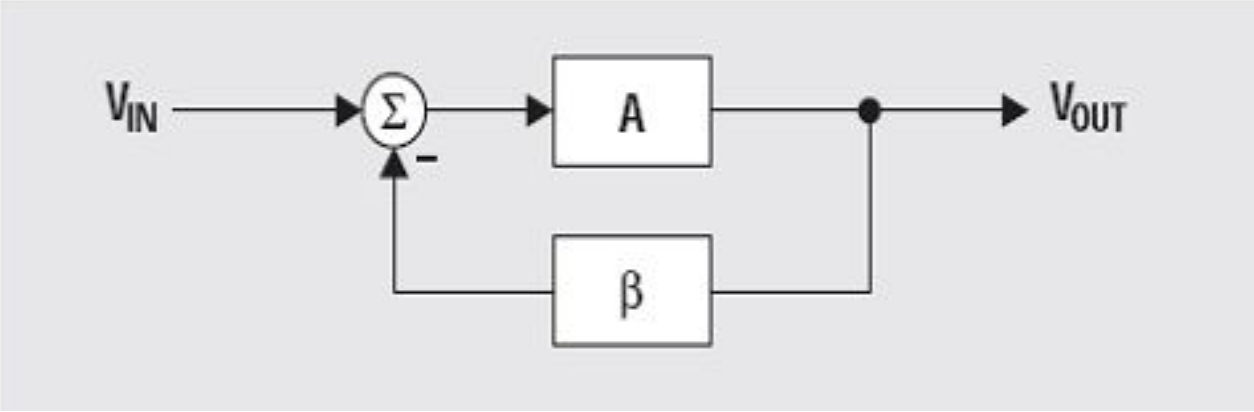
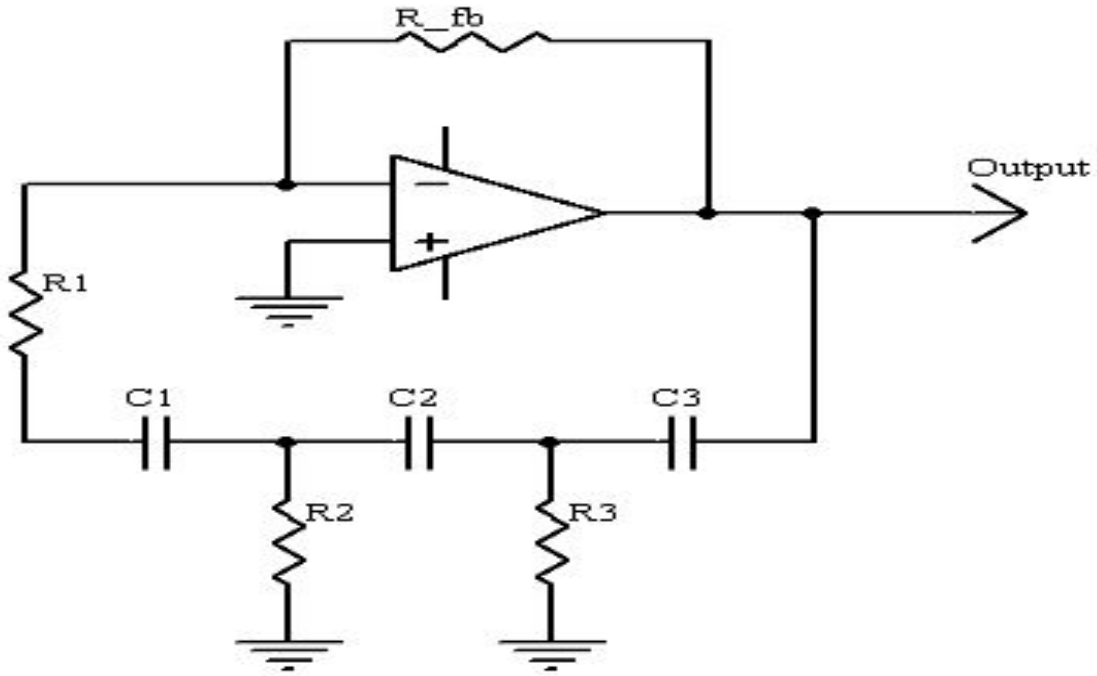
Waveform Generators and Special function ICs
UNIT–V

Sine wave generators(Oscillators)

