



CAPITAL UNIVERSITY - KODERMA

ANALOG ELECTRONIC CIRCUIT -1 ASSIGNMENT

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1. What do you mean by thermal runaway?

Thermal runaway describes a process that is accelerated by increased temperature,

in turn releasing energy that further increases temperature. Thermal runaway occurs

in situations where an increase in temperature changes the conditions in a way that

causes a further increase in temperature, often leading to a destructive result. It is a

kind of uncontrolled positive feedback. thermal runaway is typically associated with

increased current flow and power dissipation.

2. Illustrate the main idea of compensation techniques.

A compensator is a component in the control system and it is used to regulate

another system. In most of the time, it is done by conditioning the input or the

output to that system. There are three types of compensators: lag, lead and lag-lead

compensators.

Adjusting a control system in order to improve its performance might lead to

unexpected behaviour (e.g. poor stability or even instability by increasing the gain

value). In order to make the system behave as desired, it is necessary to redesign the

system and add a compensator, a device which compensates for the deficient

performance of the original system.

3. Summarize the concept of operating point.

In an electronic amplifier, an operating point is a combination of current and

voltage at "no signal" conditions; application of a signal to the stage - changes

voltage and current in the stage. The operating point in an amplifier is set by the

intersection of the load line with the non-linear characteristics of the device.

By

adjusting the bias on the stage, an operating point can be selected that maximizes

the signal output of the stage and minimizes distortion.

4. Build the fixed bias single stage transistor circuit.

The single stage transistor amplifier consists of a single npn transistor T1 (BC547),

four resistors R_1 , R_2 , R_c and R_e , two coupling capacitors C_1 and C_2 , one bypass

capacitor C_e connected across emitter resistor R_e

$+V_{cc}$ is the supply voltage, V_i the input signal and V_o the output signal. I_1 , I_2 , I_c and

I_e , as shown in the figure, are DC currents. Resistors R_1 , R_2 and R_e are used to

provide proper voltages to base b, emitter e and collector c of T1, so that base-emitter junction is forward-biased and base-collector junction is reverse-biased.

Collector resistor R_c is used as the load that provides output voltage V_o .

Bypass

capacitor C_e is used to bypass the AC audio-frequency signal towards the ground so

that constant DC emitter voltage V_e is maintained to prevent negative feedback in the

amplifier. Coupling capacitors C_1 and C_2 are used to block the DC signal and pass the

AC signal.

5. How would you adapt a D.C load line in fixed bias amplifier circuit?

The load line analysis of transistor means for the given value of collector-emitter voltage we find the value of collector current. This can be done by plotting

the output characteristic and then determine the collector current I_C with respect to

collector-emitter voltage V_{CE} . The load line analysis can easily be obtained by

determining the output characteristics of the load line analysis methods.

The DC load represents the desirable combinations of the collector current and the

collector-emitter voltage. It is drawn when no signal is given to the input, and the

transistor becomes bias.

ANSWER ANY 2 QUESTION

1. Demonstrate the Stability factor for voltage divider bias circuit and give reason why it is advantageous than fixed bias circuit.

Among all the methods of providing biasing and stabilization, the voltage divider bias

method is the most prominent one. Here, two resistors R_1 and R_2 are employed,

which are connected to VCC and provide biasing. The resistor R_E employed in the

emitter provides stabilization.

The name voltage divider comes from the voltage divider formed by R_1 and R_2 . The

voltage drop across R_2 forward biases the base-emitter junction. This causes the

base current and hence collector current flow in the zero signal conditions.

The equation for Stability factor of this circuit is obtained as

$$\text{Stability Factor} = S = (\beta + 1) \frac{(R_o + R_3) R_o + R_E + \beta R_E}{R_o + R_E + \beta R_E}$$

$$= (\beta + 1) \times \frac{1 + R_o R_E}{\beta + 1 + R_o R_E}$$

Where

$$R_o = R_1 R_2 / (R_1 + R_2)$$

If the ratio R_o/R_E is very small, then R_o/R_E can be neglected as compared to 1 and the

stability factor becomes

$$\text{Stability Factor} = S = (\beta + 1) \times \frac{1}{\beta + 1} = 1$$

This is the smallest possible value of S and leads to the maximum possible thermal

stability.

