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

Course Details

Course Title:	Electronic Circuit Design	**Module:**	04
Instructor:		**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
	(a)	Low pass & high pass filters	04+04
	(b)	Active and passive filters	CLO 2

Qno1 (a)

Ans:

Darlington Connection for multistage amplifiers.

- 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

  β_1 and β_2

So, the current gain

$$\beta_D = \beta_1\beta_2$$

If $\beta_1 = \beta_2 = \beta$

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

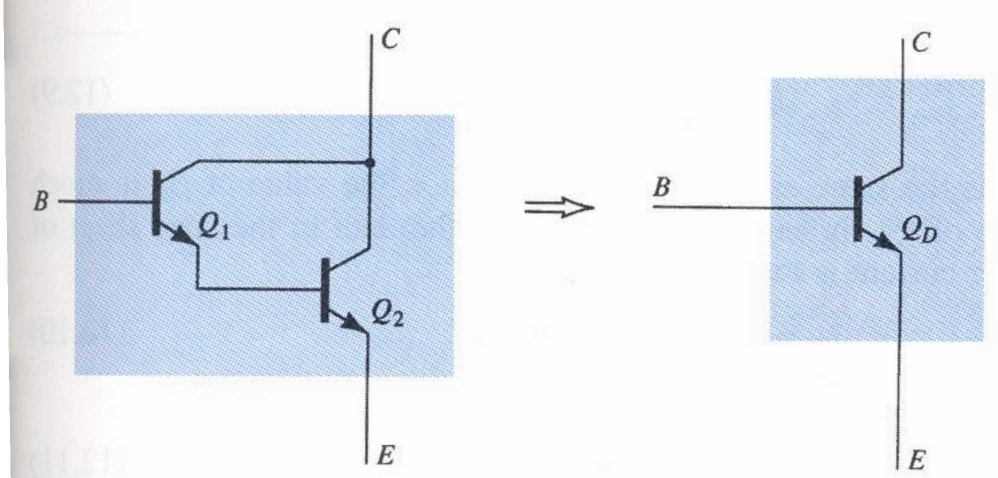
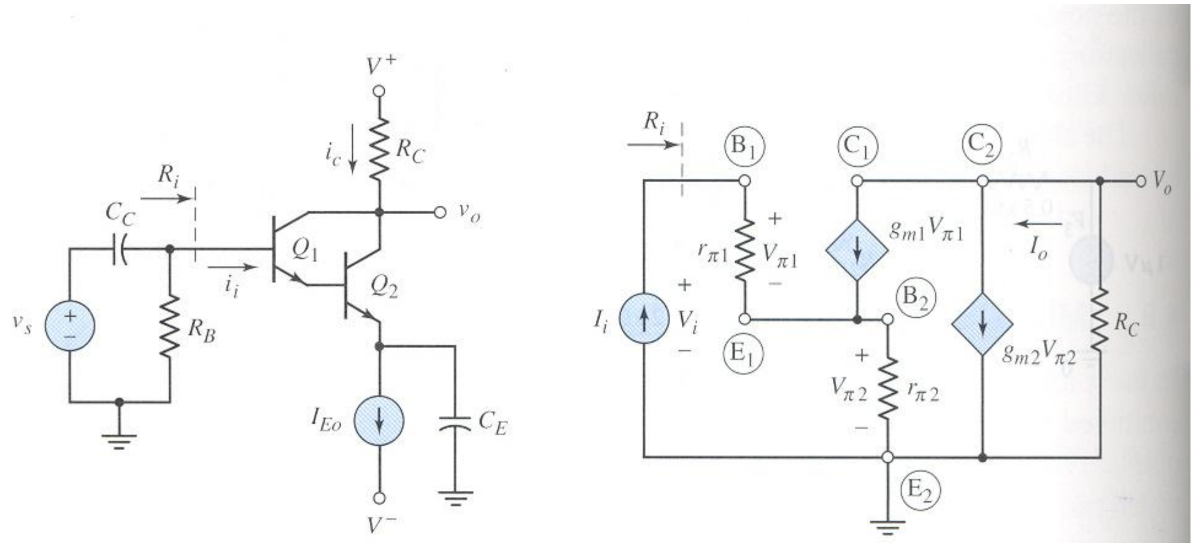


Figure 12.8 Makeup of Darlington transistor.



