Department of Electrical Engineering

Assignment

Date: 24/06/2020

Course Details

Course Title: Electronic Circuit Design **Module:** 04

Instructor: **Engr. Mujtaba Ihsan** **Total Marks:** 50

Student Details

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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 04+04
	(a)	Low pass & high pass filters	
	(b)	Active and passive filters	CLO 2

QUES 1 (PART A)

Discuss the darlington connection for multistage amplifiers?

ANSWER:

Darlington Connection:

The main feature 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 Provides high current gain than a single BJT.

The connection is made using two separate transistors having current gains of

And

So, the current gain $\beta_D = \beta_1 \beta_2$

if $\beta_1 = \beta_2 = \beta$

The Darlington connection provides a current gain of $\beta_D = \beta^2$

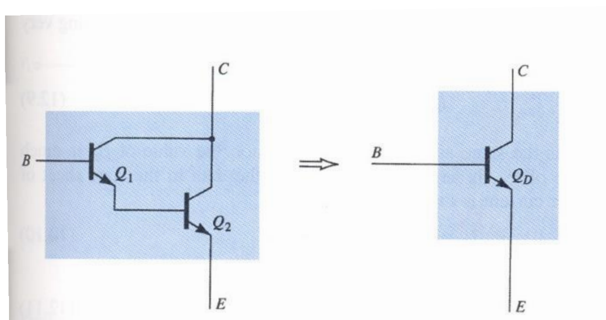


Figure 12.8 Makeup of Darlington transistor.

- **Figure shown a Darlington configuration**

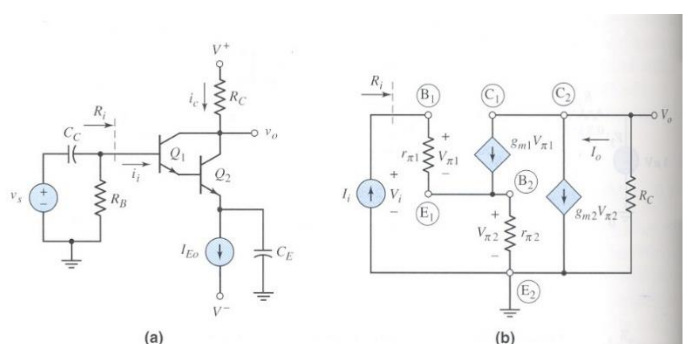


Figure 4.63 (a) A Darlington pair configuration; (b) small-signal equivalent circuit

- **The small current gain** $A_i = I_o :/ I_i$

Since $V_{\pi 1} = I_i r_{\pi 1}$

Therefore $g_{m1} V_{\pi 1} = g_{m1} r_{\pi 1} I_i = \beta_1 I_i$

Then, $V_{\pi 2} = (I_i + \beta_1 I_i) r_{\pi 2}$

The o/p current is: $I_0 = g_{m1} V_{\pi 1} + g_{m2} V_{\pi 2} = \beta_1 I_i + \beta_2 (1 + \beta_1) I_i$

The overall gain is: $A_i = \frac{I_0}{I_i} = \beta_1 + \beta_2 (1 + \beta_1) \cong \beta_1 \beta_2$

The overall small-signal current gain = the product of the individual current gain.

QUES 1 (PART 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

Solution:

$$Line\,Regulation = \left(\frac{\triangle Vout}{\triangle Vin} \right) X 100\%$$

$$Line\,Regulation = \left(\frac{\triangle Vout / Vout}{\triangle Vin} \right) X 100\%$$

Consider the following data:

Change in input voltage △Vin = 4.5V

Change in output Voltage △Vout = 0.062V

Nominal Output Voltage Vout = 40V

$$Line\,Regulation = \left(\frac{0.062}{4.5} \right) X 100\% = \mathbf{1.377\%}$$

$$Line\,Regulation = \left(\frac{0.062 / 40v}{4.5v} \right) X 100\% = \mathbf{0.03\%/V}$$

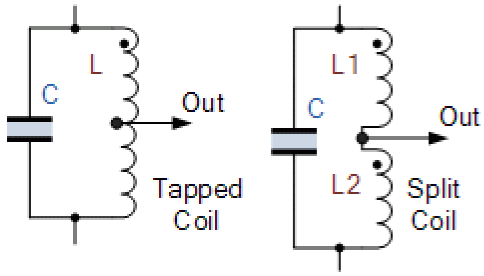
QUES 2:

Explain Colpitts and Hartley oscillators.