Advantage of voltage divider bias circuit is

In voltage divided bias adopted for BJT the divider gives a fixed bias voltage and fixed

input resistance. More over the emitter has a resistor. When the beta of the transistor changes the base current changes to compensate thus the change in

operating point is less

2. With neat diagrams, how would you show two bias compensation techniques and state its advantages and disadvantages.
3. Relate the various methods of biasing using BJT in terms of their stability factors.

Base Resistor Method

In this method, a resistor R_B of high resistance is connected in base, as the name implies. The required zero signal base current is provided by V_{CC} which flows

through R_B . The base emitter junction is forward biased, as base is positive with

respect to emitter.

The required value of zero signal base current and hence the collector current

(as $I_C = \beta I_B$) can be made to flow by selecting the proper value of base resistor R_B .

Hence the value of R_B is to be known.

Stability factor

$$S = \beta + 1 - \beta(dI_B/dI_C)$$

In fixed-bias method of biasing, I_B is independent of I_C so that,

$$dI_B/dI_C = 0$$

Substituting the above value in the previous equation,

$$\text{Stability factor, } S = \beta + 1$$

Thus the stability factor in a fixed bias is $(\beta + 1)$ which means that I_C changes $(\beta + 1)$ times as

much as any change in I_{CO} .

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Voltage Divider Bias Method

Among all the methods of providing biasing and stabilization, the voltage divider bias

method is the most prominent one. Here, two resistors R_1 and R_2 are employed,

which are connected to V_{CC} and provide biasing. The resistor R_E employed in the

emitter provides stabilization.

The name voltage divider comes from the voltage divider formed by R_1 and R_2 . The

voltage drop across R_2 forward biases the base-emitter junction. This causes the base

current and hence collector current flow in the zero signal conditions. The figure

below shows the circuit of voltage divider bias method.

Stability Factor

The equation for Stability factor of this circuit is obtained as

$$\text{Stability Factor} = S = (\beta + 1)(R_1 + R_2)R_E + \beta R_E$$

$$= (\beta + 1) \times \frac{R_1 + R_2}{\beta + 1 + R_1/R_E + R_2/R_E}$$

Where

$$R_o = R_1 R_2 / (R_1 + R_2)$$

If

the ratio R_o/R_E is very small, then R_o/R_E can be neglected as compared to 1 and the

stability factor becomes

$$\text{Stability Factor} = S = (\beta + 1) \times 1 / (\beta + 1) = 1$$

This is the smallest possible value of S and leads to the maximum possible thermal

stability.

4. Analyze various techniques of stabilization of Q-point in a transistor
5. Elaborate the various techniques that use temperature sensitive devices to maintain constant operating point and explain in detail.

PART II

ANSWER ALL QUESTION

1. Define Bypass and Coupling Capacitor.

The Bypass capacitor is used to prevent noise from entering the system by bypassing it to the

ground. The bypass capacitor is placed between the pins of supply voltage (V_{cc}) and Ground (GND)

in order to reduce both Power supply noise and the result of spikes on the supply lines.

A coupling capacitor is used to connect two circuits such that only the AC signal from the first circuit

can pass through to the next while DC is blocked. This technique helps to isolate the DC bias settings

of the two coupled circuits.

2. Summarize the amplifiers classification according to the input?

The electronic amplifier uses only one variable i.e. current or voltage. It may be current or

voltage can be used in the input or either in the output. There are four types of amplifiers and

which are dependent on the source used as a linear analysis.

Input output Dependent source Amplifier type Gain Units

I I

Current Controlled Current

Source CCCS Current Amplifier Unitless

I V

Current Controlled Voltage

Source CCVS

Trans resistance

Amplifier Ohm

V I

Voltage Controlled Current

Source VCCS

Trans Conductance

Amplifier Siemens

V V

Voltage Controlled Voltage

Source VCVS Voltage Amplifier Unitless

3. Discuss about Power Gain.

The power gain of an electrical network is the ratio of an output power to an input

power. Unlike other signal gains, such as voltage and current gain, "power gain" may

be ambiguous as the meaning of terms "input power" and "output power" is not

always clear. Three important power gains are operating power gain, transducer

power gain and available power gain.

3. List the various methods of improving CMRR.

Methods to improve CMRR in Differential Amplifier:

I. Use of constant current bias

II. Use of current mirror circuit

The circuit in which the output current is forced to equal the input current is said to be a current mirror circuit. Thus in a current mirror circuit, the output current is a mirror image of the input current.