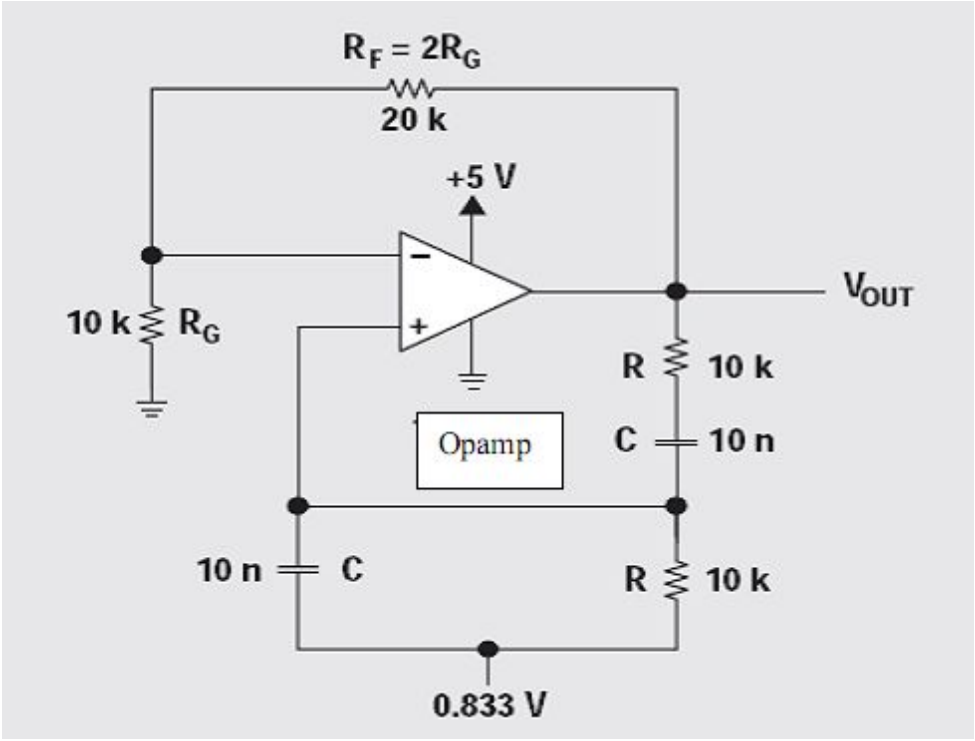


$$\frac{V_{OUT}}{V_{IN}} = \frac{A}{1 + A\beta}$$

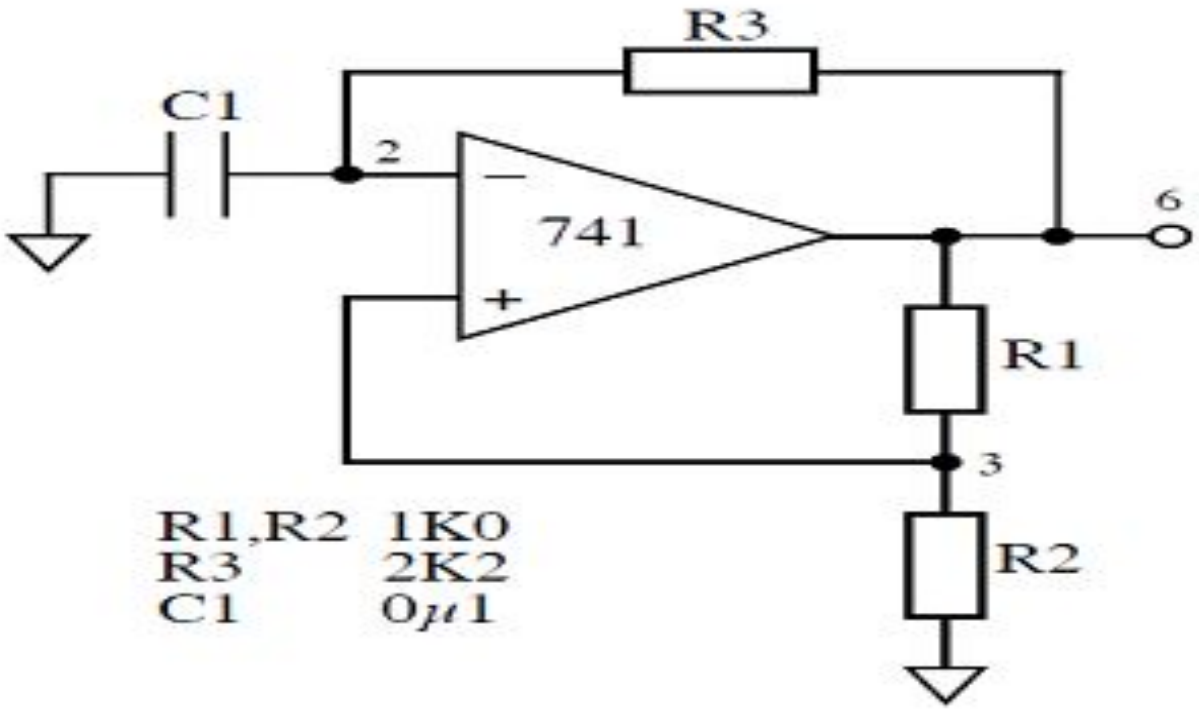
RC Phase Shift Oscillators



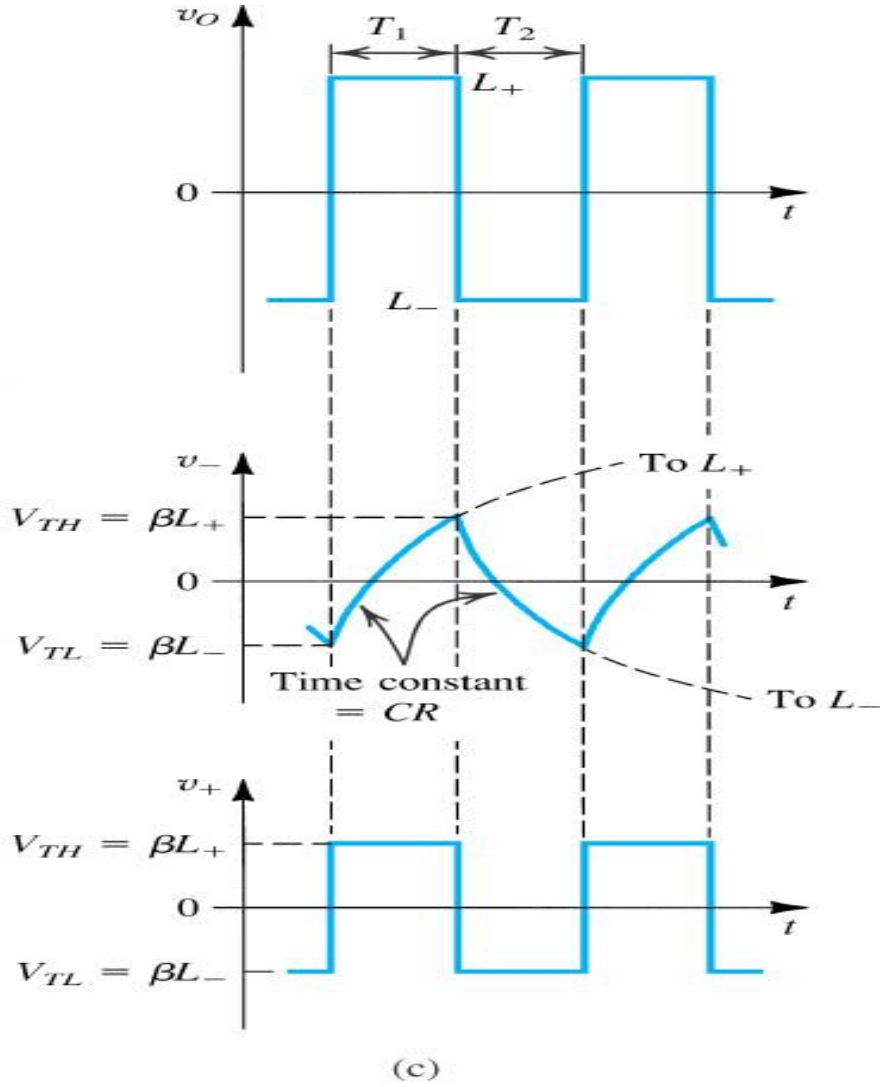
Wien Bridge Oscillator



Astable Multivibrators using opamp

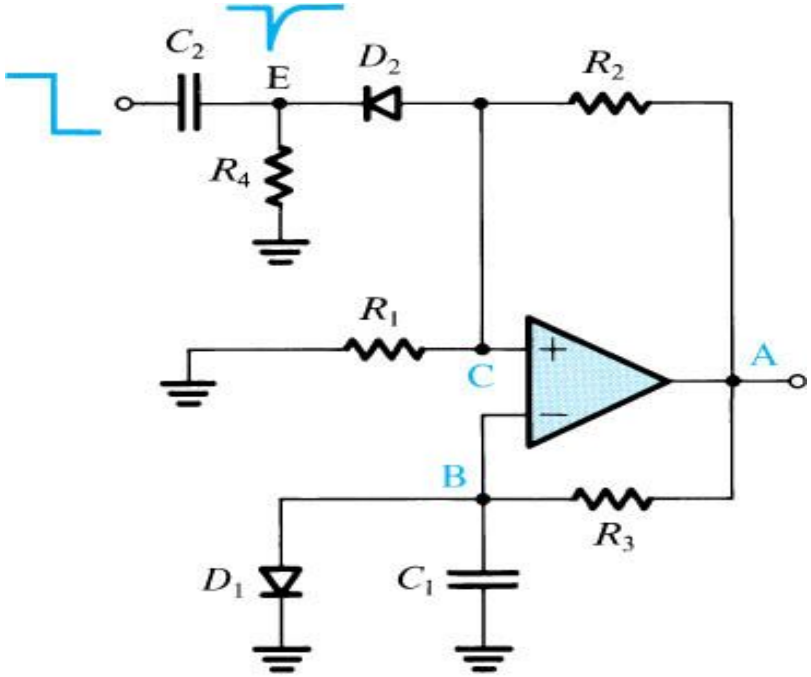


Astable Multivibrators using opamp