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

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

Since

$$V_{\pi1} = I_i r_{\pi1}$$

Therefore

$$g_{m1}V_{\pi1} = g_{m1}r_{\pi1}I_i = \beta_1 I_i$$

Then,

$$V_{\pi2} = (I_i + \beta_1 I_i)r_{\pi2}$$

The o/p current is:

$$I_0 = g_{m1}V_{\pi1} + g_{m2}V_{\pi2} = \beta_1 I_i + \beta_2(1+\beta_1)I_i$$

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 gains

Qno1 (b)

Solution

Given data

$\Delta V_{out} = 0.062\ V$

$V_{out} = 40V$

$\Delta V_{in} = 4.5V$

formulas

→ Line Regulation $= \left(\dfrac{\Delta V_{out}}{\Delta V_{IN}} \right) \times 100\%$

→ Line Regulation $= \dfrac{(\Delta V_{out} / V_{out}) \times 100}{\Delta V_{IN}}$

① Line Regulation $= \left(\dfrac{0.062}{4.5} \right) \times 100$

$= 1.3\ \%$

② Line Regulation $= \dfrac{(0.062/40) \times 100}{4.5}$

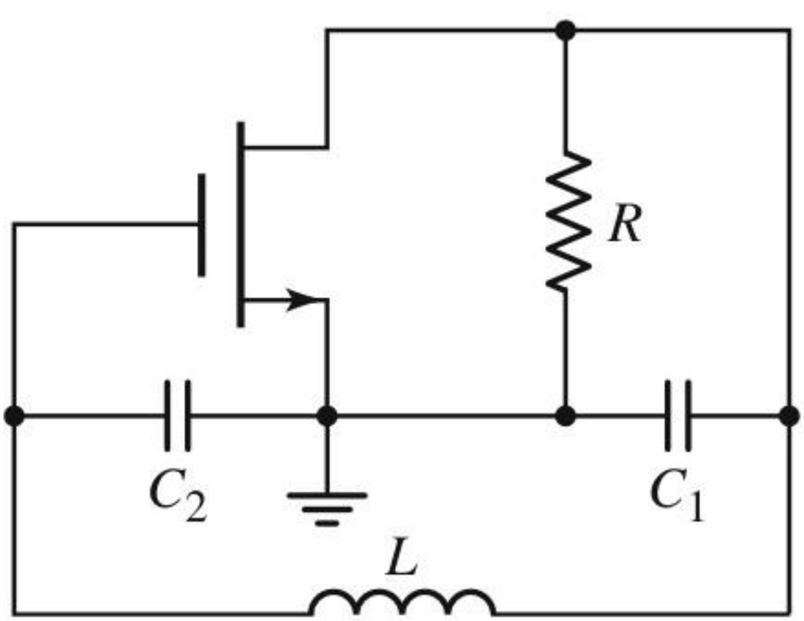
$= 0.0344\ \%/V$

QNo 2

Colpitts Oscillator

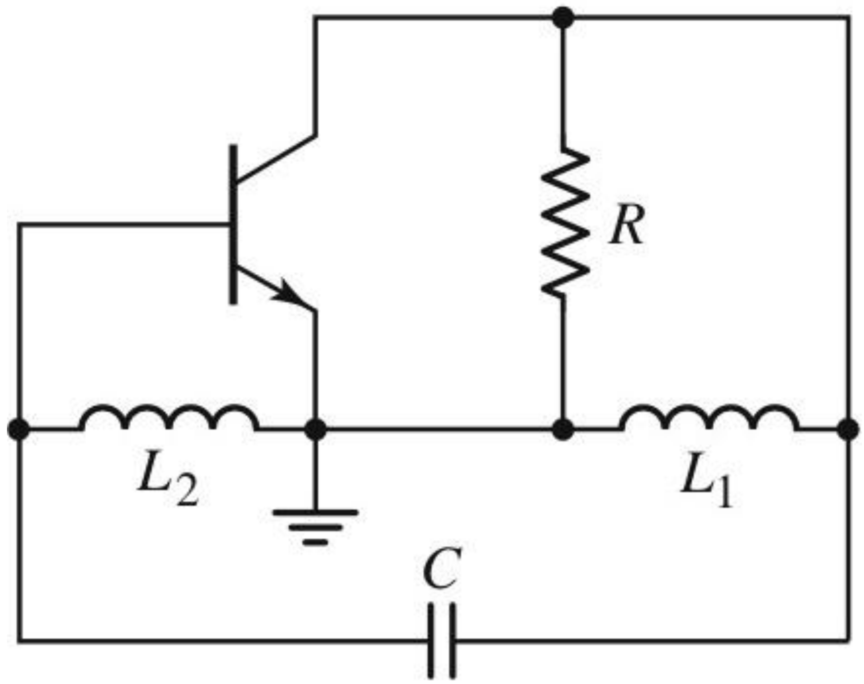
- The Colpitts oscillator is a type of oscillator that uses an LC circuit in the feed-back loop.
- The feedback network is made up of a pair of *tapped capacitors (C_1 and C_2)* and *an inductor L* to produce a feedback necessary for oscillations.
- The output voltage is developed across C_1.
- The feedback voltage is developed across C_2

Oscillator is an amplifier with the positive feedback and it converts DC input signal into AC output waveform with certain variable frequency drive and certain shape of output waveform (like sine wave or square wave, etc) by using the positive feedback instead of input signal. Oscillators which utilizes the inductor L and capacitor C in their circuit are called as LC oscillator which is a type of linear oscillator



Hartley Oscillator

- The Hartley oscillator is almost identical to the Colpitts oscillator.
