Assiut University
Faculty of Engineering
Dept. of Mechanical Engineering

E302-ELECTRONIC CIRCUITS (1)
First Term Final Exam
January 2013

3rd Year
Mechatronics Section

Attempt all questions, full mark: 100 Points **Time: 3 Hours**

Question #1: (20 Points)

Choose the right answer:

1) A positive ion is formed when

D

(A) an atom gains an extra valence electron (B) there are more holes than electrons in the outer orbit
(C) two atoms bond together (D) a valence electron breaks away from the atom

2) Recombination is when

A

(A) an electron falls into a hole (B) a positive and a negative ion bond together
(C) a crystal is formed (D) a valence electron becomes a conduction electron

3) Holes in an *n*-type semiconductor are

A

(A) minority carriers that are thermally produced (B) minority carriers that are produced by doping
(C) majority carriers that are thermally produced (D) majority carriersthat are produced by doping

4) When a diode is forward-biased,

D

(A) the only current is hole current (B) the only current is produced by majority carriers
(C) the only current is electron current (D) the current is produced by both holes and electrons

5) The average value of a half-wave rectified voltage with a peak value of 200 V is

A

(A) 63.7 V (B) 127.2 V
(C) 141 V (D) 0 V

6) The ideal dc output voltage of a capacitor-input filter is equal to

A

(A) the peak value of the rectified voltage (B) the average value of the rectified voltage
(C) the rms value of the rectified voltage

7) The internal resistance of a photodiode

B

(A) increases with light intensity when reverse-biased (B) decreases with light intensity when reverse-biased
(C) increases with light intensity when forward-biased (D) decreases with light intensity when forward-biased

8) For operation as an amplifier, the base of an *npn* transistor must be

A

(A) positive with respect to the emitter (B) negative with respect to the emitter
(C) positive with respect to the collector (D) 0 V

9) In a JFET, I_{DSS} is

C

(A) the drain current with the source shorted (B) the drain current at cutoff
(C) the maximum possible drain current (D) the midpoint drain current

10) In an E-MOSFET, there is no drain current until V_{GS}

A

(A) reaches $V_{GS(th)}$ (B) is positive
(C) is negative (D) equals 0 V

Question #2: (20 Points)

a) The total secondary voltage in a center-tapped full-wave rectifier is 125 V rms. Find the rms output voltage, assuming that the diode drop is 0.7V.

V_{ip} = 176.78 V
$V_{op} = V_{ip}/2 - 0.7$ = 87.7 V
$V_{o(rms)}$ = 62 V

b) A certain power-supply filter produces an output with a ripple of 100 mV peak-to-peak and a dc value of 20 V. Find the ripple factor.

Ripple factor = peak-to-peak ripple/dc voltage
= 0.5 %

c) For a certain 12 V zener diode, a 10 mA change in zener current produces a 0.1 V change in zener voltage. Find the zener impedance.

$R_Z = \Delta V/\Delta I$ = 10 Ω

d) In a Darlington pair configuration, each transistor has β_{ac} = 120. If R_E is 470 Ω. Find the input resistance, neglecting r_e'.

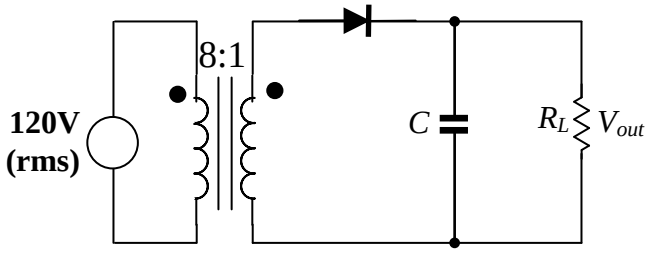
$R_{in} = (\beta_{ac} + 1)^2 R_E$ = 6.88 MΩ

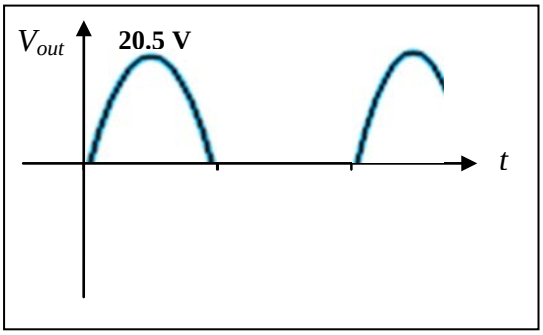
e) Each stage of a four-stage amplifier has a voltage gain of 20. Find the overall gain expressed in dBs.

