Department of Electrical Engineering
Assignment
Date: 24/06/2020

Course Details

Course Title: Electronic Circuit Design **Module:** 04
Instructor: ______ **Total Marks:** 50

Student Details

Name: ______ **Student ID:** ______

Q1.	(a)	**Discuss** the darlington connection for multistage amplifiers.	Marks 05+10
	(b)	The input of a certain regulator increases by 4.5 V. As a result, the output voltage increases by 0.062 V. The nominal output is 40 V. **Evaluate** the line regulation in both % and in %/V	CLO 2
Q2.		**Explain** Colpitts and Hartley oscillators.	Marks 10
			CLO 2
Q3.	(a)	**Describe** the idea behind class B amplifiers.	Marks 06+06
	(b)	**Explain the** types of voltage regulators and their purposes.	CLO 2
Q4.		**Explain** the working of Flash ADC.	Marks 05
			CLO 2
Q5.		**Differentiate** between the following:	Marks
	(a)	Low pass & high pass filters	04+04
	(b)	Active and passive filters	CLO 2

<u>**Department of Electrical Engineering**</u>

Course Title: Electronic Circuit Design

Module: 4^{th} semester

<u>**Student Detail**</u>

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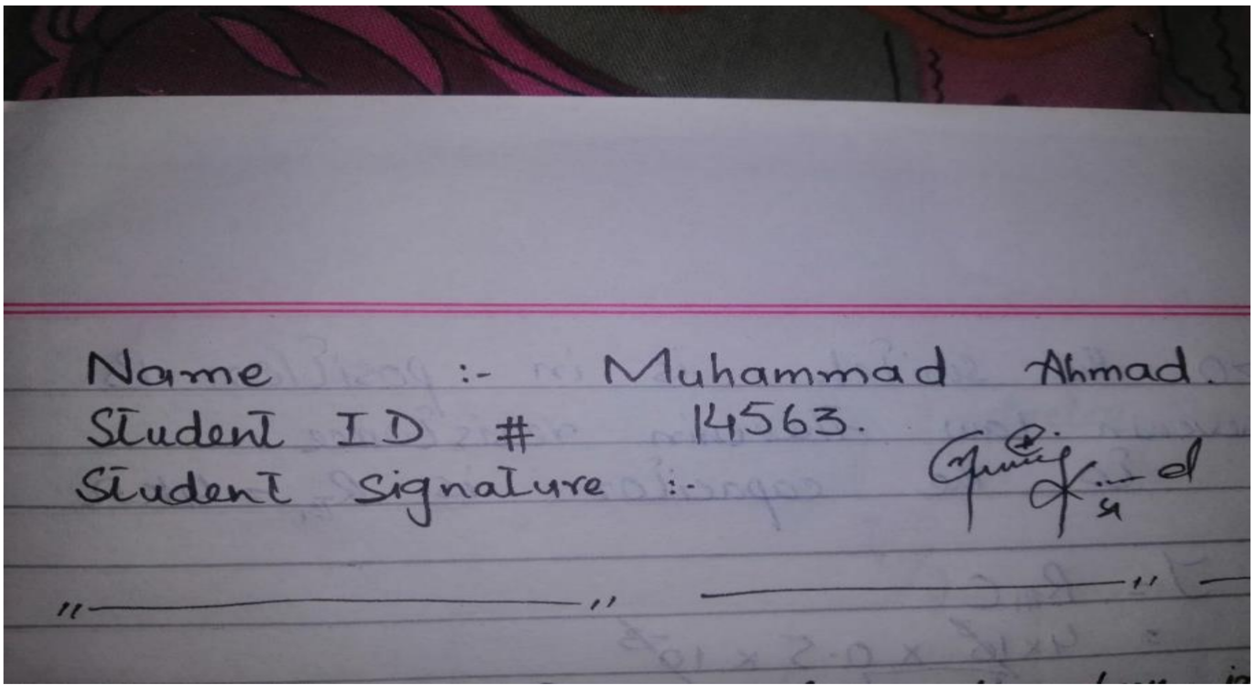
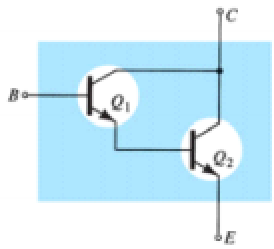


Qno 1= Discuss the Darlington connection for multistage amplifiers.
Ans # <u>Multistage Amplifier for Darlington connection</u>

A very popular connection of two bipolar junction transistors for operation as one "superbeta" transistor is the Darlington connection shown in Fig.1 . The main feature of the Darlington connection is that the composite transistor acts as a single unit with a current gain that is the product of the current gains of the individual transistors. If the connection is made using two separate transistors having current gains of β_1 and β_2, the Darlington connection provides a current gain of $\beta_D = \beta_1\beta_2$.
with Darlington connection we have better buffering (barrier between input and output) in addition to high current (I).



Qno 1(b)=The input of a certain regulator increases by 4.5 V. As a result, the output voltage increases by 0.062 V. The nominal output is 40 V. Evaluate the line regulation in both % and in %/V

Ans ;

Solution;

Find Line regulation in both % and in %/V?