- The primary difference is that the feedback network of the Hartley oscillator uses *tapped inductors (L_1 and L_2)* and *a single capacitor C*.



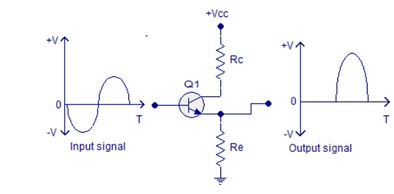
- The analysis of Hartley oscillator is identical to that Colpitts oscillator.
- the frequency of oscillation:

$$\omega_o = \frac{1}{\sqrt{(L_1 + L_2)C}}$$

Qno 3(a)

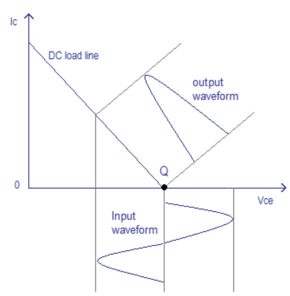
Class B power amplifier.

Class B amplifier is a type of power amplifier where the active device (transistor) conducts only for one half cycle of the input signal. That means the conduction angle is 180° for a Class B amplifier. Since the active device is switched off for half the input cycle, the active device dissipates less power and hence the efficiency is improved. Theoretical maximum efficiency of Class B power amplifier is 78.5%. The schematic of a single ended Class B amplifier and input , output waveforms are shown in the figure below.



Single ended Class B amplifier www.circuitstoday.com

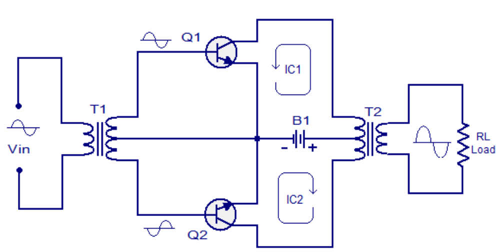
From the above circuit it is clear that the base of the transistor Q1 is not biased and the negative half cycle of the input waveform is missing in the output. Even though it improves the power efficiency, it creates a lot of distortion. Only half the information present in the input will be available in the output and that is a bad thing.Single ended Class B amplifiers are not used in present day practical audio amplifier application and they can be found only in some earlier gadgets. Another place where you can find them is the RF power amplifiers where the distortion is not a matter of major concern. Anyway, Class C amplifiers are more often used in RF power amplifier applications. Output characteristics of a single ended Class B power amplifier is shown in the figure below.