Answer:

The Hartley Oscillator:

The Hartley Oscillator design uses two inductive coils in series with a parallel capacitor to form its resonance tank circuit producing sinusoidal oscillations



One of the main disadvantages of the basic LC Oscillator circuit is that they have no means of controlling the amplitude of the oscillations and also, it is difficult to tune the oscillator to the required frequency. If the cumulative electromagnetic coupling between L_1 and L_2 is too small there would be insufficient feedback and the oscillations would eventually die away to zero.

Likewise if the feedback was too strong the oscillations would continue to increase in amplitude until they were limited by the circuit conditions producing signal distortion. So it becomes very difficult to "tune" the oscillator.

However, it is possible to feed back exactly the right amount of voltage for constant amplitude oscillations. If we feed back more than is necessary the amplitude of the oscillations can be controlled by biasing the amplifier in such a way that if the oscillations increase in amplitude, the bias is increased and the gain of the amplifier is reduced.

If the amplitude of the oscillations decreases the bias decreases and the gain of the amplifier increases, thus increasing the feedback. In this way the amplitude of the oscillations are kept constant using a process known as **Automatic Base Bias**.

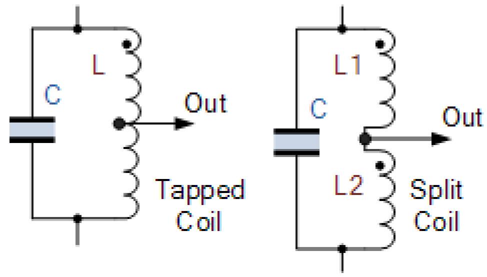
One big advantage of automatic base bias in a voltage controlled oscillator, is that the oscillator can be made more efficient by providing a Class-B bias or even a Class-C bias condition of the transistor. This has the advantage that the collector current only flows during part of the oscillation cycle so the quiescent collector current is very small. Then this "self-tuning" base oscillator circuit forms one of the most common types of LC parallel resonant feedback oscillator configurations called the **Hartley Oscillator** circuit.

In the **Hartley Oscillator** the tuned LC circuit is connected between the collector and the base of a transistor amplifier. As far as the oscillatory voltage is concerned, the emitter is connected to a tapping point on the tuned circuit coil.

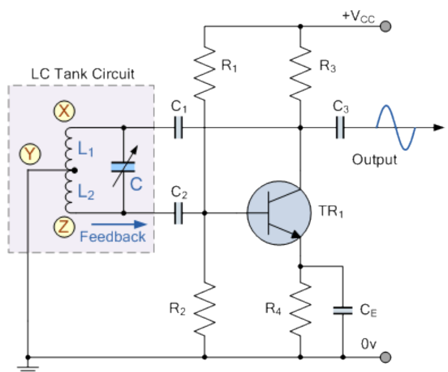
The feedback part of the tuned LC tank circuit is taken from the centre tap of the inductor coil or even two separate coils in series which are in parallel with a variable capacitor, C as shown.

The Hartley circuit is often referred to as a split-inductance oscillator because coil L is centre-tapped. In effect, inductance L acts like two separate coils in very close proximity with the current flowing through coil section XY induces a signal into coil section YZ below.

An Hartley Oscillator circuit can be made from any configuration that uses either a single tapped coil (similar to an autotransformer) or a pair of series connected coils in parallel with a single capacitor as shown below.



Basic Hartley Oscillator Design



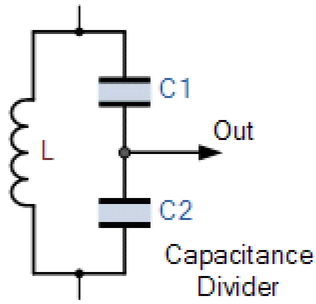
When the circuit is oscillating, the voltage at point X (collector), relative to point Y (emitter), is 180^o out-of-phase with the voltage at point Z (base) relative to point Y. At the frequency of oscillation, the impedance of the Collector load is resistive and an increase in Base voltage causes a decrease in the Collector voltage.

Thus there is a 180^o phase change in the voltage between the Base and Collector and this along with the original 180^o phase shift in the feedback loop provides the correct phase relationship of positive feedback for oscillations to be maintained.