Line regulation $= \frac{0.062v}{4.5v} \times 100\%$

=1.38%

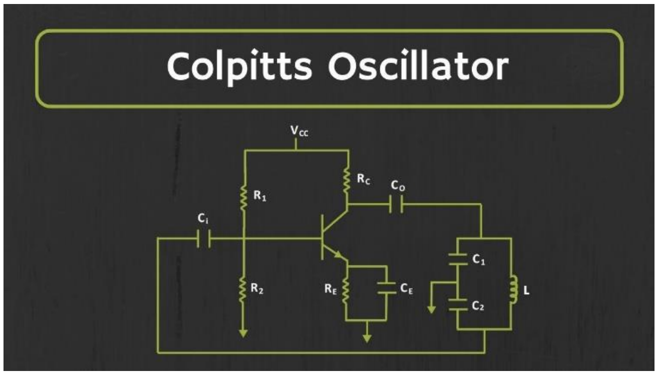
Line regulation$= \frac{(\frac{0.062}{40})\times 100}{4.5}$

=0.0344%/V

Q2.Explain Colpitts and Hartley oscillators.

Answer = Colpitts Oscillator

Colpitts Oscillator is a type of LC oscillator which falls under the category of Harmonic Oscillator and was invented by Edwin Colpitts in 1918. Figure 2 shows a typical Colpitts oscillator with a tank circuit in which an inductor L is connected in parallel to the serial combination of capacitors C1 and C2 .

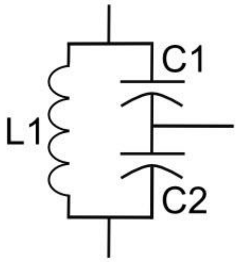


Colpitts oscillator

Other components in the circuit are the same as that found in the case of common-emitter CE which is biased using a voltage divider network i.e. RC is the collector resistor, RE is the emitter resistor which is used to stabilize the circuit and the resistors R1 and R2 form the voltage divider bias network. Further, the capacitors Ci and Co are the input and output decoupling capacitors while the emitter capacitor CE is the bypass capacitor used to bypass the amplified AC signals.

Colpitts Oscillator Working

Whenever power supply is switched on, the capacitors C1 and C2 shown in the above circuit start charging and after the capacitors get fully charged, the capacitors starts discharging through the inductor L1 in the circuit causing damped harmonic oscillations in the tank circuit. Thus, an AC voltage is produced across C1 & C2 by the oscillatory current in the tank circuit. While these capacitors get fully discharged, the electrostatic energy stored in the capacitors get transferred in the form of magnetic flux to the inductor and thus inductor gets charged.



Similarly, when the inductor starts discharging, the capacitors start charging again and this process of energy charging and discharging capacitors and inductor continues causing the generation of oscillations and the frequency of these oscillations can be determined by using the resonant frequency of the tank circuit consisting of inductor and capacitors. This tank circuit is considered as the energy reservoir or energy storage. This is because of frequent energy charging and discharging of the inductor, capacitors that part of LC network forming the tank circuit.

The resonant frequency is given by

$f_r=1/(2\Pi\sqrt{(L1*C)})$

Where f_r is the resonant frequency

C is the equivalent capacitance of series combination of C1 and C2 of the tank circuit

It is given as

C=(C1*C2)/((C1+C2))

L1 represents the self inductance of the coil.

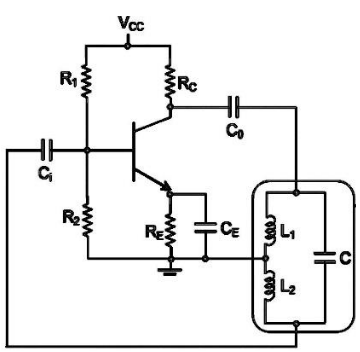
Applications of Colpitts Oscillator

- It is used for generation of sinusoidal output signals with very high frequencies.
- The Colpitts oscillator using SAW device can be used as the different type of sensors such as temperature sensor. As the device used in this circuit is highly sensitive to perturbations, it senses directly from its surface.
- It is frequently used for the applications in which very wide range of frequencies are involved.
- Used for applications in which undamped and continuous oscillations are desired for functioning.
- This oscillator is preferred in situations where it is intended to withstand high and low temperatures frequently.
- It is used for the development of mobile and radio communications.
- It has many applications used for the commercial purposes.

Hartley oscillator

Hartley oscillator was invented in 1915 by the American engineer Ralph Hartley while he was working for the Western Electric company. The original design was tube based and he got a patent for it in the year 1920.

