**Homework12**



**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) *vC*(*t*); (b) *vO*(*t*); (c) *iO*(*t*); (d) the total energy dissipated in the 60 kΩ resistor as *t*→∞.

**Solution:** (a) At *t* = 0-, *vC*(0-) = 100 V; the resistance seen by *C* when the switch is in position ‘b’ is 32 + 240||60 = 32 + 48 = 80 kΩ; *τC* =80×103×0.5×10-6 = 40×10-3 s; 1/*τC* = 1000/40 = 25/s. As *t*→∞, *vC*→ 0. Hence, V, *t* is in s.

(b) From voltage division, *vO* = 48*vC*/80; hence, V.

(c) *iO* = *vO*/60 mA, so that  mA.

The energy dissipated in the 60 kΩ resistor is W = = mJ = mJ.



**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) *vC*(*t*) (b) *iC*(*t*) from initial and final values as well as from the *v*-*i* relation for the capacitor.

**Solution:** (a) *vC*(0-) = 40×60/80 = 30 V; after the switch is moved to position ‘b’, *vC*(∞) =



-75×160/200 = -60 V; the resistance seen by *C* is: 8 + 160||40 = 8 + 32 = 40 kΩ; *τC* = 40×10-3×0.25×10-6 = 10×10-3; 1/*τC* = 100/s; *vC*(*t*) = -60 + (30 + 60) = -60 + 90 V, *t* is in s.

(b) The circuit at *t* = 0+ is a two-essential-node circuit. From KCL,

 = 0; this gives *Va* =

12 V, *iC*(0+) = (12 – 30)/8 = -2.25 mA. *iC*(∞) = 0, so that  mA. From the*v*-*i* relation for the capacitor mA.



###### P11.1.17 The capacitor in Figure P11.1.17, was initially uncharged and the switch was in position ‘a’. At the switch is moved to position ‘b’. Determine for *t* ≥ 0+: (a) *vC*(*t*); (b) *iC*(*t*); (c) the energy delivered by the 12 V battery as *t*→∞ (d) the energy absorbed by the 6 V battery as *t*→∞; (e) the energy dissipated in the resistor as *t*→∞; verify this by integrating the power dissipated by *iC* from *t* = 0+ to *t*→∞; (f) If after a long time, *t′* = 0, the switch is moved to position c, determine*vC*(*t*′) and*iC*(*t*′) for *t′*≥ 0+, the energy delivered by the 6 V battery, the energy gained or lost by the capacitor, and the energy dissipated in the resistor.

**Solution:** (a) *vC*(0-) = 0;. *vC*(∞) = 6 V. *τ* = 1×1 = 1 ms. Hence, *vC* =  V, *t*is in ms;

(b) *iC*(0+) = (12 – 6)/1 = 6 mA; *iC*(∞) = 0;  mA.

(c) Energy delivered by the 12 V battery is = = ≡ 72 μJ as *t*→∞.

(d) Energy absorbed by the 6V battery is =≡36μJ as *t*→∞.

(e) As *t*→∞, net energy delivered by the two batteries is 36 μJ. Energy stored in capacitor is (1/2)×10-6×36 = 18 μJ.Energy dissipated in the resistor = 36 – 18 = 18 μJ= 18 μJ.

(f) For *t*′≥ 0, initial value of *vC* is 6 V, final value is -6 V, *τ* being the same. Hence, V; initial value of *iC* is -12/1 mA, final value is zero;. As , energy delivered by the battery is = 72 μJ; net energy lost by the capacitor is 18 – 18 = 0, energy dissipated in the resistor is μJ.

**P11.1.18** Both switches in Figure P11.1.18 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.



**P11.1.19** Switch S1 in Figure P11.1.19 has been in position a for a long time, with switch S2 closed. At *t* = 0, S1 is moved to position b and remains in this position. S2 is opened at μs and closed again at *t* = 100 μs.



Determine *vC* for: (a) 0 ≤ *t ≤* 50 μs; (b) 50 ≤ *t ≤* 100 μs; (c) *t* ≥ 100 μs.

**Solution:** (a) With S1 in position ‘a’ and S2 closed, it follows from current division that the current in the 10 kΩ resistor is 10×30/42 = 50/7 mA; *vC*(0-) = 500/7 V.



: The circuit is as shown; *vC*(∞) = 0; *τ* = 20×(10||7) = μs. Hence, *vC*(*t*) = V,*t* is in μs. At *t* = 50 μs, *vC*(50) = 38.9 V.

(b) : The circuit becomes as shown. Initial value of *vC* is 38.9 V, and the final value is zero,*τ* = 20×7 = 140 μs. Hence, *vC*(*t*) = V,*t* is in μs. At *t* = 100 μs, *vC*(100) = 27.2 V.



(c) : The circuit becomes as in (a). The initial value of *vC* is *vx*(100), the final value is zero, and *τ* = μs. Hence,

*VC*(*t*) = V, *t* is in μs.