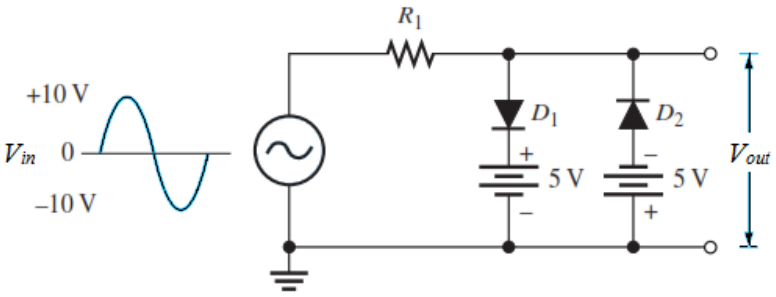
$A_v = (20)^4$
= 104 dBs

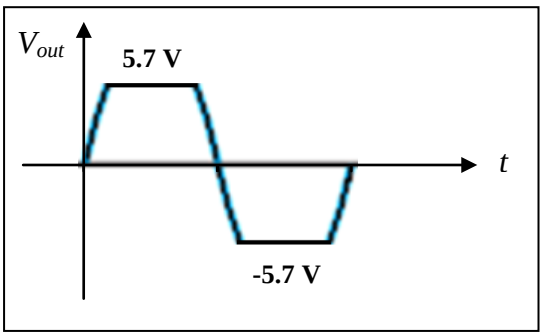
Question #3: (12 Points)

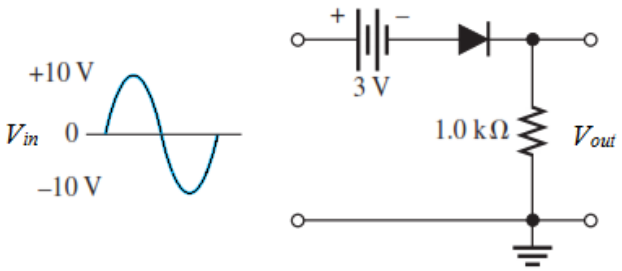
Sketch the output voltage waveform for each circuit shown and include the voltage values. Assume a practical diode model with barrier potential = 0.7 V.

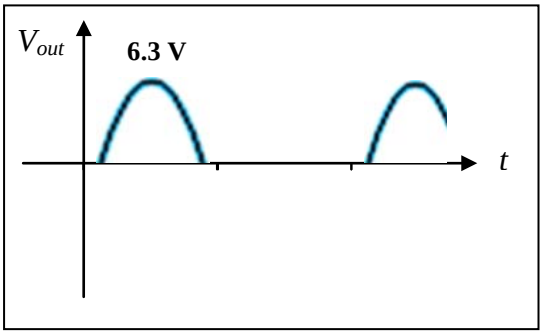












Question #4: (10 Points)

3. The silicon npn transistor used in the common emitter amplifier in Fig.4 has $\beta_{dc} = \beta_{ac} = 100$.
   a) Find I_{CQ} and V_{CEQ}. (4 Points)
   b) Find r_e'. (2 Points)
   c) Find the voltage gain and input impedance of the circuit. (4 Points)

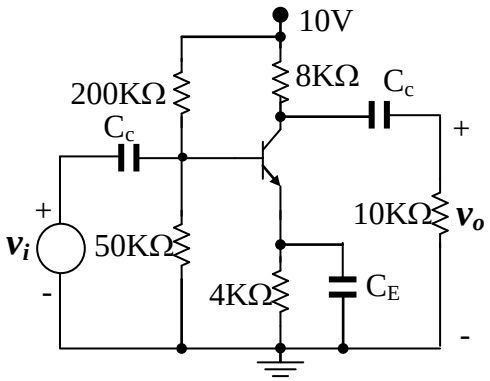
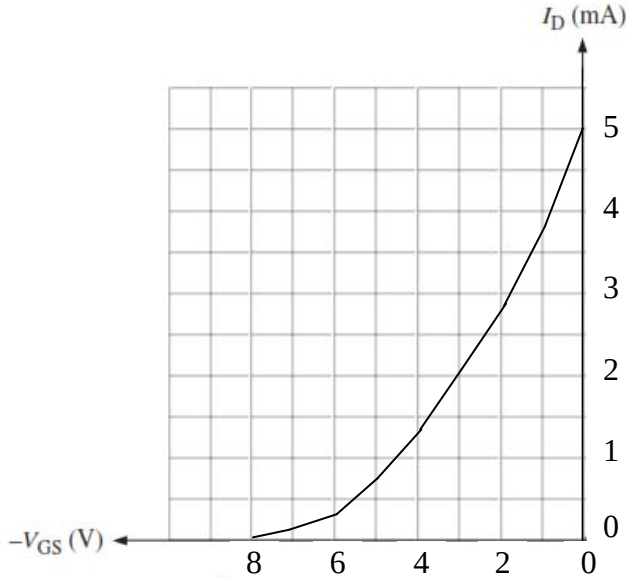


Fig.4

I_{CQ}= 0.3 mA	V_{CEQ}= 6.45 V	r_e'= 84.6 Ω
A_v= - 52.5	Z_{in}= 7 KΩ	

Question #5: (8 Points)

The following parameters are obtained from a certain JFET datasheet: I_{DSS} = 5 mA and $V_{GS(off)}$ = - 8 V. Determine the values of I_D for each value of V_{GS} ranging from 0 V to -8 V in 1 V steps. Plot the transfer characteristic curve from these data.