In a Hartley oscillator the oscillation frequency is determined by a tank circuit comprising of two inductors and one capacitor. The inductors are connected in series and the capacitor is connected across them in parallel. Hartley oscillators are commonly used in radio frequency (RF) oscillator applications and the recommended frequency range is from 20KHz to 30MHz. Hartley oscillators can be operated at frequencies lower than 20KHz, but for lower frequencies the inductor value need to be high and it has a practical limit. The circuit diagram of a typical Hartley oscillator is shown in the figure below



Hartley Oscillator Circuit and Working

The circuit diagram of a Hartley oscillator is shown in the below figure. An NPN transistor connected in a common emitter configuration works as the active device in amplifier stage. R1 and R2 are biasing resistors and RFC is the radio frequency choke, which provides the isolation between AC and DC operation. At high frequencies, the reactance value of this choke is very high, hence it can be treated as an open circuit. The reactance is zero for DC condition, hence causes no problem for DC capacitors. The CE is the emitter bypass capacitor and RE is also be a biasing resistor. The CC1 and CC2 are the coupling capacitors. When the DC supply (Vcc) is given to the circuit, the collector current starts raising and begins with the charging of the capacitor C. Once capacitor C is fully charged, it starts discharging through L1 and L2 and again starts charging.This back-and-fourth voltage waveform is a sine wave which is a small and leads with its negative alteration. It will eventually die out unless it is amplified.

The frequency of oscillations in this circuit is

fo = 1/ (2π √ (Leq C))

Where Leq is the total inductance of coils in the tank circuit is given as

Leq = L1 + L2 + 2M

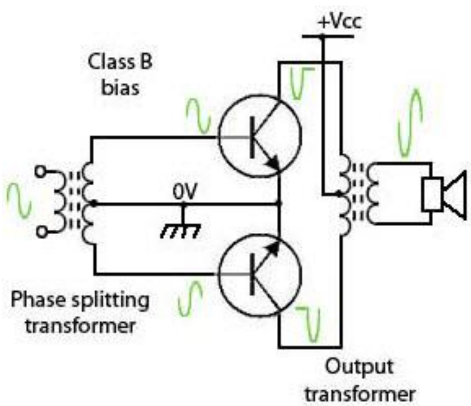
Applications

- The Hartley oscillator is to produce a sine wave with the desired frequency
- Hartley oscillators are mainly used as radio receivers. Also note that due to its wide range of frequencies, it is the most popular oscillator
- The Hartley oscillator is Suitable for oscillations in RF (Radio-Frequency) range, up to 30MHZ

Qno 3 = Describe the idea behind class B amplifiers.

Class B Amplifier

The class B amplifiers are the positive and negative halves of the signals, that are allocated to the different parts of the circuits and the output device switched ON and OFF continuously. The basic class B amplifiers are used in two complementary transistors which are FET and bipolar. These two transistors of each half of the waveform with its output are configured in a push-pull type arrangement. Hence the each amplifier only half of the output waveform.



Class B Amplifier

In the Class B amplifier, if the input signal is positive, then the positively biased transistor conduct and the negative transistor is switched OFF. If the input signal is negative, then the positive transistor switches OFF and negative biased transistor turn ON. Hence the transistor conduct half of the time whatever it may be like positive or negative half cycle of the input signal.

Advantages

- Some amount of distortion in the circuit gives the more output per device because of there is no presence of the even harmonics
- The use of push-pull system in the class B amplifier eliminates the even harmonic
- High efficiency when compared to the Class A configurations.

Disadvantages

- In the class B amplifier, there is high harmonic distortion
- In this amplifier, there is no need for self bias

- The major disadvantage is the cross-over distortion
- It is difficult to find ideal transformers.

Applications

- The class B amplifiers are used in low-cost design
- This amplifier is more significant than the class A amplifier
- The class B amplifier suffers from the bad distortion if the signal level is low

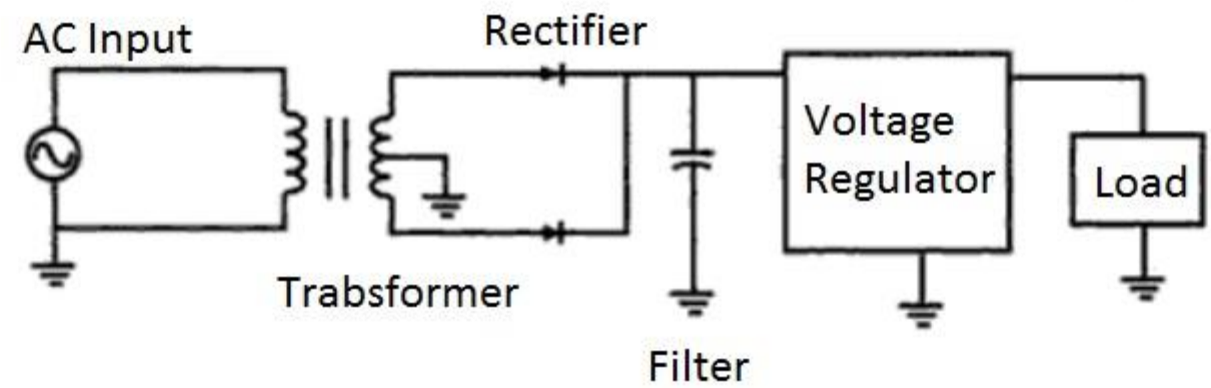
Qno 3 (b) Explain the types of voltage regulators and their purposes.

Answer = Voltage Regulators

A voltage regulator is designed to automatically ‘regulate’ voltage level. It basically steps down the input voltage to the desired level and keeps that in that same level during the supply. This makes sure that even when a load is applied the voltage doesn’t drop.

