ANALOG ELECTRONICS

2 MARKS AND 16 MARKS (Q&A)

UNIT 1

1. Define PN junction.

When a p type semiconductor is joined to a N type semiconductor the contact surface is called PN junction. P Type (majority of holes and minority of electrons) and N Type (majority of electrons and minority of holes).

2. Explain the forward bias of diode (PN junction). (MAY 2014)

If p type terminal is connected to Anode (positive electrode), and N type terminal is connected to cathode (Negative electrode) it is known as forward bias. At forward bias, large current will flow in the range of milli amperes (10-3A). Forward bias is equivalent to short circuit.

3. Explain reverse bias of diode (PN Junction).

If p type is connected to cathode and N type is connected to anode, it is reverse bias. At reverse bias, small current will flow in the range of micro amperes (10-6). Reverse bias is equivalent to open circuit.

4. Explain the V-I characteristics of PN Junction diode.

It is a graph drawn between voltage in x axis and current in y axis.

5. A Germanium diode has a saturation current of 10 μA at 300°K. Find the saturation current at 400°K. (NOV 2012)

I300 = 10μA T1 = 300K T2 = 400K

I400 = I300 X 10-6 X 210 = 10.2 mA.

6. What is the effect of junction temperature on forward current and reverse current of a PN diode?

For the same forward voltage, the forward current of a PN diode increases and reverse saturation current increases with increase in junction temperature.

7. Differentiate between breakdown voltage and PIV of a PN diode.

The breakdown voltage of a PN diode is the reverse voltage applied to it at which the PN junction breaks down with sudden rise in reverse current. Whereas, the peak inverse voltage (PIV) is the maximum reverse voltage that can be applied to the PN junction without damage to the junction.

8. Define rectifier. (NOV 2013)

It is a device which converts alternating current into direct current.

9. Define knee voltage.

It is the forward voltage of a PN diode at which the current thorough the junction starts increasing rapidly.

10. Define breakdown voltage.

It is the reverse voltage of a PN junction diode at which the junction breaks down with sudden rise in the reverse current.

11. Mention the type of rectifier circuits. (MAY2015)

(i) Half wave rectifier

(ii) Full wave rectifier

(a) centre tap rectifier

(b) Bridge rectifier

12. Explain the Half wave circuit.

Half wave rectifier circuit consists of one Semiconductor Diode D1 and load Resistance RL. That is current will flow during positive half cycle and no current will be conducted during negative half cycle.

13. List the advantages of full bridge rectifier.

1. Centre-tapped transformer is not needed.

2. For the same secondary voltage, the output is doubled than that of the centre-tap circuit.

14. Define Zener diode.

A zener diode is a properly doped crystal diode which has a sharp breakdown voltage.

15. Compare between half wave and full wave rectifiers.

1. The efficiency of a full wave rectifier is double that of a half wave rectifier

2. The ripple factor is large and frequency of voltage is low in a half wave rectifier, hence the waveform cannot be easily smoothed whereas in full wave rectifier, the frequency is large therefore can be filtered easily with simple filtering circuits.

16. Define ripple factor

The ripple factor is a measure of purity of the dc output of a rectifier and is defined as

17. Define rectifier efficiency.

The rectification efficiency tells us what percent of total input ac power is converted into useful dc output power. Thus rectification efficiency is defined as

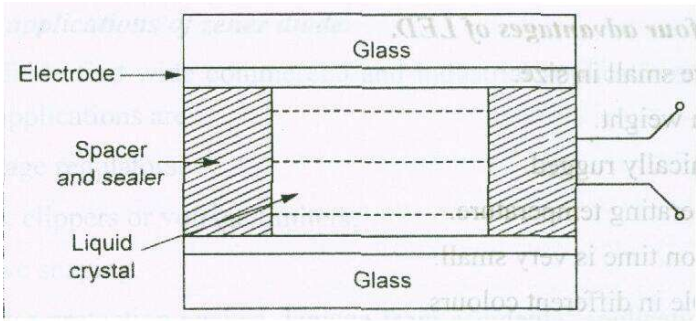
18. Define voltage regulation

Voltage regulation is a measure of the ability of a rectifier to maintain a specified output voltage with the variation of load resistance and is defined as follows.

