Banha University — Second Term 2012/2013
Faculty of Computers and Informatics — First Year General

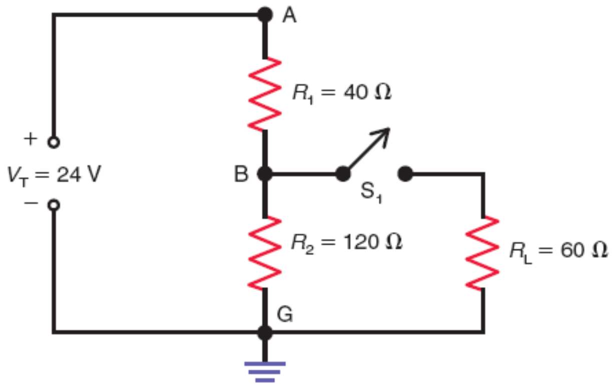
Solution of Questions For The Term Examination

Subject: Electronics (Regular) — Allowed Time: 3 Hours

Answer all questions. No. of questions: 5 No. of pages: 3

Solution to Question 1

a)Calculate I_1, I_2, I_L, V_{BG}, V_{AG} when (i) S_1 is open, (ii) S_2 is closed.



Answer

(i) When S_1 open,

$I_L = 0$

R_1 and R_2 are in series, $R_T = R_1 + R_2 = 40 + 120 = 160\ \Omega$

$I_1 = I_2 = 24/160 = 0.15$ A

$V_{BG} = I_2R_2 = 0.15*120 = 18$ V

$V_{AG} = V_T = 24$ V

(ii) When S_2 is closed,

$R_{L2} = R_L//R_2 = (60)(120)/(60+120) = 40\ \Omega$

$R_T = R_1 + R_{L2} = 40 + 40 = 80\ \Omega$

$I_T = I_1 = 24/80 = 0.3$ A

By current divider rule,

$I_2 = (0.3)*(60)/(60+120) = 0.1$ A

$I_L = (0.3)*(120)/(60+120) = 0.2$ A

$V_{BG} = I_2R_2 = 0.1*120 = 12$ V

$V_{AG} = V_T = 24$ V

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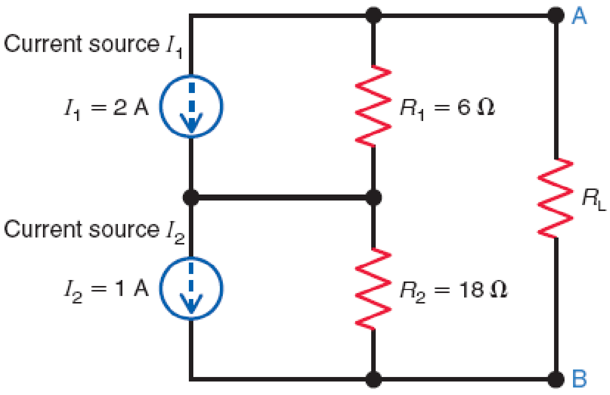
b) Find the value of R_L for maximum power transfer in circuit shown. What is this maximum power?



Answer

Using the conversion from Norton equivalent circuit to thevenin equivalent circuit,

For current source I_1 and resistance R_1 cnovert to,

$V_{th1} = I_1R_1 = 2*6 = 12$ V $\quad$ $R_{th1} = R_1 = 6\ \Omega$

$V_{th2} = I_2R_2 = 1*18 = 18$ V $\quad$ $R_{th2} = R_2 = 18\ \Omega$

The total equivalent circuit consists of a battery of voltage,

$$V = V_{th1} + V_{th2} = 12 + 18 = 30 \text{ V}$$

in series with a resistance $R = R_{th1} + R_{th2} = 6 + 18 = 24$ V

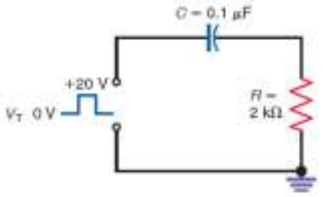
in series with R_L.

