Course/Branch : B.E/EEE /	**Year / Semester** :II/IV	Format No.	NAC/TLP-07a.5
Subject Code :EE8451	**Subject Name** :LINEAR INTEGRATED CIRCUITS AND APPLICATIONS	Rev. No.	02
Unit No : 05	**Unit Name : APPLICATION ICs**	Date	14-11-2017

LECTURE NOTES

UNIT-V APPLICATION ICs

- All electronic circuits need a dc power supply for their operation. To obtain this dc voltage from 230 V ac mains supply, we need to use rectifier.
- Therefore the filters are used to obtain a ―stead y‖ dc voltage from the pulsating one.
- The filtered dc voltage is then applied to a regulator which will try to keep the dc output voltage constant in the event of voltage fluctuations or load variation.
- We know the combination of rectifier & filter can produce a dc voltage. But the problem with this type of dc power supply is that its output voltage will not remain constant in the event of fluctuations in an ac input or changes in the load current(I_L).
- The output of unregulated power supply is connected at the input of voltage regulator circuit.
- The voltage regulator is a specially designed circuit to keep the output voltage constant.
- It does not remain exactly constant. It changes slightly due to changes in certain parameters.

Factors affecting the output voltage:

I_L (Load Current)

V_{In}(Input Voltage)

T (Temperature)

IC Voltage Regulators:

They are basically series regulators with all the basic blocks present inside the IC. Therefore it is easier to use IC voltage regulator instead of discrete voltage regulators.

Important features of IC Regulators:

1. Programmable output
2. Facility to boost the voltage/current
3. Internally provided short circuit current limiting

LECTURE NOTES

4. Thermal shutdown
5. Floating operation to facilitate higher voltage output

Classifications of IC voltage regulators:

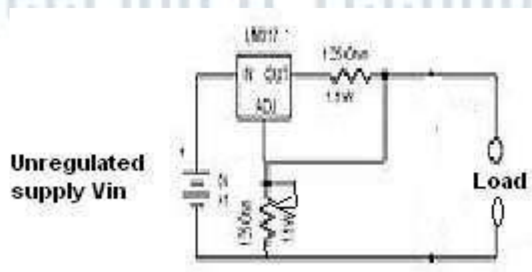
IC Voltage Regulator

- Fixed & Adjustable output Voltage Regulators are known as Linear Regulator.
- A series pass transistor is used and it operates always in its active region. Switching Regulator:

1. Series Pass Transistor acts as a switch.
2. The amount of power dissipation in it decreases considerably.
3. Power saving result is higher efficiency compared to that of linear. Adjustable Voltage Regulator:

Advantages of Adjustable Voltage Regulator over fixed voltage regulator are,

1. Adjustable output voltage from 1.2v to 57 v
2. Output current 0.10 to 1.5 A
3. Better load & line regulation
4. Improved overload protection
5. Improved reliability under the 100% thermal overloading Adjustable Positive Voltage Regulator (LM317):



- LM317 series adjustable 3 terminal positive voltage regulator, the three terminals are Vin, Vout & adjustment (ADJ).
- LM317 requires only 2 external resistors to set the output voltage.
- LM317 produces a voltage of 1.25v between its output & adjustment terminals. This voltage is called as Vref.
- Vref (Reference Voltage) is a constant, hence current I1 flows through R1 will also be constant. Because resistor R1 sets current I1. It is called —current set‖ or —program resistor‖.
- Resistor R2 is called as — Output set‖ resistors, hence current through this resistor is the sum of I1 & Iadj
- LM317 is designed in such as that Iadj is very small & constant with changes in line voltage & load current.
- The output voltage Vo is, Vo=R1I1+(I1+Iadj)R2 ----------------(1)

Where I1= Vref/R1

Vo =(Vref/R1)R1 + Vref/R1 + Iadj R2

= Vref + (Vref/R1)R2 + Iadj R2

Vo = Vref [1 + R2/R1] + Iadj R2 ------------------------------ (2)

R1 = Current (I1) set resistor

R2 = output (Vo) set resistor

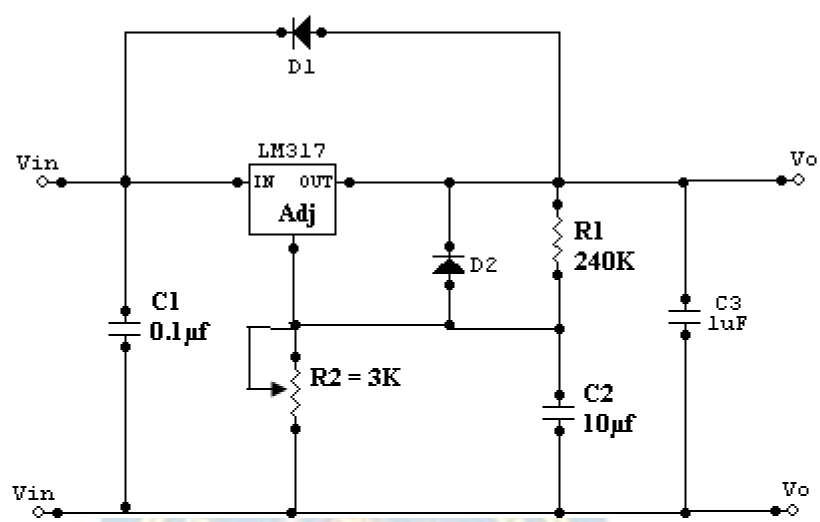
Vref = 1.25v which is a constant voltage between output and ADJ terminals.

- Current Iadj is very small. Therefore the second term in (2) can be neglected.
- Thus the final expression for the output voltage is given by

Vo= 1.25v[1 + R2/R1] --------------------------------(3)

Eqn (3) indicates that we can vary the output voltage by varying the resistance R2. The value of R1 is normally kept constant at 240 ohms for all practical applications.

Practical Regulator using LM317:



- If LM317 is far away from the input power supply, then 0.1µf disc type or 1µf tantalum capacitor should be used at the input of LM317.

  The output capacitor Co is optional. Co should be in the range of 1 to 1000µf.

- The adjustment terminal is bypassed with a capacitor C2 this will improve the ripple rejection ratio as high as 80 dB is obtainable at any output level.
- When the filter capacitor is used, it is necessary to use the protective diodes.
- These diodes do not allow the capacitor C2 to discharge through the low current point of the regulator.
- These diodes are required only for high output voltages (above 25v) & for higher values of output capacitance 25µf and above.

IC 723 – GENERAL PURPOSE REGULATOR

Disadvantages of fixed voltage regulator:

1. Do not have the shot circuit protection
2. Output voltage is not adjustable

These limitations can be overcomes in IC723. Features of IC723:

1. Unregulated dc supply voltage at the input between 9.5V & 40V
2. Adjustable regulated output voltage between 2 to 3V.
3. Maximum load current of 150 mA (I_{Lmax} = 150mA).
4. With the additional transistor used, I_{Lmax} upto 10A is obtainable.
5. Positive or Negative supply operation
6. Internal Power dissipation of 800mW.
7. Built in short circuit protection.
8. Very low temperature drift.
9. High ripple rejection.

The simplified functional block diagram can be divided in to 4 blocks.

1. Reference generating block
2. Error Amplifier
3. Series Pass transistor
4. Circuitry to limit the current
5. Reference Generating block:

The temperature compensated Zener diode, constant current source & voltage reference amplifier together from the reference generating block. The Zener diode is used

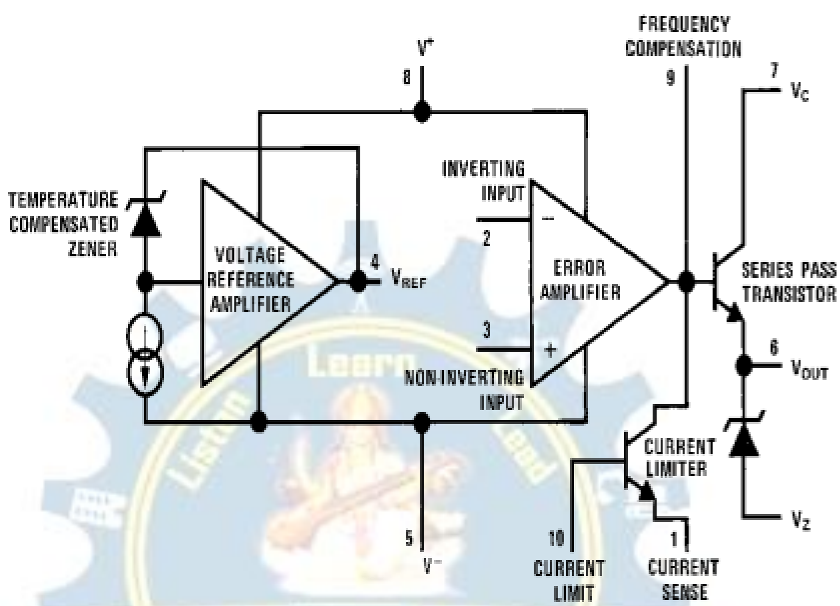
to generate a fixed reference voltage internally. Constant current source will make the

