EECE 290 – Quiz 3

May 8, 2010

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1. Determine *F*(*s*) of the function *f*(*t*), assuming *A* = 2.

**Solution:** *f*(*t*) = *u*(*t*) + (*A* – 1)*u*(*t* – 2); *F*(*s*) = .

**Version 1:** *A* = 2, *F*(*s*) = 

**Version 2:** *A* = 3, *F*(*s*) = 

**Version 3:** *A* = 4, *F*(*s*) = 

**Version 4:** *A* = 5, *F*(*s*) = 

**Version 5:** *A* = 6, *F*(*s*) = .

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1. The circuit shown is the *s*-domain representation of a parallel *LC* circuit with initial energy storage in *L* and *C*, the current values being in As. Determine the initial values *IL*0 and *VC*0.



**Solution:** The impulse source is *CVC*0, where *C* = 0.5 F; hence, *VC*0 = 1/*C* = 2 V. The step current source is -*IL*0/*s*, so that *IL*0 = -1 A.

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1. Two identical circuits are cascaded, without the second circuit having any loading effect on the first circuit. If the Laplace transform of the impulse response of the cascade is , with *K* = 4 and *a* = 1, determine the impulse response of each circuit alone as a function of time.

**Solution:** If the impulse response of each circuit is *H*(*s*), then , which gives .

**Version 1:** *K* = 4, *a* = 1, , 

**Version 2:** *K* = 9, *a* = 2, , 

**Version 3:** *K* = 16, *a* = 3, , 

**Version 4:** *K* = 25, *a* = 4, , 

**Version 5:** *K* = 36, *a* = 5, , 

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1. If a signal *u*(*t*) is applied to the input of the first circuit in Problem 3, determine the output of the second circuit as function of time.

**Solution:** *Method* 1 *–* The impulse response of the cascade is L-1 . Since the step is the integral of the impulse function, the output of the second circuit as a function of time is: .

*Method* 2 – The Laplace transform of the output is . Taking the ILT gives the same result as before.

**Version 1:** *K* = 4, *a* = 1,

**Version 2:** *K* = 9, *a* = 2, 

**Version 3:** *K* = 16, *a* = 3, 

**Version 4:** *K* = 25, *a* = 4, 

**Version 5:** *K* = 36, *a* = 5, .

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1. If , determine the residues, in any order, of the partial fraction expansion of *F*(*s*).

**Solution:** . The residues are 1, 0, -1.

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1. In the circuit shown, *R* = 5 Ω, *C* = 1 F, and *iSRC* = A, where *B* = 1 A and *ω* = 1/*RC*, *RC* being the time constant of the circuit. Determine *v*(*t*).

**Solution:** ; ; ; V = V.

**Version 1:** *B* = 1, V

**Version 2:** *B* = 2, V

**Version 3:** *B* = 3, V

**Version 4:** *B* = 4, V

**Version 5:** *B* = 5, V.

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1. The transfer function of a circuit has two poles,one of which is at *s* = -5 - *j*108 rad/s. The circuit is:
2. Stable, second-order, and critically damped
3. Unstable, second-order, and underdamped
4. Stable, second-order, and underdamped
5. Stable, first-order, and overdamped
6. Stable, second-order, and overdamped.

**Solution:** The two poles of the transfer function are complex conjugates and in the left-half of the *s*-plane. The circuit is therefore, stable, second-order, and underdamped.

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1. The impulse response of a circuit is *Ku*(*t*), where *K* = 1. Determine the steady-state response to the sinusoidal input, 5cos2*t*.

**Solution:** The transfer function is . Replacing *s* by *jω*, . Hence, the steady-state sinusoidal response is .

**Version 1:** *K* = 1, response: 

**Version 2:** *K* = 2, response: 

**Version 3:** *K* = 3, response: 

**Version 4:** *K* = 4, response: 

**Version 5:** *K* = 5, response: .

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1. Determine *z*21 in the circuit shown, assuming *K* = 1 V/A, given that the *z*-parameter equations are:

*V*1 = *z*11*I*1 + *z*12*I*2; *V*2 = *z*21*I*1 + *z*22*I*2

**Solution:** With the output port open circuited, the output voltage *V*2 is 2*IX* + *KIX* = (*K* + 2)*IX*. Hence *z*21 = *V*2/*IX* = (*K* + 2) Ω.

**Version 1:** *K* = 1, *z*21 = (*K* + 2) = 3 Ω

**Version 2:** *K* = 2, *z*21 = (*K* + 2) = 4 Ω

**Version 3:** *K* = 3, *z*21 = (*K* + 2) = 5 Ω

**Version 4:** *K* = 4, *z*21 = (*K* + 2) = 6 Ω

**Version 5:** *K* = 5, *z*21 = (*K* + 2) = 7 Ω.

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1. Determine *K* in Problem 9 so that the circuit is symmetric.

**Solution:** For the circuit to be symmetric, *z*12 = *z*21. When the input port is open circuited, *V*1 = 2*I*2, so that *z*12 = *V*1/*I2* = 2 Ω. It follows that *K* = 0.

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1. *vSRC* is an unknown voltage. If *vO* = *Ke*-*t*, determine *iR*(*t*) and *iC*(*t*).

**Version 1:** *K* = 2

**Version 2:** *K* = 3

**Version 3:** *K* = 4

**Version 4:** *K* = 5

**Version 5:** *K* = 6

**Solution:** The circuit in the *s* domain is as shown. ; ; hence, .



; ; *u*(*t*) A. ; ; and  A.



1. The switch is opened at *t* = 0 after having been closed for a long time. Moreover *i*2(0-) = 1 A. Determine: (a) *I*2(*s*) and *i*2(*t*); (b) *V*1(*s*) and *v*1(*t*).

**Version 1:** *R* = 5 Ω

**Version 2:** *R* = 10 Ω

**Version 3:** *R* = 15 Ω



**Version 4:** *R* = 20 Ω

**Version 5:** *R* = 25 Ω

**Solution:** *i*1(0-) = 10/5 = 2 A. The circuit in the *s* domain at *t* = 0+ is as shown, where *I*1(*s*) = 0.

(a) From KVL around the RHS mesh, *I*2(*s*)(2*s* + *R* + 8*s*) = 2 – 8, or *I*2(*s*)(*R* + 10*s*) = -6, or ; A.

(b) ; V.

**Interpretation:** *i*1 can only be reduced instantaneously to zero by a voltage impulse in the primary. Because of magnetic coupling, the voltage impulse will appear in the secondary as well. In terms of impulses, we need only consider the inductances since the resistances will have finite voltages across them and can be neglected during the impulses. The circuit in the time domain will be as shown, where the impulse polarities are voltage drops in the direction of current. Each impulse is the product of the inductance and the final current minus the initial current. For *δ*1(*t*), *δ*1(*t*) = 4(0 – 2) = -8 Vs. The impulses in the secondary must be equal, from KVL. For the 2 H inductor, *δ*2(*t*) = 2[*i*2(0+) – 1], and for the 8 H inductor, *δ*2(*t*) = 8{[0 – *i*2(0+)] – [2 – 1]} = -8[*i*2(0+) + 1). Equating the two expressions for *δ*2(*t*) gives: 2*i*2(0+) – 2 = -8*i*2(0+) – 8, or 10*i*2(0+) = -6, or *i*2(0+) = -0.6, as above.



*δ*2(*t*) = 2[-0.6 – 1] = -3.2 Vs. Hence, the impulse in the primary is *δ*1(*t*) + *δ*2(*t*) = -8 – 3.2 = -11.2 Vs, as above. At *t* = 0+, , as above.