Class B power amplifier output characteristics wwww.circuitstoday.com

One way to realize a practical Class B amplifier is to use a pair of active devices (transistors) arranged in push-pull mode where one transistor conducts one half cycle and the other transistor conducts the other half cycle. The output from both transistors are then combined together to get a scaled replica of the input. But there is a snag – there must be some way to split the input wave form to feed the individual transistors and there must be some way to put together the output of the individual transistors. Transformer coupling is solution for this problem and such amplifiers are called transformer coupled Class B amplifiers.

Transformer coupled Class B amplifier.



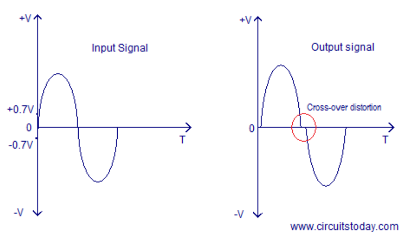
Transformer coupled Class B amplifier www.circuitstoday.com

The circuit diagram of a simple transformer coupled class B power amplifier is shown in the figure above. Transistor Q1 and Q2 are the active elements. The transformer T1 reproduces the input signal into two copies which are 180° out of phase. From the above figure you can see that the transistor Q1 amplifies the positive half of the input signal and transistor Q2 amplifies the negative half of the input signal. Current flow path of the two transistors are also depicted in the above figure. The amplified two halves are joined together by the transformer T2. If an ideal transformer is used the DC components of the collector current of each transistors will flow in opposite directions through the transformer primary and they will cancel each other. That means there is no core saturation and there will be no DC components in the output.

Since the transistors are not biased they remains OFF when there is no input signal and no current flows through the load. Each transistor starts conduction only when the amplitude of the input signal goes above the base-emitter voltage (**V***be*) of the transistor which is about 0.7 V. This improves the efficiency but creates a problem called cross-over distortion.

Cross over distortion.

Since the active elements start conduction only after the input signal amplitude has risen above 0.7V, the regions of the input signal where the amplitude is less than 0.7V will be missing in the output signal and it is called cross over distortion. The schematic representation of cross-over distortion is shown in the figure below. In the figure, you can see that the regions of the input waveform which are under 0.7V are missing in the output waveform.



Advantages of Class B amplifier.

- High efficiency when compared to the Class A configurations.
- Push-pull mechanism avoids even harmonics.
- No DC components in the output (in ideal case).

Disadvantages of Class B amplifier.

- The major disadvantage is the cross-over distortion.
- Coupling transformers increases the cost and size.
- It is difficult to find ideal transformers.
- Transformer coupling causes hum in the output and also affects the low frequency response.
- Transformer coupling is not practical in case of huge loads.

Qno3(b)

Voltage regulators

A voltage regulator is used to regulate voltage levels. When a steady, reliable voltage is needed, then the voltage regulator is the preferred device. It generates a fixed output voltage that remains constant for any changes in an input voltage or load conditions. It acts as a buffer for protecting components from damages. A voltage regulator is a device with a simple feed-forward design and it uses negative feedback control loops. There are mainly two types of voltage regulators: Linear voltage regulators and switching voltage regulators; these are used in wider applications. The linear voltage regulator is the easiest type of voltage regulator. It is available in two types, which are compact and used in low power, low voltage systems. Let us discuss different types of voltage regulators.

Types of Voltage Regulators and Their Working Principle

Basically, there are two types of Voltage regulators: Linear voltage regulator and Switching voltage regulator.

- There are two types of Linear voltage regulators: Series and Shunt.
- There are three types of Switching voltage regulators: Step up, Step down and Inverter voltage regulators.

Linear Regulator

Linear regulator acts as a voltage divider. In the Ohmic region, it uses FET. The resistance of the voltage regulator varies with load resulting in constant output voltage.

Advantages of a linear voltage regulator

- Gives a low output ripple voltage
- Fast response time to load or line changes
- Low electromagnetic interference and less noise

Series Voltage Regulator

A series voltage regulator uses a variable element placed in series with the load. By changing the resistance of that series element, the voltage dropped across it can be changed. And, the voltage across the load remains constant.