“OR”

A Voltage Regulator is a device or a circuit that is responsible for providing a steady DC Voltage to an electronic load. The following image shows a typical power supply with voltage regulator.



As mentioned earlier, the job of a DC Power Supply is to take AC power from mains outlets (typically, 240V @ 50Hz) and convert it into steady DC Output. In this process, the AC voltage from the mains is first rectified with the help of a rectifier circuit to produce a pulsating DC voltage.

This pulsating DC is then filtered to produce a relatively smooth voltage. Finally, a Voltage Regulator produces a constant output voltage.

Thus, a voltage regulator is used for two reasons:-

1. To regulate or vary the output voltage of the circuit.
2. To keep the output voltage constant at the desired value in-spite of variations in the supply voltage or in the load current.

Voltage regulators find their applications in computers, alternators, power generator plants where the circuit is used to control the output of the plant. Voltage regulators may be classified as electromechanical or electronic. It can also be classified as AC regulators or DC regulators.

Different Types of Voltage Regulators

Voltage Regulators can be implemented using discrete component circuits or ICs. Irrespective of the implementation, voltage regulators can be classified into two types:

- Linear Voltage Regulators
- Switching Voltage Regulators

Taking the above discussion on the components of a voltage regulator and its basic functionality into consideration, let us assume that the pass element in the voltage regulator circuit is a Transistor.

This transistor can be operated either in its active region or as a switch in order to regulate the output voltage. If the transistor stays in active region or the Ohmic region or Linear region of its operation during the course of voltage regulation, then the regulator is called as a Linear Voltage Regulator.

When the transistor operates in cutoff state and saturation state i.e. it switches between off state and saturation state, then the regulator is called as Switching Voltage Regulator.
Now, let us dive into both these voltage regulators and take a closer look at their working and types.

Linear Voltage Regulators

The original form of regulators in regulating power supplies are Linear Voltage Regulators. In a linear voltage regulator, the variable conductivity of the active pass element (usually a BJT or a MOSFET) is responsible for regulating the output voltage.
When a load is connected, the changes in either input or load will result in a variation in current through the transistor so that the output is maintained constant. For the transistor to be able to vary its current (collector-emitter current in case of a BJT), it must be operated in active or Ohmic region (also known as Linear Region).
During this process, the linear voltage regulator wastes a lot power as the net voltage i.e. the difference between the input and output is dropped in the transistor and is dissipated as heat.
Usually, linear voltage regulators are classified into five categories. They are:

- Positive Adjustable Regulators
- Negative Adjustable Regulators
- Fixed Output Regulators
- Tracking Regulators
- Floating Regulators

Example of Positive Adjustable Linear Voltage Regulators is the famous LM317 Regulator IC. The output voltage of LM317 can be adjusted between 1.2V and 37V.
Coming to Fixed Output Linear Voltage Regulators, the famous 78XX series of voltage regulator ICs fall under this category. 7805 is a commonly used fixed voltage regulator with 5V output.

Advantages of Linear Voltage Regulators

The advantages of Linear Voltage Regulators are as follows:

- Implementation of Linear Voltage Regulators is very simple and they are easy to use.
- In spite of their power dissipation, linear voltage regulators are robust in over current protection and thermal protection.
- Adjustable Voltage regulators require a very few external components to achieve its operation. Fixed voltage regulators require almost no external components (may be a couple of bypass capacitors).
- At low cost you have a wide range of voltage and current selection.

Disadvantages of Linear Voltage Regulators

The disadvantage of Linear Voltage regulators are as follows:

- Usually, linear voltage regulators are step down only i.e. the output voltage is always less than the input voltage.
- When operating from AC mains supply, a step-down transformer is required to bring the voltage to an operable level. Hence, they are usually bulky.
- As the regulation is done by dissipating excess power as heat, they tend to become extremely hot and the use of a heat sink is unavoidable.
- Also, the efficiency of linear regulators is usually very less, somewhere between 20% to 60%.

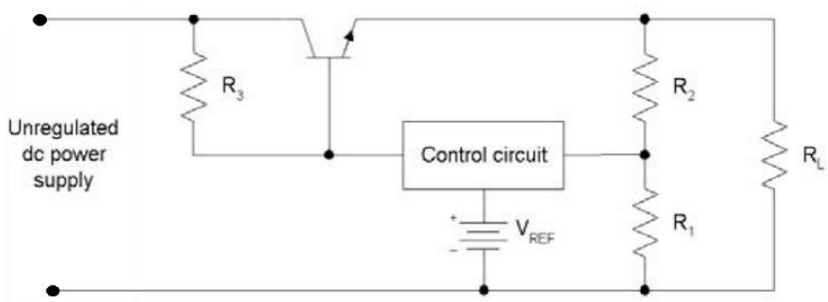
Further, Linear Voltage Regulators are again classified based on how the load is connected. They are:

- Series Voltage Regulators
- Shunt Voltage Regulators

Let us now briefly take a look at both these types of Linear Voltage Regulators.