V_{GS}/volts	0	-1	-2	-3	-4	-5	-6	-7	-8
I_D/mA	5	3.8	2.8	2	1.25	0.7	0.31	0.08	0

Question #6: (12 Points)

The JFET used in the common source amplifier of Fig.6 has $V_{GS(off)}$ = -5V and I_{DSS} = 10 mA.

a) Determine the operating point I_{DQ}, V_{GSQ} and V_{DSQ}. (6 Points)

b) Calculate the value of the transconductance g_m at the *Q*-point. (2 Points)

c) Determine the amplifier voltage gain and input impedance. (4 Points)

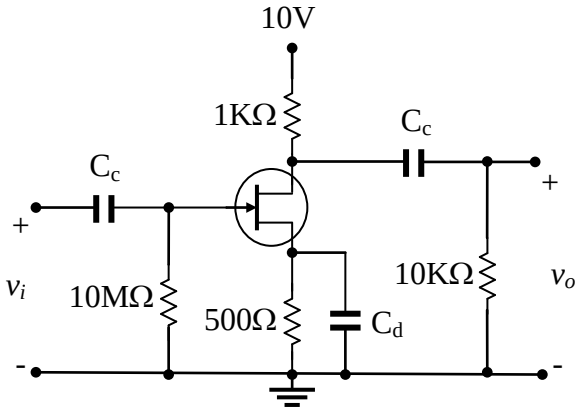


Fig.6

V_{GSQ}= -1.91 V	I_{DQ}= 3.82 mA	V_{DSQ} = 4.3 V
g_m= 2.47 mS	A_v= -2.25	Z_{in}= 10 MΩ

Question #7: (18 Points)

Determine the output voltage V_{out} for each circuit of Fig. 7 assuming ideal op-amps.

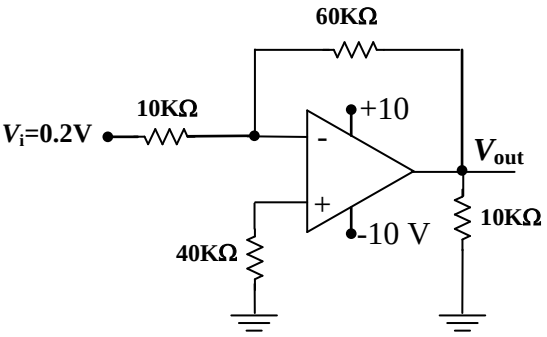


Fig.7 (a)

V_{out} = **-1.2 V**

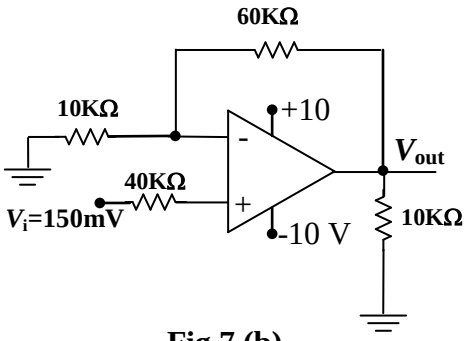


Fig.7 (b)

V_{out} = **1.05 V**

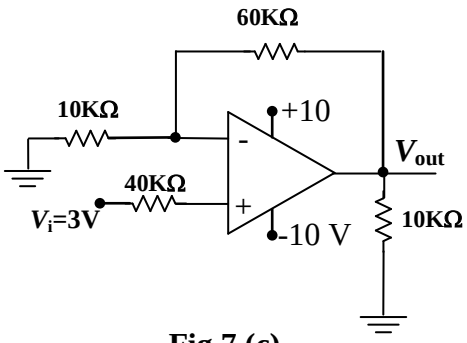


Fig.7 (c)

V_{out} = **10 V**

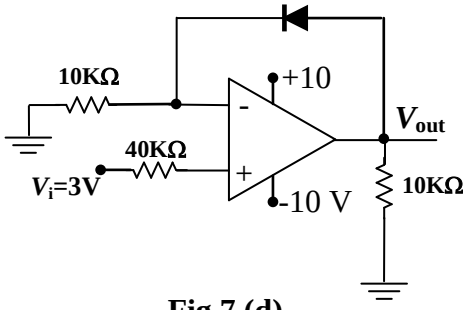


Fig.7 (d)

V_{out} = **3.7 V**

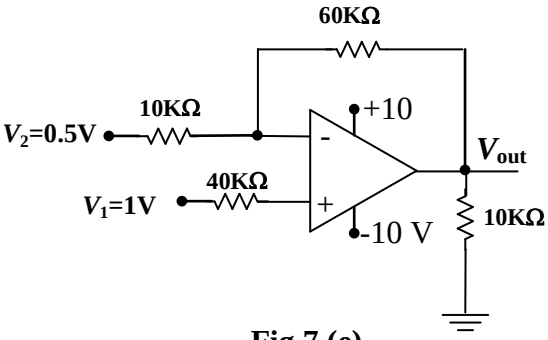


Fig.7 (e)

V_{out} = **4 V**

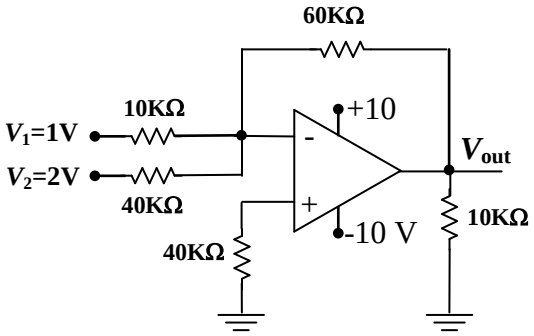


Fig.7 (f)