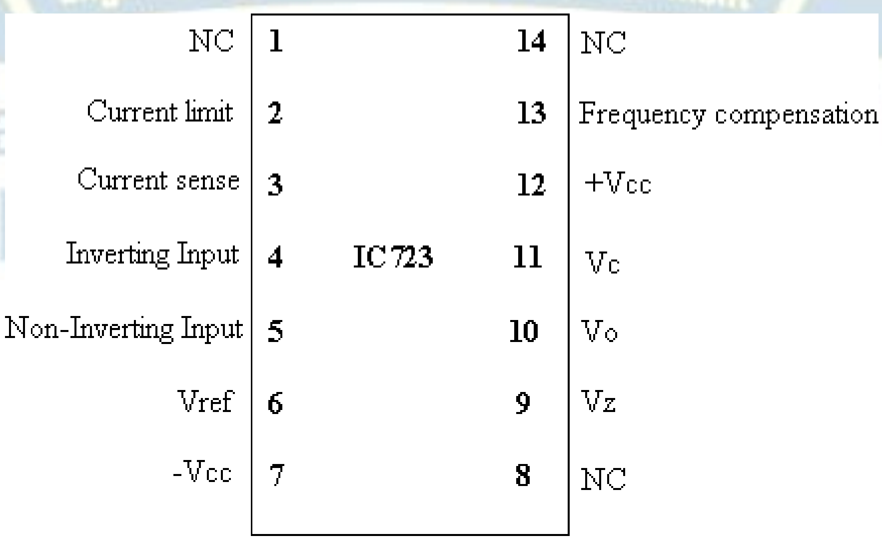
Zener diode to operate at affixed point & it is applied to the Non – inverting terminal of error amplifier. The Unregulated input voltage ±Vcc is applied to the voltage reference amplifier as well as error amplifier.

2. Error Amplifier:

LECTURE NOTES

Error amplifier is a high gain differential amplifier with 2 input (inverting & Non- inverting). The Non-inverting terminal is connected to the internally generated reference voltage. The Inverting terminal is connected to the full regulated output voltage.





Course/Branch : B.E/EEE /	**Year / Semester** :II/IV	Format No.	NAC/TLP-07a.5
Subject Code :EE8451	**Subject Name** :LINEAR INTEGRATED CIRCUITS AND APPLICATIONS	Rev. No.	02
Unit No : 05	**Unit Name : APPLICATION ICs**	Date	14-11-2017

LECTURE NOTES

3. Series Pass Transistor:

Q1 is the internal series pass transistor which is driven by the error amplifier. This transistor actually acts as a variable resistor

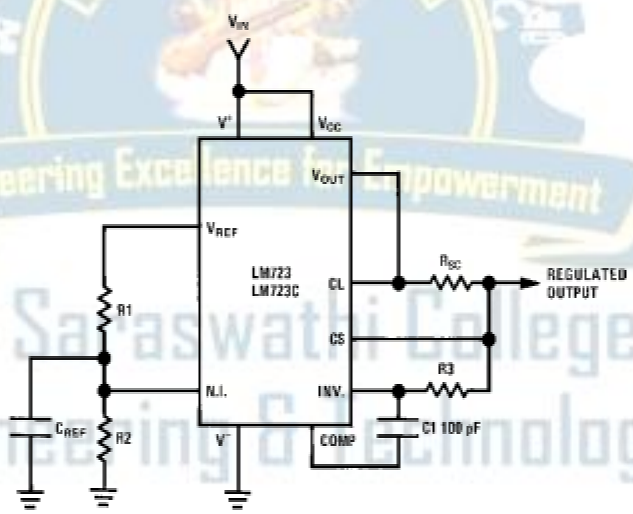
& regulates the output voltage. The collector of transistor Q1 is

connected to the Un-regulated power supply. The maximum collector voltage of Q1 is limited to 36Volts. The maximum current which can be supplied by Q1 is 150mA.

4. Circuitry to limit the current:

The internal transistor Q2 is used for current sensing & limiting. Q2 is normally OFF transistor. It turns ON when the I_L exceeds a predetermined limit.

- Low voltage , Low current is capable of supplying load voltage which is equal to or between 2 to 7Volts.



- R1 & R2 from a potential divider between Vref & Gnd.
- The Voltage across R2 is connected to the Non – inverting terminal of the regulator IC

LECTURE NOTES

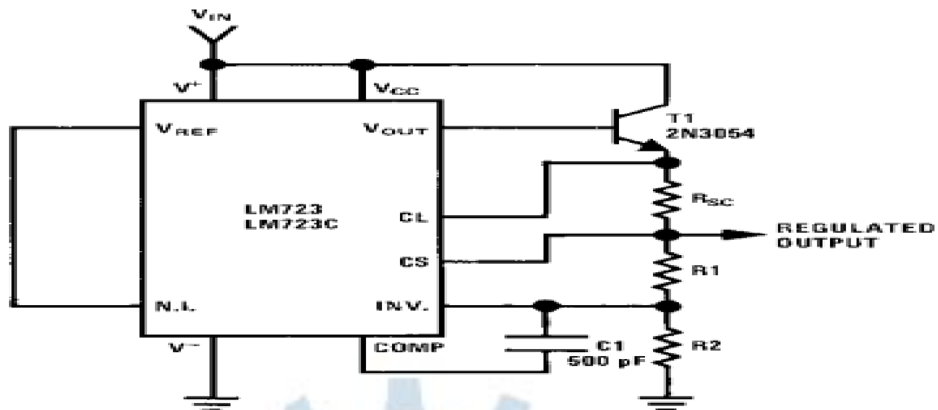


Fig: Typical circuit connection diagram

- An external transistor Q is added in the circuit for high voltage low current regulator to improve its current sourcing capacity.
- For this circuit the output voltage varies between 7 & 37V.
- Transistor Q increase the current sourcing capacity thus $I_{L(MAX)}$ ia greater than 150mA.
- The output voltage Vo is given by ,

V0=(R2/R1+R2)Vref

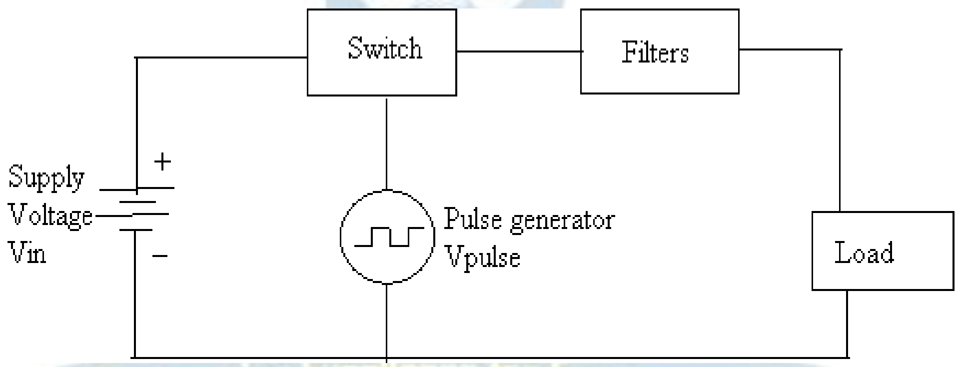
SWITCHING REGULATOR:

An example of general purpose regulator is Motorola‘s MC1723. It can be used in many different ways, for example, as a fixed positive or negative output voltage regulator, variable regulator or switching regulator because of its flexibility.

To minimize the power dissipation during switching, the external transistor used must be a switching power transistor.

To improve the efficiency of a regulator, the series pass transistor is used as a switch rather than as a variable resistor as in the linear mode.

- A regulator constructed to operate in this manner is called a series switching regulator. In such regulators the series pass transistor is switched between cut off & saturation at a high frequency which produces a pulse width modulated (PWM) square wave output.
- This output is filtered through a low pass LC filter to produce an average dc output voltage.
    - Thus the output voltage is proportional to the pulse width and frequency.
    - The efficiency of a series switching regulator is independent of the input & output differential & can approach 95%



A basic switching regulator consists of 4 major components,

1. Voltage source Vin
2. Switch S1
3. Pulse generator Vpulse
4. Filter F1
5. **Voltage Source Vin:**

It may be any dc supply – a battery or an unregulated or a regulated voltage. The voltage source must satisfy the following requirements.

- It must supply the required output power & the losses associated with the switching regulator.

- It must be large enough to supply sufficient dynamic range for line & load regulations.
- It must be sufficiently high to meet the minimum requirement of the regulator system to be designed.
- It may be required to store energy for a specified amount of time during power failures.

2. **Switch S1:**

It is typically a transistor or thyristor connected as a power switch & is operated in the saturated mode. The pulse generator output alternately turns the switch ON & OFF

3. **Pulse generator Vpulse:**

It provides an asymmetrical square wave varying in either frequency or pulse width called frequency modulation or pulse width modulation respectively. The most effective frequency range for the pulse generator for optimum efficiency 20 KHz. This frequency is inaudible to the human ear & also well within the switching speeds of most inexpensive transistors & diodes.

- The duty cucly of the pulse wave form determines the relationship between the input & output voltages. The duty cycle is the ratio of the on time ton, to the period T of the pulse waveform.

4. **Filter F1:**

It converts the pulse waveform from the output of the switch into a dc voltage. Since this switching mechanism allows a conversion similar to transformers, the switching regulator is often referred to as a dc transformer.