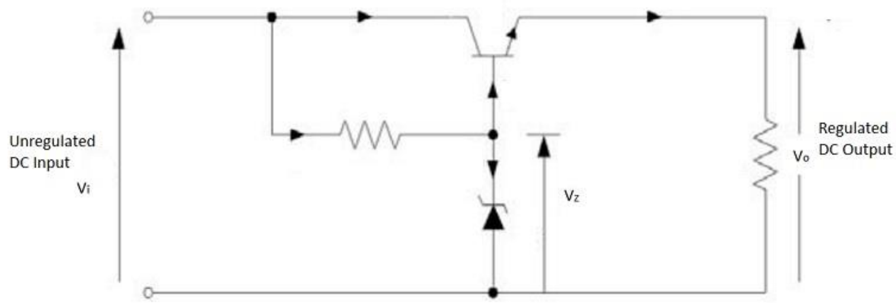
Series Voltage Regulator

In a Linear Voltage Regulators, if the active pass element i.e. a transistor for example, is connected in series with the load, then it is known as a Series Voltage Regulators.
The following circuit shows a typical Linear Series Voltage Regulator.



In this circuit, the output voltage of the regulator is sensed through the voltage divider network R1 and R2. This voltage is compared to a reference voltage V_{REF}. The resulting error signal will control the conduction of the Pass Transistor.

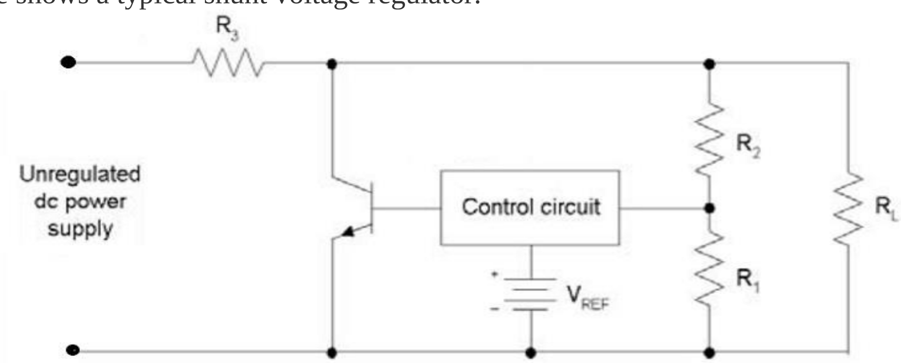
As a result, the voltage across the transistor is varied and the output voltage across the load is essentially maintained constant. A type of series voltage regulator is a Zener Diode Voltage Regulator, which can maintain a constant voltage across the load.



This type of voltage regulator can reduce the ripple in the power supply and improve the regulation. But due to the non-zero Zener Resistance, the efficiency is low. This can be improved by limiting the Zener current.

Shunt Voltage Regulator

A Shunt voltage regulator is contrast to a Series voltage regulator. If the pass transistor in the linear voltage regulator is connected in parallel to the load, then the regulator is known as a Shunt Voltage Regulator. Additionally, there is a voltage limiting resistor connected in series with the load. The following image shows a typical shunt voltage regulator.

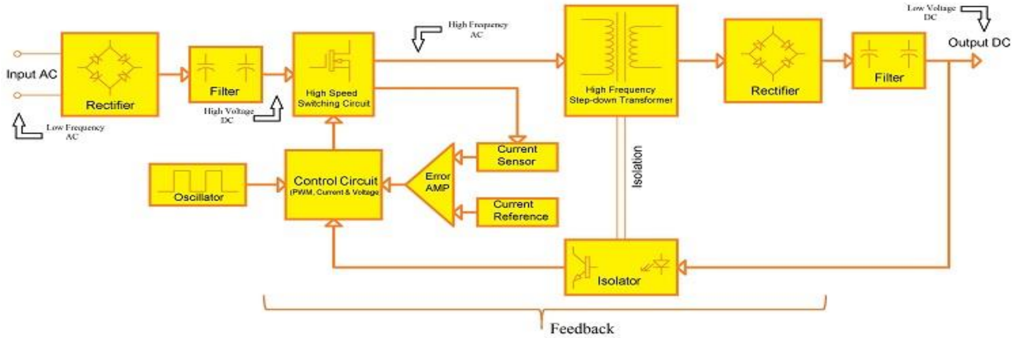


In this circuit, the conduction of the transistor is controlled based on the feedback and reference voltage such that the current through the series resistor remains constant. As the current through transistor is varied, the voltage across the load remains essentially constant. When compared to series regulators, shunt regulators are slightly less efficient but have a simpler implementation.

Switching Voltage Regulators

In both the Linear Voltage Regulators i.e. the Series Regulator and the Shunt Regulator, the active pass element i.e. the transistor is operating in its Linear region. By varying the conduction of the transistor, output voltage is maintained at a desirable level. In contrast, a Switching Regulator operates slightly different than the Linear Regulator in the sense that the pass transistor acts as a switch i.e. it either stays in off state (cutoff region) or in on state (saturation region).

By adjusting the ON time of the pass transistor, the output voltage is maintained as a constant value. Block diagram of a typical Switching Power Supply is shown below.



In fact, there is a separate tutorial on Switch Mode Power Supply or SMPS with the working, types and their operation as well.