4. Design a cascade amplifier and its ac equivalent circuit

A cascade amplifier is a two-port network designed with amplifiers which are

connected in series when every amplifier transmits its o/p to the second amplifiers

input in a daisy chain. The problem in measuring the gain of the cascaded stage is the

non-perfect coupling among two stages because of loading. The circuit can be

designed with two configurations of a transistor namely CE (common-emitter) and

CB (common base). The CB (common base) configuration provides a good high-frequency operation. The current gain, as well as the i/p resistance of the cascade

arrangement, is equivalent to the related value of a common emitter single-stage

amplifier. The o/p resistance can be equivalent to the common base configuration.

The miller's capacitor shunting the common emitter input stage is extremely small.

PART IIA

ANSWER ANY 2 QUESTION

1. Find the gain, input and output resistance of common emitter amplifier with a

neat circuit diagram and equivalent circuit.

The common emitter amplifier is a three basic single-stage bipolar junction transistor

and is used as a voltage amplifier. The input of this amplifier is taken from the base

terminal, the output is collected from the collector terminal and the emitter terminal

is common for both the terminals. The basic symbol of the common emitter amplifier

is shown below.

Working of Common Emitter Amplifier

The above circuit diagram shows the working of the common emitter amplifier

circuit and it consists of voltage divider biasing, used to supply the base bias voltage

as per the necessity. The voltage divider biasing has a potential divider with two

resistors are connected in a way that the midpoint is used for supplying base bias

voltage.

There are different types of electronic components in the common emitter amplifier

which are R_1 resistor is used for the forward bias, the R_2 resistor is used for the

development of bias, the R_L resistor is used at the output it is called the load resistance. The R_E resistor is used for thermal stability. The C_1 capacitor is used to

separate the AC signals from the DC biasing voltage and the capacitor is known as the

coupling capacitor.

The figure shows that the bias vs gain common emitter amplifier transistor characteristics if the R_2 resistor increases then there is an increase in the forward

bias and R_1 & bias are inversely proportional to each other. The alternating current is

applied to the base of the transistor of the common emitter amplifier circuit then

there is a flow of small base current. Hence there is a large amount of current flow

through the collector with the help of the R_C resistance. The voltage near the

resistance R_C will change because the value is very high and the values are from 4 to

10k Ω . Hence there is a huge amount of current present in the collector circuit

which amplified from the weak signal, therefore common emitter transistors work as

an amplifier circuit.

Voltage Gain of Common Emitter Amplifier

The current gain of the common emitter amplifier is defined as the ratio of change in

collector current to the change in base current. The voltage gain is defined as the

product of the current gain and the ratio of the output resistance of the collector to

the input resistance of the base circuits. The following equations show the mathematical expression of the voltage gain and the current gain.

$$\beta = \Delta I_c / \Delta I_b$$

$$A_v = \beta R_c / R_b$$

Circuit Elements and their Functions

The common emitter amplifier circuit elements and their functions are discussed

below.

Biasing Circuit/ Voltage Divider

The resistances R_1 , R_2 , and R_E used to form the voltage biasing and stabilization

circuit. The biasing circuit needs to establish a proper operating Q-point otherwise, a

part of the negative half cycle of the signal may be cut-off in the output.

CE Amplifier Circuit Currents

Base current $i_B = I_B + i_b$ where,

I_B = DC base current when no signal is applied.

i_b = AC base when AC signal is applied and i_B = total base current.

Collector current $i_C = I_C + i_c$ where,

i_C = total collector current.

I_C = zero signal collector current.

i_c = AC collector current when the AC signal is applied.

Emitter Current $i_E = I_E + i_e$ where,

I_E = Zero signal emitter current.

i_e = AC emitter current when AC signal is applied.

i_E = total emitter current.

2. Summarize the gain, input impedance and output impedance of single stage BJT

amplifier using mid band analysis.

3. What is CMRR? Derive CMRR of differential amplifier with its equivalent circuit.

The common mode rejection ratio (CMRR) of a differential amplifier is a metric used to quantify the ability of the device to reject common-mode signals, i.e.

those that appear simultaneously and in-phase on both inputs. An ideal differential

amplifier would have infinite CMRR, however this is not achievable in practice. A high

CMRR is required when a differential signal must be amplified in the presence of a

possibly large common-mode input, such as strong electromagnetic interference

(EMI). An example is audio transmission over balanced line in sound reinforcement

or recording.

