**EECE 210 Final Exam fall 2009/2010 – Sections 1, 3 and 4**

**Closed Book – Three Hours**

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1. Determine the power dissipated in the circuit, assuming *I* = 1 A.

**Solution:** The 1 Ω Y is paralleled with a 3 Ω Δ, so that it effectively becomes a 0.5 Ω Y, and the circuit reduces to that shown. The resistance seen by the current source is 1||1 + 2.5 = 3 Ω, so that the power dissipated in the circuit is *P* = 3*I*2 W.



**Version 1**: *I* = 1 A, *P* = 3 W

**Version 2**: *I* = 2 A, *P* = 12 W

**Version 3**: *I* = 3 A, *P* = 27 W

**Version 4**: *I* = 4 A, *P* = 48 W

**Version 5**: *I* = 5 A, *P* = 75 W.

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2. Determine the power delivered by the 3 V source, assuming *ρ* = 2 V/A.

**Solution:** The upper node is at 5 V with respect to the lowest node, the middle node is at 3 V. hence, *Ix* = 0.5 A and the current in the 6 Ω resistor is also 0.5 A. The current supplied by the 3 V source is (3 – 0.5*ρ*)/2 and the power delivered by the source is *P* = 1.5(3 – 0.5*ρ*) = 4.5 – 0.75*ρ* W*.*

**Version 1**: *ρ* = 2, *P* = 4.5 – 0.75×2 = 3 W

**Version 2**: *ρ* = 3, *P* = 4.5 – 0.75×3 = 2.25 W

**Version 3**: *ρ* = 4, *P* = 4.5 – 0.75×4 = 1.5 W

**Version 4**: *ρ* = 5, *P* = 4.5 – 0.75×5 = 0.75 W

**Version 5**: *ρ* = 6, *P* = 4.5 – 0.75×6 = 0

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3. Determine the impedance seen by the source, assuming *a* = 2.

**Solution:** Reflection of the (5 – *j*5) Ω through the RH transformer gives (20 – *j*20) Ω. The impedance on the secondary side of the LH transformer is (25 – *j*10) Ω. Reflected to the primary side, this becomes (25 – *j*10)/*a*2 Ω.

**Version 1**: *a* = 2, *Z* = 6.25 – *j*2.5 Ω

**Version 2**: *a* = 3, *Z* = 2.78 – *j*1.11 Ω

**Version 3**: *a* = 4, *Z* = 1.56 – *j*0.63 Ω

**Version 4**: *a* = 5, *Z* = 1 – *j*0.4 Ω

**Version 5**: *a* = 6, *Z* = 0.69 – *j*0.28 Ω

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4. If *vsrc* = 10cos(1,000*t*) V, determine the energy stored in the circuit in the sinusoidal steady state at *t* = 0, assuming *C* = 1 μF.

**Solution:** At *t* = 0, the voltage across *C* is 10 V and the current through the inductors is zero, being proportional to the integral of *vsrc*. The energy stored is *W* = 50*C*.

**Version 1**: *C* = 1 μF, *W* = 50 μJ

**Version 2**: *C* = 2 μF, *W* = 100 μJ

**Version 3**: *C* = 3 μF, *W* = 150 μJ

**Version 4**: *C* = 4 μF, *W* = 200 μJ

**Version 5**: *C* = 5 μF, *W* = 250 μJ.



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5. Determine *Rx* given that **I** = 0 and *R* = 2 Ω.

**Solution:** Since **I** = 0, the voltage across *Rx* is 10 V, and the same

current  flows through *R* and *Rx*. It follows that , or .

**Version 1**: *R* = 2 Ω, *Rx* = 1 Ω

**Version 2**: *R* = 3 Ω, *Rx* = 1.5 Ω

**Version 3**: *R* = 4 Ω, *Rx* = 2 Ω

**Version 4**: *R* = 5 Ω, *Rx* = 2.5 Ω

**Version 5**: *R* = 6 Ω, *Rx* = 3 Ω

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6. Determine the power absorbed or delivered by the dependent source assuming *R* = 1 Ω.

**Solution:** The current in the 2 Ω resistor is 2*Ix* flowing downwards. From KVL in the mesh on the left, 10 = 4*Ix* + 2, or *Ix* = 2 A. The voltage rise *Vx* across the dependent source is given by: *Vx* – *RIx* = 5, or *Vx* = 2*R* + 5; The power *P* delivered by the source is *P* = 2(2×*R* + 5).