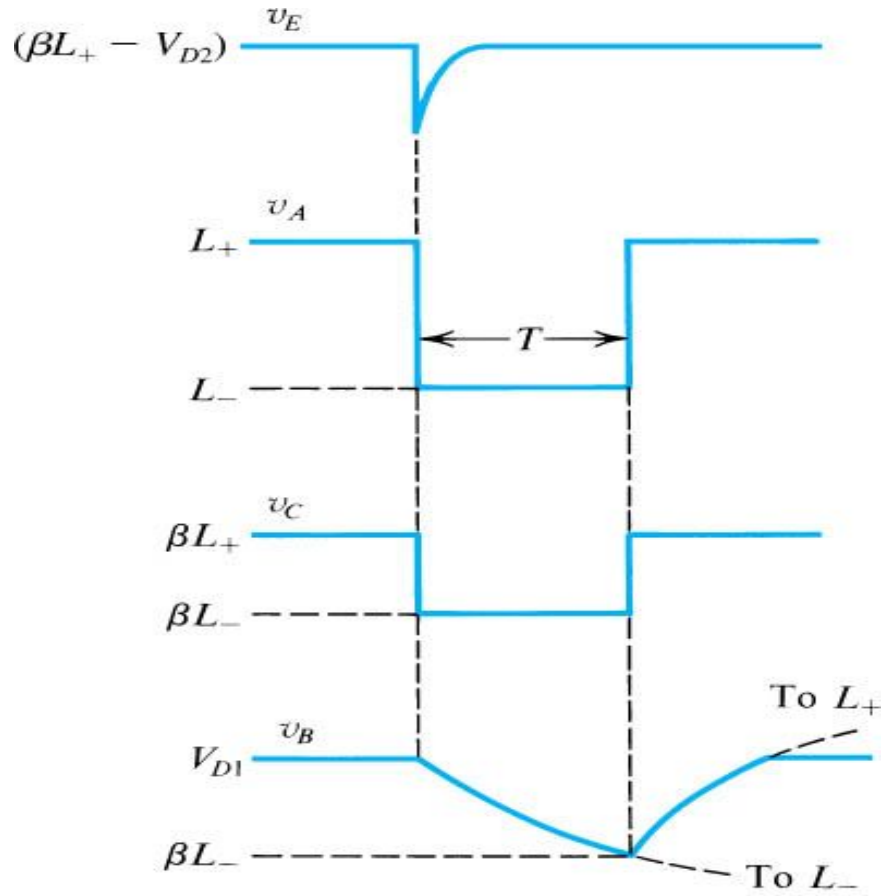


(c)

Monostable Multivibrators using opamp

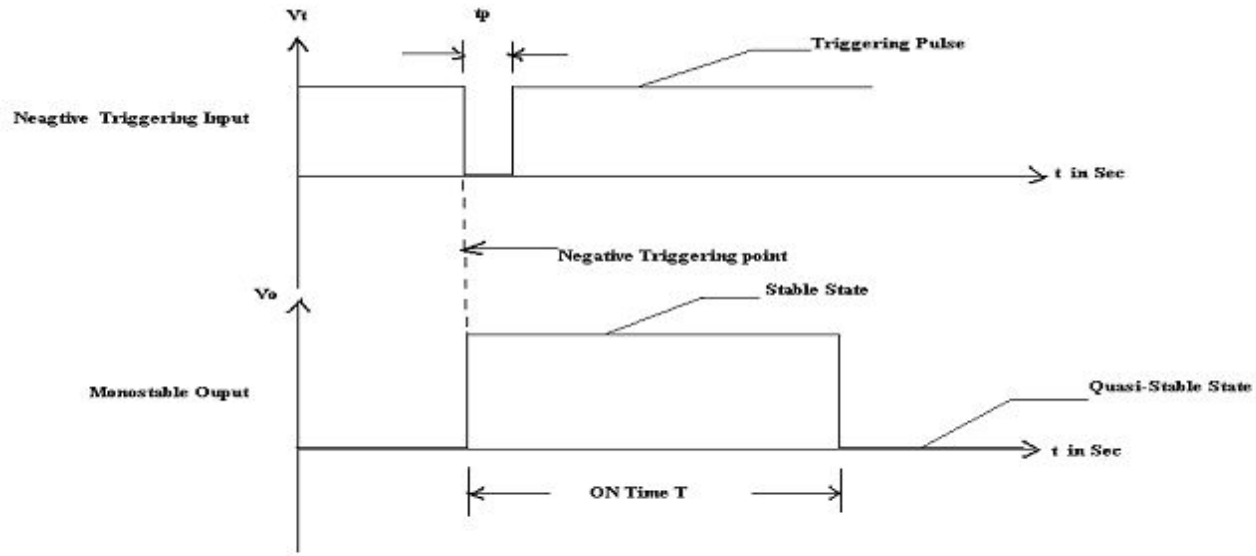


(a)



(b)

Monostable Multivibrators using opamp



Monostable Multivibrators using opamp

Calculating β from expression

$$\beta = \frac{R1}{R1 + R2}$$

The value of R & C from the pulse width time expression.