The output voltage Vo of the switching regulator is a function o f duty cycle & the input voltage Vin.

- This equation indicates that, if time period T is constant, Vo is directly proportional to the ON-time, ton for a given value of Vin. This method of changing the output voltage by varying ton is referred to as a pulse width modulation.
- Similarly, if ton is held constant, the output voltage Vo is inversely proportional to the period T or directly proportional to the frequency of the pulse waveform. This method of varying the output voltage is referred to as frequency modulation (FM).

MONOLITHIC SWITCHING REGULATOR [µA78S40]:

The µA78S40 consists of a temperature compensated voltage reference, duty cycle controllable oscillator with an active current limit circuit, a high gain comparator, a high- current, high voltage output switch, a power switching diode & an uncommitted op-amp.

Important features of the µA78S40 switching regulators are:

- Step up, down & Inverting operation
- Operation from 2.5 to 40V input

80dB line & load regulations

- Peak current to 1.5A without external resistors
- Variable frequency, variable duty cycle device

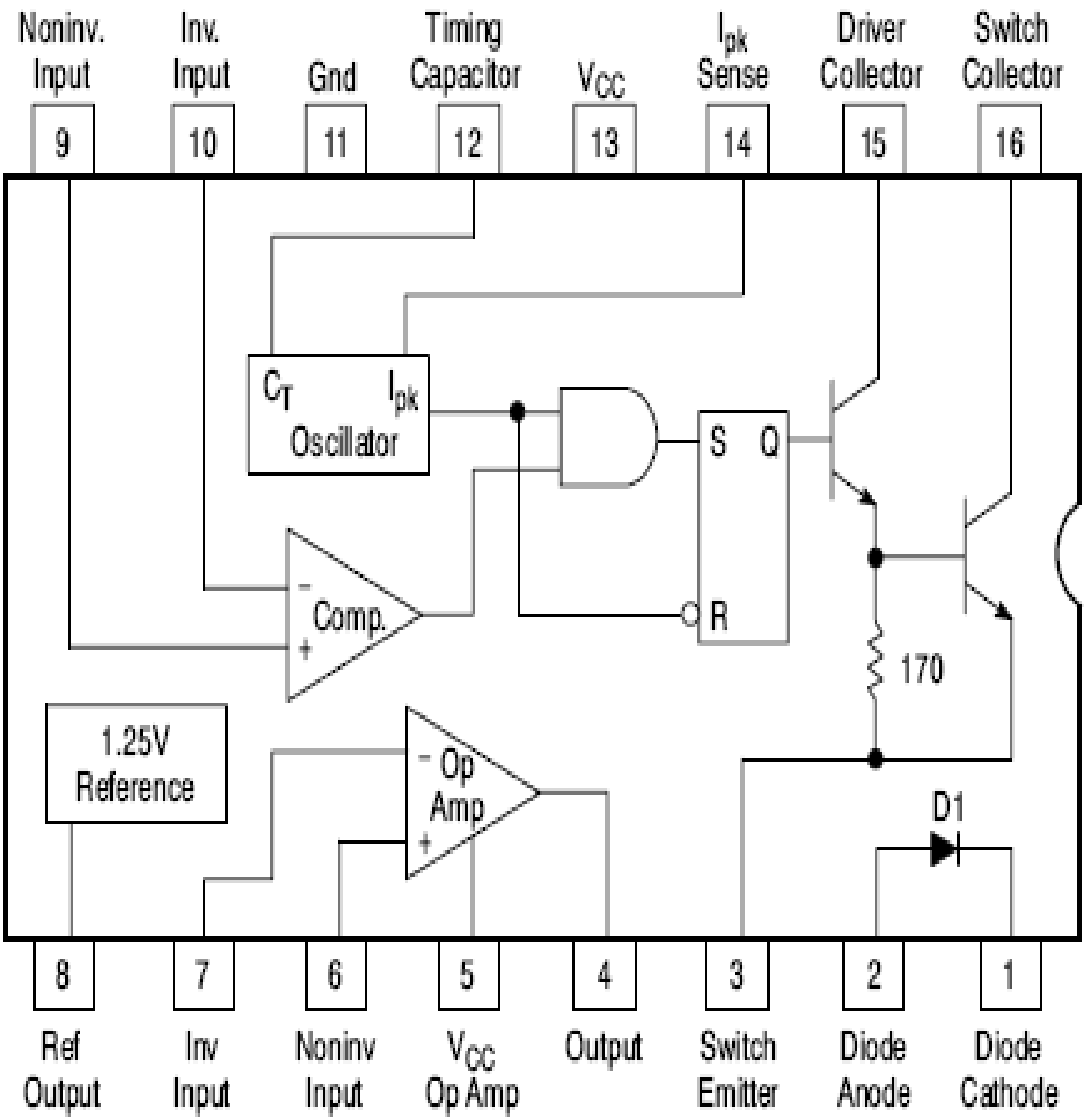
The internal switching frequency is set by the timing capacitor C_T, connected between pin12 & ground pin 11. the initial duty cycle is 6:1. The switching frequency & duty cycle can be modified by the current limit circuitry, I_{PK}sense, pin14, 7 the comparator, pin9 & 10.

Comparator:

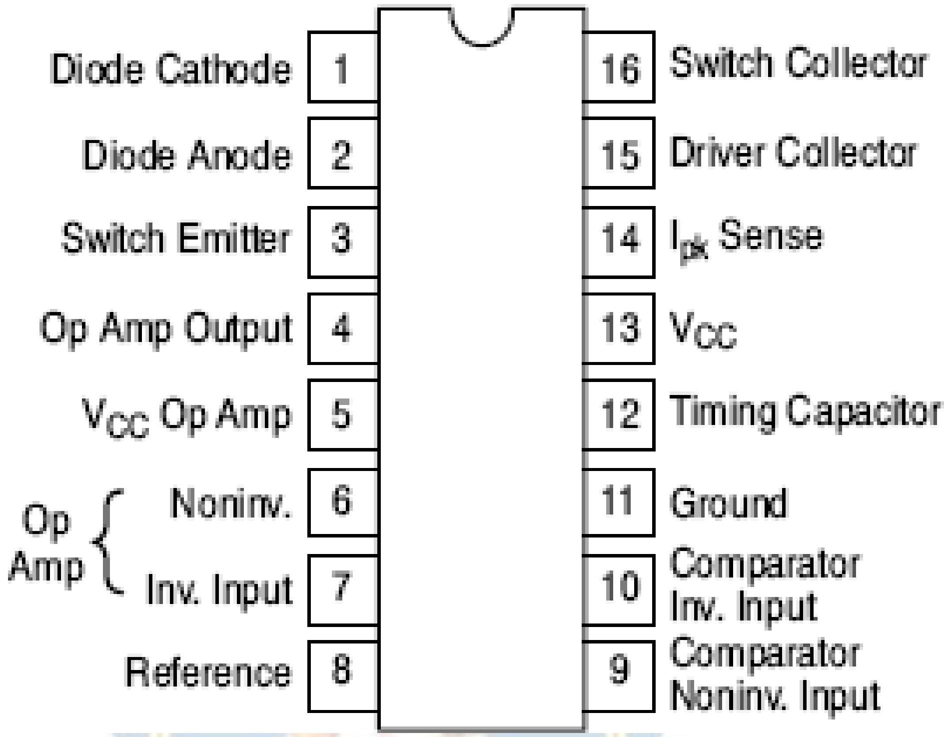
The comparator modifies the OFF time of the output switch transistor Q1 & Q2. In the step

– up & step down modes, the non- inverting input(pin9) of the comparator is connected to the voltage reference of 1.3V (pin8) & the inverting input (pin10) is connected to the output terminal via the voltage divider network.

LECTURE NOTES



LECTURE NOTES



- In the Inverting mode · the non – inverting input is connected to both the voltage reference & the output terminal through 2 resistors & the inverting terminal is connected to ground.
- When the output voltage is correct, the comparator output is in high state & has no effect on the circuit operation.
- However, if the output is too high & the voltage at the inverting terminal is higher than that at the non-inverting terminal , then the comparator output goes low.
- In the LOW state the comparator inhibits the turn on of the output switching transistors. This means that, as long as the comparator output is low, the system is in off time.
- As the output current rises or the output voltage falls, the off time of the system decreases.
- Consequently, as the output current nears its maximum Io_{MAX}, the off time approaches its minimum value.

In all 3 modes (Step down, step up, Inverting), the current limit circuit is completed by connecting a sense resistor Rsc, between I_{PK} sense & Vcc.

LECTURE NOTES

- The current limit circuit is activated when a 330mV potential appears across Rsc.
- Rsc is selected such that 330mV appears across it when the desired peak current I_{PK},

flows through it.

- When the peak current is reached, the current limit circuit is turned on.
- The forward voltage drop, V_D, across the internal power diode is used to determine the value of inductor L off time & efficiency of the switching regulator.
- Another important quantity used in the design of a switching regulator is the saturation voltage Vs
  - ✓ In the step down mode an —output saturation volt‖ is 1.1V typical, 1.3 V_{MAX}.
  - ✓ In the step up mode an — Output saturation volt‖ is 0.45V typical, 0.7 maximum.
- **Step – Down Switching Regulator:**
  - ✓ C_T is the timing capacitor which decides the switching frequency.
- Rsc is the current sensing resistance. Its value is given by The Non- inverting terminal of the internal op-amp(pin9) is connected to the 1.3V reference (pin8).
- Resistances R1 & R2 from a potential divider, across the output voltage Vo. Their value should be such that the potential at the inverting input of the op-amp should be equal to 1.3V ref when Vo is at its desired level.