The amount of feedback depends upon the position of the "tapping point" of the inductor. If this is moved nearer to the collector the amount of feedback is increased, but the output taken between the Collector and earth is reduced and vice versa. Resistors, R1 and R2 provide the usual stabilizing DC bias for the transistor in the normal manner while the capacitors act as DC-blocking capacitors.

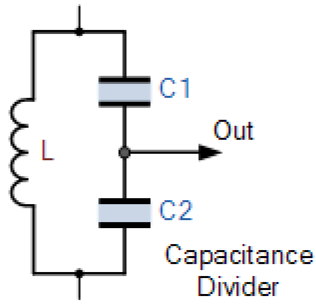
The Colpitts Oscillator:

The Colpitts Oscillator design uses two centre-tapped capacitors in series with a parallel inductor form its resonance tank circuit producing sinusoidal oscillations



In many ways, the Colpitts oscillator is the exact opposite of the **Hartley Oscillator**. Just like the Hartley oscillator, the tuned tank circuit consists of an LC resonance sub-circuit connected between the collector and the base of a single stage transistor amplifier producing a sinusoidal output waveform.

The basic configuration of the **Colpitts Oscillator** resembles that of the *Hartley Oscillator* but the difference this time is that the centre tapping of the tank sub-circuit is now made at the junction of a "capacitive voltage divider" network instead of a tapped autotransformer type inductor as in the Hartley oscillator.



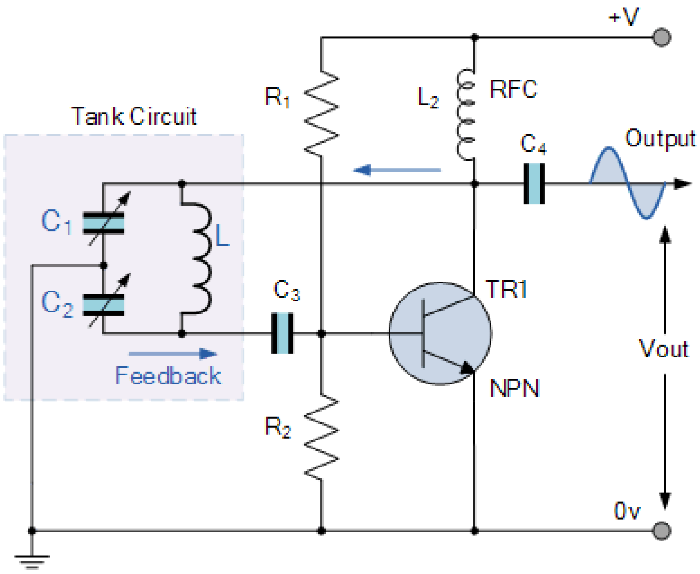
Colpitts Oscillator
Tank Circuit

The Colpitts oscillator uses a capacitive voltage divider network as its feedback source. The two capacitors, C1 and C2 are placed across a single common inductor, L as shown.
Then C1, C2 and L form the tuned tank circuit with the condition for oscillations being: $X_{C1} + X_{C2} = X_L$, the same as for the Hartley oscillator circuit.

The advantage of this type of capacitive circuit configuration is that with less self and mutual inductance within the tank circuit, frequency stability of the oscillator is improved along with a more simple design.

As with the Hartley oscillator, the Colpitts oscillator uses a single stage bipolar transistor amplifier as the gain element which produces a sinusoidal output. Consider the circuit below.

Basic Colpitts Oscillator Circuit



The emitter terminal of the transistor is effectively connected to the junction of the two capacitors, C1 and C2 which are connected in series and act as a simple voltage divider. When the power supply is firstly applied, capacitors C1 and C2 charge up and then discharge through the coil L. The oscillations across the capacitors are applied to the base-emitter junction and appear in the amplified at the collector output.

Resistors, R1 and R2 provide the usual stabilizing DC bias for the transistor in the normal manner while the additional capacitors act as a DC-blocking bypass capacitors. A radio-frequency choke (RFC) is used in the collector circuit to provide a high reactance (ideally open circuit) at the frequency of oscillation, (fr) and a low resistance at DC to help start the oscillations.

The required external phase shift is obtained in a similar manner to that in the Hartley oscillator circuit with the required positive feedback obtained for sustained undamped oscillations. The amount of feedback is determined by the ratio of C1 and C2. These two capacitances are generally “ganged” together to provide a constant amount of feedback so that as one is adjusted the other automatically follows.