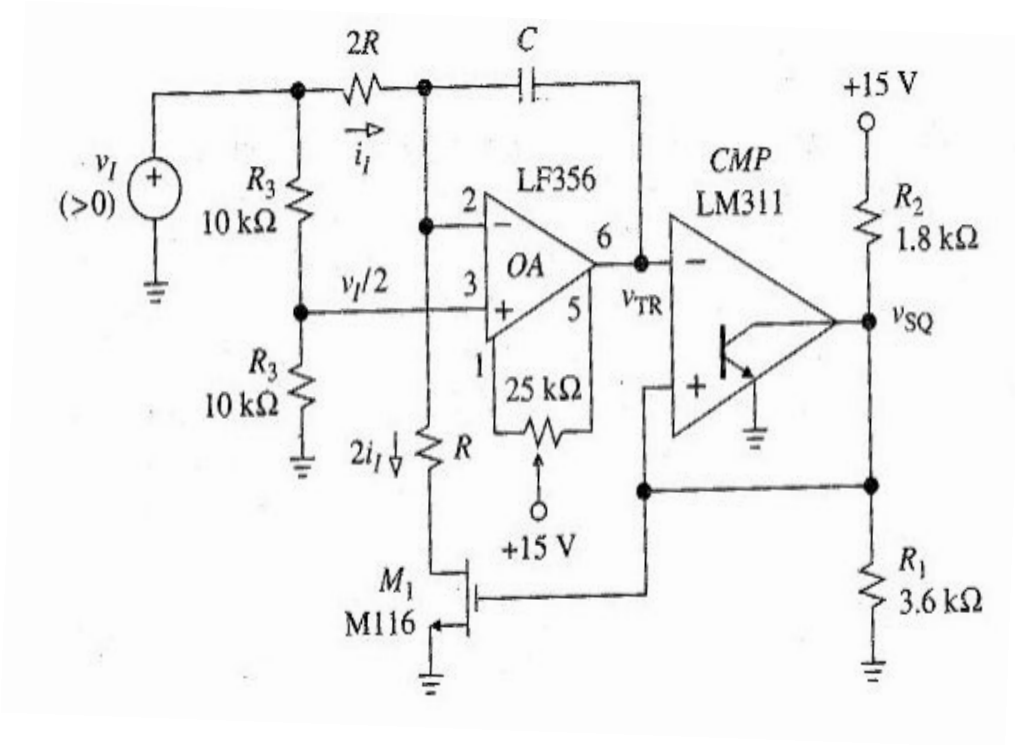
$$T = RC \ln \frac{(1 + V_D / V_{sat})}{1 - \beta}$$

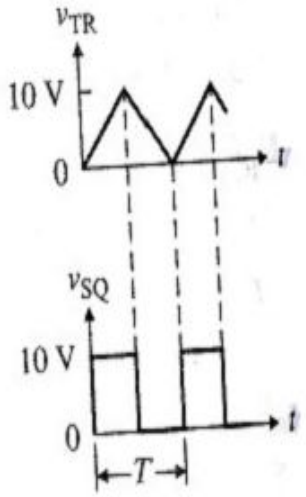
$$T = RC \ln \frac{(1 + V_D / V_{sat})}{0.5}$$

$$T \equiv 0.69RC.$$

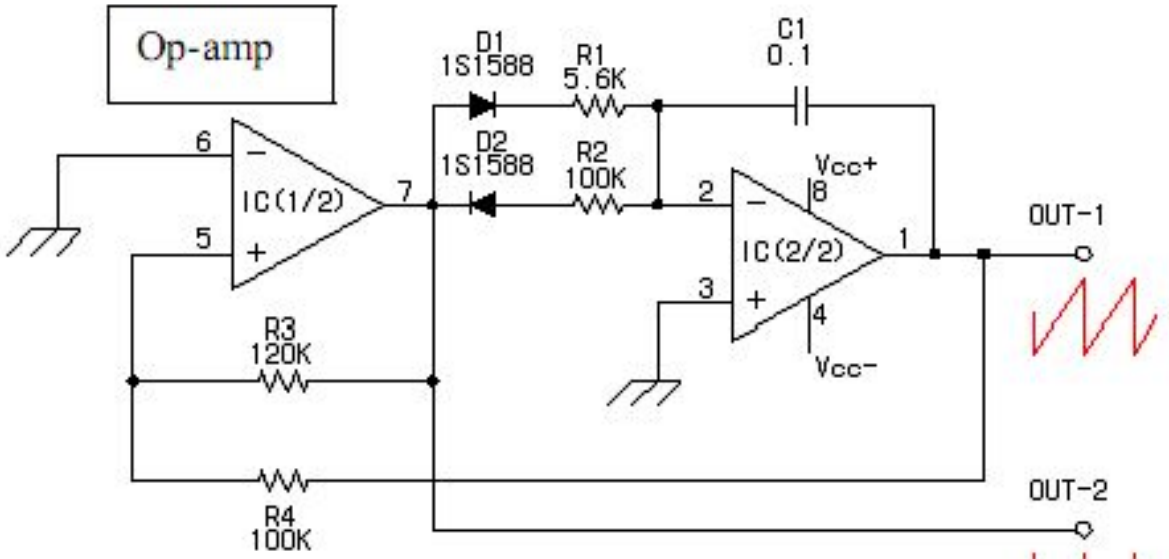
Triggering pulse width T_p must be much smaller then T. $T_p < T$.