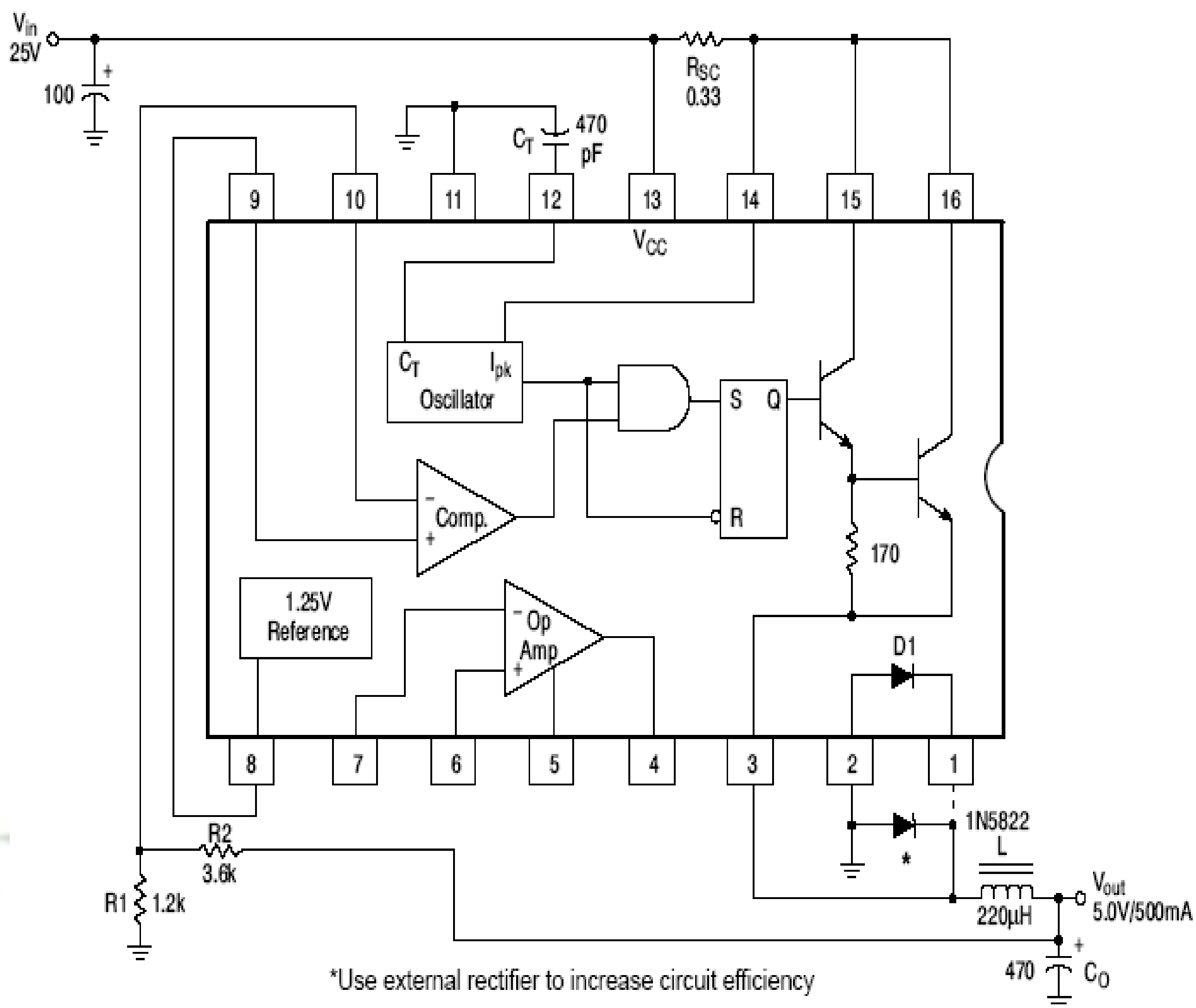


Figure 6. Step–Down Converter

LECTURE NOTES

Step – Up Switching Regulator

- Note that inductor is connected between the collectors of Q1 & Q2.
- When Q1 is ON, the output is shorted & the collector current of Q1 flows through L.
- The diode D1 is reverse biased & Co supplies the load current.
- The inductor stores the energy. When the Q1 is turned OFF, there is a self induced emf that appears across the inductor with polarities.
- The output voltage is given by,

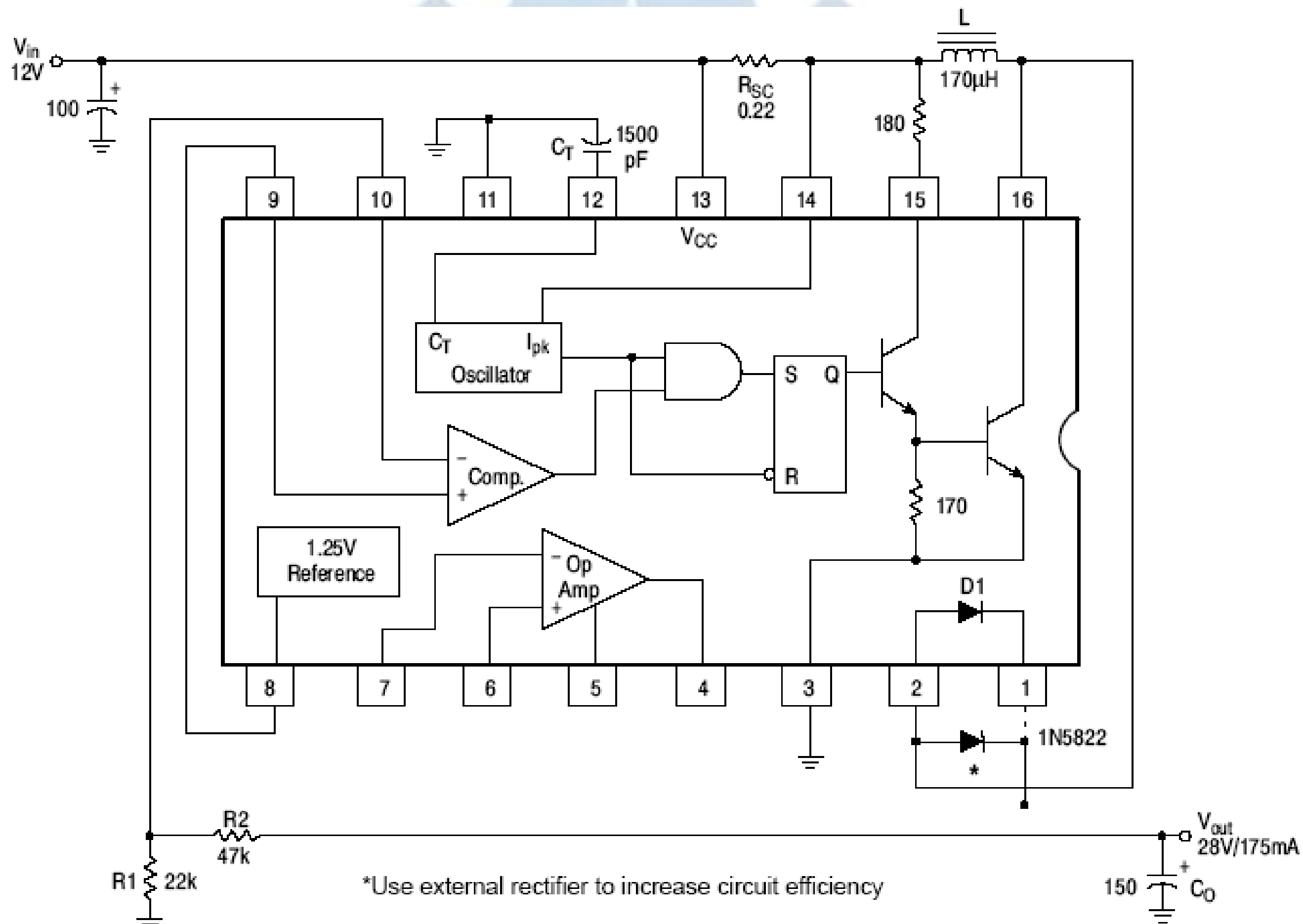
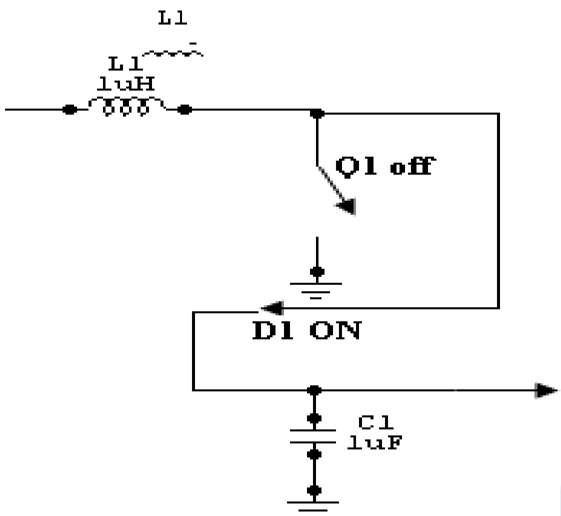
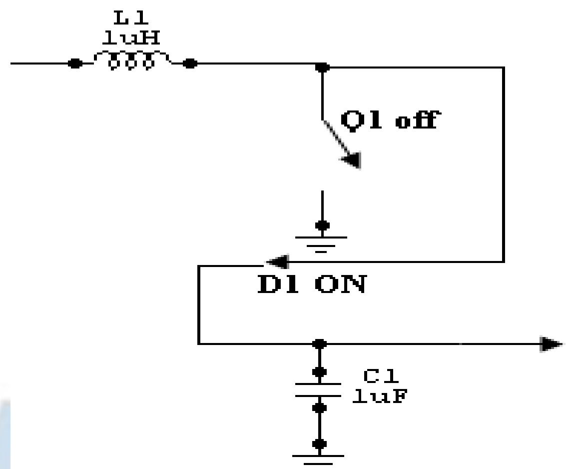