Advantages of Switching Voltage Regulator

- The main advantage of the Switching Power Supply or Switching Voltage Regulators is the efficiency. Usually, with a better design efficiency up to 95% can be achieved.
- As the transistor is oscillating between ON and OFF states, and the times it stays in active region is very less, the amount of power wasted is very less.
- The output voltage can be higher or lesser than the input voltage.
- Doesn't need a step down or step up transformer but requires a tiny high frequency switching transformer.

Disadvantages of Switching Voltage Regulators

- The complexity of the design of switching power supply is very high.
- Due to frequent switching of the transistor and as a result the transistor current, there exists a high interference and noise.

Based on the design of the circuit, switching voltage regulators can be classified into two topologies.

- Non-isolated Converters
- Isolated Converters

In non-isolated converters, there are again several types but the important ones are:

- Step Down Voltage Regulator (Buck Converter)
- Step Up Voltage Regulator (Boost Converter)
- Buck / Boost Converter

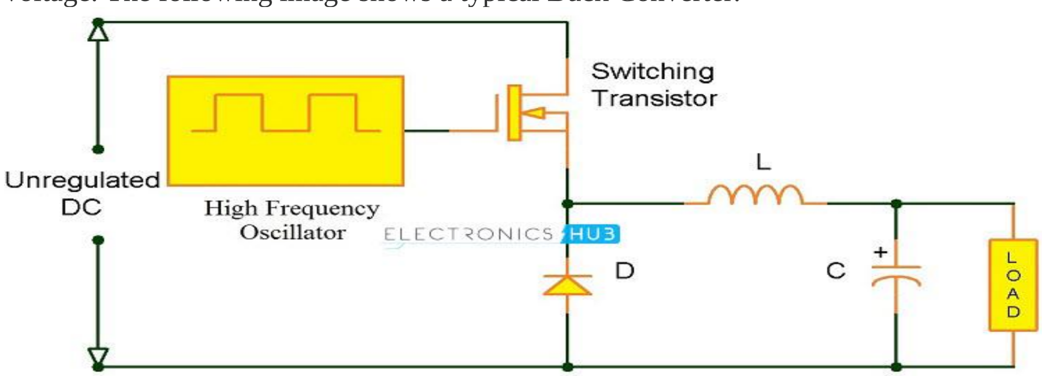
In isolated converters, there are basically, two important types. They are:

- Flyback Converters
- Forward Converters

All these types are discussed in the Switch Mode Power Supply topic. So, refer to that document for more information.

Step Down Voltage regulator (Buck Converter)

In a Step Down Voltage regulator or a Buck converter, the output voltage is less than that of the input voltage. The following image shows a typical Buck Converter.

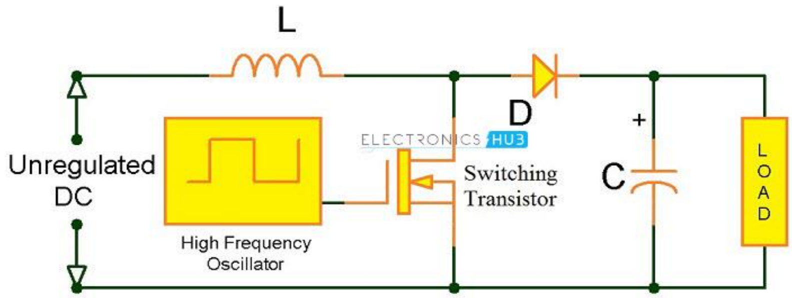


Buck Converter

Step Up Voltage Regulator (Boost Converter)

In contrast to Buck Converter, a Boost Converter or a Step Up Voltage regulator provides a voltage that is higher at the output than the input.

The following image shows a typical Boost Converter.

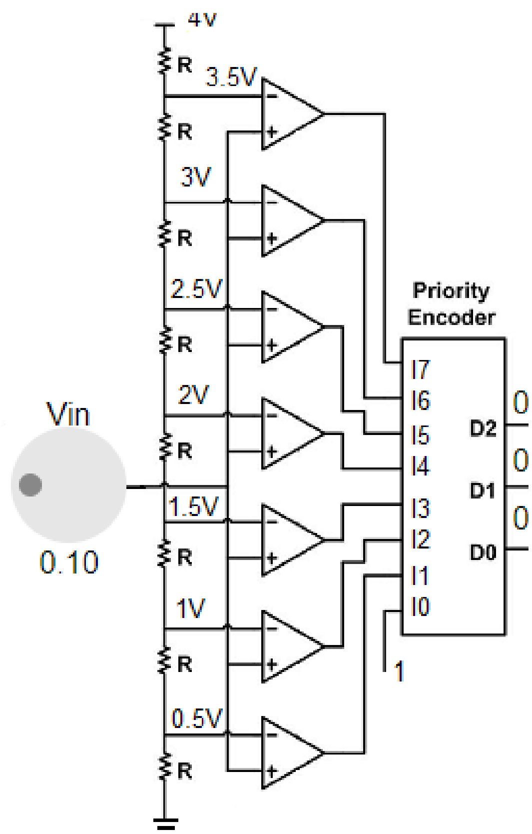


Boost Converter

There are many other Switching Voltage Regulator topologies like continuous, discontinuous, half-bridge, full-bridge, etc.