**Version 1**: *R* = 1 Ω, *P* = 2(2×1 + 5) = 14 W

**Version 2**: *R* = 2 Ω, *P* = 2(2×2 + 5) = 18 W

**Version 3**: *R* = 3 Ω, *P* = 2(2×3 + 5) = 22 W

**Version 4**: *R* = 4 Ω, *P* = 2(2×4 + 5) = 26 W

**Version 5**: *R* = 5 Ω, *P* = 2(2×5 + 5) = 30 W.



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7. Determine the maximum power that can be delivered to *RL*, assuming *R* = 0.5 Ω.

**Solution:** The primary voltage of the upper transformer is always 1 V. On open circuit, the source current is zero, the primary voltage is 5 – 1 = 4 V, and *VTh* = 8 V. On short circuit, the primary voltage of the lower transformer is zero, the source current is (5 – 1)/*R* and the short circuit current is 2/*R*. This gives, *RTh* = 4*R*. The maximum power delivered is (8)2/(4×4*R*) = 4/*R*.

**Version 1**: *R* = 0.5 Ω, *P* = 4/0.5 = 8 W

**Version 2**: *R* = 1 Ω, *P* = 4/1 = 4 W

**Version 3**: *R* = 2 Ω, *P* = 4/2 = 2 W

**Version 4**: *R* = 2.5 Ω, *P* = 4/0.8 = 1.6 W

**Version 5**: *R* = 4 Ω, *P* = 4/4 = 1 W.

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8. Given that the load *L* consumes 1200 W at 0.8 p.f. lagging and the magnitude of the voltage across *L* is 300 V rms. Determine the power dissipated in the resistance *R*line, if *R*line = 0.5 Ω.

**Solution:** The reactive power absorbed by the load is  VAR. The reactive power absorbed by the capacitor is  VAR. The total complex power is 1200 + *j*(900 – 3000) = 1200 – *j*2100 VA. The magnitude of the line current  A. The power dissipated in *R*line is 65*R*line.

**Version 1**: *R* = 0.5 Ω, *P* = 65×0.5 = 32.5 W

**Version 2**: *R* = 0.6 Ω, *P* = 65×0.6 = 39 W

**Version 3**: *R* = 0.7 Ω, *P* = 65×0.7 = 45.5 W

**Version 4**: *R* = 0.8 Ω, *P* = 65×0.8 = 52 W

**Version 5**: *R* = 0.9 Ω, *P* = 65×0.9 = 58.5 W.

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9. Two identical coils, each having an inductance of 10 mH, are connected in series. When the connections to one of the coils are reversed, the total inductance is multiplied by a factor *a*. Determine the coupling coefficient of the coils.

**Solution:** (10 + 10 + 2*M*) = *a*(10 + 10 – 2*M*); 2*M*(*a* + 1) = 20(*a* – 1); ; 

**Version 1**: *a* = 1.5, 0.2

**Version 2**: *a* = 1.6, 0.23

**Version 3**: *a* = 1.7, 0.26

**Version 4**: *a* = 1.8, 0.29

**Version 5**: *a* = 1.9, 0.31.

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10. Determine **Ix**, assuming *R* = 4 Ω.



**Solution:** The voltage across all windings is zero. Hence, **I1** = A, and **I2** = A. Setting the net mmf to zero, 400**I1** – 100**I2** + 200**I3** = 0, or **I3** = 0, which gives **I3** = ; **IX** = **I2** – **I3** = .



**Version 1:** *R* = 4 Ω; **Ix** = 6 A

**Version 2**: *R* = 5 Ω; **Ix** = 5 A

**Version 3**: *R* = 8 Ω; **Ix** = 3.5 A

**Version 4**: *R* = 10 Ω; **Ix** = 3 A

**Version 5**: *R* = 20 Ω; **Ix** = 2 A.

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11. Determine the frequency at which maximum power is dissipated in the 10 Ω resistor, assuming *L* = 1 H.

**Solution:**  Ω. Maximum power is dissipated in the 10 Ω resistor when *XL* = -*XC*, which gives *ωL* =  , or  rad/s.

**Version 1**: *L* = 1 H;  rad/s

**Version 2**: *L* = 2 H;  = 0.71rad/s

**Version 3**: *L* = 3 H;  = 0.58 rad/s

**Version 4**: *L* = 4 H;  rad/s

**Version 5**: *L* = 5 H;  = 0.45 rad/s

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12. For *n* = 1, 2, 3,…, the function shown has:



1. *an* and *bn* nonzero for all *n*
2. *an* and *bn* are zero for even *n*
3. *an* and *bn* are zero for odd *n*
4. *an* = 0 for all *n*
5. *bn* = 0 for all *n*

**Solution:** When the dc value is removed, the ac component has half-wave symmetry but is neither even nor odd. Hence, *an* and *bn* are zero for even *n.*

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13. Determine the total power dissipated if *vI* is a full-wave rectified waveform given by: *vI* = 6|sin(500*t*)| V.