4. Examine the circuit diagram for a differential amplifier using BJT's. Describe

common mode and differential modes of working.

5. Discuss about the classification of differential amplifiers using BJT

The simplest form of differential amplifier can be constructed using Bipolar Junction

Transistors as shown in the below circuit diagram. It is constructed using two

matching transistors in common emitter configuration whose emitters are tied

together.

Configurations

Based on the methods of providing input and taking output, differential amplifiers

can have four different configurations as below.

Single Input Unbalanced Output

Single Input Balanced Output

Dual Input Unbalanced Output

Dual Input Balanced Output

Single Input Unbalanced Output

In this case, only one input signal is given and the output is taken from only one of

the two collectors with respect to ground

Single Input Balanced Output

As above only one input signal is given even though the output is taken from both

collectors.

This will give us more amplified version of output as it is combining the effect of both

transistors. There won't be any unnecessary dc content in balanced output as the dc

contents in both outputs gets canceled each other.

Dual Input Unbalanced Output

Both inputs are given in this case ie, differential input but the output is taken from

only one of the two collectors with respect to ground

Amplified version of difference in both signals will be available at the output. The

voltage gain is half the gain of the dual input, balanced output differential amplifier.

Unbalanced output will contain unnecessary dc content as it is a dc coupled amplifier

therefore this configuration should follow by a level translator circuit.

PART III

ANSWER ALL QUESTION

1. List the advantages of common drain amplifier.

The common drain or source follower circuit is able to provide a very high input

impedance and low output impedance and is used to act as a buffer amplifier. The

like the transistor emitter follower, the FET source follower configuration itself

provides a high level of buffering and a high input impedance.

2. Can you recall voltage swing limitation in JFET?

The output stage voltage swing limitation is caused by the saturation and diode

voltage drops on internal transistors. CMOS amplifiers tend to have better output

voltage swing limitations, because CMOS transistors can have lower saturation

voltages.

3. Define rise time and give the relation between bandwidth and rise time.

when describing a voltage or current step function, rise time is the time taken by

a signal to change from a specified low value to a specified high value. These values

may be expressed as ratios or, equivalently, as percentages with respect to a given

reference value.

Rise time and bandwidth are two closely-related parameters used to describe the

limit of a system's ability to respond to abrupt changes in an input signal.

Rise time

and bandwidth are inversely proportional, with a proportionality constant of ~ 0.35

when the system's response resembles that of an RC low-pass filter. Having a

mathematical expression relating the two is useful, since it is possible that only one

of these parameters is known or can be found using available resources.

Rise time is measured with respect to time, while bandwidth is measured with

respect to electrical frequency. Rise time is the time separating two points on the rising edge of the signal output in response to an input step function. The bandwidth is found by referencing the system's frequency response. The inversely proportional relationship between rise time and bandwidth can be derived by considering the time and frequency response of an ideal RC low-pass filter, which consists of a resistor and capacitor in series.

5. Explain the importance of multistage amplifiers.

In practical applications, the output of a single stage amplifier is usually insufficient, though it is a voltage or power amplifier. Hence they are replaced by Multi-stage transistor amplifiers.

In Multi-stage amplifiers, the output of first stage is coupled to the input of next stage using a coupling device. These coupling devices can usually be a capacitor or a transformer. This process of joining two amplifier stages using a coupling device can be called as Cascading.

5. Why N channel FET's are preferred over P channel FET's?

N channel means flow of free electrons whereas P channel means flow of holes. The mobility of electrons is twice that of mobility of holes. As current is rate of

flow of electric charge. Hence more the speed of charge, more is the current, more is

the power. To make the speed of holes equal to that of electrons for specific dimensions of device, one has to increase the length and width of P-channel device. Therefore, N-channel device with comparatively small dimension to that of P-channel device, having greater speed of flow of charge, is preferred.

PART IIIA

ANSWER ANY 2 QUESTION

1. Explain the expression for common gate circuit of JFET.

The common-gate FET amplifier configuration is comparable to the common-base BJT

amplifier. Like the CB, the common-gate (CG) amplifier has a low input resistance. This is different from the CS and CD configurations, which have very

high input resistances

Common-Gate Amplifier Operation A self-biased common-gate amplifier is shown in

figure. The gate is connected directly to ground. The input signal is applied at the

source terminal through C_1 . The output is coupled through C_2 from the drain terminal.

Voltage Gain The voltage gain from source to drain is developed as follows:

Where $R_d = R_D \parallel R_L$.