QUES 3 (PART A):

Describe the idea behind class B amplifiers?

Answer:

Class AB amplifiers:

As might be expected a Class AB amplifier falls between Class A and Class B. It seeks to overcome the cross-over distortion by slightly turning on the transistors so that they conduct for slightly more than half the cycle and the two devices overlap by a small amount during the switch-on / switch-off phase, thereby overcoming the crossover distortion.

This approach means that the amplifier sacrifices a certain amount of potential efficiency for better linearity - there is a much smoother transition at the crossover point of the output signal. In this way, Class AB amplifiers sacrifice some of the efficiency for lower distortion. Accordingly class AB is a much better option where a compromise between efficiency and linearity is needed.

ClassesAB1&AB2:

Thermionic valves or vacuum tubes were widely used for high power audio and RF linear amplifiers. To save cost, weight and power consumption, amplifiers were run in class AB, and two amplifier sub-classes were often mentioned: Class AB1 and AB2. These sub-classes are applicable to only thermionic or vacuum tube technology as they refer to the way in which the grid was biased:

- ***Class AB1:*** Class AB1 is where the grid is more negatively biased than it is in class A. In Class AB1, the valve is biased so that no grid current flows. This class of amplifier also gives lower distortion than one running in class AB2.
- ***Class AB2:*** Class AB2 is where the grid is often more negatively biased than in AB1, also the size of the input signal is often larger. In this class grid current flows during part of the positive input half-cycle. It is normal practice for the Class AB2 grid bias point to be closer to cut-off than occurs in Class AB1, and Class AB2 gives a greater power output.

QUES 3 (PART B):

Explain the types of voltage regulators and their purposes.

Answer:

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

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.

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

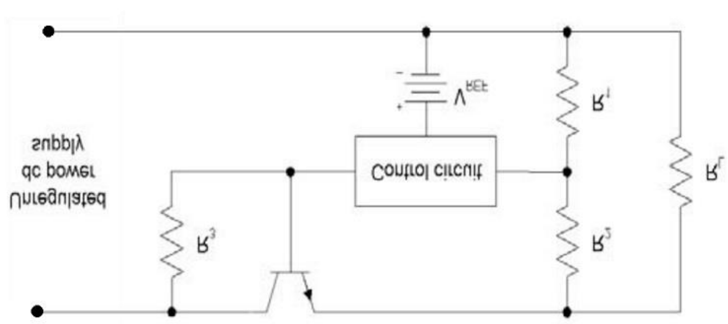
- **Series Voltage Regulators**
- **Shunt Voltage Regulators**

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

<u>Series Voltage Regulator</u>

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.

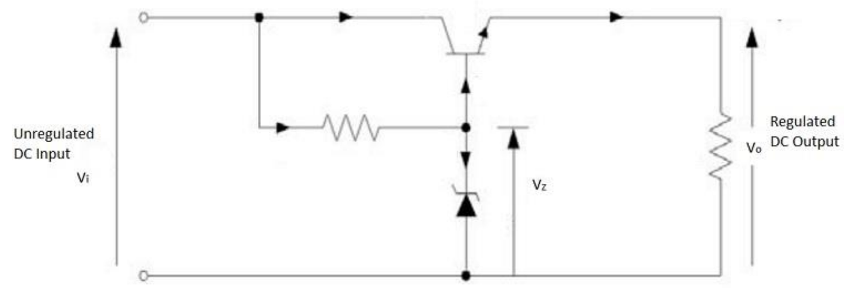
The following circuit shows a typical Linear Series Voltage Regulator.



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.

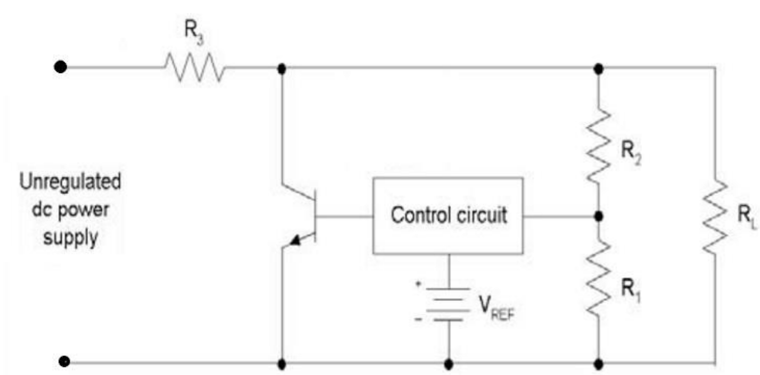


This type of voltage regulator can reduce the ripple in the power supply and improve the regulation. But due to the non-zero Zener Resistance, the efficiency is low. This can be improved by limiting the Zener current.

