EECE 210 – Quiz 3

Dec 1, 2012

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1. A susceptance of -1 S is connected in series with an admittance (3 + *j*4) S. Determine the reactance of the series combination.
2. -0.84 Ω
3. -1.16 Ω
4. -0.66 Ω
5. 0.84 Ω
6. 1.16 Ω

**Solution:** Let the susceptance be -*A* S. The admittance of this susceptance is -*jA* S. The corresponding impedance is *j*/*A* Ω. The impedance of the given admittance   Ω, and the impedance of the series combination is . The reactance is Ω.

**Version 1:** *A =* 1, Ω

**Version 2:** *A =* 2, Ω

**Version 3:** *A =* 4, Ω

**Version 4:** *A =* 5, Ω

**Version 5:** *A =* 10, Ω.



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1. Given a phasor **A** = *A*∠*α*. Express the phasor ‘Ob’ in terms of **A** and *j*, assuming that the phasors ‘Oa’ and ‘ab’ have a magnitude *A*.
2. *j*(1 – *j*)**A** Ω
3. *j*(1 + *j*)**A** Ω
4. *j*(-1 + *j*)**A** Ω
5. *-j*(1 + *j*)**A** Ω
6. -*jA* Ω

**Solution:** Phasor ‘Oa’ is *A*∠(*α* + 90°) = *j***A**. Phasor ‘ab’ is -**A**, and phasor ‘Ob’ is *j***A** – **A** = *j***A** + *j*2**A** = *j*(1 + *j*)**A**.

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**3.** *v* is the voltage between two terminals of a given circuit, and *i* is the current entering these terminals in the direction of a voltage drop *v*. Determine the impedance looking into these terminals,

1. -2∠-45° Ω
2. 2∠45° Ω
3. 2∠-45° Ω
4. -2∠45° Ω
5. 0

**Solution:** *T* = 40 ms and the current leads the voltage by 5 ms, or *T*/8, corresponding to 45°. Considering the phase angle of *v* to be zero, **V** = 1∠0 V, and **I** = 0.5∠45° A, so that *Z* = **V**/I = 2∠-45° Ω.

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1. Two coils are magnetically coupled through a core of high permeability. A current of 0.5 A in coil 1, with coil 2 open circuited, results in a flux of 0.1 Wb in the core, whereas a current of 0.25 A in coil 2, with coil 1 open circuited, results in a flux of 0.2 Wb in the core. If coil 1 has 100 turns, determine the number of turns of coil 2.
2. 400 turns
3. 200 turns
4. 1000 turns
5. 600 turns
6. 800 turns

**Solution:** The flux linkage in coil 1 due to current in coil 2 is 0.2×*N*1 = 0.2*N*1 Wb-turns, and the flux linkage in coil 1 per unit current in coil 2 is 0.2*N*1/0.25 = 0.8*N*1 H. By equality of mutual conductance between the two coils, the flux linkage in coil 2 per unit current in coil 1 is also 0.8*N*1. That is, 0.8*N*1 = 0.1*N*2/0.5, which gives *N*2 = 4*N*1.

**Version 1:** *N*1 *=* 100 turns, *N*2 = 400 turns

**Version 2:** *N*1 *=* 150 turns, *N*2 = 600 turns

**Version 3:** *N*1 *=* 200 turns, *N*2 = 800 turns

**Version 4:** *N*1 *=* 250 turns, *N*2 = 1000 turns

**Version 5:** *N*1 *=* 300 turns, *N*2 = 1200 turns.

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**5.** Given *vSRC* = V, with *A* = 1, *R* = 500 Ω, *L* = 2 H, *C* = 1 µF. Determine *iSRC* as a phasor in rectangular coordinates.

1. 2 – *j*2 mA
2. *j*2 mA
3. -*j*4 mA
4. -*j*
5. -*j*2 mA

**Solution:** *ωL* = 2000 Ω, 1/*ωC =* 1000 Ω, the impedance of each *LC* branch is *j*2000 – *j*1000 = *j*1000 Ω, and the impedance of two the branches in parallel is *j*500 Ω. The total impedance in series with the source is 500 + *j*500 = Ω; **V** =  V; **ISRC** = **V**/*Z* =  A  mA.

