**Homework 13**



**P11.1.5** The switch in Figure P11.1.5 is moved to position ‘b’ at *t* = 0 after being in position ‘a’ for a long time. Determine, for *t* ≥ 0: (a) *vO*; (b) *iO.*

Ans. (a)  V, *t* is in s; (b)  A.

**Solution:** (a) Just before the switch is moved, *IL*0 = -8 A. Just after the switch is moved *iL* stays the same and *VL*0 = 24 + 2×8 = 40 V. *VLS* = 0, and the time constant is 0.2/2 = 0.1 s.



**P11.1.11** The switch in Figure P11.1.11 is moved to position ‘b’ at t = 0, after being in position ‘a’ for a long time. Determine *vC* for *t* ≥ 0.

**Solution:** Just before the switch is moved, *VC*0 = -30 V; *VCS* = -20 V. The time constant is 50×103×2×10-6 = 0.1 s. Hence, **** V, *t* is in s.

**P11.1.14** The switch in Figure P11.1.14 is moved to position ‘b’ at *t* = 0, after being in position ‘a’ for a long time. Determine, for *t* ≥ 0, (a) *vL*; (b) *iL*.



**Solution:** (a) Just before the switch is moved, *IL*0= 4 A. Just after the switch is moved, *iL* remains the same and the 1 A source current flows through the 5 Ω resistance, so *VL*0 = 5 V; *VLS* = 0, and the time constant is 2/5 = 0.4 s. Hence, *vL* = 0 + (5 – 0)=  V.

(b) *IL*0= 4 A and *ILS* = 5 A. Hence,  A.

**P11.1.16** In Figure P11.1.16,  is infinite for , while the capacitor is charging. When   becomes zero, instantly discharging the capacitor, and immediately becomes infinite again, so that the capacitor starts charging, and the cycle is repeated. Determine the frequency of oscillation.



**Solution:** Let *t* = 0 be the time when the capacitor is fully discharged and *R* becomes infinite. For *t* ≥ 0, the capacitor charges toward 6 V with *τ* = 10×0.1 = 1 ms. Hence, *v*c = 6(1 – *e*-*t*) V, where *t* is in ms and *v*c ≤ 3 V. When *v*c = 3 V, *e*-*t* = 0.5, or *t* = ln2 ms; hence, *f* = = 1.44 kHz.

**P11.1.19** The switch in Figure P11.1.19, is moved to position ‘b’ after being in position ‘a’ for a long time. Determine  for 



**Solution:** After the switch has been in position ‘a’ for a long time, the circuit will be as shown;  A. From KVL, *VO*0 = 12 +2*Iφ* = 16.8 V. Just after the switch is moved, *IL* and hence *VO* stays the same. Hence this value of *VO* is the initial value, as assumed.



After the switch has been in position ‘b’ for a long time, the circuit will be as shown. *Vφ* = 5*Iφ*, so that *IS* = , and *IL* = . Moreover, *Vφ* = 5*Iφ* = 10*IL* – 2*Iφ*. Solving for *Iφ* , *Iφ* = A, *IL* = A, and *VOS* =  V.



To determine the effective resistance seen by *L*, *L* is replaced by a test source *VT*, with the 24 V source set to zero. The circuit becomes as shown. , From KVL: *VT* = , which gives  Ω, so that s. It follows that *vO* =  V, *t* ≥ 0 s.

**P11.1.24** Both switches in Figure P11.1.24 have been open for a long time.  is closed at  and  at  Determine  for 



**Solution:** The initial value of *vC* is zero. When S1 is closed, the final value of *vC* is  V, and s. Hence, *vC* =  V, 0 ≤ *t* ≤ 1 s. At *t* = 1 s, *vC*(1) = -11.21 V.

When S2 is closed at *t* = 1s, the initial value of *vC* is *vC*(1). To find the final value, the voltage sources are transformed to current sources, as shown. The combined current source is mA, and the combined resistance is (12||6||24) = kΩ. Hence, *VCS* =  V.  s. This gives  V, *t* ≥ 1 s.



**P11.2.1** The switch in Figure P13.1.11 is moved to position ‘b’ at *t* = 0 after being in position ‘a’ for a long time. Determine *ix*, *t* ≥ 0.



**Solution:** After the switch has been in position ‘a’ for a long time, the currents through the capacitors are zero, so that the voltage across the capacitors is, from voltage division, 4 V. After the switch is moved to position ‘b’, the circuit becomes effectively as shown. *IC*0 =  mA; *ICS* = 0; *τ* = 0.3×(6||12) = 1.2 ms. Since , it follows that  mA, where *t* is in ms.



**P11.2.5** Both switches are opened

at *t* = 0 after being closed for a long time.

Determine *iO* for *t* ≥ 0.

**Solution:** Just before *t* = 0, the capacitor currents are zero, and the current through the 2 kΩ and 18 kΩ resistors is 25×8/20 = 10 mA. Just after t = 0, the capacitor voltages, and hence, *iO*, remain the same. The final value of iO is zero. The two capacitances inn series are 300×150/450 = 100 nF. The time constant is 2×103×100×10-9 = 2×10-4 s ≡ 0.2 ms. It follows that  mA, where *t* is in ms.