Notice that the gain expression is the same as for the common-source JFET amplifier.

Input Resistance As you have seen, both the common-source and common-drain

configurations have extremely high input resistances because the gate is the input

terminal. In contrast, the common-gate configuration where the source is the input

terminal has a low input resistance. This is shown as follows. First, the input current

is equal to the drain current

Second, the input voltage equals V_{gs} .

Therefore, the input resistance at the source terminal is

2. What is JFET amplifier? Derive gain, input and output impedance of common

source JFET amplifier with neat circuit diagram and equivalent circuit.

A JFET is a three terminal semiconductor device in which current conduction is

by one type of carrier i.e. electrons or holes. The current conduction is controlled by

means of an electric field between the gate and the conducting channel of the

device. The JFET has high input impedance and low noise level.

A common-source JFET amplifier is one in which the ac input signal is applied to the gate and the ac output signal is taken from the drain. The source terminal is common to both the input and output signal. A common-source amplifier either has no source resistor or has a bypassed source resistor, so the

source is connected to ac ground. A self-biased common-source n-channel JFET

amplifier with an ac source capacitively coupled to the gate is shown in Figure

below. The resistor, R_G , serves two purposes: It keeps the gate at approximately 0 V

dc (because I_{GSS} is extremely small), and its large value (usually several megohms)

prevents loading of the ac signal source. A bias voltage is produced by the drop

across R_S . The bypass capacitor, C_2 , keeps the source of the JFET at ac ground.

The input signal voltage causes the gate-to-source voltage to swing above and

below its Q-point value (V_{GSQ}), causing a corresponding swing in drain current. As

the drain current increases, the voltage drop across R_D also increases, causing the

drain voltage to decrease. The drain current swings above and below its Q-point value in phase with the gate-to-source voltage. The drain-to-source voltage swings above and below its Q-point value (V_{DSQ}) and is 180° out of phase

with the gate-to-source voltage, as illustrated in Figure above. A Graphical Picture

The operation just described for an n-channel JFET is illustrated graphically on

both the transfer characteristic curve and the drain characteristic curve in

Figure below. Part (a) shows how a sinusoidal variation, V_{gs} , produces a corresponding sinusoidal variation in I_d . As V_{gs} swings from its Q-point value to a

more negative value, I_d decreases from its Q-point value. As V_{gs} swings to a less

negative value, I_d increases. The signal at the gate drives the drain current above

and below the Q-point on the load line, as indicated by the arrows. Lines projected

from the peaks of the gate voltage across to the I_D axis and down to the V_{DS} axis

indicate the peak-to-peak variations of the drain current and drain-to-source voltage,

as shown. Because the transfer characteristic curve is nonlinear, the output will have

some distortion. This can be minimized if the signal swings over a limited portion of

the load line

AC Equivalent Circuit to analyze the signal operation of the amplifier in Figure

below, an ac equivalent circuit is as follows. Replace the capacitors by effective

shorts, based on the simplifying assumption that at the signal frequency. Replace

the dc source by a ground, based on the assumption that the voltage source has a zero internal resistance. The V_{DD} terminal is at a zero-volt ac potential and

therefore acts as an ac ground. The ac equivalent circuit is shown in Figure below.

Notice that the V_{DD} end of R_d and the source terminal are both effectively at ac

ground. Recall that in ac analysis, the ac ground and the actual circuit ground are

treated as the same point.

An ac voltage source is shown connected to the input in Figure above. Since the input

resistance to a JFET is extremely high, practically all of the input voltage from the

signal source appears at the gate with very little voltage dropped across the internal

source resistance.

Voltage Gain The expression for JFET voltage gain that was given in Equation below

applies to the common-source amplifier.

Phase Inversion The output voltage (at the drain) is out of phase with the input

voltage (at the gate). The phase inversion can be designated by a negative voltage gain, Recall that the common-emitter BJT amplifier also exhibited a phase

inversion.

Input Resistance is derived as follows, because the input to a common-source

amplifier is at the gate, the input resistance is extremely high. Ideally, it approaches infinity and can be neglected. As you know, the high input resistance is

produced by the reverse-biased PN junction in a JFET and by the insulated gate

structure in a MOSFET. The actual input resistance seen by the signal source is,

the gate-to-ground resistor, R_G , in parallel with the FET's input resistance, $V_{GS} I_{GSS}$.

