Electronic Circuits **Homework 3**

1. A sine wave goes through 5 cycles in 10 µs. What is its period? 2 µs (8-3)
2. A sine wave has a peak value of 12 V. Determine the following voltage values: (8-6)
   (a) rms 8.484 (b) peak-to-peak 24 (c) half-cycle average 7.644
3. A sinusoidal voltage is applied to the resistive circuit in Figure 1. Determine the following: (8-21)
   (a) Irms (b) Iavg (c) Ip (d) Ipp (e) i at the positive peak

   (a) $\frac{10}{1000} \times 0.707 = 0.00707\ (\text{A}) = 7.07\ (\text{mA})$

   (b) $\frac{10}{1000} \times 0.637 = 0.00637\ (\text{A}) = 6.37\ (\text{mA})$

   (c) $\frac{10}{1000} = 0.01\ (\text{A}) = 10\ (\text{mA})$

   (d) $\frac{10}{1000} \times 2 = 0.02\ (\text{A}) = 20\ (\text{mA})$

   (e) $= \text{Ip} = 10\ (\text{mA})$

Figure 1

4. Find the half-cycle average value of the voltages across **R**1 and **R**2 in Figure 2. (8-22)
   All values shown are rms.

   R1: $\frac{120-65}{0.707} \times 0.637 \approx 49.554(\text{V})$

   R2: $\frac{65-30}{0.707} \times 0.637 \approx 31.535(\text{V})$

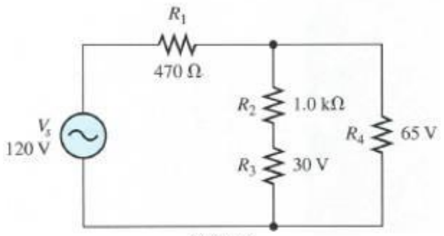


Figure 2

5. (a) Find the capacitance when Q = 50 µC and V = 10 V. 5 µF (9-1)
   (b) Find the charge when C = 0.001 µF and V = 1 kV. 1µC
   (c) Find the voltage when Q = 2 mC and C = 200 µF. 10 V
6. What size capacitor is capable of storing 10 mJ of energy with 100V across its plates? (9-5)

   $\frac{10}{1000} = \frac{1}{2} \times \text{C} \times 100^2 \rightarrow \text{C} = 0.000002\ (\text{F}) = 2\ (\mu\text{F})$
7. Find the total capacitance for each circuit in Figure 3. (9-19)

   (a) $\frac{1}{\frac{1}{1}+\frac{1}{2.2}} = 0.6875\ (\mu\text{F})$

   (b) $\frac{1}{\frac{1}{100}+\frac{1}{560}+\frac{1}{390}} \approx 69.687\ (\text{pF})$

   (c) $\frac{1}{\frac{1}{10}+\frac{1}{4.7}+\frac{1}{47}+\frac{1}{22}} \approx 2.635\ (\mu\text{F})$

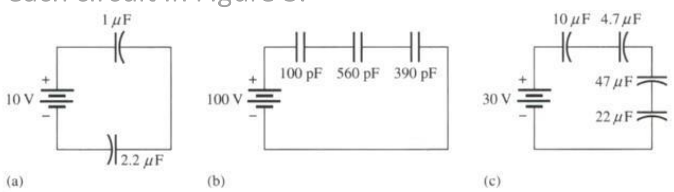


Figure 3

8. The total charge stored by the series capacitors in Figure 4 is 10 µC. (9-21)
   Determine the voltage across each of the capacitors.

   $C_1 = \frac{\frac{10}{4}}{4.7} \approx 0.532\ (\text{V}), C_2 = \frac{\frac{10}{4}}{1} = 2.5\ (\text{V})$

   $C_3 = \frac{\frac{10}{4}}{2.2} \approx 1.136\ (\text{V}), C_4 = \frac{\frac{10}{4}}{10} = 0.25\ (\text{V})$

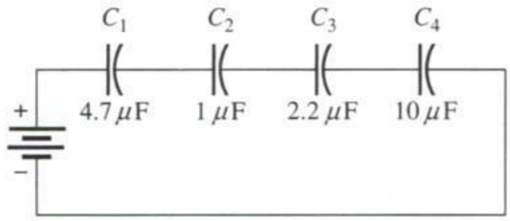


Figure 4

9. Determine C_T for each circuit in Figure 5. (9-22)
   (a) 47+10+0.001x1000000=1057 (pF)
   (b) 0.1+0.01+0.001+10000x0.000001=0.121 (µF)
10. Determine the time constant for each of the following series **RC** combinations: (9-25)
    (a) R = 100Ω , C = 1µF 0.0001 (s)
    (b) R = 10MΩ , C = 56pF 0.00056 (s)
    (c) R = 4.7kΩ , C = 0.0047µF 0.00002209 (s)
    (d) R = 1.5MΩ , C = 0.01µF 0.015 (s)