V_{out} = **-9 V**

********** أطيب التمنيات بالتوفيق **********

أ.د. مجدى مفيد دوس

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Dept. of Mechanical Engineering

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First Term Final Exam
January 2014

3rd Year
Mechatronics Section

Attempt all questions, full mark: 100 Points **Time: 3 Hours**

Question #1: (20 Points)
Mark True (✓) or False (x)

X	1)	The *p* and *n* regions are formed by a process called ionization.
✓	2)	The output frequency of a full-wave rectifier is twice the input frequency.
✓	3)	In a bridge rectifier, two diodes conduct during each half cycle of the input.
X	4)	Full wave rectifier circuits can be used for *DC* to *AC* conversion.
X	5)	Common Collector amplifiers are characterized by high voltage gain and high input impedance.
✓	6)	A Zener diode can be used as a voltage regulator.
✓	7)	When a transistor is saturated, the collector current is maximum.
X	8)	For operation in the linear or active region, the base-colector junction of a transistor is forward biased.
✓	9)	Base bias is less stable than voltage-divider bias.
X	10)	A bypass capacitor in a *CE* amplifier decreases the voltage gain.
✓	11)	In a *CE* amplifier, the gain can be stabilized by using a swamping resistor.
X	12)	In a class-*A* power amplifier, efficiency is the ratio of output signal power to input signal power.
✓	13)	Class *AB* operation overcomes the problem of crossover distortion.
X	14)	The drain current I_D of a JFET becomes zero if V_{DS} is at the pinch-off voltage.
X	15)	Forward transconductance is the change in drain voltage for a given change in gate voltage.
✓	16)	A D-MOSFET has a physical channel and an E-MOSFET has an induced channel.
✓	17)	A common-source (*CS*) amplifier has a very high input resistance.
✓	18)	Negative feedback reduces the gain of an op-amp from its open-loop value.
X	19)	The gain of a voltage-follower is very high.
✓	20)	A summing amplifier can have more than two inputs.

Question #2: (20 Points)
Choose the right answer:

1) The process of adding an impurity to an intrinsic semiconductor is called

A
(A) doping (B) recombination
(C) atomic modification (D) ionization

2) When the rms output voltage of a bridge full-wave rectifier is 20 V, the peak inverse voltage across the diodes is (neglecting the diode drop)

B
(A) 20 V (B) 28.3 V
(C) 40 V (D) 56.6 V

3) A silicon Zener diode having Vz = 5 V. How much voltage appears across it when it is forward-biased?

A
(A) 0.7 V (B) 4.3 V
(C) 5 V (D) 5.7V

4) The overall voltage gain of three identical cascaded voltage amplifiers each has a no load voltage gain AV = -10, Zi = 1 kΩ, and Zo = 1 kΩ is:

C
(A) 1000 (B) -1000
(C) -250 (D) -125

5) What are the bias conditions of the base-emitter and base-collector junctions for a transistor to operate as an amplifier?

B
(A) Both are forward biased (B) The base-emitter is forward and the base-collector is reverse
(C) Both are reverse biased (D) The base-collector is forward and the base-emitter is reverse

6) What characteristic of the common-collector amplifier makes it a useful circuit?

A
(A) it has a high input resistance (B) its output is in-phase with the input
(C) it has a high voltage gain (D) it has a high power gain

7) The Q-point for a class AB amplifier is

D
(A) at the middle of the load line (B) at cut-off
(C) near saturation (D) near cut-off

8) A certain D-MOSFET is biased at VGS = 0 V. Its datasheet specifies IDSS = 20 mA and VGS(off) = -5 V. The value of the drain current

C
(A) is 0 A (B) is 10 mA
(C) is 20 mA (D) cannot be determined

9) If the gate-to-source voltage in an n-channel E-MOSFET is made more positive, the drain current will

A
(A) increase (B) remain unchanged
(C) decrease

10) In a JFET, IDSS is

C
(A) the drain current with the source shorted (B) the drain current at cutoff
(C) the maximum possible drain current (D) the midpoint drain current

Question #3: (15 Points)

a) A certain power-supply filter produces an output with a ripple of 100 mV peak-to-peak and a *dc* value of 20 V. Find the ripple factor.

$r = V_{r(p\text{-}p)}/V_{dc} = 0.005$

b) If a transistor has a *dc* beta of 120, V_B = 2 V, and I_E = 2 mA, what is the *dc* input resistance at the base?

$I_B = I_E/(\beta + 1) = 0.0165$ mA

$R_{in} = V_B/I_B = 121$ KΩ

c) Explain swamping.

R_E is partially bypassed so that a reasonable gain can be achieved, and the effect of r_e' on the gain is greatly reduced.

d) A differential amplifier has a differential mode gain A_d= 60 and a common mode gain A_c= 0.5. Calculate the *CMRR* in dBs.

$CMRR = 20 \log(A_d / A_c) = 41.6$ dBs

e) A certain scaling adder has two inputs, one having twice the weight of the other. If the resistor value for the lower-weighted input is 10 kΩ, what is the value of the other input resistor?