The reverse leakage current, I_{GSS} , is typically given on the datasheet for a specific

value of V_{GS} so that the input resistance of the device can be calculated.

3. Demonstrate gain, input and output impedance of MOSFET source follower with

neat circuit diagram and equivalent circuit

4. Analyze a simple JFET source-follower amplifier circuit and discuss the general AC

circuit characteristics

5. Design and analyze the characteristics of BiCMOS cascode amplifier, and explain

graphically the amplification process in a simple MOSFET amplifier circuit.

PART IV

ANSWER ALL QUESTION

1. What is the effect of miller's capacitance on the frequency response of an amplifier?

The Miller effect accounts for the increase in the equivalent input capacitance of an inverting voltage amplifier due to amplification of the effect of capacitance between the input and output terminals. As most amplifiers are inverting the effective capacitance at their inputs is increased due to the Miller effect. This can reduce the bandwidth of the amplifier, restricting its range of operation to lower frequencies.

2. Can you recall the need of cascading multistage amplifiers?

For most systems a single transistor amplifier does not provide sufficient

gain or bandwidth or will not have the correct input or output impedance matching.

The solution is to combine multiple stages of amplification. We have the three basic

one transistor amplifier configurations to use as building blocks to create more

complex amplifier systems which can provide better optimized specifications and

performance.

3. What is the reason for reduction in gain for lower and higher frequencies in case of amplifiers?

The low input impedance offered by the capacitor $\{C\}$ present in the circuit and

also the transistor gain reduces the output at high frequency are the reason off gain

falling down at high frequencies.

The gain of capacitor goes low at lower frequencies due to the reactance that is

offered by Capacitor that is present in the coupling at this frequency in the circuit.

The gain throughout the range remains static and regular, changes occur only at

low and high frequency.

4. Create the hybrid π equivalent model of the BJT

Develop the high frequency equivalent circuit model for MOSFET

PART IVA

ANSWER ANY 2 QUESTION

1. Describe with neat diagram and derive the expression for cut off frequency of a

BJT.

2. Explain the upper and lower cut off frequencies of multistage amplifier with

expressions.

3. How would you describe the relation between rise time, upper cut off frequency

and

bandwidth?

4 Can you recall the operation of high frequency common source FET amplifier with

neat diagram?

This increase in input capacitance C_i over the capacitance from gate to source is

called Miller effect.

This input capacitance affects the gain at high frequencies in the operation of

cascaded amplifiers. In cascaded amplifiers, the output from one stage is used as the

input to a second amplifier. The input impedance of a second stage acts as a shunt

across output of the first stage and R_d is shunted by the capacitance C_i .

Output Admittance:

From above figure, the output impedance is obtained by looking into the drain with

the input voltage set equal to zero. If $V_i = 0$ in figure, r_d , C_{ds} and C_{gd} in parallel.

Hence the output admittance with R_L considered external to the amplifier is given by

4. Derive the expression for i) Voltage gain ii) Input admittance iii) input capacitance

iv) Output admittance.

5. Summarize the expressions for the short circuit current gain of common emitter

amplifier at a high frequency. Define alpha cut-off frequency, beta cut-off frequency

and transition frequency and derive their values in terms of the circuit parameters

PART V

ANSWER ALL QUESTION

1. Point out the advantages and disadvantages of linear power supply.

Advantages for linear mode power supplies include simplicity, reliability, low noise levels and low cost. These power supplies, also known as linear regulators

(LR), have a very simple design in that they require few components making it an

easy device for design engineers to work with. This simplistic design makes linear

power supplies more reliable because the low complexity level does not allow for

many issues to arise. A performance advantage to linear mode power supplies is that

they are relatively noise-free. Linear regulators have a low output voltage ripple

making them best suitable for applications where noise-sensitivity is essential. A final

advantage to linear power supplies is their overall cost-effectiveness because they

contain a low number of components making them a preferred power supply option

if a linear regulator solution suits the application's requirements.

2. Recall the concept of Voltage regulation.

Voltage regulation is a measure of change in the voltage magnitude between

the sending and receiving end of a component, such as a transmission or distribution

line. Voltage regulation describes the ability of a system to provide near constant

voltage over a wide range of load conditions. The term may refer to a passive

property that results in more or less voltage drop under various load conditions, or to

the active intervention with devices for the specific purpose of adjusting voltage.