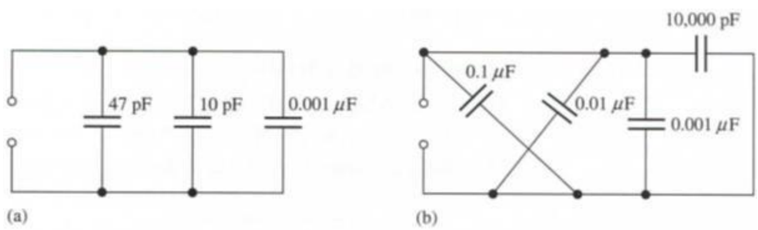


Figure 5

11. In the circuit of Figure 6, the capacitor initially is uncharged. Determine the capacitor voltage at the following times after the switch is closed: (a) 10 µs (b) 20 µs (c) 30 µs (d) 40 µs (e) 50 µs (9-27)
    Time constant: 0.00001 (s) = 10 (µs)
    (a) 15x63%=9.45(V) (b) 15x86%=12.9(V) (c) 15x95%=14.25(V)
    (d) 15x98%=14.7(V) (e) 15x99%=14.85(V)

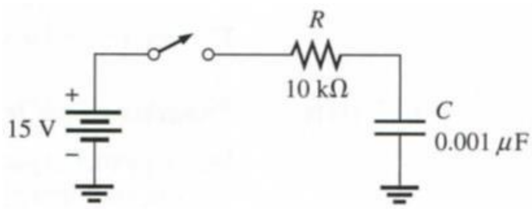


Figure 6

12. Determine X_C for a 0.047 μF capacitor at each of the following frequencies:
(a) 10 Hz (b) 250 Hz (c) 5 kHz (d) 100 kHz (9-31)

(a) $\frac{1}{2\pi\times10\times0.000000047}\approx 338628\ (\Omega)=338.628\ (\mathrm{k}\Omega)$

(b) $\frac{1}{2\pi\times250\times0.000000047}\approx 13545\ (\Omega)=13.545\ (\mathrm{k}\Omega)$

(c) $\frac{1}{2\pi\times5000\times0.000000047}\approx 677.255\ (\Omega)$

(d) $\frac{1}{2\pi\times100000\times0.000000047}\approx 33.863\ (\Omega)$

13. What is the value of total capacitive reactance in each circuit in Figure 7? (9-32)

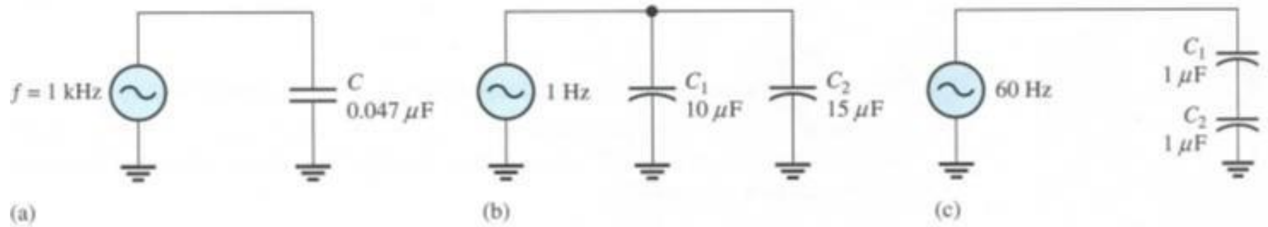


Figure 7

(a) $\frac{1}{2\pi\times1000\times0.000000047}\approx 3386\ (\Omega)=3.386\ (\mathrm{k}\Omega)$

(b) $\frac{1}{2\pi\times1\times(0.00001+0.000015)}\approx 6366\ (\Omega)=6.366\ (\mathrm{k}\Omega)$

(c) $\frac{1}{2\pi\times60\times\frac{1}{\frac{1}{0.000001}+\frac{1}{0.000001}}}\approx 5305\ (\Omega)=5.305\ (\mathrm{k}\Omega)$

14. In each circuit of Figure 7, what frequency is required to produce an $X_{C(tot)}$ of 100 Ω? (9-34)
An $X_{C(tot)}$ of 1 kΩ?