19. List the classification of filters

1. Low pass filter which transmits low frequencies to the load and attenuates high frequencies.
2. High pass filter which transmit high frequencies.
3. Band pass filter which transmits a band of frequencies.

20. Define LED. (NOV 2013)



The PN junction diode can emit light through a process known as electro luminescence. When a diode is forward biased, majority of the carriers on both side of the junction will cross the junction potential barrier. This recombination emission is responsible for the diode emitting light.

21. Define LCD (Liquid Crystal Display). (MAY 2014)

A thin film of LC fluid is sandwiched between two glass plates. The glass plates are coated with conductive transparent in the film formed of the desired alpha numeric image. LCD's consume less power and have the shortest life.

22. Mention the types of LCD.

- Dynamic scattering
- Field effect.

23. Mention the materials used in LED. (MAY 2014)

- Gallium Arsenic Zinc Antimony.
- Gallium Phosphorous.
- GA As Ps.
- Ga PN.

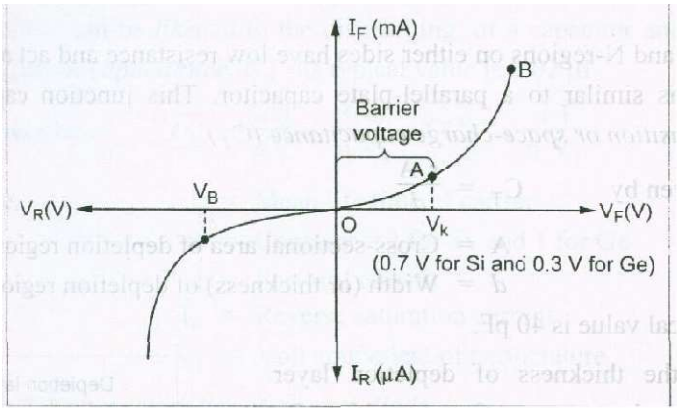
24. What is an ideal diode?

An ideal diode is one which offers zero resistance when forward biased and infinite resistance when reverse biased.

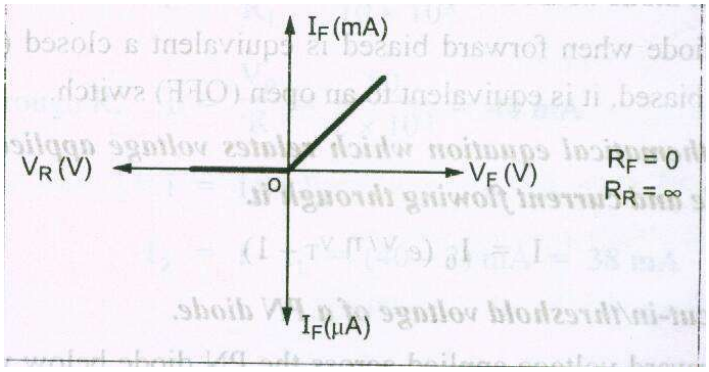
25. Compare ideal diode as a switch.

An ideal diode when forward biased is equivalent a closed (ON) switch and when reverse biased, it is equivalent to an open (OFF) switch.

26. Draw the circuit diagram of PN Diode



27. Draw the V-I characteristics of an ideal diode.



28. List the PN diode parameters. (MAY 2013)

1. Bulk Resistance. ( )
2. Static Resistance/Junction Resistance (or) DC Forward Resistance (or)
3. Dynamic Resistance (or) AC Forward Resistance (or or)
4. Reverse Resistance ( )
5. Knee Voltage ( )
6. Breakdown Voltage ( )
7. Reverse Current (or) Leakage Current

29. State the PN diode ratings.

Even PN-Junction has limiting values of maximum forward current, peak inverse voltage and maximum power rating.

30. Define reverse recovery time.

It is maximum time taken by the device to switch from ON to OFF stage.

31. List the PN diode switching times.

- Recovery Time
- Forward Recovery Time
- Reverse Recovery Time
- Reverse recovery time
- Storage and Transition Times

32. Define transition capacitance of a diode.

Transition Capacitance (CT) or Space-charge Capacitance: When a PN-junction is reverse-biased, the depletion region acts like an insulator or as a dielectric.