3. Analyze the three importance of over voltage protection.

Protection from overvoltages and electromagnetic current peaks can be achieved by

using device protection products that are used between the power supply (socket)

and the device. Protective elements, such as voltage-dependent resistors and gas

discharge valves, are important components that ensure that dangerous

overvoltages are earthed in split seconds, thus ensuring that the destructive high

voltage cannot reach the protected devices.

Lightning strikes can lead to overvoltages in the power supply, which, in turn, can

lead to connected electrical appliances such as coffee and food processors, televisions, internet routers and computers being damaged.

The number of expensive electronic devices in private households has risen sharply

in the last few years. In addition, electric appliances are becoming ever smaller and

more powerful; however, they thus also react more sensitively to overvoltages.

The subsequent financial damage and hassle is great when expensive electric

appliances such as televisions, computers and food processors are damaged by

lightning strikes and overvoltages. To prevent these overvoltages, overvoltage

protection can reduce occurring voltage peaks to a level that is not dangerous for the

terminal device.

4. What is meant by switched mode power supply?

A switched-mode power supply (switching-mode power supply, switch-mode power

supply, switched power supply, SMPS, or switcher) is an electronic power supply that

incorporates a switching regulator to convert electrical power efficiently.

Like other power supplies, an SMPS transfers power from a DC or AC source (often

mains power, see AC adapter) to DC loads, such as a personal computer, while

converting voltage and current characteristics. Unlike a linear power supply, the pass

transistor of a switching-mode supply continually switches between low-dissipation,

full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode

power supply dissipates no power. Voltage regulation is achieved by varying the ratio

of on-to-off time (also known as duty cycles). In contrast, a linear power supply

regulates the output voltage by continually dissipating power in the pass transistor.

This higher power conversion efficiency is an important advantage of a switchedmode power supply.

5. Compare the SMPS with linear power supply.

| Parameters | Linear Power Supply | Switch Mode Power Supply (SMPS) |
|--------------------|--|--|
| Definition | It completes the stepping down of AC voltage first then it converts it into DC. It converts the input signal into DC first then it steps down the voltage up to desired level. | |
| Efficiency | Low efficiency i.e. about 20-25%(Linear Power Supply) | High Efficiency i.e. about 60-65%(SMPS) |
| Voltage Regulation | Voltage regulation is done by voltage regulator.(Linear Powersupply) | Voltage regulation is done feedback circuit.(SMPS) |

Magnetic material used Stalloy or CRGO core is used Ferrite core is used
Weight It is bulky. It is less bulky in comparison to linear power supply.

Reliability More reliable in comparison to SMPS.

its reliability depends on the transistors used for switching

Complexity Less complex than SMPS. More complex than Linear power supply.

Transient response It possess faster response. It possess slower response.

RF interference No RF interference RF shielding is required as switching produces more RF interference.

Noise and Electromagnetic interference It is immune to noise and electromagnetic interference. Effect of noise and electromagnetic interference is quite significant, thus EMI filters are required.

Applications

Used in Audio frequency

applications and RF

applications.

Used in chargers of mobile phones,

DC motors etc.

PART VA

ANSWER ANY 2 QUESTION

1. Define voltage regulation and describe about series voltage regulation.

Voltage regulation is a measure of change in the voltage magnitude between the

sending and receiving end of a component, such as a transmission or distribution

line. Voltage regulation describes the ability of a system to provide near constant

voltage over a wide range of load conditions. The term may refer to a passive

property that results in more or less voltage drop under various load conditions, or to

the active intervention with devices for the specific purpose of adjusting voltage.

The series voltage regulator or series pass voltage regulator uses a variable element

placed in series with the load. By changing the resistance of the series element, the

voltage dropped across it can be varied to ensure that the voltage across the load

remains constant.

Block diagram of a series voltage regulator - this basic concept is used in most linear

power supplies

The advantage of the series voltage regulator is that the amount of current drawn is

effectively that used by the load, although some will be consumed by any circuitry

associated with the regulator. Unlike the shunt voltage regulator, the series regulator

does not draw the full current even when the load does not require any current. As a

result the series voltage regulator is considerably more efficient.

Instead of drawing the current not required by the load to maintain the voltage, it

drops the voltage difference between the input voltage and the required stabilised

voltage.

To maintain a sufficient level of regulation and rejection of noise and transients that

may be on the incoming voltage, series linear voltage regulators need to drop a

significant voltage. Many high quality, low noise and ripple voltage regulators need

several volts across the series regulator element. This means that significant levels of

power may be dissipated in this component, and good heat sink and heat removal

capability is required for the series pass regulator device and also the power supply

as a whole.