Figure 7. Step–Up Converter

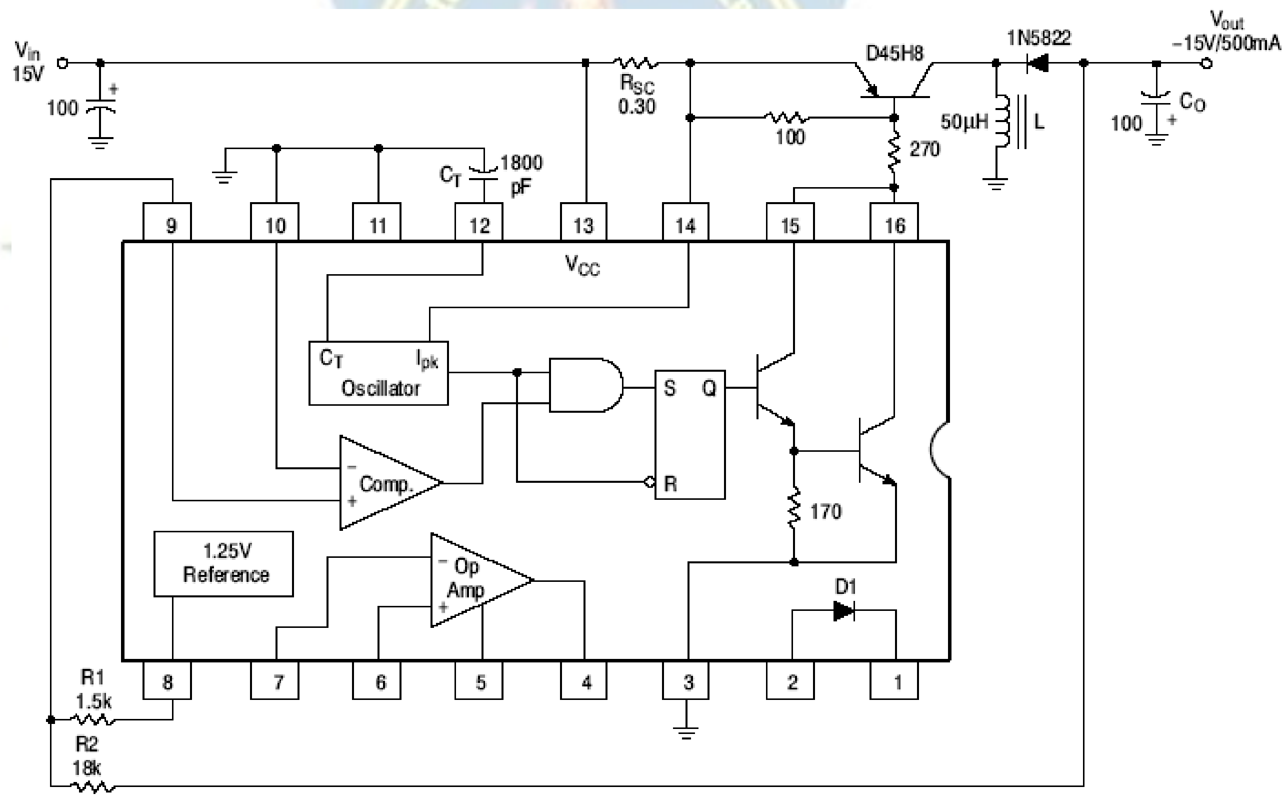
Course/Branch : B.E/EEE /	**Year / Semester** :II/IV	Format No.	NAC/TLP-07a.5
Subject Code :EE8451	**Subject Name** :LINEAR INTEGRATED CIRCUITS AND APPLICATIONS	Rev. No.	02
Unit No : 05	**Unit Name : APPLICATION ICs**	Date	14-11-2017

LECTURE NOTES





Inverting Switching Regulator:



POWER AUDIO AMPLIFIER IC LM380:

Features of LM380:

1. Internally fixed gain of 50 (34dB)
2. Output is automatically self centring to one half of the supply voltage.
3. Output is short circuit proof with internal thermal limiting.
4. Input stage allows the input to be ground referenced or ac coupled.
5. Wide supply voltage range (5 to 22V).
6. High peak current capability.
7. High impedence.
8. Low total harmonic distortion
9. Bandwidth of 100KHz at Pout = 2W & $R_L = 8\Omega$

Introduction:

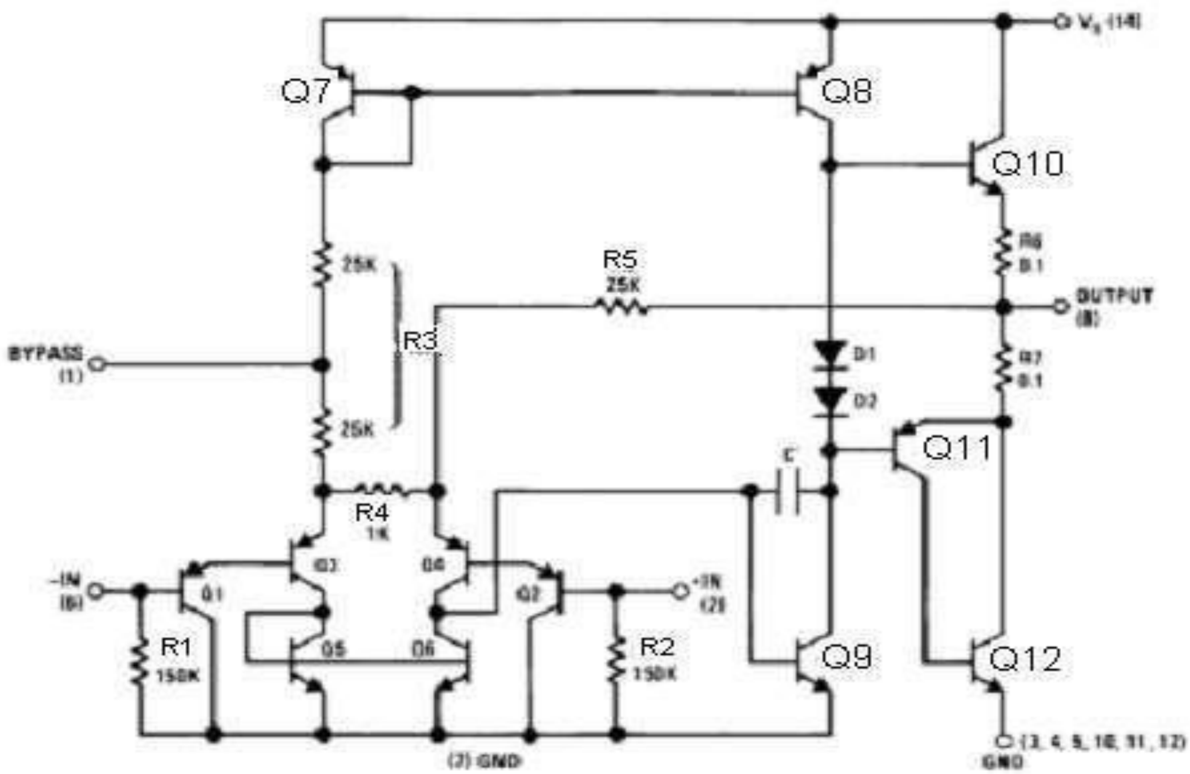
Small signal amplifier are essentially voltage amplifier that supply their loads with larger amplifier signal voltage.