QNo 4 = Explain the working of Flash ADC.

Answer =Flash analog-to-digital converters, also known as parallel ADCs, are the fastest way to convert an analog signal to a digital signal. Flash ADCs are ideal for applications requiring very large bandwidth, but they consume more power and much bigger in size than other ADC architectures. A Flash converter requires a huge number of comparators compared to other ADCs, especially as the resolution increases. A Flash converter requires 2^{n-1} comparators for an n-bit conversion



I7	I6	I5	I4	I3	I2	I1	I0	D2	D1	D0
0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	1	1	0	0	1
0	0	0	0	0	1	1	1	0	1	0
0	0	0	0	1	1	1	1	0	1	1
0	0	0	1	1	1	1	1	1	0	0
0	0	1	1	1	1	1	1	1	0	1
0	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1

Note

- Circuit shown is a 3 bit flash converter
- Reference ladder consists of 2^n ($2^3 = 8$) equal size resistors

- Input voltage is compared to 2^n-1 reference voltages using 2^n-1 comparators. The reference voltages can be calculated using KVL.
- A Priority Encoder is used to transform the comparator outputs to the correct digital binary output.
- Change the input voltage and observe the comparators and the priority encoder digital outputs.

Advantages:

- It is the fastest type of ADC because the conversion is performed simultaneously through a set of comparators, hence referred as flash type ADC. Typical conversion time is 100ns or less.
- The construction is simple and easier to design.

Disadvantages:

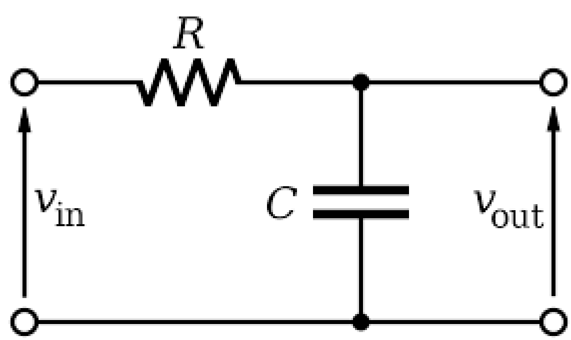
- It is not suitable for higher number of bits.
- To convert the analog input voltage into a digital signal of n-bit output, (2n – 1) comparators are required. The number of comparators required doubles for each added bit.
-

QNo 5(a) = Differentiate between Low pass & high pass filters

Answer = The main disparity between LPF-low pass filter and high pass filter-HPF is the frequency range which they exceed. An HPF (high pass filter) is one kind of circuit which permits the high frequency and blocks low frequency for flowing through it. In the same way, an LPF (low pass filter) is one kind of circuit which permits the low-frequency and blocks high-frequency for flowing through it. In filters, the cut off frequency will decide the range of high frequency as well as low frequency. Before discussing the filter operational method, we have to know the required components of these filters. The LPF and HPF can be designed with electronic components like resistor, amplifier, capacitor, etc.

Low Pass Filter

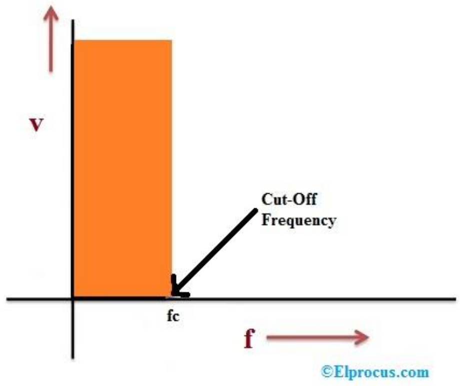
The **circuit diagram of the low pass filter** is shown below. The circuit of LPF can be built with a resistor as well as a capacitor in series so that the output can be achieved. Once the input is given to the circuit of the LPF, then the resistance will give a stable obstacle, however, the capacitor position will have an effect on the output signal.



Low Pass Filter

If the high-frequency signal is applied to the **LP circuit**, thus it will exceed from resistance which will offer the standard resistance, however, the resistance accessible from the capacitor will be nothing. This is due to the resistance offered from the capacitor toward the high-frequency signal will be zero whereas the low-frequency signal is unlimited. From the above circuit of the low pass filter, It is understandable that once the high-frequency signal comes LPF circuit afterward the capacitor will permit it to flow as well as it will pass to the GND. In this state, the o/p voltage achieved will be zero because the whole voltage is supplied to the ground.

However when the low-frequency signal goes through the LPF circuit then the output will be generated, as the resistance will give a similar obstacle like the high-frequency signal although the capacitor will offer infinite resistance.

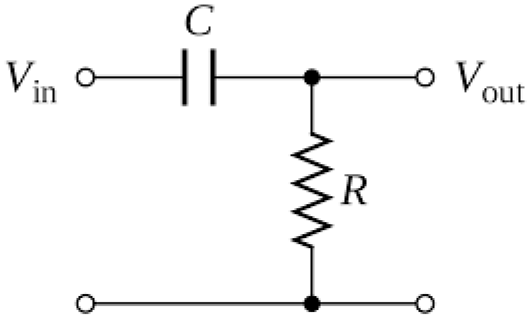


Low Pass Filter Response

Therefore, in this state, the signal cannot flow through the lane of the capacitor. So the total low-frequency signal will be supplied to the output terminal.