$R_2 = R_1/2 = 5$ KΩ

Question #4: (8 Points)

Sketch the output voltage for each Zener limiting circuit in Fig.4 in the following cases:

a) V_{in} = 20 V p-p, V_{Z1}=5.3V, and V_{Z2}=2.3V.
b) V_{in} = 40 V p-p, V_{Z1}=5.3V, and V_{Z2}=2.3V.
c) V_{in} = 30 V p-p, V_{Z1}=5.3V, and V_{Z2}=15.3V.
d) V_{in} = 10 V p-p, V_{Z1}=5.3V, and V_{Z2}=15.3V.

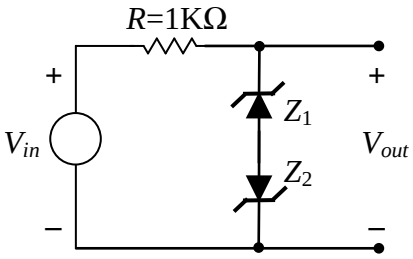
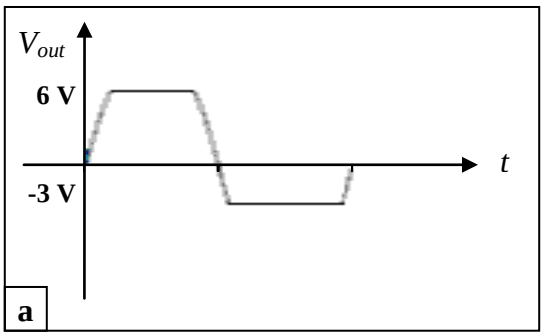
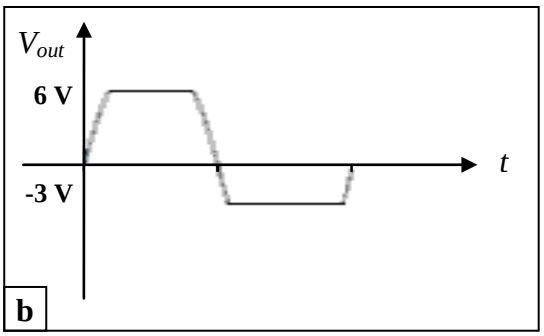
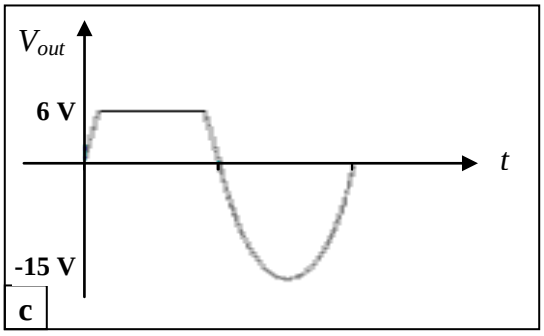
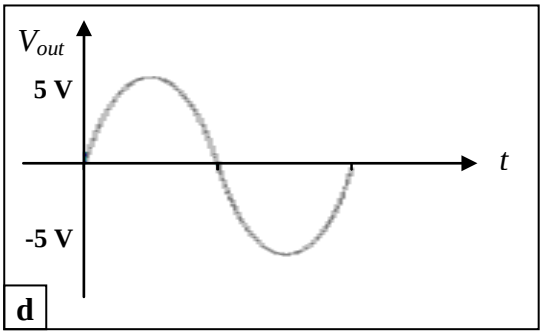


Fig.4









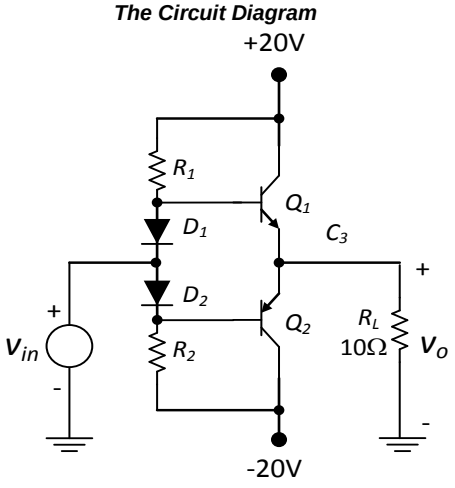
Question #5: (15 Points)

A class-*AB* complementary-symmetry push-pull power amplifier is connected to a 10 Ω load. The supply voltages are ±20 V.

a) Draw the amplifier circuit diagram. (3 Points)
b) Find the peak value of the collector current, the DC power delivered by the source and the amplifier efficiency, if the ac power delivered to the load is 6 W. (6 Points)
c) Find the maximum allowable value of the peak collector current. (2 Points)
d) Find the maximum output power, and maximum DC power. (4 Points)

I_{Cp}= 1.095 A	P_{DC}= 13.95 W
Efficiency = 43 %	$I_{Cp(max)}$ = 2 A
$P_{DC(max)}$ = 25.5 W	$P_{out(max)}$ = 20 W

The Circuit Diagram



Question #6: (12 Points)

The JFET used in the common source amplifier of Fig.6 has $V_{GS(off)}$ = -5V and I_{DSS} = 10 mA.