(a) $\frac{1}{2\pi\times f\times0.000000047}=100\ (\Omega)\rightarrow f=\frac{1}{2\pi\times0.000000047\times100}\approx 33862\ (\mathrm{Hz})=33.862\ (\mathrm{kHz})$

$\frac{1}{2\pi\times f\times0.000000047}=1000\ (\Omega)\rightarrow f\approx\frac{33862}{10}\ (\mathrm{Hz})\approx 3.386\ (\mathrm{kHz})$

(b) $\frac{1}{2\pi\times f\times(0.00001+0.000015)}=100\ (\Omega)\rightarrow f=\frac{1}{2\pi\times(0.00001+0.000015)\times100}\approx 63.66\ (\mathrm{Hz})$

For 1 kΩ, $f\approx\frac{63.66}{10}=6.366\ (\mathrm{Hz})$

(c) $\frac{1}{2\pi\times f\times\frac{1}{2\times\frac{1}{0.000001}}}=100\ (\Omega)\rightarrow f=\frac{1}{2\pi\times\frac{1}{2\times\frac{1}{0.000001}}\times100}\approx 3183\ (\mathrm{Hz})=3.183\ (\mathrm{kHz})$

For 1 kΩ, $f\approx\frac{3183}{10}=318.3\ (\mathrm{Hz})$

15. Determine the impedance and the phase angle in each circuit in Figure 8. (10-4)

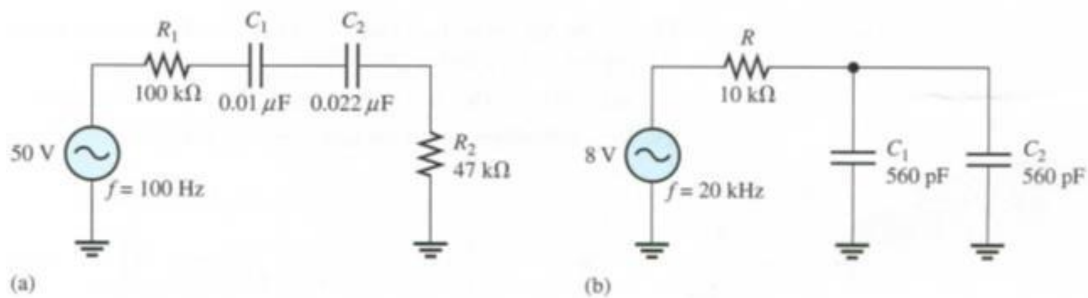


Figure 8

(a) $X_{C(tot)}=\frac{1}{2\pi\times100\times\frac{1}{\frac{1}{0.00000001}+\frac{1}{0.000000022}}}\approx 231498\ (\Omega)=231.498\ (\mathrm{k}\Omega)$

value: $\sqrt{(100+47)^2+\left(X_{C(tot)}\right)^2}\approx 274.227\ (\mathrm{k}\Omega)$

angle: $\tan^{-1}\frac{X_{C(tot)}}{100+47}\approx 1.0050\ (\mathrm{rad})$

(b) $X_{C(tot)}=\frac{1}{2\pi\times20000\times(2\times0.00000000056)}\approx 7105\ (\Omega)=7.105\ (\mathrm{k}\Omega)$

value: $\sqrt{10^2+\left(X_{C(tot)}\right)^2}\approx 12.267\ (\mathrm{k}\Omega)$

angle: $\tan^{-1}\frac{X_{C(tot)}}{10}\approx 0.6177\ (\mathrm{rad})$

16. For the circuit of Figure 9, determine the impedance for each of the following frequencies: (10-5)
(a) 100 Hz (b) 500 Hz (c) 1.0 kHz (d) 2.5 kHz

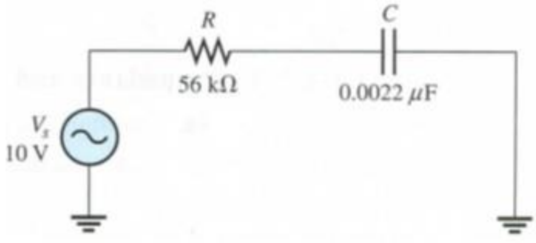


Figure 9

(a) value: $\sqrt{56000^2+\left(\frac{1}{2\pi\times100\times0.0000000022}\right)^2} \approx 725595\ (\Omega) = 725.595\ (\text{k}\Omega)$

angle: $\tan^{-1}\frac{\left(\frac{1}{2\pi\times100\times0.0000000022}\right)}{56000} \approx 1.4935\ (\text{rad})$