**Version 1:** *A* = 1, **ISRC** *=* -*j*2*A* = -*j*2 mA

**Version 2:** *A* = 1.5, **ISRC** *=* -*j*2*A* = -*j*3 mA

**Version 3:** *A* = 2, **ISRC** *=* -*j*2*A* = -*j*4 mA

**Version 4:** *A* = 2.5, **ISRC** *=* -*j*2*A* = -*j*5 mA

**Version 5:** *A* = 3, **ISRC** *=* -*j*2*A* = -*j*6 mA.

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**6.** Determine the frequency at which the impedance looking into terminals ‘a’ and ‘b’ is purely resistive, given *L* = 2.5 mH.

1. 10 krad/s
2. 12.5 krad/s
3. 20 krad/s
4. 5 krad/s
5. 40 krad/s

**Solution:** The input impedance is purely resistive when the susceptances of *L* and *C* add to zero, that is, *ωC* -1/*ωL* = 0, or  krad/s, where *L* is in henries.

**Version 1:** *L =* 2.5 mH*,*krad/s

**Version 2:** *L =* 6.4 mH*,*krad/s

**Version 3:** *L =* 10 mH*,*krad/s

**Version 4:** *L =* 40 mH*,*krad/s

**Version 5:** *L =* 160 mH*,*krad/s.

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**7**. Given *i*1 = 3 A and decreasing at a rate of 0.2 A/s, that is, *di*1/*dt* = -0.2 A/s at a given instant of time. Determine *vcd* at this instant, assuming *k* = 0.7.

1. 0.14 V
2. 0.28 V
3. 0.54 V
4. 0.30 V
5. 0.32 V

**Solution:** H. The magnitude of the induced voltage is  0.4*k* V. Since *di*1/*dt* < 0, terminal ‘b’ is positive with respect to ‘a’ so as to enhance *i*1. Because the polarities of the dotted terminals with respect to the unmarked terminals is the same in both windings, terminal ‘c’ is positive with respect to ‘a’. Hence, *vcd* = 0.4*k* V.

**Version 1:** *k* = 0.7, *vcd* = 0.4*k* = 0.28 V

**Version 2:** *k* = 0.75, *vcd* = 0.4*k* = 0.30 V

**Version 3:** *k* = 0.8, *vcd* = 0.4*k* = 0.32 V

**Version 4:** *k* = 0.85, *vcd* = 0.4*k* = 0.34 V

**Version 5:** *k* = 0.9, *vcd* = 0.4*k* = 0.36 V.

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**8.** Given two coils, one having a self-inductance of 1 mH, the other a self-inductance of 4 mH. They are magnetically-coupled and connected in series so that the fluxes due to the current in the two coils add to one another. In the T-equivalent circuit representing the two coupled coils, the magnetic energy that depends on the self-inductance of 4 mH is twice the magnetic energy that depends on the self-inductance of 1 mH. Determine the coefficient of coupling.

1. 0.57
2. 0.44
3. 1.25
4. 0.75
5. 1

**Solution:** When the two coils are coupled and connected in series so the fluxes are additive, the effective inductances of the coils are (*L*1 + *M*) and (*L*2 + *M*), according to the T-equivalent circuit. The stored energy associated with each coil is 0.5(*L*1 + *M*)*i*2 and 0.5(*L*2 +*M*)*i*2. Let the ratio of these stored energies be *A*. Then . This gives ,  .

**Version 1:** 

**Version 2:** *A* = 2.2, 

**Version 3:** *A* = 2.4, 

**Version 4:** *A* = 2.6, ,

**Version 5:** *A* = 2.8, .

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**9.** Two coils are wound on a high-permeability core, the leakage flux being negligible. Coil 1 has 1000 turns and carries a current *i*1 = 1 A. Coil 2 has 500 turns. Determine the magnitude and direction of the current in coil 2 so that the net flux in the core is zero.