**Solution:** ohms; ; ; ;  ; .

**Version 1**: *Vm* = 6 V,  W

**Version 2**: *Vm* = 7 V,  2.91 W

**Version 3**: *Vm* = 8 V,  3.81 W

**Version 4**: *Vm* = 9 V,  4.82 W

**Version 5**: *Vm* = 10 V,  5.95 W.



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14. A period of a periodic function *f*(*t*) is given by: *K*(4 + 2sin*t*), 0 < *t* < 2*π*. Determine the rms value of *f*(*t*), if *K* = 0.5.

**Solution:** The square of *f*(*t*) is 

. The area under the square is ; the mean square is  and the rms value is .

**Version 1**: *K* = 0.5, rms =  = 2.12

**Version 2**: *K* = 0.6, rms =  = 2.55

**Version 3**: *K* = 0.7, rms =  = 2.97

**Version 4**: *K* = 0.8, rms =  = 3.39

**Version 5**: *K* = 0.9, rms =  = 3.82.

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15. Determine the total power dissipated in *R* if *R* = 1 Ω.

**Solution:** With either of the 10cos100*t* V acting alone, *iR*1 = . The current due to both 10cos100*t* V sources, with the 10cos200*t* V source set to zero, is  and the power dissipated in *R* is . With the 10cos200*t* V source acting alone, *iR*3 = , and the power dissipated in *R* is . The total power dissipated in *R* is .

**Version 1**: *R* = 1 Ω; *P* =  W

**Version 2**: *R* = 1.5 Ω; *P* = 24 W

**Version 3**: *R* = 2 Ω; *P* = 22.22 W

**Version 4**: *R* = 2.5 Ω; *P* = 20.41 W

**Version 5**: *R* = 3 Ω; *P* =  18.75 W.

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1. Determine *VO*.

**Solution:** The 2*Vx* source is replaced by a 10 A source. The current in the 2 Ω resistor is *Ix*. The current in the dependent source is 5 – 2*Ix*, so that the current in the 1 Ω resistor is 15 – *Ix*. From KVL around the mesh abcd, 2*Ix* + 15 – *Ix* = 4*Ix*, which gives *Ix* = 5 A. It follows that *VO* = 15 – *Ix* = 10 V.



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1. Determine *iO*, given that *VSRC*1 is 15 V dc and *VSRC*2 = 10cos(3,000*t*) V.



**Solution:** With *VSRC*1 applied and *VSRC*2 set to zero, the circuit becomes as shown. 15 = 3*Vx*, so that *Vx* = 5 V and  A.



With *VSRC*2 applied and *VSRC*1 set to zero, the circuit becomes as shown. It follows that: -2*Vx* = *Vx* + , or , which gives *Vx* = 0. Hence, **IO2** A. Thus,



*iO* = -1 + 2cos(3,000*t*) A.

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1. Determine *k* so that the input resistance is purely resistive.



**Solution:** Disregarding the 10 Ω resistance and replacing the linear transformer by its T-equivalent circuit, the circuit becomes as shown. The input reactance is , or , which gives . Hence, 0.71.



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1. Determine *Z* so that maximum power is transferred to it and calculate this power given that the source voltage is 10 V peak value.

**Solution:** We will determine TEC as seen by *Z*. On open circuit, the currents are as shown. From KVL: 10∠0° – 5**I**/2 + 5**I**/2 = **VTh**. In This particular problem, the voltages across the 5 Ω resistors cancel out. Hence, **VTh** = 10∠0° V peak value



When Z is replaced by a short circuit, the currents are as shown. From KVL: 10∠0° – 5(**Isc** + **I**/2) – 5(**Isc** – **I**/2) = **0**. Again, the terms involving I cancel out. Hence, **Isc** = 1∠0° A, and *ZTh* = Ω. It follows that for maximum power transfer, *Z* = 10 Ω. The power dissipated in the load is  W.



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1. Derive the trigonometric Fourier expansion of the given periodic function *f*(*t*).



**Solution:** Since *f*(*t*) is odd, *a*0 = 0 = *an*; *T* = 2, *ω*0 = 2*π*/*T* = *π*; *f*(*t*) = *t* + 1;

= =   = =  *f*(*t*) =.