The P- and N-regions on either side have low resistance and act as the plates. Hence it is similar to a parallel-plate capacitor. This junction capacitance is called transition or space-charge capacitance (CT).

It is given by =

Where, A = Cross-sectional area of depletion region.

D = Width (or) thickness of depletion region.

Its typical value is 40 pF.

Since the thickness of depletion layer depends on the amount of reverse bias, CT can be controlled with the help of applied bias.

This property of variable capacitance is used in varicap or varactor diode.

This capacitance is is voltage dependent and is given by

Where, = Knee voltage,

= Applied reverse voltage,

K = Constant depending on semiconductor material,

n = for alloy junction,

= for diffused junction.

33. Define diffusion capacitance of a diode. **(MAY2015)**

Diffusion or Storage Capacitance (CD): This capacitive effect is present when the junction is forward-biased.

It is called diffusion capacitance due to the time delay in minority charges across the junction by diffusion process. Due to this fact, this capacitance cannot be identified in terms of a dielectric and plates. It varies directly with forward current. When a forward-biased PN-junction is suddenly reverse biased, a reverse current flows which is large initially, but gradually decreases to the level of saturation current, I0.

This effect can be likened to the discharging, of a capacitor and is, therefore called diffusion capacitance, CD. Its typical value is 0.02 F

It is given by:

Where, = Mean life time of carrier

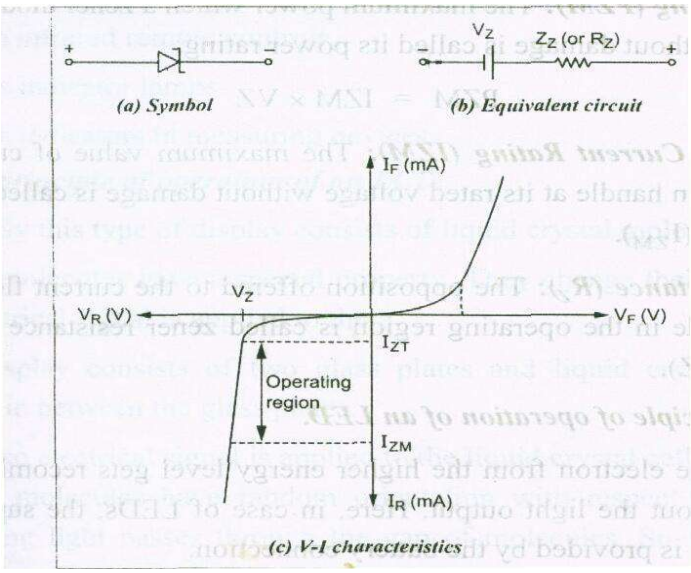
= Constant =2 for Si and 1 forGe

I = Forward current

I0 = Reverse saturation current

VT = Volt equivalent of temperature

34. Draw the V-I characteristics of a zener diode



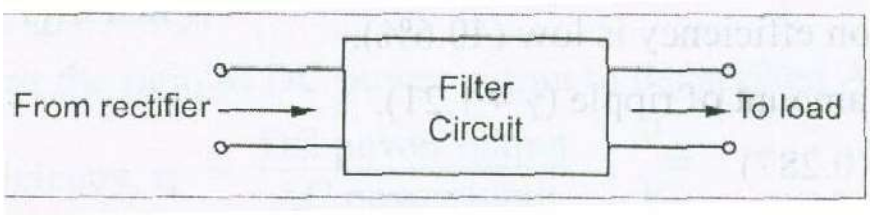
35. List some applications of zener diode.

Zener diode finds wide commercial and industrial applications. Some of their common applications are:

- As voltage regulators.
- As peak clippers or voltage limiters.
- For wave shaping.
- For meter protection against damage from accidental application of excessive voltage.
- As a fixed reference voltage in a network for biasing and comparison purposes and for calibrating voltmeters.

36. What is a rectifier-filter? List the different types of filters.

A filter circuit is a device which removes the AC component but allows the DC components of the rectifier to reach the load.