1. 2 A, entering terminal 2′
2. 0.5 A, entering terminal 2′
3. 4 A, entering terminal 2′
4. 2 A, leaving terminal 2′
5. 0.5 A, leaving terminal 2′

**Solution:** The mmf due to *i*1 is 1000*i*1, and the mmf due to *i*2 is 500*i*2. To have zero mmf acting on the core, 1000*i*1 = 500*i*2, or *i*2 = 2*i*1, and *i*2 should enter at terminal 2′.

**Version 1:** *i*1 *=* 1 A, *i*2 = 2*i*1 = 2 A, entering terminal 2′

**Version 2:** *i*1 *=* 1.5 A, *i*2 = 2*i*1 = 3 A, entering terminal 2′

**Version 3:** *i*1 *=* 2 A, *i*2 = 2*i*1 = 4 A, entering terminal 2′

**Version 4:** *i*1 *=* 2.5 A, *i*2 = 2*i*1 = 5 A, entering terminal 2′

**Version 5:** *i*1 *=* 3 A, *i*2 = 2*i*1 = 6 A, entering terminal 2′.

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**10.** Determine *v*2 in the steady state, given *N*1:*N*2 = 1:2 and the secondary winding is open circuited.

1. 3 V
2. 6 V
3. -3 V
4. 0
5. -6 V

**Solution:**Under dc conditions, there is no induced voltage in the secondary winding, so *v*2 = 0.

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**11.** Given *iSRC* = cos108*t* A, *R* = 100 Ω, *L* = 1 μH, and *C* = 100 pF.

(a) Represent the circuit in the frequency domain (6 points).

(b) Determine the phasor **Vab** in rectangular coordinates (8 points).

(c) Determine the phasor **Ix** in rectangular coordinates (3 points).

(d) Determine *v***o** as a function of time 2 (3 points).

**Solution:** (a) **ISRC** = 1∠0 A, *ωL* = 108×10-6 = 100 Ω, 1/*ωL* = 1/(108×10-10) = 100 Ω. The circuit in the frequency domain becomes as shown.

(b) Note that *R* and *C* to the left of

node ‘a’ are redundant as far as finding **Ix** and **Vo** are concerned and can be ignored. Taking the lower node as reference, **Vb** = 2**Vx** + **Vx** = 3**Vx**. Taking KCL at node ‘b’, , or , , ; **Vab** = -**Vx** = 20(-3 + *j*) V, **Vab** = -60 + *j*20 V.

(c) , **Ix** = 0.2 + *j*0.6 A.

(d),

**Vo** = 60 – *j*120 V; *vO* = 

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**12.** Given that the source voltage is 10sin(*ωt* + 30°) V, where *ω* is not specified. Determine *vo* as a function of time.

**Solution:** Replacing the linear transformer with its T-equivalent circuit, the circuit becomes as shown. The parallel impedance between

nodes ‘a’ and ‘b’ is Ω. The -*j*15 Ω and the *j*15 Ω cancel out, leaving the circuit as shown. It follows from voltage division that . From voltage division in the original circuit,  V. Since *vSRC* is a sine function, *vo* = 5sin(*ωt* + 83.1°) V.

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**13.** Determine *ρ* so that the impedance seen by the independent source is purely reactive and specify this reactance, assuming *Z* = 5 + *j*10 Ω.

**Solution:** **Vo** = **V1** – 2**V1** = -**V1**, and *N*(**I1** – **Io**) + 2*N*Io *=* 0, or **Io** = -**I1**. Moreover, **V1** = **VSRC** + *ρ***Io**, **Vo** = *Z***Io**. Eliminating, **Vo**, **V1**, and **Io**, Z**I1** = **VSRC** – *ρ***I1***,* which gives **VSRC**/**I1** = Z +*ρ =* 5 + *ρ* + *j*10. To have a purely reactive **VSRC**/**I1**, *ρ = -*5, and *X* = 10 Ω.

