**Homework 14**

**P12.33** The switch In Figure P12.33, is moved to position ‘b’ at  after being in position ‘a’ for a long time. Determine (*t*) for *t* ≥ 0+.

**Solution:** The initial current through the inductor in Figure P12.33 is  10mA, and the initial voltage across the capacitor is 5 V. After the switch is moved to position ‘b’, the circuit becomes a parallel circuit having *C* = 1μF, *L* = 4 H, and *Rp* = 500 Ω. Hence,  krad/s, rad/s; V, where  krad/s,  krad/s and *t* is in ms.   mA, where if *vO* is in V, *t* is ms and *L* is in henries, *i* is in mA. At *t* = 0, *A + B* = -5 and  mA. This gives:  V and  V. It follows that  V.

**P12.36** The switch in Figure

P12.36 is moved

at *t* = 0 from position ‘a’ to position ‘b’ after being in position ‘a’ for a long time.

Determine *vO*(*t*) for *t* ≥ 0+.

**Solution:** From current division in Figure P12.36, the current through the dependent source is 5*iX* in the direction of a voltage drop across the source. It follows that the dependent source is equivalent to 2×104*iX*/5*iX* = 4 kΩ. the 20 kΩ in parallel with 80 kΩ is 16 kΩ, and in series with 4 kΩ, the resistance is 20 kΩ.  rad/s.  rad/s; *ωd* =  rad/s. Hence, . Since *iL* = 0 at *t* = 0, *A* = 0. *vO*(*t*) = *vL* = 40*diL*/*dt* = 40*Be*-100*t*(-100sin300*t* + 300cos300*t*). At *t* = 0, 40*B*×300 = 30, or *B* = 1/400. It follows that V, *t* is in s.

**P12.38** Switch S1 in Figure P12.38 is moved at *t* = 0 from position ′a′ to position ′b′ after



being in position ′a′ for a long time. Switch S2 is opened at *t* = 0.2 s. Determine *iL*(*t*), *t* ≥ 0+.

**Solution:** At *t* = 0- the capacitor in Figure P12.38 acts as an open circuit and the inductor as a short circuit, which makes *iX* = 0. It follows that *IL*0 = 2 A.

0≤ *t* ≤ 0.2 s: the inductor discharges through the upper 5 Ω resistor; *τ* = 0.5/5 = 0.1 s. The initial value is 2 A and the inductor discharges towards a final value of zero. It follows that A, *t* is in s. *iL*(*t*) at *t* = 0.2 s is 0.271 A.

*t* ≥ 0.2+ s, or *t*′ = 0, so that *t*′ = *t* – 0.2. The circuit reduces to a series *RLC* circuit having *L* = 0.5 H, *C* = 20 mF, *R* = 6 Ω, with initial current  in the inductor, and zero initial voltage across the capacitor. *α* = *R*/2*L* = 6/1 = 6 rad/s;  10 rad/s. It follows that the circuit is underdamped, with  rad/s. *vC*(*t*′) = . At *t*′ = 0, *vC*(*t*′) = 0, so that *A* = 0, and *vC*(*t*′) = . Differentiating, retaining only the cosine terms, and setting *t*′ = 0,  = *CBωd*, or *B* = /*ωdC*. Hence, , and  . Substituting numerical values and

in terms of *t*,  A, *t* ≥ 0.2+ s.

**P12.39** The current in a second-order circuit is governed by the differential equation: , *t* ≥ 0+, with *i*(0+) = 0 = . Determine *i*(*t*) for *t* ≥ 0+.

**Solution:** ; it is seen that *α* = 1 rad/s, , *ω*0 = 2 rad/s,  =  rad/s, and *IF* = 3 A. it follows that ; at *t* = 0, 0 = A + 3, so that *A* = -3. Differentiating and retaining the cosine terms only,

*di*/*dt* = . At *t* = 0, , which gives . It follows that  A.



**P12.42** The switch in Figure P12.42 is moved at *t* = 0 from position ‘a’ to position ‘b’ after being in position ‘a’ for a long time, with the capacitor uncharged. Determine *vL*(*t*) for *t* ≥ 0+.

**Solution:**  = 80 rad/s and  = 100 rad/s in Figure P12.42; hence,

*s*1 = -100 +  rad/s;

*s*2 = -100 –  rad/s;

 + 10; since *vC* = 0 at *t* = 0, *A* + *B*

= -10; *i* = *CdvC*/*dt* = 156.25×10-6 =

-625×10-5 = 0.1 at *t* = 0, so that *A* + 4*B* = -16; Solving for *A* and *B* gives *A* = -8 and *B* = -2. Hence,  + 10.

