**EECE 210 Electric Circuits**

**Final Exam – Dec 19, 2018**

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**1.** Derive NEC looking into terminals ‘ab’, where the short-circuit current is directed from ‘a’ to ‘b’, assuming *VSRC* = 1 V.

**Solution:** The dependent voltage source partitions the circuit into independent subcircuits. In the subcircuit on the RHS, no current passes though the upper 1 Ω resistor, so that the voltage across this resistor is zero. The circuit reduces to that shown. On open circuit, KVL gives: -*IX* + *VSRC* – *IX* = 0, so that *IX* = *VSRC*/2 A, and *Vab* = *VSRC*/2 V. On short circuit, *IX* = 0 and the dependent sources are set to zero. It follows that *ISC* = *VSRC*/1 A. Hence, *RN* = 0.5 Ω and *IN* = *VSRC* A.

**Version 1:** *VSRC* = 1 V, *IN* = 1 A, *RN* = 0.5 Ω

**Version 2:** *VSRC* = 2 V, *IN* = 2 A, *RN* = 0.5 Ω

**Version 3:** *VSRC* = 3 V, *IN* = 3 A, *RN* = 0.5 Ω

**Version 4:** *VSRC* = 4 V, *IN* = 4 A, *RN* = 0.5 Ω

**Version 5:** *VSRC* = 5 V, *IN* = 5 A, *RN* = 0.5 Ω.

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**2**. Determine *vO*(*t*), assuming *VSRC* = 1 V dc and *iSRC*(*t*) = 1.5sin1000*t* A.

**Solution:** *ω* = 1000 rad/s, *jωL* = *j* Ω. Under dc conditions, the inductor acts as a short circuit, the capacitor and independent current source as open circuits. *VO* = *VSRC*, irrespective of *IL*. Under ac conditions, the independent voltage source acts as a short circuit. The downward current in the 100 Ω resistor is (**ISRC** + 2**IL**) A in the frequency domain. This current divides between the inductor and capacitor. **IL** = , or, , or, . **VO** = *jωL***IL** = . Substituting numerical values, **VO** =  V. The ac component of *vO*(*t*) =  = . It follows that: *vO*(*t*) =  V.

**Version 1:** *VSRC* = 1 V, *Isrc* = 1.5 A; *vO*(*t*) =  V

**Version 2:** *VSRC* = 2 V, *Isrc* = 3 A; *vO*(*t*) =  V

**Version 3:** *VSRC* = 3 V, *Isrc* = 4.5 A; *vO*(*t*) =  V

**Version 4:** *VSRC* = 4 V, *Isrc* = 6 A; *vO*(*t*) =  V

**Version 5:** *VSRC* = 5 V, *Isrc* = 7.5 A; *vO*(*t*) =  V.

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**3.** Determine **VO**, assuming **VSRC** =  V.

**Solution:** The impedance seen at the primary of the ideal transformer will be derived. The impedance on the secondary side of the ideal transformer is reflected to the primary side as a reactance of *j*10 Ω in parallel with a resistance of 40 Ω, with -2**VO** appearing across the parallel combination, as shown. The two series-coupled coils in series with the capacitor will have a reactance of: *j*10 – *j*5 – *j*25 = -*j*20 Ω. The two reactances in parallel are Ω. TEC seen by this reactance is  in series with 20 Ω, the circuit becoming as shown. It follows that:  =   and .

**Version 1:** **VSRC** = = (-1 + *j*) V;  = 0.25 V

**Version 2:** **VSRC** = 2= 2(-1 + *j*) V;  = 0.5 V

**Version 3:** **VSRC** = 3= 3(-1 + *j*) V;  = 0.75 V

**Version 4:** **VSRC** = 4= 4(-1 + *j*) V;  = 1 V

**Version 5:** **VSRC** = 5= 5(-1 + *j*) V;  = 1.25 V



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**4.** The switch is opened at *t* = 0 after being closed for a long time. Determine *RL* and *C* so that the voltage *vS* across the open switch is a constant for *t* ≥ 0+, assuming *RC* = 1 Ω and *L* = 1 H.

**Solution:** In the steady state, with the switch closed, the inductor acts as short circuit and the capacitor as an open circuit. A current 5/*RC* flows, establishing a voltage of 5 V across *C.* At *t* = 0+, the initial current through *L* is 5/*RC* and the initial voltage across *C* is 5 V. For *t* > 0+, *L* and *C* will each discharge independently through the parallel resistance, as first-order circuits, so that  and . *vS* = 5 – *vC* – *vL* = 5. For *vS* to be a constant, the two exponential terms must cancel out. It follows that *RL* = *RC* and , or .