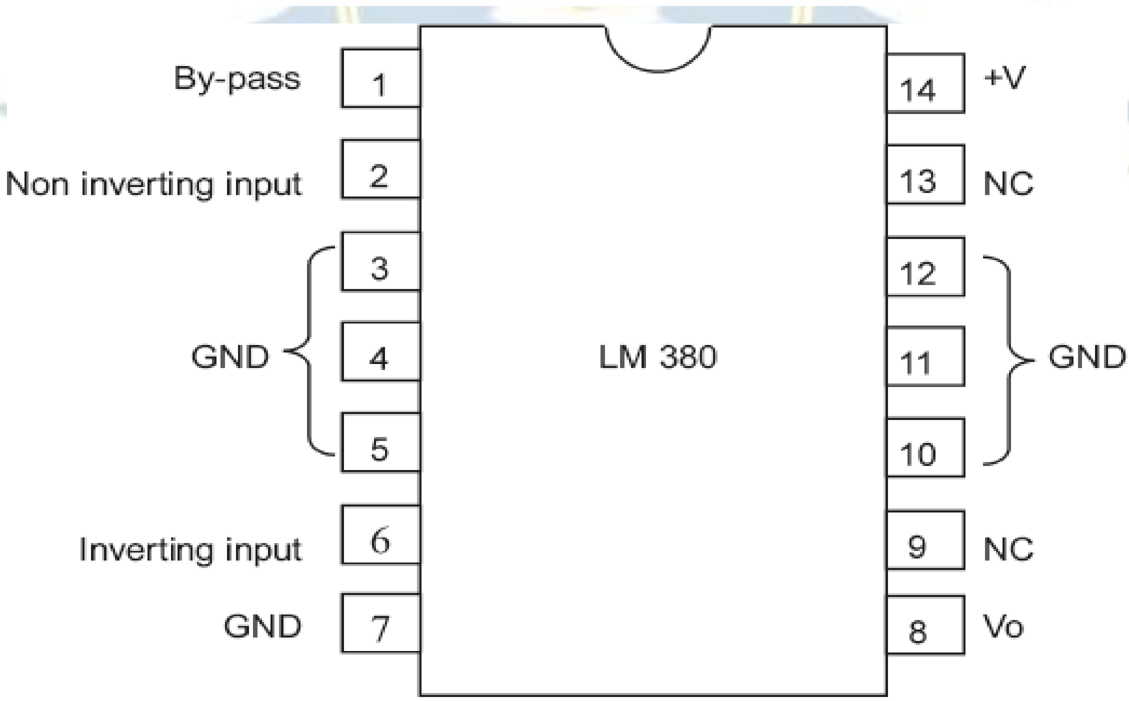
On the other hand , large signal or power amplifier supply a large signal current to current operated loads such as speakers & motors

In audio applications, however, the amplifier called upon to deliver much higher current than that suppkied by general purpose op-amps. This means that loads such as speakers & motors requiring substantial currents cannot be driven directly by the output of general purpose opo-amps.

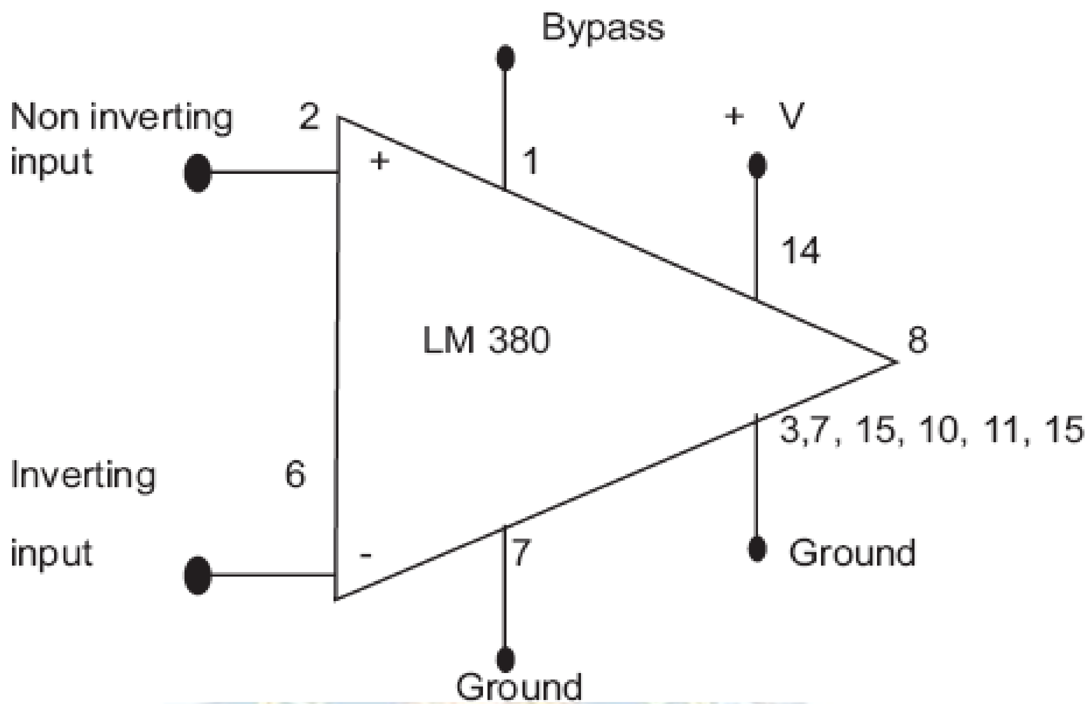
there are two possible solutions,

- To use discrete or monolithic power transistors called power boosters at the output of the op-amp
- To use specialized ICs designed as power amplifiers. However


Q7
Q8
Q10
R5
25K
R3
25K
25K
BYPASS
(1)
OUTPUT
(8)
D1
D2
Q11
R4
1K
Q3
Q4
Q1
Q2
Q5
Q6
R1
150K
R2
150K
Q9
Q12
(7) GND
GND


By-pass
Non inverting input
GND
Inverting input
GND
1
2
3
4
5
6
7
LM 380
14
13
12
11
10
9
8
+V
NC
GND
NC
Vo

LECTURE NOTES



LM380 circuit description:

It is connected of 4 stages,

PNP emitter follower

Different amplifier

Common emitter

Emitter follower

(i) PNP Emitter follower:

- The input stage is emitter follower composed of PNP transistors Q1 & Q2 which drives the PNP Q3-Q4 differential pair.
- The choice of PNP input transistors Q1 & Q2 allows the input to be referenced to ground i.e., the input can be direct coupled to either the inverting & non-inverting terminals of the amplifier.
- Differential Amplifier:

LECTURE NOTES

- The current in the PNP differential pair Q3-Q4 is established by Q7, R3 & +V.
- The current mirror formed by transistor Q7, Q8 & associated resistors then establishes the collector current of Q9.
- Transistor Q5 & Q6 constitute of collector loads for the PNP differential pair.
- The output of the differential amplifier is taken at the junction of Q4 & Q6 transistors & is applied as an input to the common emitter voltage gain.
- Common Emitter:
- Common Emitter amplifier stage is formed by transistor Q9 with D1, D2 & Q8 as a current source load.

- The capacitor C between the base & collector of Q9 provides internal compensation & helps to establish the upper cutoff frequency of 100 KHz.
- Since Q7 & Q8 form a current mirror, the current through D1 & D2 is approximately the same as the current through R3.
- D1 & D2 are temperature compensating diodes for transistors Q10 & Q11 in that D1 & D2 have the same characteristics as the base-emitter junctions of Q11. Therefore the current through Q10 & (Q11-Q12) is approximately equal to the current through diodes D1 & D2.

(iv) (Output stage) - Emitter follower:

- Emitter follower formed by NPN transistor Q10 & Q11. The combination of PNP transistor Q11 & NPN transistor Q12 has the power capability of an NPN transistors but the characteristics of a PNP transistor.
- The negative dc feedback applied through R5 balances the differential amplifier so that the dc output voltage is stabilized at +V/2;
- To decouple the input stage from the supply voltage +V, by pass capacitor in order of micro farad should be connected between the by pass terminal (pin 1) & ground (pin 7).
- The overall internal gain of the amplifier is fixed at 50. However gain can be increased by using positive feedback.

LECTURE NOTES

OPTOCOUPLERS/OPTOISOLATORS:

- Optocouplers or Optoisolators is a combination of light source & light detector in the same package.
- They are used to couple signal from one point to other optically, by providing a completer electric isolation between them. This kind of isolation is provided between a low power control circuit & high power output circuit, to protect the control circuit.

Depending on the type of light source & detector used we can get a variety of optocouplers. They are as follows,

It is defined as the ratio of output collector current (Ic) to the input forward current (If)

CTR = Ic/If * 100%

Its value depends on the devices used as source & detector.

(ii) Isolation voltage between input & output:

It is the maximum voltage which can exist differentially between the input & output without affecting the electrical isolation voltage is specified in K Vrms with a relative humidity of 40 to 60%.

(iii) Response Time:

Response time indicates how fast an optocoupler can change its output state. Response time largely depends on the detector transistor, input current & load resistance.