a) Determine the operating point I_{DQ}, V_{GSQ} and V_{DSQ}. (6 Points)
b) Calculate the value of the transconductance g_m at the *Q*-point. (2 Points)
c) Determine the amplifier voltage gain and input impedance. (4 Points)

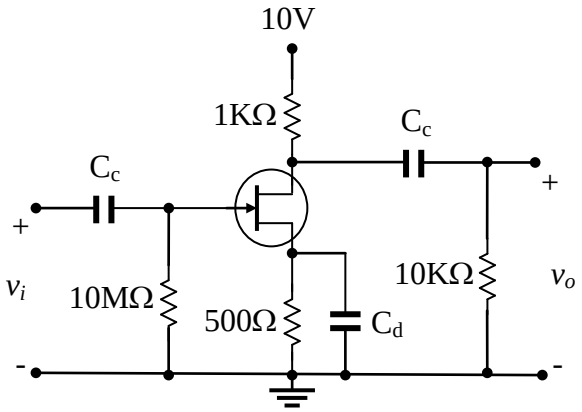
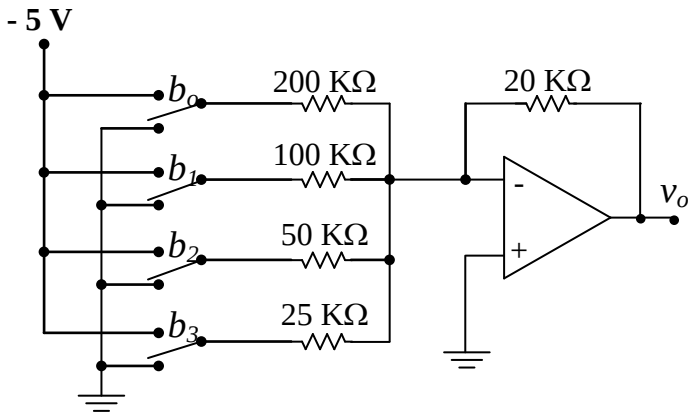


Fig.6

V_{GSQ}= -1.91 V	I_{DQ}= 3.82 mA	V_{DSQ} = 4.3 V
g_m= 2.47 mS	A_v= - 2.25	Z_{in}= 10 MΩ

Question #7: (10 Points)

Design a four bit digital to analog converter using a scaling adder. The maximum analog output should be 7.5 volts. Draw the circuit diagram of the converter and give the value of the elements used and the input voltage level.



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Question #1: (20 Points)
Mark True (✓) or False (x)

✓	1)	Valence electrons exist in the outer shell of an atom.
X	2)	The output frequency of a half-wave rectifier is twice the input frequency.
X	3)	Each diode in a full-wave rectifier conducts for the entire input cycle.
✓	4)	Silicon doped with p and n impurities has one pn junction
X	5)	When reverse-biased, a diode ideally appears as a short.
X	6)	Line and load regulation are the same.
X	7)	Full wave rectifier circuits can be used for *DC* to *AC* conversion.
X	8)	The varactor diode normally operates in forward bias.
✓	9)	The LED is normally operated in forward bias.
X	10)	The base current and collector current are approximately equal.
✓	11)	A transistor in cutoff acts as an open switch.
X	12)	The dc load line intersects the vertical axis of a transistor characteristic curve at $I_C = V_{CE}/R_L$.
✓	13)	Input resistance at the base of the transistor can affect voltage-divider bias.
✓	14)	A *pnp* transistor requires bias voltage polarities opposite to an *npn* transistor.
✓	15)	In an amplifier, a coupling capacitor should appear ideally as a short to the signal.
X	16)	If R_C in a *CE* amplifier is increased, the voltage gain is reduced.
✓	17)	Ideally, the Q-point should be centered on the load line in a class A amplifier.
✓	18)	Class *AB* operation overcomes the problem of crossover distortion.
✓	19)	The JFET always operates with a reverse-biased gate-to-source *pn* junction.
✓	20)	A D-MOSFET has a physical channel and an E-MOSFET has an induced channel.

Question #2: (20 Points)
Choose the right answer:

1) Every known element has

C
(A) the same type of atoms (B) the same number of atoms
(C) a unique type of atom (D) several different types of atoms

2) In an intrinsic semiconductor,

D
(A) there are no free electrons (B) there are only electrons
(C) there are only holes (D) there are as many electrons as there are holes

3) Holes in an *n*-type semiconductor are

A
(A) minority carriers that are thermally produced (B) minority carriers that are produced by doping
(C) majority carriers that are thermally produced (D) majority carriers that are produced by doping

4) The cathode of a zener diode in a voltage regulator is normally

A
(A) more positive than the anode (B) more negative than the anode
(C) at+0.7 V (D) grounded

5) When operated in cutoff and saturation, the transistor acts like a

B
(A) linear amplifier (B) switch
(C) variable capacitor (D) variable resistor

6) In saturation, V_{CE} is

C
(A) 0.7 V (B) equal to V_{CC}
(C) minimum (D) maximum

7) A certain common-emitter amplifier has a voltage gain of 100. If the emitter bypass capacitor is removed,