**Version 1:** *RC* = 1 Ω, *L* = 1 H; *RL* = 1 Ω, and *C* = 1 F

**Version 2:** *RC* = 2 Ω, *L* = 2 H; *RL* = 2 Ω, and *C* = 2/4 = 0.5 F

**Version 3:** *RC* = 3 Ω, *L* = 3 H; *RL* = 3 Ω, and *C* = 3/9 = 0.33 F

**Version 4:** *RC* = 4 Ω, *L* = 4 H; *RL* = 4 Ω, and *C* = 3/16 = 0.25 F

**Version 5:** *RC* = 5 Ω, *L* = 5 H; *RL* = 5 Ω, and *C* = 5/25 = 0.2 F.

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**5.** Switch S1 is opened at *t* = 0 with no initial energy stored in the circuit. Switch S2 is moved from position ‘a’ to position ‘b’ at *t* = *t*0, at the first zero of *iL* for *t* > 0+. Determine (a) *t*0, (b) *iC*(*t*) and *vC*(*t*) for *t* ≥ 0+, where *t* is in ms. Assume that *ISRC* = 1 mA and *VSRC* = 5 V.

**Solution:** (a) 0 ≤ *t* ≤ *t*0: *vC*(*t*) = *A*cos*ω*0*t* + *B*sin*ω*0*t*, since there can be no steady value of *vC*. At *t* = 0+, *vC*(0+) = 0, so that *A* = 0, and *vC*(*t*) = *B*sin*ω*0*t* V. *iC*(*t*) = *ω0CB*cos*ω*0*t*. At *t* = 0+, *iC*(0+) = *ISRC*, so that *B* = *ISRC*/*ω0C*, and *iC*(*t*) = *ISRC*cos*ω*0*t*. *iL*(*t*) = *ISRC* – *iC*(*t*) = *ISRC*(1 – cos*ω*0*t*) A. The first zero of *iL*(*t*) for *t* > 0+ occurs at *t*0 = 2*π*/*ω*0, where  rad/s, so that ms.

 (b) 0 ≤ *t* ≤ *t*0: *vC*(*t*) = (*ISRC*/*ω0C*)sin*ω*0*t* = (*ISRC*×10-3/(104*×*10-7)sin10*t* = *ISRC*sin10*t* V, where *ISRC* is in mA and *t* is in ms. *iC*(*t*) = *ISRC*cos10*t* mA.

*t* ≥ *t*0: At *t* = *t*0, *vC*(*t*0) = 0 and *iC*(*t*) =*ISRC* mA. At this instant, switch S2 is moved to position ‘b’, which makes *iC*(*t*0) =*ISRC* +  = (*ISRC* + 5) mA, and the final value is zero, when the capacitor is fully charged. *τ* = 103×10-7 ≡ 0.1 ms. Hence, mA, where *t* is in ms. The final value of *vC*(*t*) is: *ISRC*×1 + 5 = (*ISRC* + 5) V. Hence,  V*.*

**Version 1:** *ISRC* = 1 mA: *iC*(*t*) = cos10*t* mA, *vC*(*t*) = sin10*t* V, 0 ≤ *t* ≤ *t*0

mA,  V, *t* ≥ *t*0.

**Version 2:** *ISRC* = 2 mA: *iC*(*t*) = 2cos10*t* mA, *vC*(*t*) = 2sin10*t* V, 0 ≤ *t* ≤ *t*0

mA,  V, *t* ≥ *t*0.

**Version 3:** *ISRC* = 3 mA: *iC*(*t*) = 3cos10*t* mA, *vC*(*t*) = 3sin10*t* V, 0 ≤ *t* ≤ *t*0

mA,  V, *t* ≥ *t*0.

**Version 4:** *ISRC* = 4 mA: *iC*(*t*) = 4cos10*t* mA, *vC*(*t*) = 4sin10*t* V, 0 ≤ *t* ≤ *t*0

mA,  V, *t* ≥ *t*0.

**Version 5:** *ISRC* = 5 mA: *iC*(*t*) = 5cos10*t* mA, *vC*(*t*) = 5sin10*t* V, 0 ≤ *t* ≤ *t*0

mA,  V, *t* ≥ *t*0.