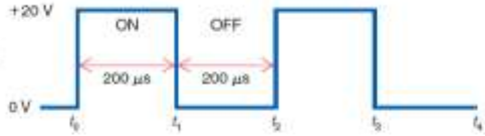
For maximum power transfer, $R_L = R = 24$ V

The maximum power $P_{max} = V^2/4R = (30)^2/(4)(24) = 9.375$ W

Solution to Question 2

a) Find the capacitor voltage $V_C(t)$ and the resistor voltage $V_R(t)$ for the circuit shown in figure. Plot these quantities.





Answer

The time constant $\tau = RC = (2k)*(0.1\mu) = 0.2$ ms $= 200$ μs

For $0 \le t \le 200$ μs, the capacitor is charging.

$V_C(0) = 0$

$V_C(200\mu s) = 20(1 - e^{-200/200}) = 12.64$ V

$V_R(0) = 20$ V

$V_R(200\mu s) = 20\ e^{-200/200} = 7.36$ V

For 200 μs $\le t \le$ 400 μs, the capacitor is discharging.

$V_C(200\mu s) = 12.6$ V

$V_C(400\mu s) = 12.6\ e^{-200/200} = 4.64$ V

$V_R(200\mu s) = -\ 12.6$ V

$V_R(400\mu s) = -\ 12.6\ e^{-200/200} = -\ 4.64$ V

For 400 μs $\le t \le$ 600 μs, the capacitor is charging.

$V_C(400\mu s) = 4.64$ V
$V_C(600\mu s) = 4.64 + (20 - 4.64)(1 - e^{-200/200}) = 14.35$ V

$V_R(400\mu s) = 20 - 4.64 = 15.36$

$V_R(600\mu s) = 15.36\ e^{-200/200} = 5.65$ V

For 600 μs $\le t \le$ 800 μs, the capacitor is discharging.

$V_C(600\mu s) = 14.35$ V

$V_C(800\mu s) = 14.35e^{-200/200} = 5.28$ V

$V_R(600\mu s)$ = - 14.35 V

$V_R(800\mu s0$ = - $14.35e^{-200/200}$ = -5.28 V

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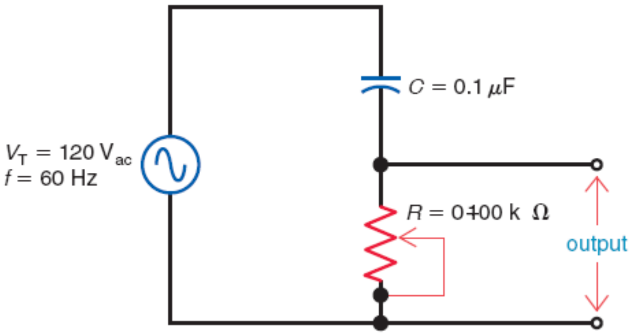
b) For the phase shifter shown, what is the phase shift between V_T and V_R and between V_T and V_C. Draw the voltage phasor diagram with V_T as reference voltage.



__**Answer**__

$X_C = 1/2\pi fC = 1/2\pi(60)(0.1x10^{-6}) = 26.53\ k\Omega$

The phase angle between V_T and V_R is φ,

tan φ = X_C/R = - 26.53k/400k = 0.06633

$\varphi = 3.8^o$

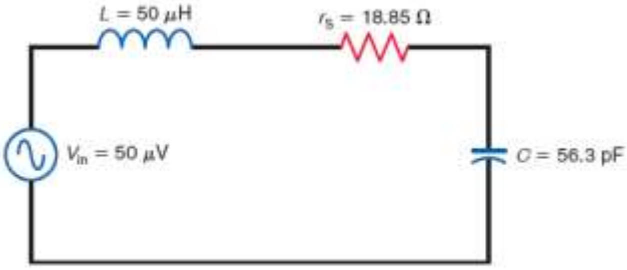
The phase angle between V_T and V_c is θ,

tan θ = - R/X_C = - 400k/26.53k = - 15.08

$\theta = -86.21^o$

__**Solution toQuestion 3**__

a) For the RLC circuit at resonance, find f_r, Z, I, V_C and V_L at f_r, V_R, quality factor and bandwidth.



