**EECE 210 Electric Circuits**

**Quiz 2 – Oct 22, 2016**

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1. Determine: (a) *VO* (6 grades), (b) the short circuit current *Iab* (6 grades), (c) Thevenin’s resistance seen by a test current source applied between terminals ‘ab’ (8 grades). Assume *R* = 10 Ω.

**Solution:** (a) The current through *R* is 0.5 – 0.1*VO*. From KVL, (0.5 – 0.1*VO*)*R* + 20 = *VO*. It follows that .

(b) When terminals ‘ab’ are short circuited,

*VO* = 0, and the dependent source is zero, that is replaced by an open circuit. It follows that *ISC* = .

(c) When a test current source is applied, with the independent sources set to zero, it follows that , so that . Alternatively, the dependent source is equivalent to a resistance of *VT*/(0.1VT) = 10 Ω, so that *RTh* = 10||*R* = .

**Version 1:** *R* = 10 Ω, (a)  V, (b) *ISC* =  2.5 A, (c)  Ω.

**Version 2:** *R* = 15 Ω, (a)  V, (b) *ISC* =   A, (c)  Ω.

**Version 3:** *R* = 20 Ω, (a)  V, (b) *ISC* =   A, (c)  Ω.

**Version 4:** *R* = 30 Ω, (a)  V, (b) *ISC* = 

 A, (c)  Ω.

**Version 5:** *R* = 40 Ω, (a)  V, (b) *ISC* =   A, (c)  Ω.

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1. Determine *IO* using NEC, assuming *R* = 1 Ω (15 grades for NEC, 5 grades for *IO*).

**Solution:** On open circuit, it follows from KVL around the 3 Ω resistor and 3 V source that *VTh* – 3 – 3 = 0, so that *VTh* = 6 V.

On short circuit, *IN* = 2 A, so that *RTh* = 3 Ω.

Alternatively, if the independent sources are set to zero, the 6 Ω resistor is short circuited, so that the resistance seen by *R* is 3 Ω.





NEC seen by *R* is as shown. It follows from current division that:

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**Version 1:** *R* = 1 Ω,  A

**Version 2:** *R* = 2 Ω,  A

**Version 3:** *R* = 3 Ω,  A

**Version 4:** *R* = 5 Ω,  A

**Version 5:** *R* = 6 Ω,  A.

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1. Determine *IS* using superposition, assuming *R* = 5 Ω.

**Solution:** The dependent source is replaced by an independent source *VY* = 5*VX*. If the 1.5 A source is applied alone, with the voltage sources set to zero, *VX*1 =

 (80||20)×1.5 = 16×1.5 = 24 V. If the 10 V source is applied alone, with the other sources set to zero, no current flows in the 20 Ω and 80 Ω resistors, so that *VX*2 = 10 V. If the source *VY* is applied alone, it follows from voltage division that *VX*3 =

. Substituting *VY* = 5*VX*, the superposition equation is: *VX* = 24 + 10 – *VX*, or *VX* = 17 V. From KVL in lower mesh on the LHS, , and .

**Version 1:** *R* = 5 Ω,  = 16.5 A.

**Version 2:** *R* = 10 Ω,  = 9 A.

**Version 3:** *R* = 15 Ω, = 6.5 A.

**Version 4:** *R* = 20 Ω,  5.25 A.

**Version 5:** *R* = 25 Ω,  = 4.5 A.

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1. Determine *VO* using the node-voltage method, assuming *ISRC* = 1 A.

**Solution:** Node-voltage equation for node ‘a’, bearing in mind that the 5 Ω resistor is redundant:

(0.5 + 0.5)*Va* – 0.5*Vb* = *Ib* = 0.5Va. This gives *Va* = *Vb*. The node-voltage equation for node ‘b’ is:

-0.5*Va* + (0.5 + 0.5)*Vb* – 0.5*Vc* = -*ISRC.*

Substituting *Vc* = 18 V and *Va* = *Vb*,

0.5*Va* = 9 – *ISRC*, or, *Va* = *VO* = 18 – 2*ISRC*.

**Version 1:** *ISRC* = 1 A, *VO* = 18 – 2*ISRC* = 16 V

**Version 2:** *ISRC* = 2 A, *VO* = 18 – 2*ISRC* = 14 V

**Version 3:** *ISRC* = 3 A, *VO* = 18 – 2*ISRC* = 12 V

**Version 4:** *ISRC* = 4 A, *VO* = 18 – 2*ISRC* = 10 V

**Version 5:** *ISRC* = 5 A, *VO* = 18 – 2*ISRC* = 8 V.

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1. Assuming a dc state and *ISRC* = 5 A, determine: (a) The charge on the capacitor; (b) the energy stored in the capacitor; (c) the flux linkage of the inductor; (d) the energy stored in the inductor; (e) if after reaching the dc state, the current source is replaced by a short circuit, determine the total power dissipated in the circuit as *t* → ∞ (4 grades for each part).

**Solution:** (a) In the dc state, the capacitor acts as an open circuit and the inductor as a short circuit. *ISRC* flows through the 1 Ω resistor and the inductor. The voltage across the capacitor is therefore *V* = 1×*ISRC* V. The charge on the capacitor is *CV* = 10-3×*ISRC* C ≡ *ISRC* mC.

(b) The energy stored in the capacitor is (1/2)*qV* = (1/2)(*ISRC*)2 mJ.

(c) The flux linkage *λ* = *LISRC* = 10-3×*ISRC* Wb-T ≡ *ISRC* mWb-T.

(d) The energy stored in the inductor is (1/2)*λISRC* = (1/2)(*ISRC*)2 mJ.

(e) As *t* → ∞, the energy dissipated in the circuit is, from conservation of energy, the energy stored in the capacitor and inductor, which totals (*ISRC*)2 mJ. The energy divided by infinite time is zero power.

**Version 1:** *ISRC* = 1 A, (a) *ISRC* mC = 1 mC; (b) (1/2)(*ISRC*)2 mJ = 0.5 mJ; (c) *ISRC* mWb-T = 1 mWb-T; (d) (1/2)(*ISRC*)2 mJ = 0.5 mJ; (e) (*ISRC*)2 mJ = 1 mJ.

**Version 2:** *ISRC* = 2 A, (a) *ISRC* mC = 2 mC; (b) (1/2)(*ISRC*)2 mJ = 2 mJ; (c) *ISRC* mWb-T = 2 mWb-T; (d) (1/2)(*ISRC*)2 mJ = 2 mJ; (e) (*ISRC*)2 mJ = 4 mJ.

**Version 3:** *ISRC* = 3 A, (a) *ISRC* mC = 3 mC; (b) (1/2)(*ISRC*)2 mJ = 4.5 mJ; (c) *ISRC* mWb-T = 3 mWb-T; (d) (1/2)(*ISRC*)2 mJ = 4.5 mJ; (e) (*ISRC*)2 mJ = 9 mJ.

**Version 4:** *ISRC* = 4 A, (a) *ISRC* mC = 4 mC; (b) (1/2)(*ISRC*)2 mJ = 8 mJ; (c) *ISRC* mWb-T = 4 mWb-T; (d) (1/2)(*ISRC*)2 mJ = 8 mJ; (e) (*ISRC*)2 mJ = 16 mJ.

**Version 5:** *ISRC* = 5 A, (a) *ISRC* mC = 5 mC; (b) (1/2)(*ISRC*)2 mJ = 12.5 mJ; (c) *ISRC* mWb-T = 5 mWb-T; (d) (1/2)(*ISRC*)2 mJ = 12.5 mJ; (e) (*ISRC*)2 mJ = 25 mJ.