B
(A) the circuit will become unstable (B) the voltage gain will decrease
(C) the voltage gain will increase (D) the Q-point will shift

8) A differential amplifier

D
(A) is used in op-amps (B) has one input and one output
(C) has two outputs (D) answers (a) and (c)

9) The peak current a class A power amplifier can deliver to a load depends on the

B
(A) maximum rating of the power supply (B) quiescent current
(C) current in the bias resistors (D) size of the heat sink

10) If the gate-to-source voltage in an n-channel E-MOSFET is made more positive, the drain current will

A
(A) increase (B) remain unchanged
(C) decrease

Question #3: (10 Points)

a) A 10 V peak-to-peak sinusoidal voltage is applied to a silicon bridge rectifier. Find the peak value of the output voltage and the peak-inverse-voltage across each diode.

$V_{p(out)} = 5 - 1.4 = 3.6$ V

$PIV = V_{p(out)} + 0.7 = 4.3$ V

b) For a certain 12 V zener diode, a 10 mA change in zener current produces a 0.1 V change in zener voltage. Find the zener impedance.

$R_Z = \Delta V/\Delta I = 10\ \Omega$

c) A common-emitter amplifier is driving a load resistance R_L= 10 kΩ. If R_C = 2.2 kΩ, I_{CQ} = 2.5mA, β_{ac} = 75 and R_E is completely bypassed at the operating frequency. Find the voltage gain.

$r_e' = 25/I_E = 10\ \Omega$
$R_C' = 2.2//10 = 1.8$ KΩ
$A_v = -R_C'/r_e' = -180$

d) Each stage of a four-stage amplifier has a voltage gain of 15. Find the overall voltage gain in dBs.

$A_v = 94.09$ dBs

e) An n-channel E-MOSFET has $I_{D(on)}$ = 18 mA at V_{GS} = 4 V, and $V_{GS(th)}$ = 2.5 V. Find I_D when V_{GS} = 3.25 V.

$K = 8\ mA/V^2$

$I_D = 4.5$ mA

Question #4: (12 Points)

The diodes used in the circuit of Fig.4, have a forward voltage of 0.7 V.

(a) What type of circuit is this?
(b) What is the total peak secondary voltage?
(c) Find the peak voltage across each half of the secondary.
(d) Sketch the voltage waveform across R_L.
(e) What is the peak current through each diode?
(f) What is the PIV for each diode?

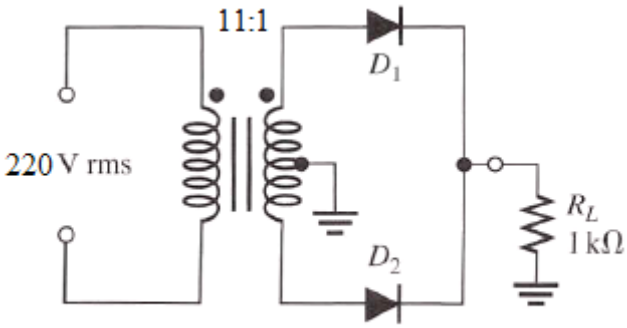


Fig.4

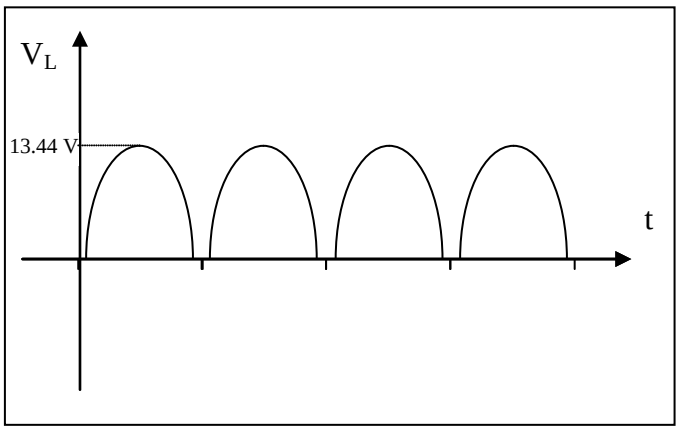
Type of circuit: **Full-wave rectifier**

Total peak secondary voltage: **28.28 V**

Peak voltage across each half of the secondary: **14.14 V**

Peak current through each diode: **13.44 mA**

PIV for each diode: **27.58 V**



Question #5: (10 Points)

The silicon npn transistor used in the common emitter amplifier in Fig.5 has $\beta_{dc} = \beta_{ac} = 100$.

a) Find I_{CQ} and V_{CEQ}. (4 Points)
b) Find r_e'. (2 Points)
c) Find the voltage gain and input impedance of the circuit. (4 Points)

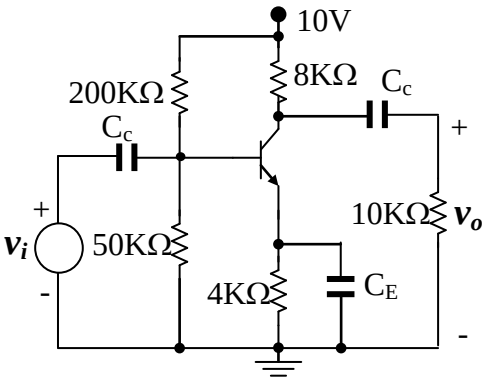


Fig.5

I_{CQ}= 0.295 mA

V_{CEQ}= 6.45 V

r_e'= 84.6 Ω

A_v= - 52.53

Z_{in}= 7 KΩ

Question #6: (8 Points)

The class AB amplifier in Fig.6 is operating with a single power supply.