Ripples can be removed by one of the following filtering methods.

(i) A capacitor, in parallel to the load, provides a easier bypass for the ripples due to low impedance to AC at ripple frequency and leave the DC appear across the load.

(ii) An inductor, in series with the load, prevents the passage of ripples due to high impedance at ripple frequency, while allowing the DC due to low resistance to DC.

(iii) Various combinations of capacitor and inductor, such has L-section filter, π-section filter, etc., which make use of both the properties depicted above.

37. What is the need for voltage regulators? What are the drawbacks of unregulated power supply?

An ordinary (unregulated) power supply from the following drawbacks:

Poor regulation

- The DC output voltage varies with the AC supply voltage which fluctuates at different times of the day and is different at different locations.
- The DC output voltage varies with temperature, in case semiconductors are used.
- For certain applications the output of the filter even with small amount of ripples is not acceptable.

38. What is voltage regulator? List some types.

A voltage regulator is a circuit which makes the rectifier-filter output voltage constant regardless of the variations in the input voltage or load.

Types of regulators: There are three principal types of regulators, viz.,

- **Shunt regulator** (control element connected with series),sample network ,error detector, constant voltage
- **Series regulators**(control element connected with shunt),sample network ,error detector, constant voltage

39. Define Dynamic resistance

Dynamic resistance defined as ratio of rate of change voltage divided by rate of change of current

40. What is the difference between diffusion current and drift current? (NOV 2013)

Drift Current	**Diffusion current**

1. Developed due to potential gradient.	1. Developed due to charge concentration gradient.
2. Phenomenon found both in semiconductors and metals.	2. Only in semiconductors

41. What is diffusion current in PN Diode?

A movement of charge carriers due to the concentration gradient in a semiconductor is called process of diffusion.when charge carriesrs move,the current is constituted in a bar.this current due to diffusion is called diffusion current.

42. What is hole and electron in PN diode?

After joining p-type and n-type semiconductors, electrons from the n region near the p–n interface tend to diffuse into the p region. As electrons diffuse, they leave positively charged ions (donors) in the n region. Likewise, holes from the p-type region near the p–n interface begin to diffuse into the n-type region, leaving fixed ions (acceptors) with negative charge. The regions nearby the p–n interfaces lose their neutrality and become charged, forming the space charge region ordepletion layer

43. Difference between zener breakdown and avalanche breakdown?

Zener breakdown	Avalanche breakdown
1.Breaking of covalant bond due to intense electric field 2.Vz less than 6V 3.Temperature coefficient is negative	Breaking of covalant bond due to collision Vz Greater than 6v Temperature coefficient is positive

44. What is drifting current?

In a **p-n junction diode**, electrons and holes are the minority charge carriers in the p-region and the n-region, respectively. Due to the diffusion of charge carriers, the diffusion **current**, which flows from the p to n region, is exactly balanced by the equal and opposite **drift current**.

45. What is peak inverse voltage?

It is defined as the maximum reverse voltage that a diode can withstand without destroying the junction. The peak inverse voltage across a diode is the peak of negative half cycle. For half- wave rectifier, PIV is V_m

46. Define zener breakdon volatge?

When a PN junction is heavily doped,the depletion region is very narrow.so under reverse bias condition,the electric field across the depletion region is intense.such as intense field is enough to pull the electrons out of the valance band of the stable atoms.such a creation of free

electrons is called zener effect.these minority carriers constitute very large current and the mechanism is called as zener breakdown.

47. Dynamic resistance of the diode?

Dynamic resistance of a diodecan be defined as the ratio of change in voltage across the diode to the change in currentthrough the diode.