Even though a series regulator is considerably more efficient than a shunt regulator,

it is considerably less efficient than a switch mode power supply. The efficiency of a

series voltage regulator and any linear power supplies using them will depend on the

load, etc, but often efficiency levels of less than 50% are achieved, whereas switch

mode power supplies can achieve levels greater than 90%.

Series voltage regulators have relatively low levels of efficiency when compared to a

switch mode power supply, but they have the advantages of simplicity and also their

output is free of the switching spikes seen on some switch mode supplies, although

SMPSs are improving and the performance of many is exceptionally good nowadays.

2. (i) What is rectifier? Explain in detail about the operation of half wave rectifier.

(ii) How would you explain about PIV in PN diode?

3. Recall the operation of switching voltage regulator.

A switching regulator rapidly switches a series device on and off. The switch's duty

cycle sets the amount of charge transferred to the load. This is controlled by a

feedback mechanism similar to that of a linear regulator. Switching regulators are

efficient because the series element is either fully conducting or switched off

because it dissipates almost no power. Switching regulators are able to generate

output voltages that are higher than the input voltage or of opposite polarity, unlike

linear regulators.

The switching voltage regulator switches on and off rapidly to alter the output. It

requires a control oscillator and also charges storage components.

In a switching regulator with Pulse Rate Modulation varying frequency, constant duty

cycle and noise spectrum imposed by PRM vary; it is more difficult to filter out that

noise.

A switching regulator with Pulse Width Modulation, constant frequency, varying duty

cycle, is efficient and easy to filter out noise.

In a switching regulator, continuous mode current through an inductor never drops

to zero. It allows the highest output power. It gives better performance.

In a switching regulator, discontinuous mode current through the inductor drops to

zero. It gives better performance when the output current is low.

Switching Topologies

It has two types of topologies: Dielectric isolation and Non- isolation.

Isolated

It is based on radiation and intense environments. Again, isolated converters are

classified into two types which include the following.

Flyback Converters

Forward Converters

In the above listed isolated converters are discussed in the switched-mode power

supply topic.

Non –Isolation

It is based on small changes in V_{out}/V_{in} . Examples are Step Up voltage regulator

(Boost) – Raises input voltage; Step Down (Buck) – lowers input voltage; Step up/

Step Down (boost/ buck) Voltage regulator – Lowers or raises or inverts the input

voltage depending on the controller; Charge pump – It provides multiples of input

without using an inductor.

Again, non-isolated converters are classified into different types however the

significant ones are

Buck Converter or Step-down Voltage Regulator

Boost Converter or Step-up Voltage Regulator

Buck or Boost Converter

Step-up switching converters also called boost switching regulators, provide a higher

voltage output by raising the input voltage. The output voltage is regulated, as long

as the power is drawn is within the output power specification of the circuit. For

driving strings of LEDs, Step up Switching voltage regulator is used.

Assume Lossless circuit $P_{in} = P_{out}$ (input and output powers are same)

Then $V_{in} I_{in} = V_{out} I_{out}$,

$$I_{out} / I_{in} = (1-D)$$

From this, it is inferred that in this circuit

Powers remain the same

Voltage increases

Current decreases

Equivalent to DC transformer

Step Down (Buck) Voltage Regulator

It lowers the input voltage.

Step Down Voltage Regulators

Step Down Voltage Regulators

If input power is equal to output power, then

$$P_{in} = P_{out}; V_{in} I_{in} = V_{out} I_{out},$$

$$I_{out} / I_{in} = V_{in} / V_{out} = 1/D$$

Step down converter is equivalent to DC transformer wherein the turns ratio is in the

range of 0-1.

Step Up/Step Down (Boost/Buck)

It is also called a Voltage inverter. By using this configuration, it is possible to raise,

lower or invert the voltage as per the requirement.

The output voltage is of the opposite polarity of the input.

This is achieved by VL forward- biasing reverse-biased diode during the off times,

producing current and charging the capacitor for voltage production during the off

times

By using this type of switching regulator, 90% efficiency can be achieved.

4. Illustrate the shunt voltage regulator and also explain the illustration of shunt

voltage regulator using op – amp.

5. Summarize and show necessary diagram of current flow during positive and

negative half cycle in full wave rectifie