Triangular waveform generator



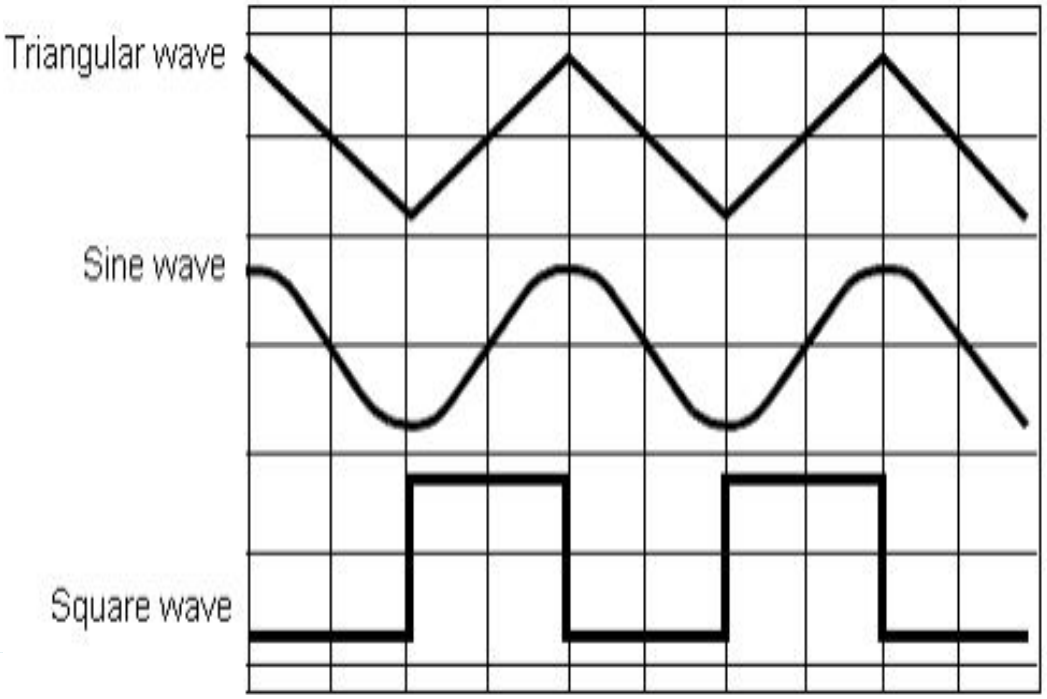


Sawtooth Waveform Generator

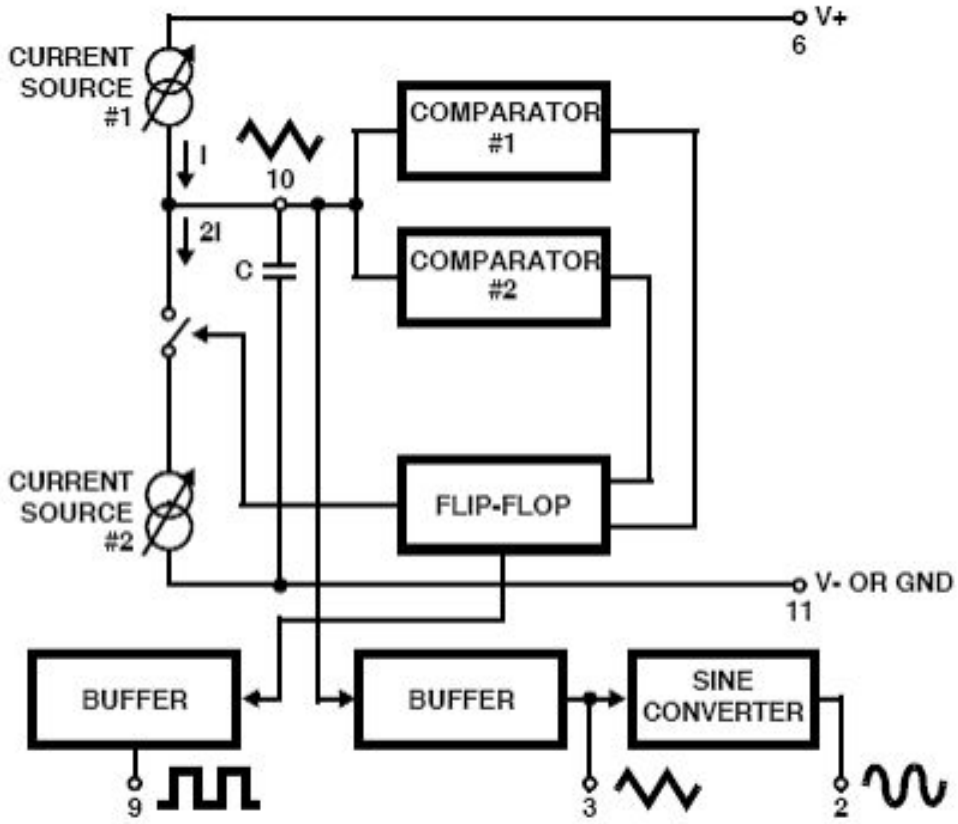


$$f = \frac{1}{2C(R_1 + R_2)}\left(\frac{R_3}{R_4}\right)$$

Sawtooth Waveform Generator



ICL8038-Function Generator



555 timer

The 555 is a monolithic timing circuit that can produce accurate & highly stable time delays or oscillation. The timer basically operates in one of two modes: either

(i) Monostable (one - shot) multivibrator or

(ii) Astable (free running) multivibrator

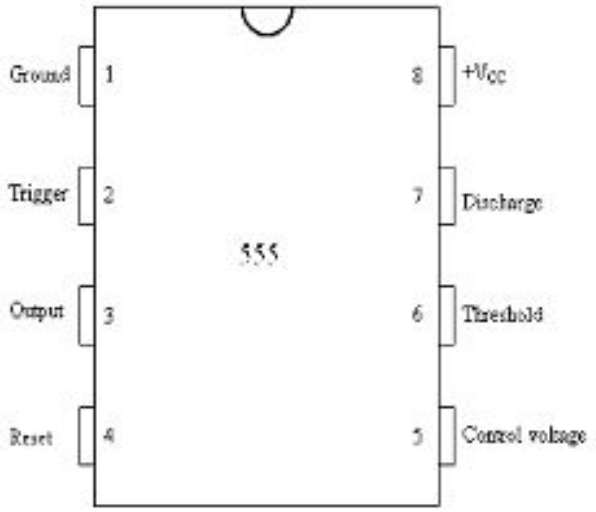
The important features of the 555 timer are these:

(i) It operates on +5v to +18 v supply voltages

(ii) It has an adjustable duty cycle

(iii) Timing is from microseconds to hours

(iv) It has a current o/p



Block Diagram of 555 timer

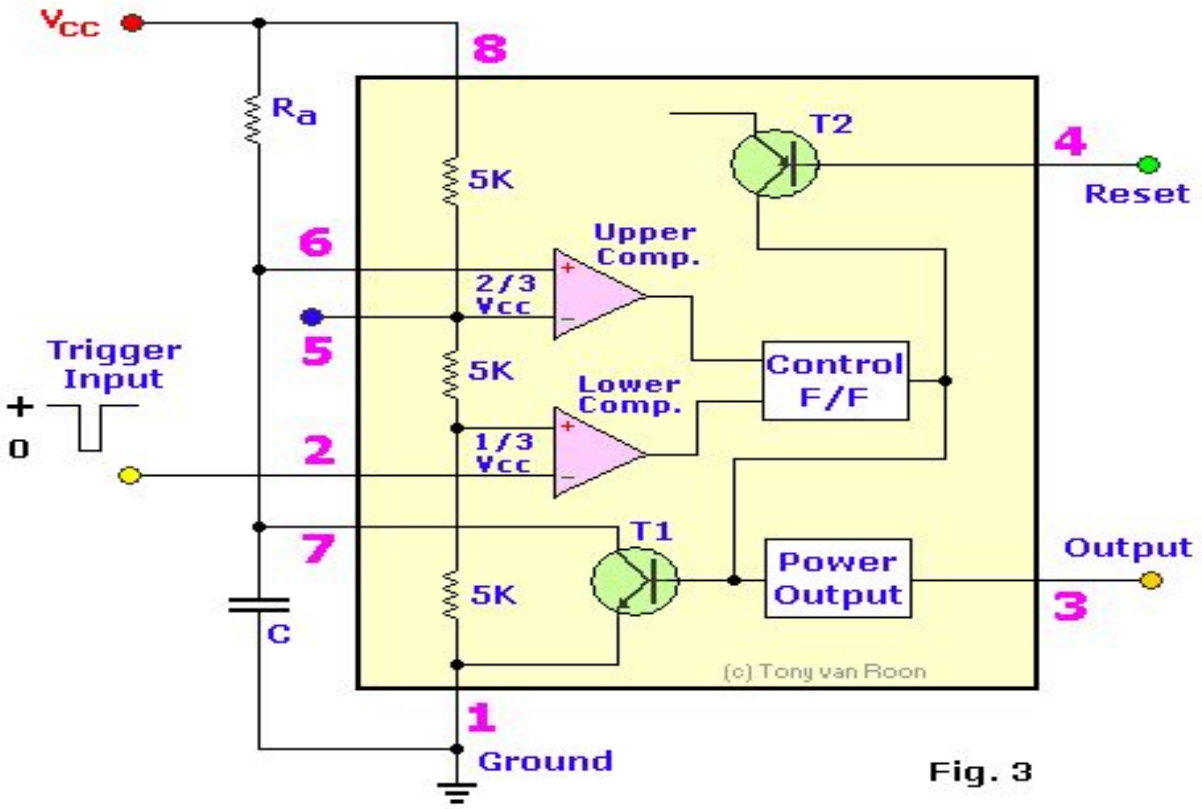
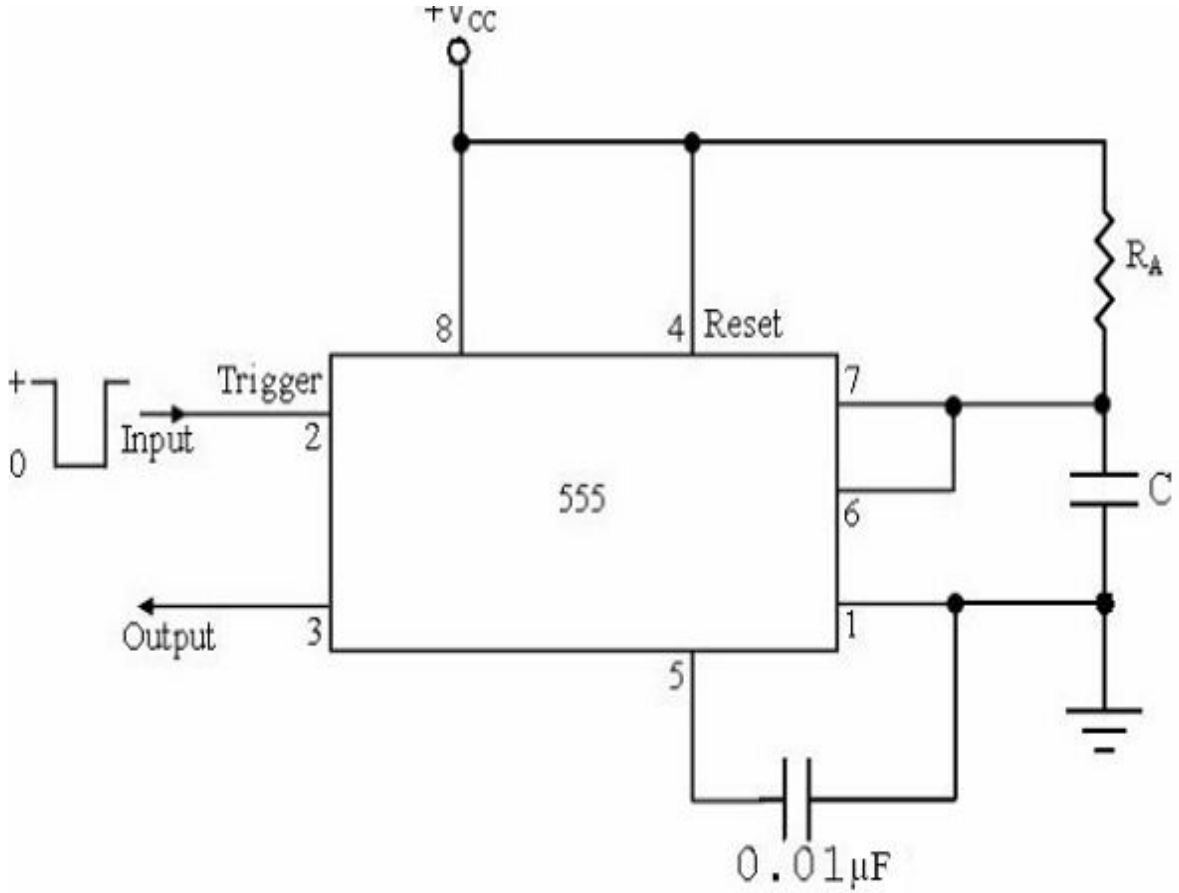
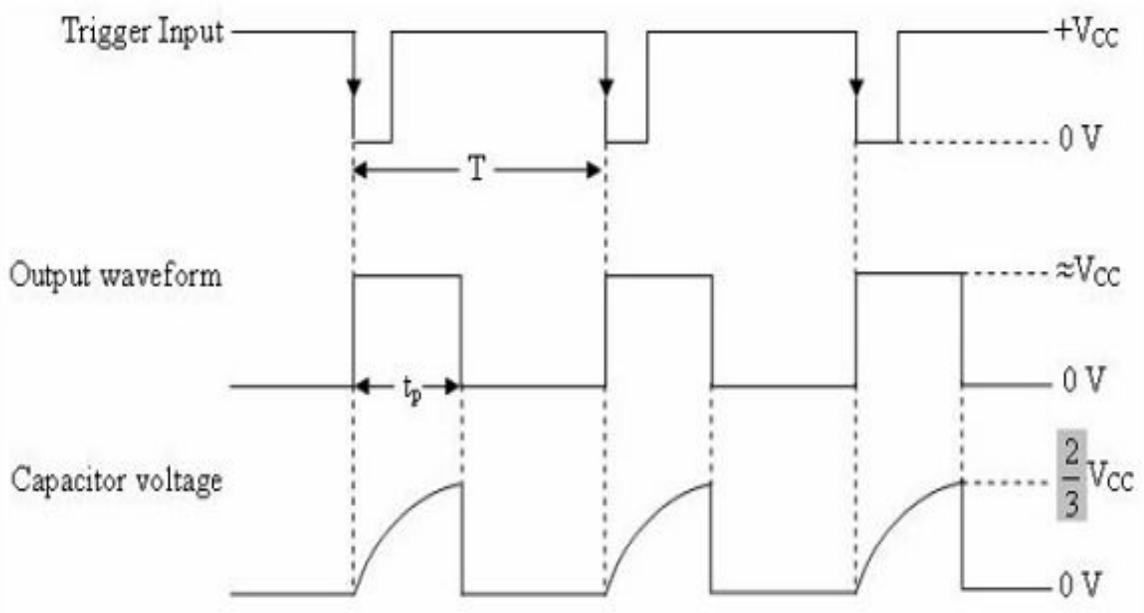