16 MARKS

UNIT-1

1. Draw the circuit diagram and explain the operation of full wave rectifier using center tap transformer and using bridge rectifier without center tap transformer. Obtain the expression for peak inverse voltage. **(MAY 2014) (NOV 2013) (MAY 2015)**
2. With neat diagram explain the construction and working of LED.**(MAY 2015)**
3. Explain the working of LASER DIODE. **(NOV 2013)**
4. What is half wave Rectifier? Explain the working principle with neat sketch.
5. Explain the operation of FWR with centre tap transformer. Also derive the following for this transformer. (6)
   (i) dc output voltage (4)
   (ii) dc output current (2)
   (iii) RMS output voltage. (4)
6. Explain the following regulator circuits :
   (i) Transistorized shunt regulator. (8)
   (ii) Zener diode shunt regulator. (8) **(MAY 2014) (NOV 2013) (MAY 2015)**
7. With a neat diagram explain the working of a PN junction diode in forward bias and reverse bias and show the effect of temperature on its V-I characteristics. **(MAY 2014) (NOV 2012) (NOV 2013)**
8. Explain V-I characteristics of Zener diode**(NOV 2013)**
9. Discuss switching characterstics of PN diode **(MAY 2014)**
10. List out and applications of LED and LASER DIODE **(NOV 2012) (MAY 2015)**

UNIT 2

1. Define Amplifier.

Amplifier is a device which amplifies the given input signal.

Example: transistor

2. Define Transistor.

It consists of two PN Junctions formed by sandwiching either p-type or n-type semiconductor between a pair of opposite types.

3. Mention the types of transistor?

1. NPN Transistor
2. PNP Transistor

4. Mention the terminals of transistor.

The transistor has three terminals namely emitter, base and collector.

5. Define doping.

The emitter is heavily doped. The base is lightly doped and the collector is moderately doped.

6. Define current amplification factor.

The ratio of change in output current to the change in input current at constant other side voltage is called current amplification factor.

7. Explain the input characteristics of transistor.

It is a graph drawn between output voltage and input current keeping other side voltage as constant.

8. Explain the output characteristics of transistor.

It is a graph drawn between output voltages and output current keeping other side current (I/P) as constant.

9. Mention the types of connection in a transistor.

1. Common base connection.
2. Common emitter connection
3. Common collector connection.

slno	characteristics	CB	CE	CC
1.	Voltage gain	About 150	About 500	Less than 1
2.	Input resistance	Low (about 75Ω)	Low (about 750Ω)	Very high (about 750KΩ)
3.	Output resistance	Very high (about 450KΩ)	High (about 45KΩ)	Low (about 45Ω)
4.	Applications	For high frequency applications	For audio frequency applications	For impedance matching

11. For a non-transistor IE = 12mA and β = 140. Determine the value of IB and Ic.

IE = 12mA, β = 140

IE = IB + IC

IC = IE - IB = 12 - 0.085 X 10-3 = 11.915mA.

12. A transistor connected in common base configuration has a low input resistance and a high output resistance.

Low=100ohm, high=450kohm

13. Differentiate FET and BJT (any two) (MAY 2014) (NOV 2013) (MAY2015)

. FET	**BJT**
1. Unipolar device (that is current conduction by only one type of either electron or hole).	1. Bipolar device (current conduction by both electron and hole).
2. High input impedance due to reverse bias.	2. Low input impedance due to forward bias.
3. Gain is characterized by trans conductance	3. Gain is characterized by voltage gain.
4. Low noise level	4. High noise level.

14. What are the biasing conditions to operate transistor in active region?

Emitter-base junction has to be forward biased and collector-base junction to be reverse biased.

15. What is thermal runaway?

The power loss in transistor is primarily at the collector junction because the voltage there is high compared to the low voltage at the forward biased emitter junction. If the collector current increases, the power developed tends to raise the junction temperature. This causes an increase in β and α further increase in collector current in temperature may occur resulting in "thermal run away."

16. If the base current in a transistor is 30μA and the emitter current is 7.2mA. What are the values of α, β and Ic? (NOV 2013)

IB = 30μA, IE = 7.2mA

H = = Ic = βIB

I + β = 240 = 239 X 30 X 10-6

β = 240 – 1 IC = 7.17mA

β = 239

17. In a transistor operating in the active region although the collector junction is reverse biased, the collector current is quite large. Explain.

Forward biasing the input side and reverse biasing the output side are the requirements of a transistor in the active region. The collector current is experimentally equal to the emitter current. Therefore the collector current will be large as emitter current is large on the other hand, in CE operation IB is multiplied by β, hence we get large collector current.