(a) Assuming the input voltage is 10 V peak-to-peak, determine the power delivered to the load resistor. (3 Points)

(b) What is the maximum power that could be delivered to the load resistor? (3 Points)

(c) Assume the power supply voltage is raised to 24 V. What is the new maximum power that could be delivered to the load resistor? (2 Points)

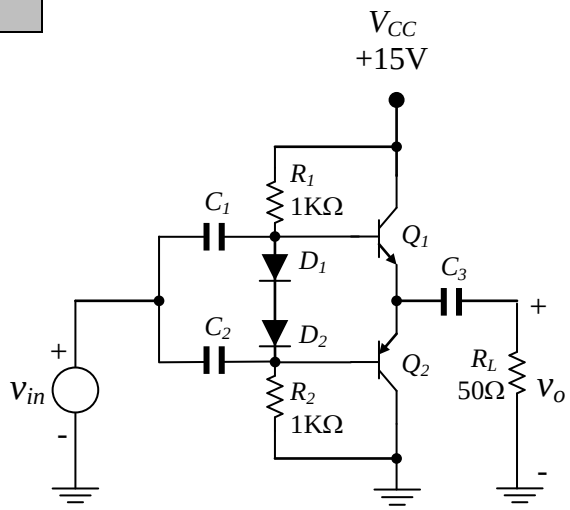


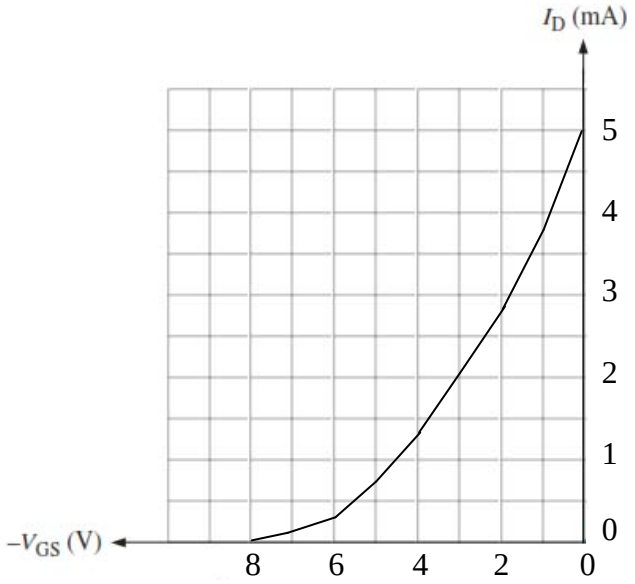
Fig.6

P_{LD} =	**0.25 W**	$P_{LD(max)}$ = For V_{CC}=15V	**0.5625 W**	$P_{LD(max)}$ = For V_{CC}=24V	**1.44 W**

Question #7: (8 Points)

The following parameters are obtained from a certain JFET datasheet: I_{DSS} = 5 mA and $V_{GS(off)}$ = - 8 V. Determine the values of I_D for each value of V_{GS} ranging from 0 V to -8 V in 1 V steps. Plot the transfer characteristic curve from these data.

V_{GS}/volts	0	-1	-2	-3	-4	-5	-6	-7	-8
I_D/mA	5	3.8	2.8	2	1.25	0.7	0.31	0.08	0



Question #8: (12 Points)

The E-MOSFET used in the common-source amplifier in Fig.8 has $I_{D(on)}$ = 200 mA at V_{GS} = 4 V and $V_{GS(th)}$ = 2 V.

a) Determine the operating point V_{GSQ}, I_{DQ} and V_{DSQ}. (6 Points)

b) Calculate the value of the transconductance g_m at the *Q*-point (2 Points)

c) Determine the voltage gain and input impedance of the amplifier. (4 Points)

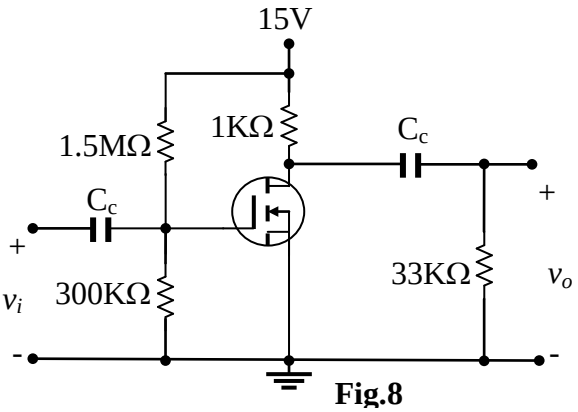


Fig.8

V_{GSQ}= 2.5 V	I_{DQ}= 12.5 mA	V_{DSQ} = 2.5 V
g_m= 50 mS	A_v= -48.5	Z_{in}= 250 KΩ