Fig. 3

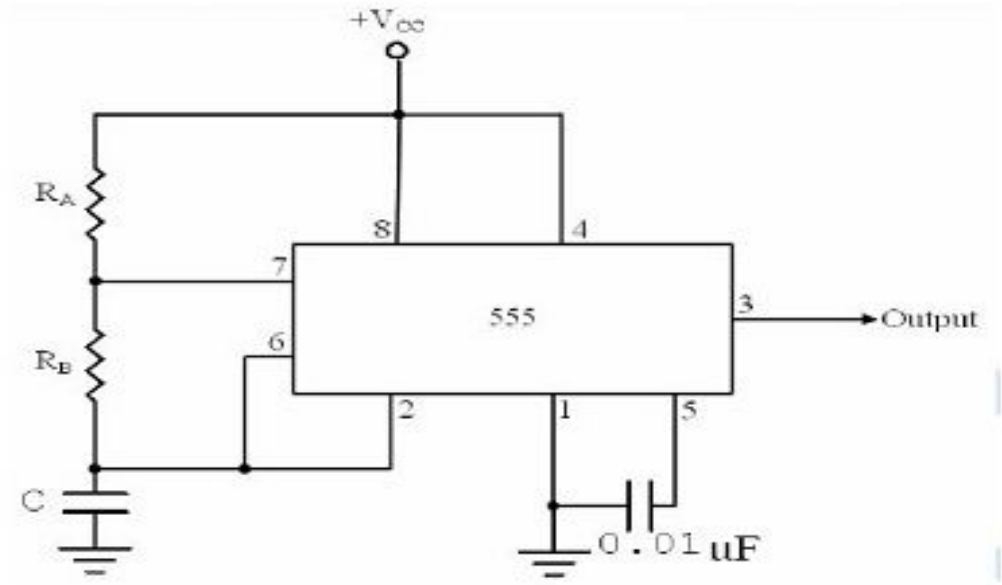
555 timer –Monostable Multivibrator



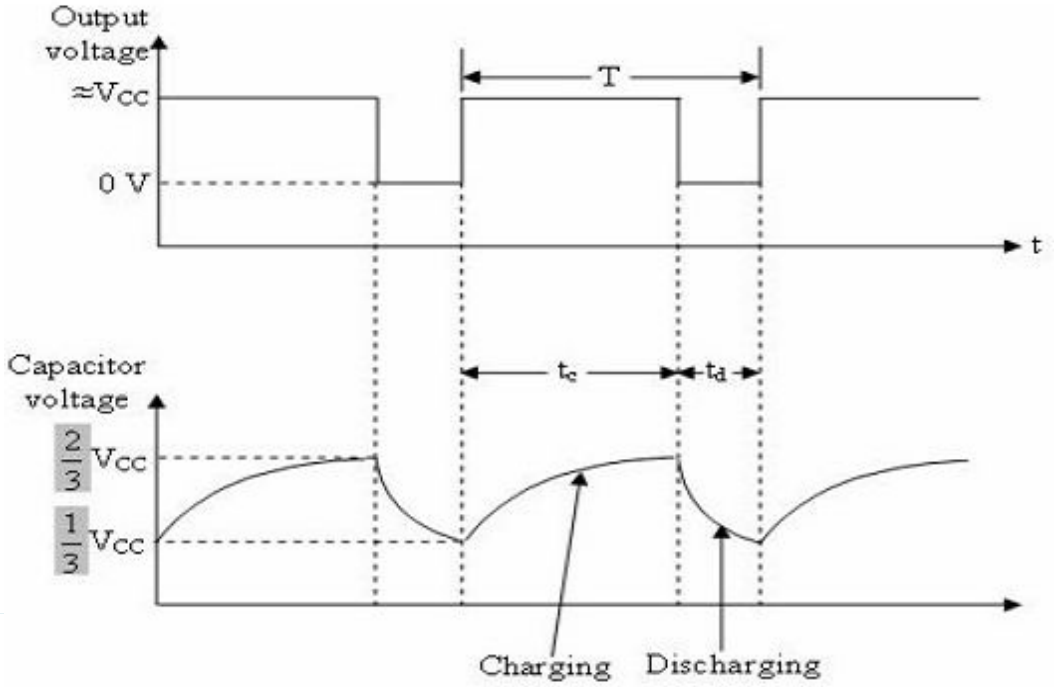
555 timer –Monostable Multivibrator



555 timer –Astable Multivibrator



555 timer –Astable Multivibrator



555 timer-Astable Multivibrator

Initially, when the output is high :

Capacitor C starts charging toward Vcc through R_A & R_B. However, as soon as voltage across the capacitor equals 2/3 Vcc. Upper comparator triggers the FF & output switches low.

When the output becomes Low:

Capacitor C starts discharging through R_B and transistor Q1, when the voltage across C equals 1/3 Vcc, lower comparator output triggers the FF & the output goes High. Then cycle repeats. The capacitor is periodically charged & discharged between 2/3 Vcc & 1/3 Vcc respectively. The time during which the capacitor charges from 1/3 Vcc to 2/3 Vcc equal to the time the output is high & is given by

$t_c = (R_A+R_B)C \ln 2$.....(1) Where [$\ln 2 = 0.69$]

$= 0.69 (R_A+R_B)C$

Similarly, the time during which the capacitors discharges from 2/3 Vcc to 1/3 Vcc is equal to the time, the output is low and is given by,

$t_c = R_B C \ln 2$

$t_d = 0.69 R_B C$ .....(2)