18. Why CE configuration is considered to be the most versatile one?

The common emitter configuration provides very good voltage gain about 500CE configuration finds excellent usage in audio frequency applications, hence used in receivers and transmitter.

19. Define bipolar junction transistors.

These devices operate with both holes and electrons and hence are called bipolar junction.

20. Write the junction transistor operation may be drawn from the analysis.

1. The major charge carriers in the PNP junction transistor are holes.
2. The major charge carriers in the NPN junction transistor are electrons.

21. Write the range of parameter values for BJT.

Parameter	**Symbol**	**Range of value**
1. Input resistance	ri	A few kΩ
2. Current gain in CB mode	α	0.9 – 0.999
3. Current gain in CE mode	β	20 - 600
4. Output resistance	r0	Tens of KΩ
5. Leakage current	ICBO	Na - μA

22. Why transistor (BJT) is called current controlled device ?

The output voltage, current or power is controlled by the input current in a transistor. So , it is called the current controlled device.

23. What are "emitter injection efficiency" and "base transport factor" of a transistor?

The ratio of current of injected carriers at emitter junction to the total emitter current is called the emitter injection efficiency.

Transport factor, β =⁄

24. Why silicon type transistors are more often used than Germanium type?

Because silicon has smaller cut-off current ICBO , small variations in ICBO due to variations in temperature and high operating temperature as compared to those in case of Germanium.

25. Why collector is made larger than emitter and base?

Collector is made physically larger than emitter and base because collector is to dissipate much power.

26. What is early effect in base configuration? (NOV 2011)

A wider depletion region around the collector-base junction and a correspondingly narrower active base region. This means that free electrons in the base region spend less time there, and have a correspondingly smaller chance to recombine with holes in the base region. This is known as the *Early effect*

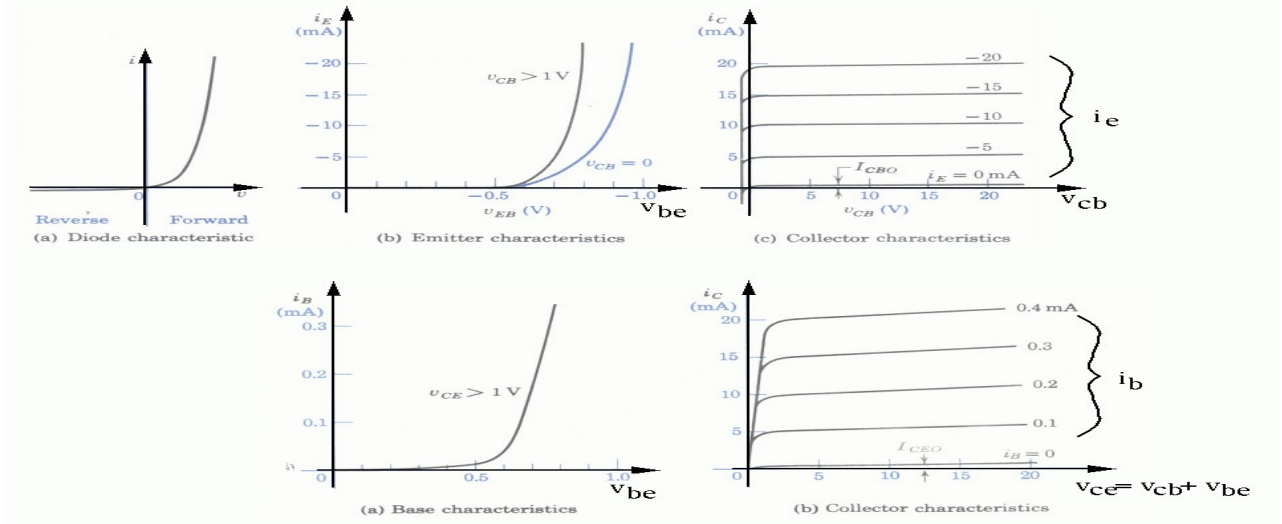
27. Why collector region wider than emitter region?

most of the BJT collector current is due to the flow of charges injected from a high-concentration emitter into the base where there are minority carriers that diffuse toward the collector, and so BJTs are classified as *minority-carrier* devices.