High Pass Filter

The **circuit diagram of the high pass filter** is shown below. An HPF blocks the low-frequency signals & allows just high-frequency signals for flowing through it. Even though it provides reduction to high-frequency signal also however the attenuation issue is so little that it can be ignored. This can be obtainable by the resistor and capacitor characteristics.

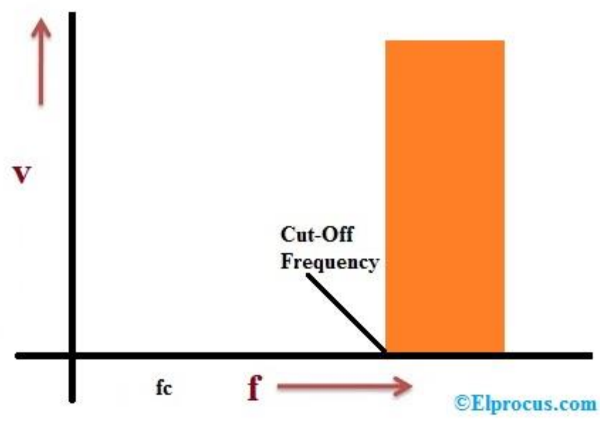


High Pass Filter

When the input signal is applied to the capacitor, then the voltage across the resistor can be achieved because of the o/p voltage. The combination of the resistance of the resistor as well as a capacitor can be called reactance.

$$Xc = 1/2\pi fc$$

From the above equation, we can conclude that the reactance will be inversely proportional to the cut-off frequency. When the input signal's frequency is superior, then the reactance will be low. Similarly, when the input signal's frequency is low, then the reactance will be low.



High Pass Filter Response

So far we have discussed the crucial difference between high-pass and low-pass filter along with the components which make it active or passive. Let's discuss other significant differences with the help of comparison chart

Difference between Low Pass Filter and High Pass Filter

The **difference between low pass filter and high pass filter** mainly includes definition, circuit architecture, significance, operating frequency, and applications.

Low Pass Filter	High Pass Filter
• LPF circuit allows the frequency underneath cut-off frequency for flowing through it.	• HPF circuit allows the frequencies over cut-off frequency for flowing through it.
• It can be built with a resistor which is followed by a capacitor.	• It can be built with a capacitor which is followed by a resistor.
• It is important in eliminating the aliasing effect.	• It is important whenever the distortion occurs because of low-frequency signal like noise is to be detached.

• It is lesser than the cut-off frequency.	• It is higher than the cut-off frequency.
• The LPF can be used as an anti-aliasing filter in communication circuits.	• The HPF can be used in amplifiers like low noise, audio, etc.

Qno 5(b) = Active and passive filters

Answer = Electronic filters are circuits which perform signal processing functions, specifically to remove unwanted frequency components from the signal, to enhance wanted ones or both.

Passive filters contains passive components (R,L,C), they do not depend upon an external power supply and/or they do not contain active components such as transistors or battery. The simplest passive filters, RC and RL filters, include only one reactive element, except HYBRIED LC Filter which is characterized by inductance and capacitance integrated in one element.

Active filters are implemented using a combination of passive and active (amplifying) components, and require an outside power source. operational filters are frequently used in active filter designs. These can have high Q Factor, and can achieve resonance without the use of inductors. However, their upper frequency limit is limited by the bandwidth of the amplifiers. The most common types of active filters are classified into four such as

- Butterworth
- Chebyshev
- Bessel
- Elliptical

The difference between Active and Passive Filters

- Passive filters consume the energy of the signal, but no power gain is available; while active filters have a power gain.
- Active filters require an external power supply, while passive filters operate only on the signal input.
- Only passive filters use inductors.
- Only active filters use elements kike op-amps and transistors, which are active elements.
- Theoretically, passive filters have no frequency limitations while, active filters have limitations due to active elements.
- Passive filters have a better stability and can withstand large currents.
- Passive filters are relatively cheaper than active filters.

Applications of Active filters

- Active filters are used in communication system for suppressing noise to isolate a communication of signal from various channels to improve the unique message signal from a modulated signal.
- These filters are used in instrumentation systems by the designers to choose a required frequency apparatus and detach unwanted ones.
- These filters can be used to limit the analog signals bandwidth before altering them to digital signals.
- audio systems by engineers to send various frequencies to various speakers. For example, in the music industry, record & playback applications are needed to control the frequency components.

- Active filters are used in biomedical instruments to interface psychological Sensors with diagnostic equipment’s & data logging.

Applications of Passive filters

- low pass filters Woofers for low frequency, and Tweeters for high frequency reproduction). In this application the combination of high and low pass filters is called a "crossover filter".
- high pass filters especially audio amplifiers
- band pass filters while rejecting signals at all frequencies above and below this band
- band stop filters older radio and TV receivers
- I.F Transformers found in older in radio and TV equipment to pass a band of radio frequencies from one stage of the intermediate frequency (IF) amplifiers.