(b) value: $\sqrt{56000^2+\left(\frac{1}{2\pi\times500\times0.0000000022}\right)^2} \approx 155145\ (\Omega) = 155.145\ (\text{k}\Omega)$

angle: $\tan^{-1}\frac{\left(\frac{1}{2\pi\times500\times0.0000000022}\right)}{56000} \approx 1.2015\ (\text{rad})$

(c) value: $\sqrt{56000^2+\left(\frac{1}{2\pi\times1000\times0.0000000022}\right)^2} \approx 91485\ (\Omega) = 91.485\ (\text{k}\Omega)$

angle: $\tan^{-1}\frac{\left(\frac{1}{2\pi\times1000\times0.0000000022}\right)}{56000} \approx 0.9121\ (\text{rad})$

(d) value: $\sqrt{56000^2+\left(\frac{1}{2\pi\times2500\times0.0000000022}\right)^2} \approx 63035\ (\Omega) = 63.035\ (\text{k}\Omega)$

angle: $\tan^{-1}\frac{\left(\frac{1}{2\pi\times2500\times0.0000000022}\right)}{56000} \approx 0.4769\ (\text{rad})$

17. Determine the impedance and the phase angle in Figure 10. (10-15)

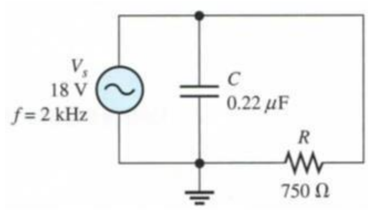


Figure 10

value: $\frac{1}{\sqrt{\left(\frac{1}{750}\right)^2+(2\pi\times2000\times0.00000022)^2}} \approx 325.804\ (\Omega)$

angle: $\tan^{-1}(2\pi\times2000\times0.00000022\times750) \approx 1.1214\ (\text{rad})$

18. For the parallel circuit in Figure 11, find each branch current and the total current. What is the phase angle between the source voltage and the total current? (10-19)

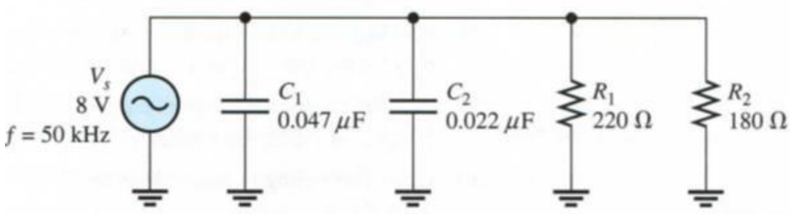


Figure 11

First solve the admittance diagram:

$G = \frac{1}{220+180} = 0.0025\ (\text{S})$

$B_c = 2\pi\times50000\times(0.000000047+0.000000022) \approx 0.0217\ (\text{S})$

$Y = \sqrt{(0.0025)^2+(0.0217)^2} \approx 0.0218\ (\text{S})$

$\angle: \tan^{-1}\left(B_c\times(220+180)\right) \approx 1.4560\ (\text{rad})$

Then multiply by 8 V to get the current phasor diagram:

$I_R = 0.02\ (\text{A}), I_C \approx 0.1736\ (\text{A})$

$I_S \approx 0.1744\ (\text{A}), \angle: \approx 1.4560\ (\text{rad})$

Note that current divide among capacitors in parallel are directly proportional to their capacitances.
We apply this rule and the current divider rule with I_C and I_R to capacitors and resistors, respectively, obtaining all branch current: $I_{C1} \approx 0.1182\ (\text{A}), I_{C2} \approx 0.0554\ (\text{A}), I_{R1} = 0.009\ (\text{A}), I_{R2} = 0.011\ (\text{A})$
Also remember that all “I-s” above stands for phasor lengths and I_S represents the phasor of total current.