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.

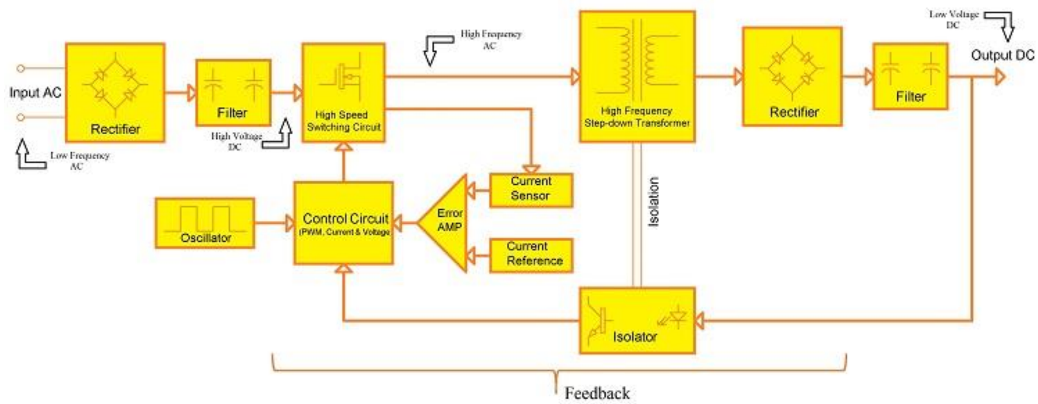
Switching Voltage Regulators

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.

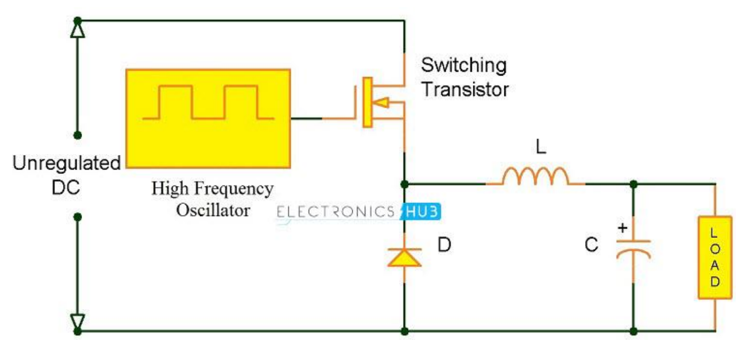
Block diagram of a typical Switching Power Supply is shown below.



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

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.

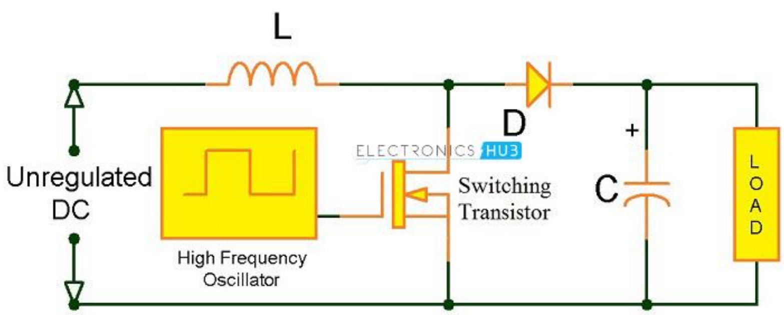


Buck Converter

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,

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QUES 4:

Explain the working of Flash ADC.

Answer:

Flash ADC :

A **flash ADC** (also known as a **direct-conversion ADC**) is a type of analog-to-digital converter that uses a linear voltage ladder with a comparator at each "rung" of the ladder to compare the input voltage to successive reference voltages. Often these reference ladders are constructed of many resistors; however, modern implementations show that capacitive voltage division is also possible. The output of these comparators is generally fed into a digital encoder, which converts the inputs into a binary value (the collected outputs from the comparators can be thought of as a unary value)

Benefits and Drawback:

Flash converters are extremely fast compared to many other types of ADCs, which usually narrow in on the "correct" answer over a series of stages. Compared to these, a flash converter is also quite simple and, apart from the analog comparators, only requires logic for the final conversion to binary.