__**Answer**__

The RLC circuit at resonance,

$$f_r = 1/2\pi\sqrt{LC} = 1/2\pi\sqrt{(50x10^{-6})(56.3x10^{-12})}$$
$$= 3x10^{6}\ Hz = 3\ MHz$$
$$Z = R = 18.85\ \Omega$$

$$I = V/Z = V/R = 50\mu/18.85 = 2.65\ \mu A$$

$$V_C = IX_C = I/2\pi f_r C = 2.65x10^{-6}/2\pi(3x10^{6})(56.3x10^{-12})$$
$$= 2.5x10^{-3}\ V = 2.5\ mV$$

$$V_L = IX_L = I*(2\pi f_r L) = (2.65x10^{-6})*(2\pi*3x10^{6}*50x10^{-6})$$
$$= 2.5x10^{-3}\ V = 2.5\ mV$$

$$V_R = V_{in} = 50\ \mu V$$

$$Q = X_L/R = 2\pi f_r L/R = 2\pi(3x10^{6})*(50x10^{-6})/18.85$$
$$= 50$$

$$Bandwidth = f_r/Q = 3x10^{6}/50 = 60x10^{3}\ Hz = 60\ kHz$$

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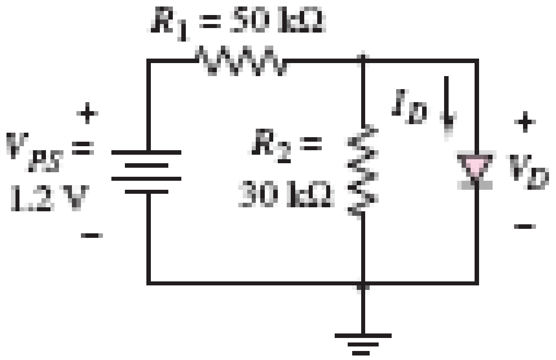
b) The diode in the circuit shown in Figure has a reverse-saturation current. Determine the diode voltage and current if (i) the diode is ideal (ii) real diode with internal resistance of 500 Ω.



Answer

By Thevenin theorm,

$$R_{th} = R_1//R_2 = 50*30/(50+30) = 18.75\ k\Omega$$

$$V_{th} = 12*30/(50+30) = 4.5\ V$$

(i) The diode is ideal. It is represented as closed switch.

$$V_D = 0$$

$I_D = 4.5/18.75 = 0.24$ A

(ii) Real diode with internal resistance of 500 Ω,

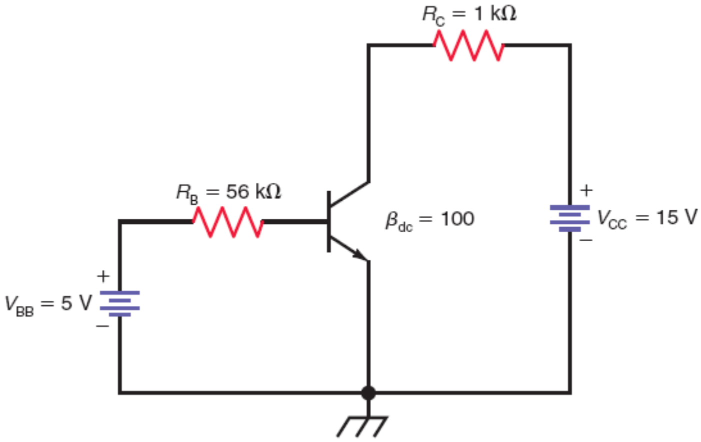
Applying KVL: $- 4.5 + 18.75k\ I_D + 0.7 + 500\ I_D = 0$

$I_D = (4.5 – 0.7)/(18.75k+500) = 0.197$ mA

$V_D = 0.7 + (500)(0.197m) = 0.7985$ V

Solution to Question 4

a) Find I_B, I_C, I_E and V_{CE} in the transistor circuit shown in figure. $V_{BEon} = 0.7$ V