28. Operating modes of BJT? (MAY 2014)

- Active region
- Cut off region
- Saturation region

29. Input and output characteristics of CE, CB, CC?



30. Define JFET

A Junction field effect Transistor is a three terminal semiconductor device in which current conduction is by one type of carrier (i.e., either electron or holes)

31. Define channel.

It is a bar like structure which determines the type of FET. Different types of N channel are FET and P channel FET.

32. Explain the biasing of JFET.

Input is always reverse biased and output is forward biased. (Note: In transistor input is forward biased and output is reverse biased).

33. Define Drain(ON) resistance.

It is the ratio of change in Drain – source voltage (ΔVDS) to the change in Drain current (ΔID) at constant gate source voltage (VGS).

34. Define Tran conductance.

It is the ratio of change in drain current (ΔID) to the change in Gate – Source Voltage (ΔVGS) at constant Drain – Source voltage (VDS)

25. Write down the formula for Amplification factor.

Drain resistance X Tran conductance = Amplification factor.

$\mu = Ro \times gm$

36. Write the advantages of JFET.

1. Input impedance of JFET is very high. This allows high degree of Isolation between the Input and Output circuit.

2. Current carriers are not crossing the junction hence noise is reduced drastically

37. List the JFET parameters.

1. A.C drain resistance (rd)

2. Tran conductance (gm)

3. Amplification factor (μ)

38. Mention the two types of field effect transistors,

1. N-channel FET

2. P-channel FET

39. Define pinch off voltage. (MAY 2014)

As the reverse bias is further increased, the effective width of the channel decreases, the depletion region or the space charge region widens, reaching further into the channel and restricting the passage of electrons from the source to drain. Finally at a certain gate to source voltage VGS = VP.

40. Explain the depletion node of operation in MOSFET.

When the gate is at negative bias, the thickness of the depletion layer further increases owing to the further increase of the induced positive charge. Thus the drain current decreases, as the gate is made more negative. This is called depletion mode of operation.

41. Explain the term Drain in FET.

The drain is the terminal through which the current leaves the bar. Convention current entering the bar is designated as ID.

42. Explain the terms source in FET.

The source is the terminal through which the current enters the bar. Conventional current entering the bar is designated as IS.

43. Define the term Gate in FET.

The gate consists of either P+ or N+ impurity regions, heavily doped and diffused to the bar. This region is always reverse biased and in fact, controls the drain current ID.

44. Write the relative disadvantages of an FET over that of a BJT.

- The gain bandwidth product in case of a FET is low as compared with a BJT.
- The category, called MOSFET, is extremely sensitive to handling therefore additional precautions have to be considered while handling.

45. Mention the methods used for biasing circuits in FET.

- Self-bias.
- Potential divider bias.

46. Mention the difference between FETs and MOSFETs.

Symbol	**JFET**	**MOSFET**
gm	1000 to 25,000 μmhoms	1000 to 20,000 pmhog
rd	0.1 to 1MΩ	1 to 50KΩ
IGSS	0.1 to 10nA	0.1 to 10nA
-ras	>109Ω	>101313Ω
Crss or Cgd	1 to 4Pf	0.005 to 1Pf

47. Explain the term MOSFET.

In the insulated gate FET, conductivity is controlled by the potential on the insulated metal plate lying on the top of the channel the insulated gate field effect transistor is often called metallic oxide semiconductor FET.

48. List some applications of JFETs.

- Used as buffers in measuring equipment, receivers and other general purpose devices.
- Used in RF amplifiers of FM tuners and communication equipment.
- Used in mixer circuits in FM and TV receivers and communication equipment.

- Used in cascade amplifiers in measuring and test equipment.
- Used as voltage variable resistor (VVR) in OP-AMPs and tone controls.
- Used in hearing aids and inductive transducers.
- Used in oscillator circuits.
- As the physical size is small; it finds use in digital circuits in computers, large scale integration (LSI) and memory circuits.

49.What is UJT?