The amount of current drawn is effectively used by the load; this is the main advantage of the series voltage regulator. Even when the load does not require any current, the series regulator does not draw full current. Therefore, a series regulator is considerably more efficient than shunt voltage regulator.

Shunt Voltage Regulator

A shunt voltage regulator works by providing a path from the supply voltage to ground through a variable resistance. The current through the shunt regulator has diverted away from the load and flows uselessly to the ground, making this form usually less efficient than the series regulator. It is, however, simpler, sometimes consisting of just a voltage-reference diode, and is used in very low-powered circuits wherein the wasted current is too small to be of concern. This form is very common for voltage reference circuits. A shunt regulator can usually only sink (absorb) current.

Applications of Shunt Regulators

Shunt regulators are used in:

- Low Output Voltage Switching Power Supplies
- Current Source and Sink Circuits
- Error Amplifiers
- Adjustable Voltage or Current Linear and Switching Power Supplies
- Voltage Monitoring
- Analog and Digital Circuits that require precision references
- Precision current limiters

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.

Qno 4

Flash ADC and its Working Principle

Another type of ADC is parallel ADC. Parallel ADC is called as Flash ADC. Its response is very fast. it converts analog signal into digital signal using parallel set of comparators. As its conversion time is very fast it is called as flash ADC.

Following figure shows circuit diagram of parallel ADC or flash ADC.

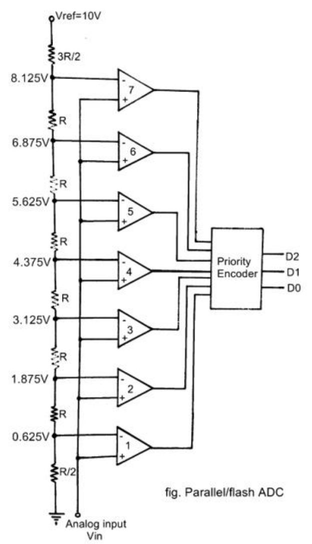


fig. Parallel/flash ADC

Flash ADC or Parallel ADC

n-bit Flash ADC consist of parallel combination of 2^n-1 comparators. Outputs of all comparators are connected to an encoder.

Working Principle of flash ADC

Analog voltage is applied to non inverting terminals of all comparators using a single line. Reference voltage is applied to inverting terminals of comparators using divider circuit.

Each comparator produces digital output in the form of 1 or 0. If unknown analog voltage is greater than reference voltage comparator produces high logic. If analog voltage is less than reference voltage then comparator produces low logic i.e. 0.

Thus all parallel comparator produces digital representation of analog voltage in the form of zero and one. These outputs of comparator are then applied to the fast encoder. Encoder converts those zeros and once into binary number and produces digital binary output.

For example,When unknown voltage is 5 i.e. lies between 4.375 &5.625 is applied to the flash ADC, first four encoders produces output '1' and last three encoders produces output '0'. Encoder converts this '1111000' comparator output into '100' binary number as digital output.

QNo5(a)

Low pass filter Vs High pass filter

PARAMETERS	HIGH PASS FILTER	LOW PASS FILTER
Definition	It is a circuit which allows the frequencies above cut off frequency to pass through it.	It is a circuit which allows the frequency below cut off frequency to pass through it.
Circuit Architecture	It consists of Capacitor followed by a resistor.	It consists of resistor followed by capacitor.
Significance	It is significant when the distortion due to low frequency signal such as noise is to be removed.	It is significant in removing aliasing effect.
Operating Frequency	Higher than the cut off frequency.	Lower than the cut off frequency.
Applications	In audio amplifiers, low noise amplifiers etc.	In communications circuit as anti-aliasing filter.

Qno 5(b)

Active filter Vs passive filter

Basis for Comparison	Active Filter	Passive Filter
Composed of	Active components like op-amp, transistor etc.	Passive components like resistor, inductor and capacitor etc.
Cost	High	Comparatively low.
Circuit complexity	More complex	Less complex than active filter.
Weight	Low	Comparatively bulkier due to presence of inductors.
Q factor	High	Very low in comparison to active filters.
External power supply	Required	Not required
Sensitivity	More sensitive	Comparatively less sensitive.