Answer

Applying KVL to the base circuit:

$- 5 + 56k\ I_B + 0.7 = 0$

$I_B = (5 – 0.7)/56k = 0.0768$ mA

$I_C = \beta\ I_B = 100*0.0768m = 7.68$ mA

$I_E = I_C + I_B = 7.68m + 0.0768m = 7.7568$ mA

Applying KVL to the collector circuit:

$- 15 + 1k\ I_C + V_{CE} = 0$

$V_{CE} = 15 - (1k)(7.68m) = 7.32$ V

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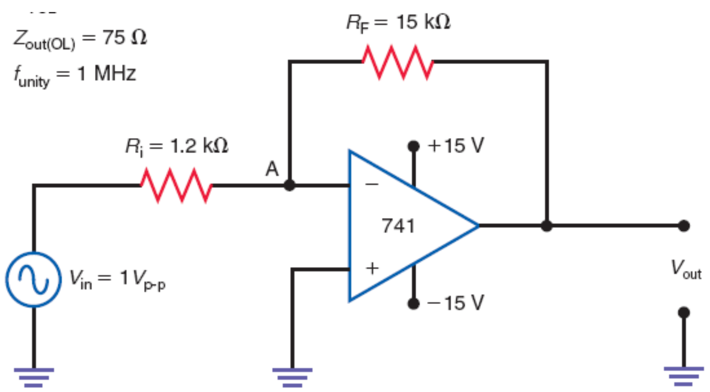
b) Find the output voltage V_{out} for each of the following operational amplifier circuits.

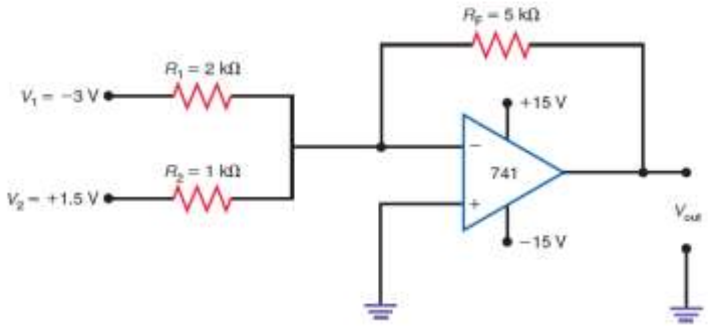


The circuit is inverting operational amplifier.

The gain,

$$A = R_F/R_i = 15k/1.2k = 12.5$$

$$V_{out} = A\ V_{in} = (12.5)*(1V_{p\text{-}p}) = 12.5\ V_{p\text{-}p}$$



The circuit is a summing operational amplifier,

$$v_{out} = R_F/R_1\ V_1 + R_F/R_2\ V_2$$

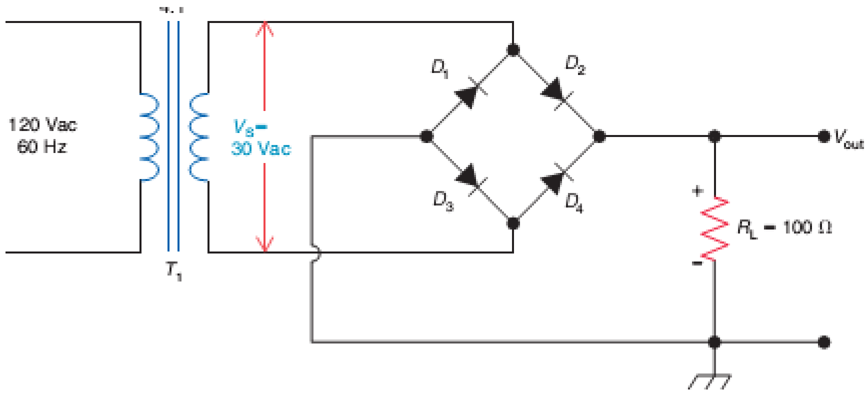
$$= (5/2)(-3) + (5/1)(1.5)$$

$$= -\ 4.167\ V$$

<u>Solution to Question 5</u>

a) Draw the half-wave rectifier circuit V_S, V_{outp}, V_{dc}, I_L, I_{diode}, PIV to rectify AC voltage of 220 V, 50 Hz. The transformer ratio is 8:1 and $R_L = 100\ \Omega$. Use second approximation for diode. If a 1000 μF capacitor is added to the output, calculate V_{ripple}, V_{dc}, I_L, PIV.