For best accuracy, often a track-and-hold circuit is inserted in front of the ADC input. This is needed for many ADC types (like successive approximation ADC), but for flash ADCs there is no real need for this, because the comparators are the sampling devices.

A flash converter requires a huge number of comparators compared to other ADCs, especially as the precision increases. A flash converter requires comparators for an *n*-bit conversion. The size, power consumption and cost of all those comparators makes flash converters generally impractical for precisions much greater than 8 bits (255 comparators). In place of these comparators, most other ADCs substitute more complex logic and/or analog circuitry that can be scaled more easily for increased precision.

QUES 5 (part A):

Differentiate between the following:

(A) Low pass & high pass filters

Answer:

Low-pass filter (LPF)

A **low-pass filter** (**LPF**) is a filter that passes signals with a frequency lower than a selected cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency. The exact frequency response of the filter depends on the filter design. The filter is sometimes called a **high-cut filter**, or **treble-cut filter** in audio applications. A low-pass filter is the complement of a high-pass filter.

In optics, **high-pass** and **low-pass** may have the different meanings, depending on whether referring to frequency or wavelength of light, since these variable are inversely related. High-pass frequency filters would act as low-pass wavelength filters, and vice versa. For this reason it is a good practice to refer to wavelength filters as "Short-pass" and "Long-pass" to avoid confusion, which would correspond to "high-pass" and "low-pass" frequencies.

Low-pass filters exist in many different forms, including electronic circuits such as a **hiss filter** used in audio, anti-aliasing filters for conditioning signals prior to analog-to-digital conversion, digital filters for smoothing sets of data, acoustic barriers, blurring of images, and so on. The moving average operation used in fields such as finance is a particular kind of low-pass filter, and can be analyzed with the same signal processing techniques as are used for other low-pass filters. Low-pass filters provide a smoother form of a signal, removing the short-term fluctuations and leaving the longer-term trend.

Filter designers will often use the low-pass form as a prototype filter. That is, a filter with unity bandwidth and impedance. The desired filter is obtained from the prototype by scaling for the desired bandwidth and impedance and transforming into the desired bandform (that is low-pass, high-pass, band-pass or band-stop)

High-pass filter (HPF)

A **high-pass filter** (**HPF**) is an electronic filter that passes signals with a frequency higher than a certain cutoff frequency and attenuates signals with frequencies lower than the cutoff frequency. The amount of attenuation for each frequency depends on the filter design. A high-pass filter is usually modeled as a linear time-invariant system. It is sometimes called a **low-cut filter** or **bass-cut filter**.[1] High-pass filters have many uses, such as blocking DC from circuitry sensitive to non-zero average voltages or radio frequency devices. They can also be used in conjunction with a low-pass filter to produce a bandpass filter.

In the optical domain, **high-pass** and **low-pass** have the opposite meanings, with a "high-pass" filter (more commonly "long-pass") passing only *longer* wavelengths (lower frequencies), and vice versa for "low-pass" (more commonly "short-pass")

QUES 5 (part B):

Active and passive filters?

Answer:

Passive and Active Filters:

Filters can be placed in one of two categories: *passive* or *active*.
Passive filters include only passive components—resistors, capacitors, and inductors. In contrast, active filters use active components, such as op-amps, in addition to resistors and capacitors, but not inductors.
Passive filters are most responsive to a frequency range from roughly 100 Hz to 300 MHz. The limitation on the lower end is a result of the fact that at low frequencies the inductance or capacitance would have to be quite large. The upper-frequency limit is due to the effect of parasitic capacitances and inductances. Careful design practices can extend the use of passive circuits well into the gigahertz range.
Active filters are capable of dealing with very low frequencies (approaching 0 Hz), and they can provide voltage gain (passive filters cannot). Active filters can be used to design high-order filters without the use of inductors; this is important because inductors are problematic in the context of integrated-circuit manufacturing techniques. However, active filters are less suitable for very-high-frequency applications because of amplifier bandwidth limitations. Radio-frequency circuits must often utilize passive filters.

End of Paper

Thank you