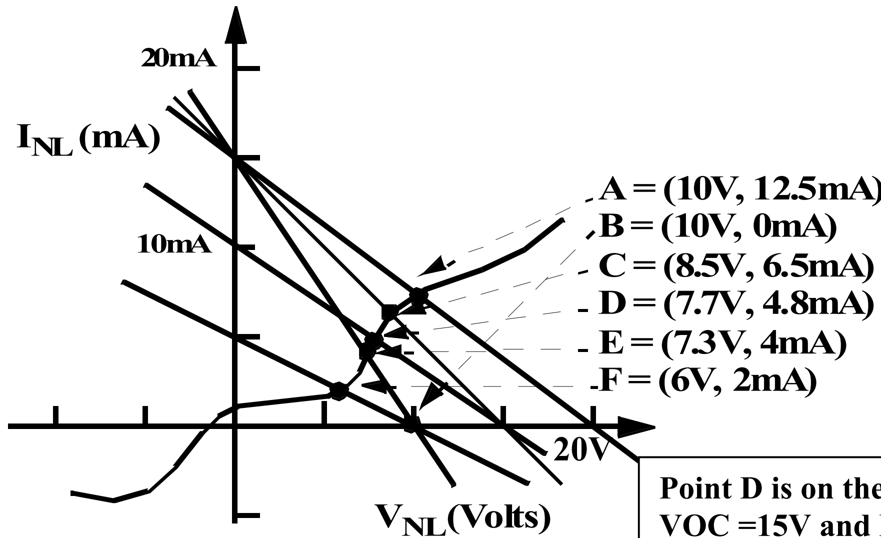
I1 forces 3 mA through R1.

KCL at Vb => 3mA – ISV – 2.5 mA = 0
ISV = 0.5 mA

III (20 Points) Equivalent Circuits and Analysis

A linear circuit is connected to a nonlinear load. Before it is connected the circuit is tested and has an open circuit voltage of 15 volts and a short circuit current of 10 mA.

a) Using one of the following load lines correctly determine the voltage and current through the nonlinear load when the circuit is connected to the nonlinear load.



Point D is on the load line with VOC =15V and ISC = 10 mA. It has VNL = 7.7V and INL = 4.8mA

V_{NL} = 7.7V **I_{NL} = 4.8 mA**

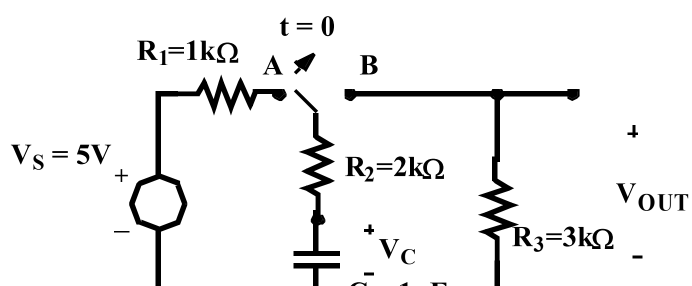
b) Find the power out of the source in the Thevinin equivalent circuit and the fraction of its power that is delivered to the nonlinear load.

VT = VOC = 15V
INL = 5 mA
PT = (VT)(INL) = (15V)(4.8mA) = 72 mW

PNL = (VNL)(INL) = (7.7V)(4.8mA) = 37 mW

Fraction = (37 mW)/(72 mW) = 0.51

IV (20 Points) Transient



The switch in the circuit moves from A to B at t = 0. Find the output voltage $V_{OUT}(t)$.

NOTE 'OUT'!

One approach is to first find VC(t) and then note that R3 and R2 form a voltage divider that scales VC(t) to form VOUT(t).

(An alternative approach is to just assume that VOUT(t) has the same EE 42 easy method form with the same time constant and find the correct values for VOUT at t=0 and infinity.)

VC(t) = A + B exp(-t/tau)

At t = 0, VC = 5V [=> A + B = 5V]

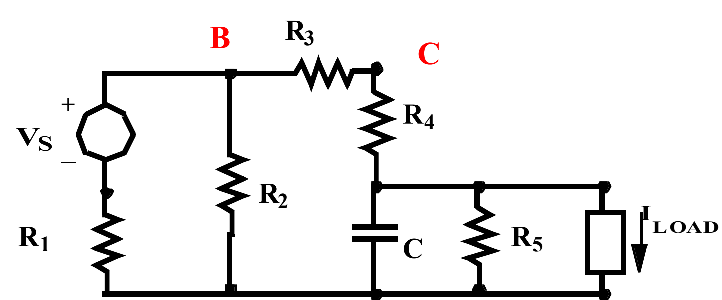
R2 and R3 appear in series to the capacitor after the switch is in position B.
Tau = (R2 +R3)C = (2k +5k) 1pF = 5ns

VC at t = infinity is 0 (discharges completely) [=> A = 0]

Combining
VC(t) = 0 + 5 exp (-t/(5ns))

Applying divider
VOUT(t) = [(3k)/(2k + 3k)] 5 exp (-t/(5ns))
VOUT(t) = 3 exp (-t/(5ns))

V (20 Points) Node Equations



Label the nodes and write a complete set of node equations for determining the node voltages that only contain the node voltages themselves and resistance, capacitance, V_S and I_{Load}.

D

A

E = ground

Plan what you are going to do because you can save yourself a lot of writing. The equations should hold for both time varying as well as steady state node voltages.

Nodes are lettered A to E.

There are 5 nodes so normally 4 equations are required.

However, there are two special situations.

1) If R3 and R4 are combined in series node C is not needed.
2) A supernode surface can be placed around VS to merge A and B and

$$\frac{V_A}{R_1} + \frac{(V_A + V_S)}{R_2} + \frac{(V_A + V_S - V_D)}{R_3 + R_4} = 0$$

Thus KCL is .

$$-\frac{(V_A + V_S - V_D)}{R_3 + R_4} + c\frac{\partial V_D}{\partial t} + \frac{V_D}{R_5} + I_{LOAD} = 0$$

These two equations contain only two unknowns VA and VD and only the resistance, capacitance, VS and ILOAD.

If VC is included as a third variable then a third equation is needed.

If the current through VS (IVS) is included then a fourth equation is needed and must be solved to eliminate IVS as it is not an allowed parameter in the final expression.