<u>Answer</u>



$V_s = V_p (N_s/N_p) = 220 (1/8) = 27.5$ V

$V_{speak} = 27.5*\sqrt{2} = 38.885$ V

$V_{outpeak} = 38.885 - 1.4 = 37.485$ V

$V_{dc} = 37.485*0.636 = 23.84$ V

$I_L = V_{dc}/R_L = 23.84/100 = 0.2384$ A = 238.4 mA
$I_{diode} = I_L/2 = 238.4/2 = 119.2$ mA

PIV = 38.885 – 0.7 = 38.185 V

Time constant = $R_L C = (100)*(1000\mu) = 0.1$ s

Discharge time = 1/50 = 0.02 s

$V_{ripple} = V_{outpeak}(1 - e^{-t/RLC})$

$= 37.485 (1 - e^{-0.02/0.1}) = 0.2526 V_{p-p}$

$V_{dc} = V_{outpeak} - V_{ripple}/2 = 37.485 - 0.1263 = 37.3587$ V

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b) Choose the correct answer, <u>**Justify**</u> your choice.

1. A 2.2kΩ R_1 is in parallel with a 3.3kΩ R_2. If these two resistors carry a total current of 7.5 mA, how much is the applied voltage?
(a) 16.5 V (b) 24.75 V <u>**(c) 9.9 V**</u> (d) 41.25 V.
<u>**Answer**</u>

R = 2.2*3.3/(2.2+3.3) = 1.32 kΩ
V = IR = (7.5m)*(1.32k) = 9.9 V

2. A sine wave whose rms voltage is 25.2 V has a peak value of ....
(a) 17.8 V (b) 16 V (c) 50.4 V <u>**(d) 35.6 V**</u>
<u>**Answer**</u>

$V_{peak} = 25.2\sqrt{2} = 36.6$ V

3. An RC low-pass filter uses a 2.2 kΩ resistor and a 0.01 μF capacitor. What is its cutoff frequency?
(a) 3.5 MHz. (b) 72.3 Hz. **(c) 7.23 kHz.** (d) 1.59 kHz.
Answer

$$f_{cutoff} = 1/2\pi RC = 1/2\pi(2.2k)(0.01\mu) = 7.23x10^3 Hz = 7.23 \text{ kHz}$$

4. In a p-type semiconductor, the majority current carriers are ....
(a) free electrons. (b) valence electrons. (c) protons. **(d) holes.**
Answer

The p-type semiconductor is doped with trivalent impurity atoms as Boron. The valence electrons of Boron are bonded to silicon atoms leaving one missing bond that serves as a hole. So the number of holes are increased without increasing the number of electrons.

5. What is the dc output voltage of an unfiltered half-wave rectifier whose peak output voltage is 9.8 V ?
(a) 6.23 V. (b) 19.6 V. (c) 9.8 V. (d) 3.1 V.
Answer

$V_{dc} = 9.8*0.636 = 6.23$ V

6. A bipolar junction transistor has ....
(a) only one *p-n* junction. (b) three *p-n* junctions.
(c) no *p-n* junctions. **(d) two *p-n* junctions.**
Answer

The bipolar junction transistor consists of three regions: Emitter, Base and Collector. There is a junction between each two regions. So there are two junctions: one between emitter and base and the other between Base and collector.

7. A noninverting amplifier has R_F = 15 kΩ and R_i = 1.2 kΩ. How much is its voltage gain?
(a) 12.5. **(b) 12.5.** (c) 13.5. (d) 9.
Answer

$A = R_F/R_i = 15/1.2 = 12.5$