**Homework 13**



**P11.1.20** The switch In Figure P11.1.20

is moved at *t* = 0 to position

‘b’ after being in position ‘a’ for a long time. Determine *vC*(*t*) for *t* ≥ 0+ and the time at which *vC*(*t*) = 0.

**Solution:** After the switch has been in position ‘a’ for a long time, the capacitor voltage is  V. When the switch is moved to position ‘b’ at *t* = 0, *vC*(0+) = 45 V, *vC*(∞) = -50 V; *τ* = 5×6 = 30 ms. It follows that *vC*(*t*) = -50 + = -50 +  V, *t* is in ms. *vC* becomes zero at *t* = 19.3 ms.

**P11.1.22** The switch In Figure P11.1.22 is moved to position b at *t* = 0 after being in



position ‘a’ for a long time. Determine *vC*(*t*) for *t* ≥ 0+.

**Solution:** When the switch has been in position ‘a’ for a long time, the two current sources may be combined into a single 2 mA source directed downwards. From current division, the upward current in the capacitive branch is 2×40/70 = 8/7 mA, and *v*C(0-) = V. When the switch is moved to position ‘b’, the 4 mA source and 10 kΩ resistor are switched out of the circuit. The current in the capacitive branch as *t* → ∞ is 8/7 mA downward, and *v*C(∞) = V. With the 2 mA source set to zero, the effective resistance across *C* is 20||(10 + 40) = 

kΩ; *τ* = s. It follows that *v*C(*t*) =   V, *t* is in s.

**P11.1.23** The capacitor in Figure P11.1.23 is charged to 10 V at *t* = 0. Determine *vC*(*t*) for *t* ≥ 0.



**Solution:** *vC*(0) = 10 V. As *t* →∞, *iC* → 0, so the voltage of the dependent source is zero. The 15 Ω and 10 Ω resistors appear in parallel with *C*, which must be completely discharged; *vC*(∞) = 0. To determine *τ*, a test *vT* is applied. From KCL, , which gives kΩ. Hence, *τ* = 8×1.25 = 10 ms. It follows that  V, *t* is in ms.



###### P11.1.26 The switch in Figure P11.1.26, is moved to position ‘b’ after being in position ‘a’ for a long time. Determine (*t*) for *t* ≥ 0+.

**Solution:** After the switch has been in

position ‘a’ for a long time, the circuit will be as shown; *iφ* =12/5



= 2.4 A.

From KVL,

*vO*(0-) = 12 +2*iφ* = 16.8 V.

As *t* → ∞, the circuit will be as shown. From KCL at the upper node, *iφ* +  = 0; From KVL, 5*iφ* = *vO* – 2*iφ*, or *iφ* = *vO*/7. Substituting for *iφ* and solving

for *vO* gives *vO*(∞) = 1680/101 V.

To determine the effective resistance seen by *L*, *L* is replaced by a test source *vT*, with the independent source set to zero. The circuit becomes as

shown. *iφ* = 3*iT*/8. From KVL, *vT* = , which gives  Ω, so that s. Hence,



*vO*(*t*) =  V, *t* ≥ 0 s.



**P11.1.27** The switch in Figure P11.1.27, is closed at after being open for a long time. Determine (*t*) for *t* ≥ 0+.



**Solution:** When the switch has been open for a long time, the capacitor current is zero, so that *vA* = 4×3 = 12 V, and *vO*(0-) = 3*v*A + 24 = 60 V. As *t* → ∞, *v*A = 0 and *vO*(∞) = 24 V. To find the effective resistance across *C*, a test source *vT* is applied in place of *C*, as shown. It is seen that *vT* = 3*v*A, where *v*A = 2*iT*; hence,  = 6 kΩ, and the effective time constant is 6×20 = 120 ms. It follows that *vO*(*t*) =



24 + 36*e*-*t*/0.12 V, where *t* is in s.



**P11.2.5** The switch in Figure P11.2.5 is moved to position ‘b’ at *t* = 0 after having been in position ‘a’ for a long time. Determine *vO*(*t*) for *t* ≥ 0+.

**Solution:** When the switch is in position ‘a’, the current in the 24 H inductor is 2 A. When the switch is moved to position ‘b’, this current initially flows in the 40 Ω resistor, producing an initial value of *vO* that is -2×40 = -80 V. The final value of *vO* is zero. The effective inductance is H. The time constant is Ω. It follows that: V.

**P11.2.8** The switch In Figure P11.2.8 is initially in position ‘a’, with the capacitors uncharged. At *t* = 0, the switch is moved to position ‘b’. When  the switch is moved to position ‘c’. Determine (*t*) for the time when the switch (a) is in position ‘b’ and (b) after it was moved to position ‘c’.



**Solution:** When the switch is in position ‘b’, the circuit is as shown. *vC*(0) = 0. As , the voltage across the capacitors becomes ; *Ceqs* = 3/4 μF. The charge on *Ceqs* and each of the two capacitors is  μC. It follows that, *vC*(∞) =  V. With the voltage source set to zero, the resistance that is effectively in series with the two capacitors is (1||105) = 0.99 kΩ. *τ* =  ms. Hence,  V, where *t* is in ms. When *vC*(*t*) = 10 V, *t* = 0.83 ms. When the switch is moved to position c, the circuit becomes as shown. *vO*(0.83) = 10 V. *vO*(∞) = V. ms. Hence, for *t* ≥ 0.83 ms, *vC* = 0.94 +  V, *t* is in ms.



**P11.2.13** The switch in Figure P11.2.13 is moved at *t* = 0 from position ‘a’ to position ‘b’, after being in position ‘a’ for a long time. Determine, for *t* ≥ 0+: (a) *iO*(*t*); (b) *vO*(*t*).



**Solution:** *Leq* = 0.2 + 0.4 – 0.2 = 0.4 H. *iO*(0-) = 12 A. The circuit for *t* ≥ 0+ is as shown, where *iO*(0+) = 12 A; *vO*(0+) = 2*iO*(0+) – 4(*iO*(0+) + 8) = -56 V. In the steady state, *VOF* = 0, and 2*IOF* – 4(*iO*(0+) + 8) = 24 – 80 = -56 V.



As *t* → ∞, the inductor acts as a short circuit,

*VOF* = 0, so that 2*IOF* = 4(*IOF* + 8), which gives *IOF* = -16 A. The resistance seen by the inductor is obtained by applying a test source, with the independent source set to zero. *VT* + 2*IT* = 4*IT*, which gives *Reff* = 2 Ω, and *R*/*L* = 5 *s*-1. It follows that:

(a) , *t* is in s

(b) V, *t* is in s. As a check, *LdiO*/*dt* = 0.4×(28)(-5)== *vO*.