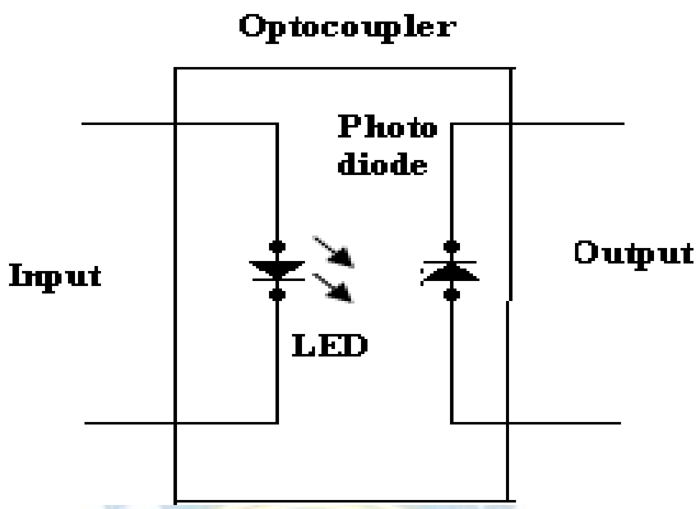
(iv) Common mode Rejection:

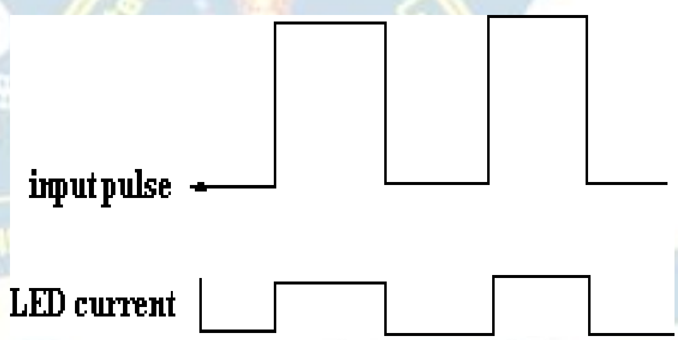
Eventhough the optocouplers are electrically isolated for dc & low frequency signals, an impulsive input signal (the signal which changes suddenly) can give rise to a displacement current

Ic= Cf*dv/dt. This current can flow between input & output due to the capacitance Cf existing between input & output. This allow the noise to appear in the output.

Types of optocoupler:

(i) LED – Photodiode optocoupler:

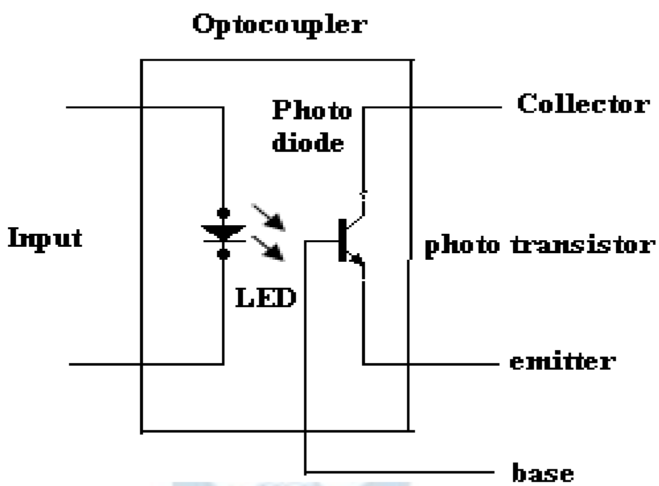


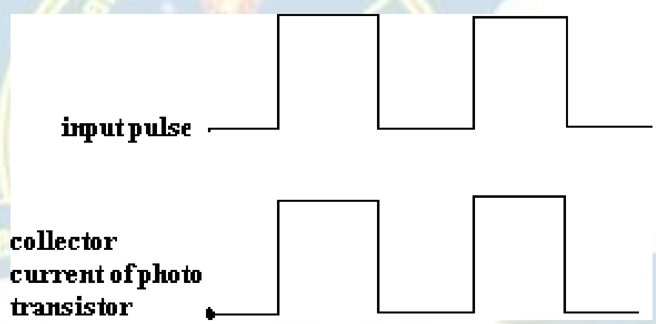


- LED photodiode shown in figure, here the infrared LED acts as a light source & photodiode is used as a detector.
- The advantage of using the photodiode is its high linearity. When the pulse at the input goes high, the LED turns ON. It emits light. This light is focused on the photodiode.
- In response to this light the photocurrent will start flowing though the photodiode. As soon as the input pulse reduces to zero, the LED turns OFF & the photocurrent through the photodiode reduces to zero. Thus the pulse at the input is coupled to the output side.

Course/Branch : B.E/EEE /	**Year / Semester** :II/IV	Format No.	NAC/TLP-07a.5
Subject Code :EE8451	**Subject Name** :LINEAR INTEGRATED CIRCUITS AND APPLICATIONS	Rev. No.	02
Unit No : 05	**Unit Name : APPLICATION ICs**	Date	14-11-2017

LECTURE NOTES





The LED phototransistor optocoupler shown in figure. An infrared LED acts as a light source and the phototransistor acts as a photo detector.

- This is the most popularly used optocoupler, because it does not need any additional amplification.

When the pulse at the input goes high, the LED turns ON. The light emitted by the LED is focused on the CB junction of the phototransistor

- In response to this light photocurrent starts flowing which acts as a base current for the phototransistor.
- The collector current of phototransistor starts flowing. As soon as the input pulse reduces to zero, the LED turns OFF & the collector current of phototransistor reduces to zero. Thus the pulse at the input is optically coupled to the output side.

Advantages of Optocoupler:

- Control circuits are well protected due to electrical isolation.
- Wideband signal transmission is possible.
- Due to unidirectional signal transfer, noise from the output side does not get coupled to the input side.
- Interfacing with logic circuits is easily possible.
- It is small size & light weight device. Disadvantages:
- Slow speed.
- Possibility of signal coupling for high power signals.

Applications:

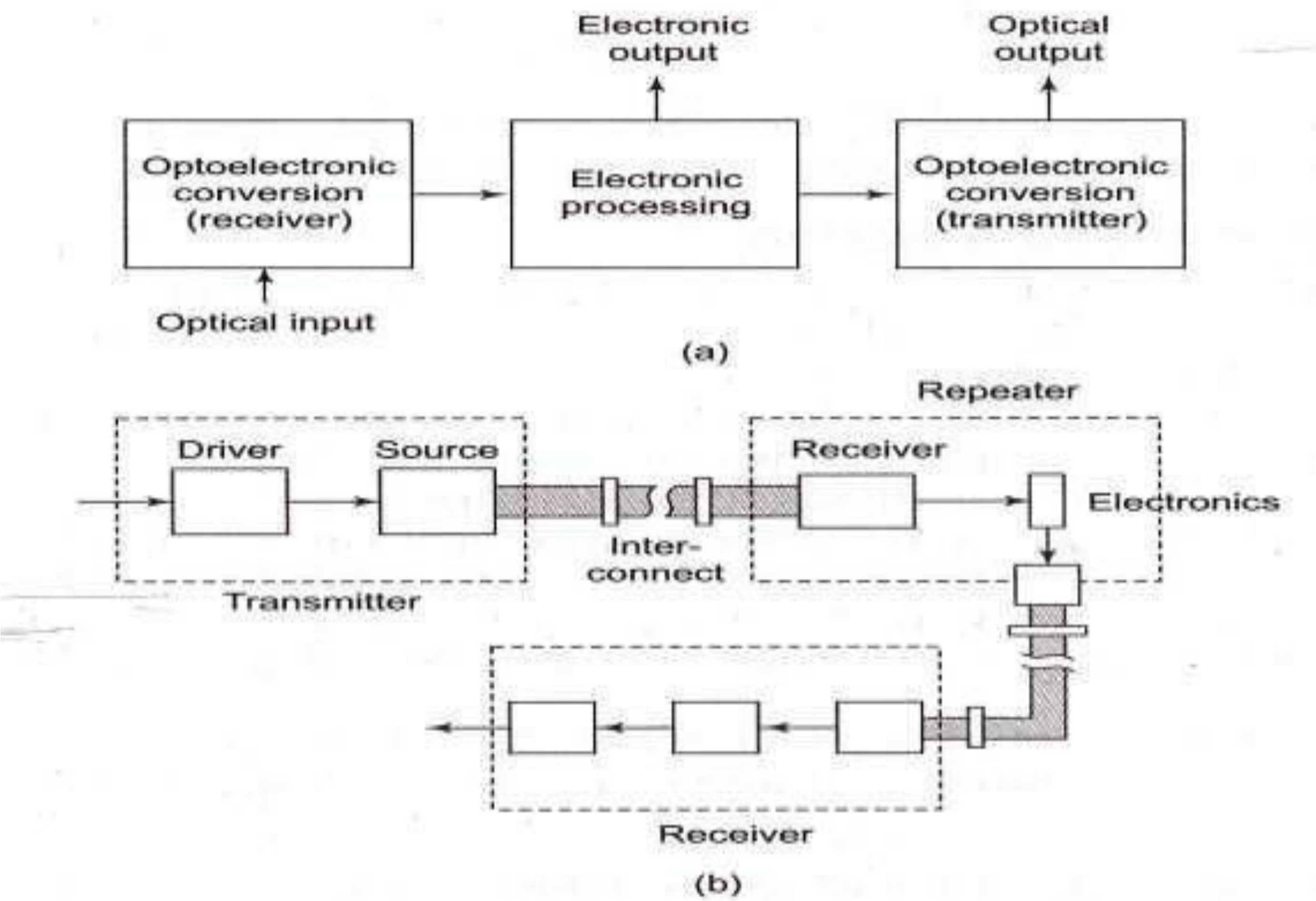
Optocouplers are used basically to isolate low power circuits from high power circuits.