Since that in a parallel RC circuit, the current through resistor(s) and the source voltage are in phase.
phase angle between source voltage and total current
→ phase angle between source voltage and total current
→ phase angle between I_S and $I_R \approx 1.4560\ (\text{rad})$

19. Determine the voltages across each element in Figure 12. Find the phase angle of the circuit. (10-23)

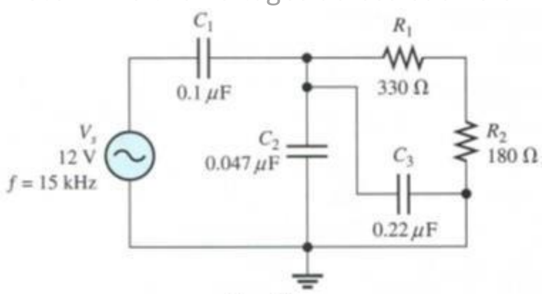


Figure 12

$Z_{R1,R2,C2,C3} = \frac{1}{\sqrt{\left(\frac{1}{330+180}\right)^2+(2\pi\times 15000\times(0.000000047+0.00000022))^2}} \approx 39.619\ (\Omega)$

$\angle_{R1,R2,C2,C3}: \tan^{-1}\big(2\pi \times 15000 \times (0.000000047 + 0.00000022) \times (330 + 180)\big) \approx 1.4930\ (\mathrm{rad})$

Convert to equivalent series RC circuit:

$R_{eq} \approx 39.619\, cos\, 1.4930 \approx 3.0791\ (\Omega)$

$X_{C(eq)} \approx 39.619\, sin\, 1.4930 \approx 39.4992\ (\Omega)$

$X_{C1} = \frac{1}{2\pi\times 15000\times 0.0000001} \approx 106.1033\ (\Omega)$

Apply voltage divider rule to C_1, R_{eq}, and C_{eq} to obtain $V_{C1} \approx 8.56 \times sin\, 30000\pi t$

So $V_{C2} = V_{C3} \approx 3.44 \times sin\, 30000\pi t$, $V_{R1} \approx 2.23 \times sin\, 30000\pi t$, $V_{R2} \approx 1.21 \times sin\, 30000\pi t$

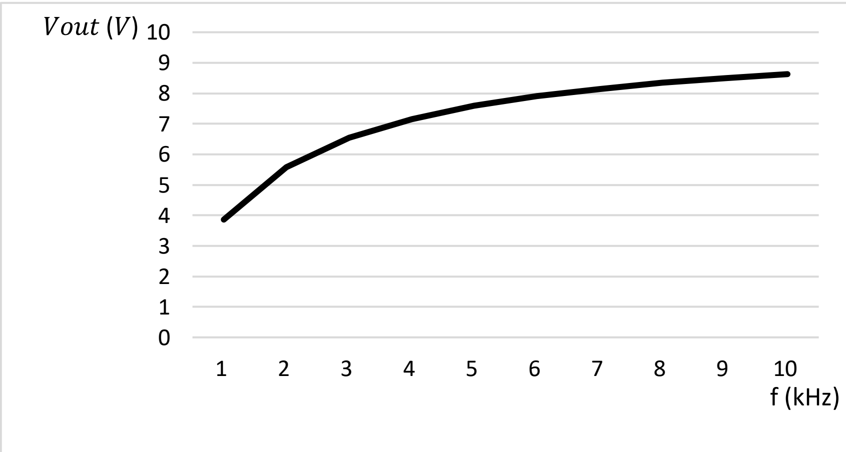
Also we find the phase angle with the equivalent series RC circuit:

$R_{tot} = R_{eq} \approx 3.0791\ (\Omega)$

$X_{C(tot)} = X_{C(eq)} + X_{C1} \approx 145.6025\ (\Omega)$

$\angle_{tot}: tan^{-1}\left(\frac{X_{C(tot)}}{R_{tot}}\right) \approx 1.5497\ (rad)$

20. Plot the frequency response curve for the circuit in Figure 13 for a frequency range of 0 Hz to 10 kHz in 1 kHz increments. (10-32)



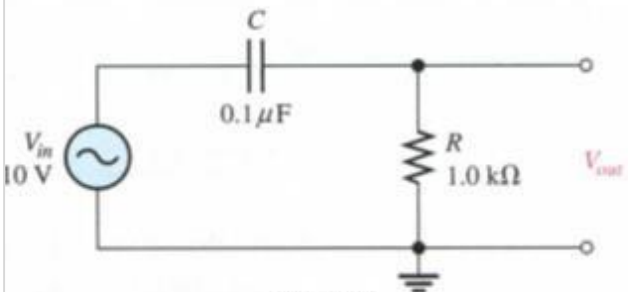


Figure 13