*i*(*t*) = 156.25×10-6 = 0.05.

*vL*(*t*) = , *t* is in s.

**P12.45** The switch in Figure P12.45 is closed at *t* = 0 after being open for a long time. Determine *iL*(*t*) and *iC*(*t*) for *t* ≥ 0+.

**Solution:** In Figure P12.45, *vC*(0+) = *vC*(0-) = 50 V and *iL*(0+) = *iL*(0-) = 0;  rad/s,  = 8 rad/s; hence,  rad/s. It follows that ; since *iL*(0+) = 0, *A* = -16. Retaining only cosine terms, *vC* = *LdiL*/*dt* = 0.5(-8*A*cos6*t* + 6*B*cos6*t*) = 50 at *t* = 0, which gives -8*A* + 6*B* = 100, or, *B* = -14/3. Hence,  16 A.



 V. It follows that 

 A, *t* is in s.

**P12.48** The switch in Figure P12.48

is moved at *t* = 0 from

position ‘a’ to position ‘b’

after being in position ‘a’ for

a long time. Determine *v*C(*t*)

and *iL*(*t*) for *t* ≥ 0+.

**Solution:** In Figure P12.48, *vC*(0+) = *vC*(0-) = 50 V; *iL*(0+) = *iL*(0-) = 0;

 5 rad/s,  rad/s; hence,  rad/s. It follows that ; at *t* = 0, *A* = 30; since *iL*(0+) = 0, retaining only cosine terms, 0 = *dvC*/*dt* = -3*A*cos4*t* + 4*B*cos4*t*, which gives *B* = (3/4)*A =* 22.5.

Hence,  V, *t* is in s.

*iL*(*t*) = *CdvC*/*dt* = 

A, *t* is in s.

**P12.54** The switch in Figure P12.54 is closed at *t* = 0 after being open for a long time. Determine *vC*(*t*) and *iL*(*t*) for *t* ≥ 0+.

**Solution:** In Figure P12.54, *iL*(0-) = *iL*(0+) = 0; *vC*(0-) = *vC*(0+) = 0.16×100 – 0.1×60 = 10 V; *ILF* = 0; *VCF* = -6 V.  = 50 krad/s. *α* = 60/(2×10-3) = 30 krad/s;

 = 40 krad/s. Hence, *vC*(*t*) = e-30*t*(*A*cos40*t* + *B*sin40*t*) – 6 V, *t* is in ms; *vC*(0+) = 10 = *A* – 6, so that *A* = 16; differentiating and equating to zero, retaining cosine terms only, -30*A*cos40*t* + 40*B*cos40*t* = 0, so that *B* = 3*A*/4 = 12. It follows that: *vC*(*t*) = 4e-30*t*(4cos40*t* + 3sin40t) – 6 V, *t* is in ms. *iL*(*t*) = *CdvC*/*dt* = 0.4×10-6×103×4e-30*t*(-120cos40*t* – 90sin40*t* – 160sin40*t* + 120 cos40*t*) ≡ A, *t* is in ms.

**P12.56** The switch in Figure P12.56 is moved at *t* = 0 from position ‘a’ to position ‘b’ after being in position ‘a’ for a long time. Determine *v*C(*t*) and *iL*(*t*) for *t* ≥ 0+.

**Solution:** At *t* = 0-, the inductor behaves as a short circuit and the capacitor as open circuit. *iL*(0-) = 6 A in Figure P12.56. The current in the upper 10 Ω resistor is 2 A, and the voltage across it is *vC*(0-) = 20 V. When the switch is moved, the source current is reduced to 3 A, so that *iL*(∞) = 3 A and *vC*(∞) = 10 V.

 When the current source is set to zero, circuit reduced to a series *RLC* circuit having *R* = 20/3 Ω. Hence, *α* = *R*/2*L* = 5 rad/s and  rad/s. The responses are overdamped, with  rad/s and  rad/s.

  V; *vC*(0-) = 20 = *A* + *B* + 10, which makes *A* + *B* = 10. At *t* = 0+, 3 = *iL*(0+) + *CdvC*/*dt*, so that (1/6) *dvC*/*dt* = 1, or, *A* + 9*B* = 18; this gives *A* = 9 and *B* = 1. It follows that:  V, *t* is in s.

  A, *t* is in s.