- At the same time the control signals are coupled from the control circuits to the high power circuits.
- Some of such applications are,
- One of the most important applications of an optocoupler is to couple the base driving signals to a power transistor connected in a DC-DC chopper.
- Note that the input & output waveforms are 180º out of phase as the output is taken at the

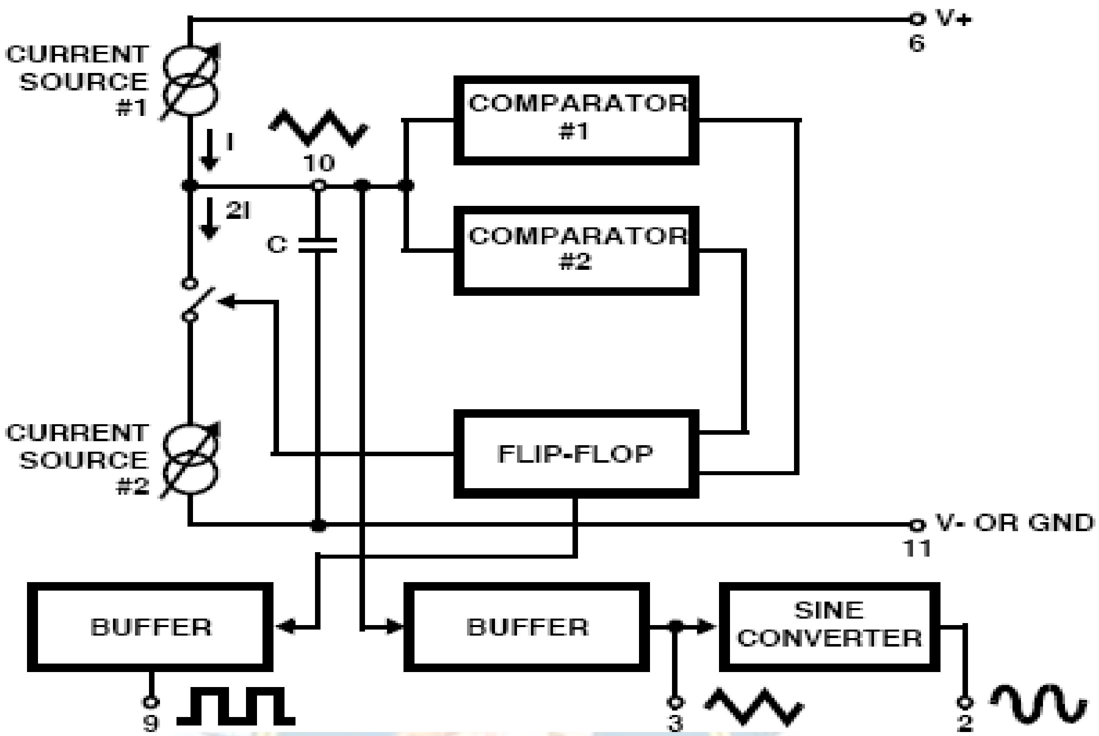
Optocoupler IC:

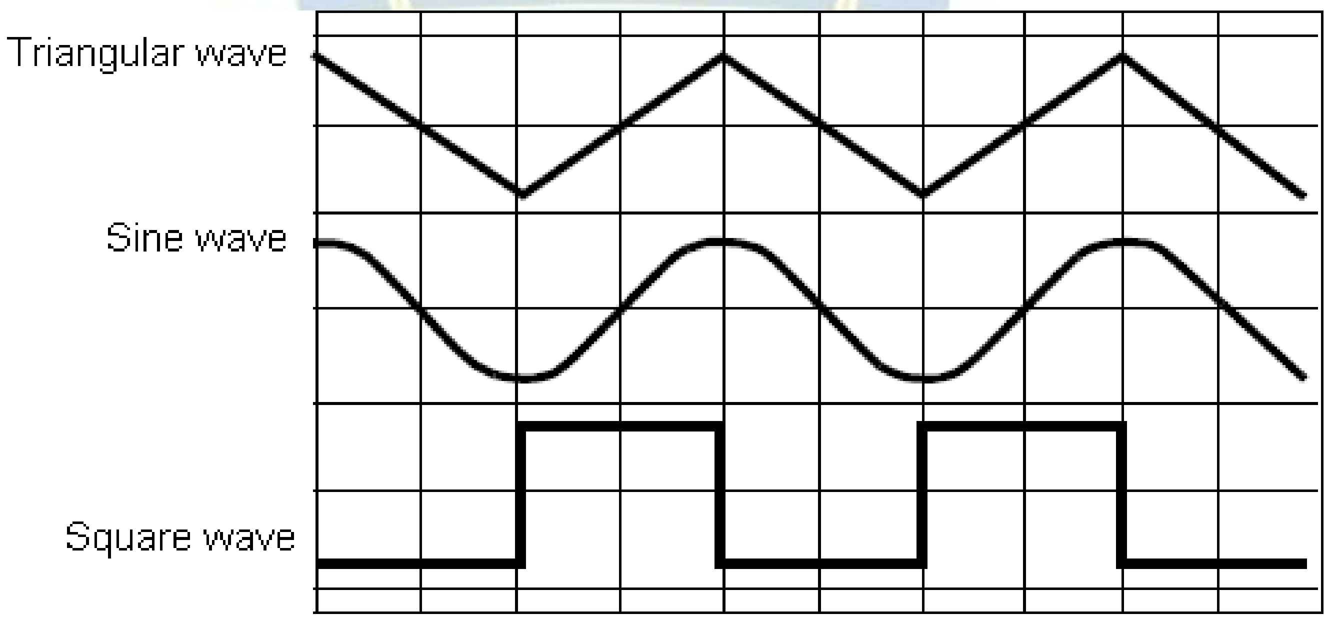
The optocouplers are available in the IC form MCT2E is the standard optocoupler IC which is used popularly in many electronic application.

- This input is applied between pin 1& pin 2. An infrared light emitting diode is connected between these pins.
- The infrared radiation from the LED gets focused on the internal phototransistor.
- The base of the phototransistor is generally left open. But sometimes a high value pull down resistance is connected from the Base to ground to improve the sensitivity.
- The block diagram shows the opto-electronic- integrated ciruit (OEIC) and the major components of a fiber-optic communication facility.



LECTURE NOTES





consists of two current sources, two comparators, two buffers, one FF and a sine wave converter.

Pin description:

Pin 1 & Pin 12: Sine wave adjusts:

The distortion in the sine wave output can be reduced by adjusting the 100KΩ pots connected between pin12 & pin11 and between pin 1 & 6.

Pin 2 Sine Wave Output:

Sine wave output is available at this pin. The amplitude of this sine wave is 0.22 Vcc. Where ± 5V ≤ Vcc ≤ ± 15 V.

Pin 3 Triangular Wave output:

Triangular wave is available at this pin. The amplitude of the triangular wave is 0.33Vcc.

Where ± 5V ≤ Vcc ≤ ± 15 V.

Pin 4 & Pin 5 Duty cycle / Frequency adjust:

The symmetry of all the output wave forms & 50% duty cycle for the square wave output is adjusted by the external resistors connected from Vcc to pin 4. These external resistors & capacitors at pin 10 will decide the frequency of the output wave forms.

Pin 6 + Vcc:

Positive supply voltage the value of which is between 10 & 30V is applied to this pin.

Pin 7 : FM Bias:

This pin along with pin no8 is used to TEST the IC 8038.

Pin9 : Square Wave Output:

A square wave output is available at this pin. It is an open collector output so that this pin can be connected through the load to different power supply voltages. This arrangement is very

useful in making the square wave output.

Pin 10 : Timing Capacitors:

The external capacitor C connected to this pin will decide the output frequency along with the resistors connected to pin 4 & 5.

Pin 11 : $-V_{EE}$ or Ground:

If a single polarity supply is to be used then this pin is connected to supply ground & if (±) supply voltages are to be used then (-) supply is connected to this pin.

Pin 13 & Pin 14: NC (No Connection) Important features of IC 8038:

1. All the outputs are simultaneously available.
2. Frequency range : 0.001Hz to 500kHz
3. Low distortion in the output wave forms.
4. Low frequency drift due to change in temperature.
5. Easy to use.

Parameters:

(i) Frequency of the output wave form:

- The output frequency dependent on the values of resistors R1 & R2 along with the external capacitor C connected at pin 10.
- If $R_A = R_B = R$ & if R_C is adjusted for 50% duty cycle then

values of external resistors at pin 4 & 5.

- The values of resistors R_A & R_B connected between Vcc * pin 4 & 5 respectively along with the capacitor connected at pin 10 decide the frequency of the wave form.
- The values of R_A & R_B should be in the range of 1kΩ to 1MΩ. (iii) FM Bias:
- The FM Bias input (pin7) corresponds to the junction of resistors R1 & R2.
- The voltage Vin is the voltage between Vcc & pin8 and it decides the output frequency.

LECTURE NOTES

- The output frequency is proportional to Vin as given by the following expression For $R_A = R_B$ (50% duty cycle).
- This input should be connected to pin 7, if we want a constant output frequency.
- But if the output frequency is supposed to vary, then a variable dc voltage should be applied to this pin.
- The voltage between Vcc & pin 8 is called Vin and it decides the output frequency as,

$$f_o = \frac{1.5\ V_{in}}{C\ R_A\ V_{cc}}$$

A potentiometer can be connected to this pin to obtain the required variable voltage required to change the output frequency.