A **unijunction transistor** (**UJT**) is an electronic semiconductor device that has only one junction. The UJT has three terminals: an emitter (E) and two bases (B1 and B2). The base is formed by lightly doped n-type bar of silicon. Two ohmic contacts B1 and B2 are attached at its ends. The emitter is of p-type and it is heavily doped. The resistance between B1 and B2, when the emitter is open-circuit is called inter base resistance.

50. Intrinsic standoff ratio in UJT? (NOV 2013)

The connections at the ends of the bar are known as bases B1 and B2; the P-type mid-point is the emitter. With the emitter disconnected, the total resistance R_{BBO}, a datasheet item, is the sum of R_{B1} and R_{B2} as. R_{BBO} ranges from 4-12kΩ for different device types. The intrinsic standoff ratio η is the ratio of R_{B1} to R_{BBO}. It varies from 0.4 to 0.8 for different devices.

51. Define latching current of SCR. [Nov/Dec 2012] (MAY2015)

The latching current is defined as the minimum value of anode current which it must attain during turn on process to maintain conduction when gate signal is removed.

52. What are the factors that influence the turn-off time of thyristor? [Nov/Dec 2010]

1. Recovery Process 2. Recombination Process

53. **What are the parameters involved in switching loss of power device? [April/May 2011]**

- Forward conduction loss
- Loss due to leakage current during forward and reverse blocking
- Switching losses at turn-on and turn-off.
- Gate triggering loss.

54. Why are IGBT becoming popular in their application to controlled converters?

- Lower hate requirements
- Lower switching losses
- Smaller snubber circuit requirements

55. In TRIAC which of the modes the sensitivity of gate is high.

The more sensitive of the triac is greatest in the first quadrant when turned on with positive gate current and also in the third quadrant when turned on with negative gate current.

56. How can a thyristor turned off?

A thyristor can be turned off by making the current flowing through it to a level below the holding current.

57. Define holding current. (NOV 2013)

The holding current is defined as the minimum value of anode current below which it must fall to for turning off the thyristor.

58. Write down the applications of IGBT?

- AC and DC motor drives
- UPS systems
- Power supplies
- Relays and Contactors

59.IGBT is a voltage controlled device. Why?

IGBT is a voltage controlled device because the controlling parameter is gate emitter voltage VGE

60. Application of UJT?

- Trigger device for SCRs and TRIACs
- Non sinusiodal oscillators
- Saw tooth generators
- Timing circuits

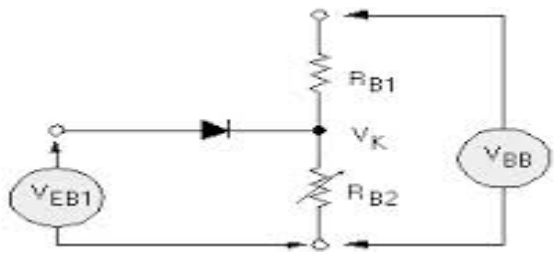
61. Special features of FET?

- Voltage control device
- Input resistance is very high
- High switching speed

62. Compare JFET with BJT?

JFET	BJT
1.Voltage control device 2.Unipolar device 3.Gate,source,drain	Current controlled device Bipolar device Emitter,base,collector

63. Draw Equivalentcircuit of UJT?



16 MARK

1. Draw and explain the Input and Output characteristics of a BJT in CE configuration. **(NOV 2013) (NOV 2013)**
2. Describe the static input and output characteristics of a CB transistor with neat circuit diagram.
3. Distinguish clearly the difference between JFET and MOSFET?
4. Explain the construction of N channel JFET. Also explain the drain and transfer characteristics of the same.
5. Explain the construction and working of enhancement MOSFET and depletion MOSFET. Draw the characteristics **(MAY 2014) (NOV 2013) (MAY 2015)**
6. Explain the operation of IGBT with the help of neat structural diagram and suitable wave forms
7. Explain the construction, equivalent circuit and operation of UJT. Draw the characteristics of UJT. **(NOV 2013) (NOV 2012) (MAY 2015)**
8. Explain the operation and characterstics of SCR
9. Explain the operation and characterstics of TRIAC
10. Compare CE, CB, and CC. **(MAY 2014)**