Thus the total period of the output waveform is

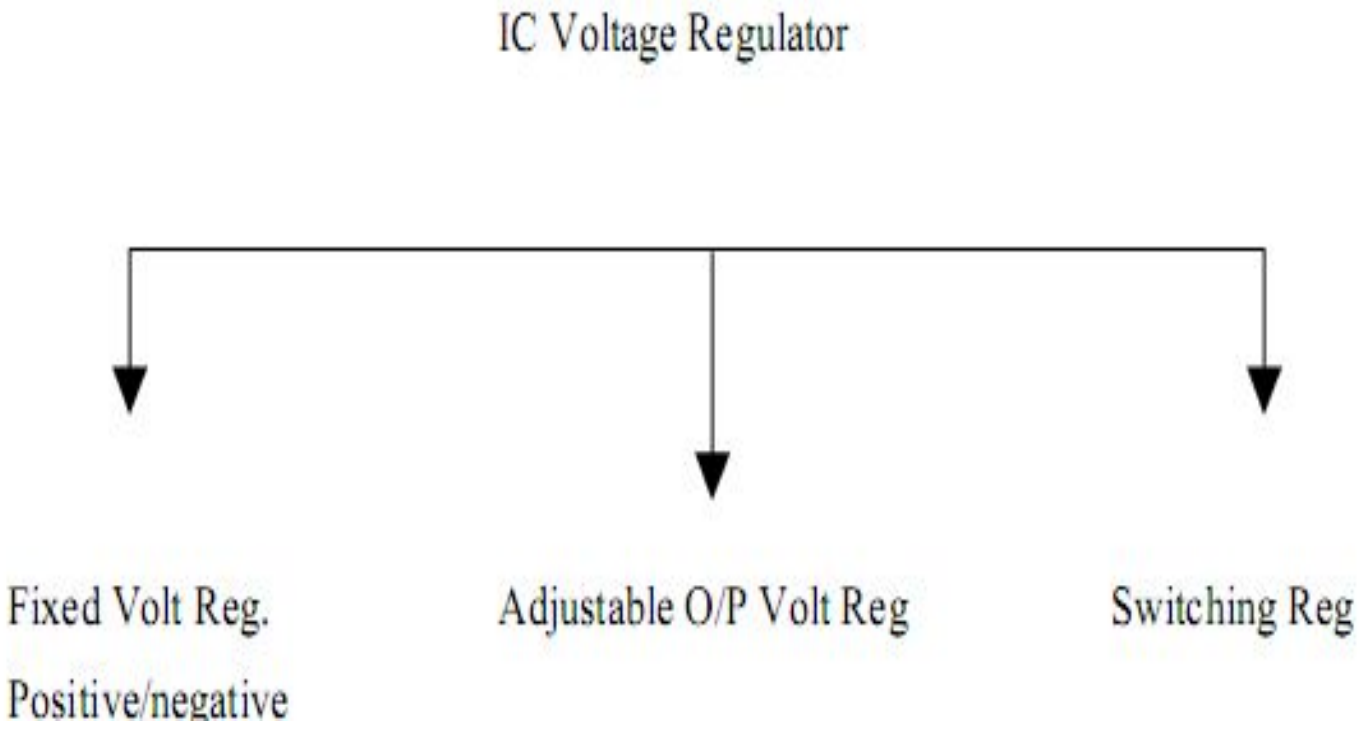
$T = t_c + t_d = 0.69 (R_A+2R_B)C$ .....(3)

This, in turn, gives the frequency of oscillation as, $f_0 = 1/T = 1.45/(R_A+2R_B)C$ .....(4)

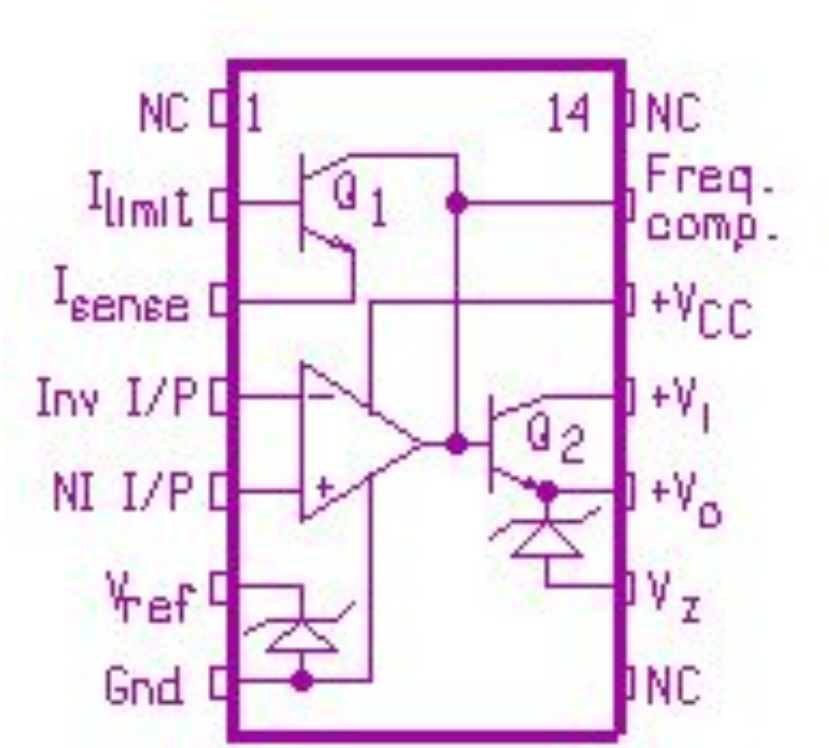
IC Voltage Regulators

- There are basically two kinds of IC voltage regulators:
  - Multipin type, e.g. LM723C
  - 3-pin type, e.g. 78/79XX
- Multipin regulators are less popular but they provide the greatest flexibility and produce the highest quality voltage regulation
- 3-pin types make regulator circuit design simple

Classification of IC Voltage regulator



Multipin IC Voltage Regulator



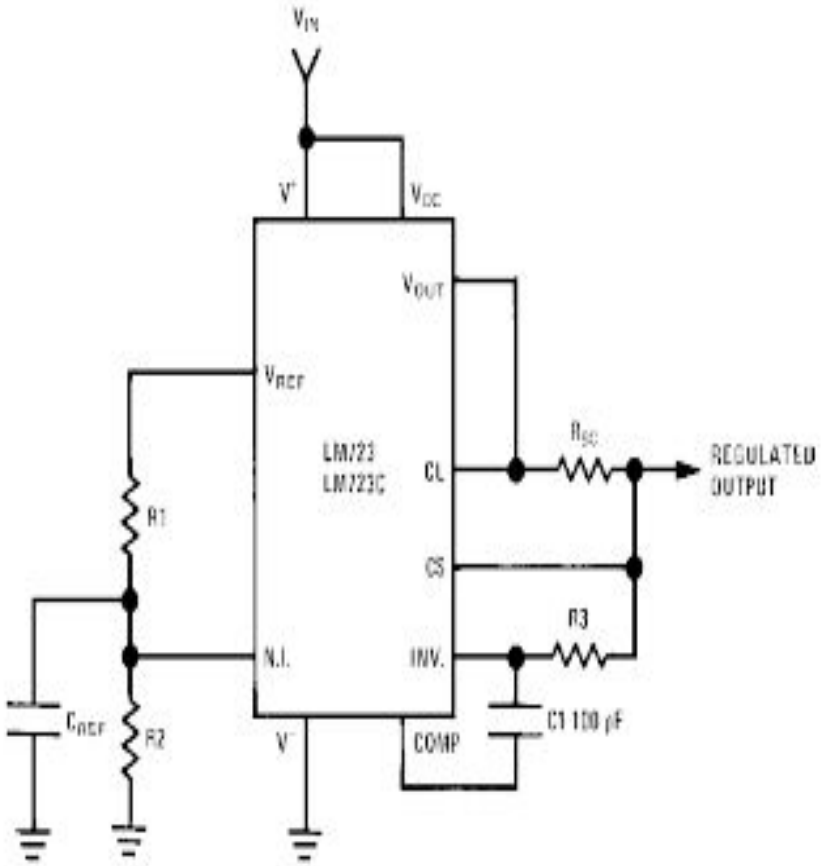
LM 723C Schematic

- The LM723 has an equivalent circuit that contains most of the parts of the op-amp voltage regulator discussed earlier.
- It has an internal voltage reference, error amplifier, pass transistor, and current limiter all in one IC package.

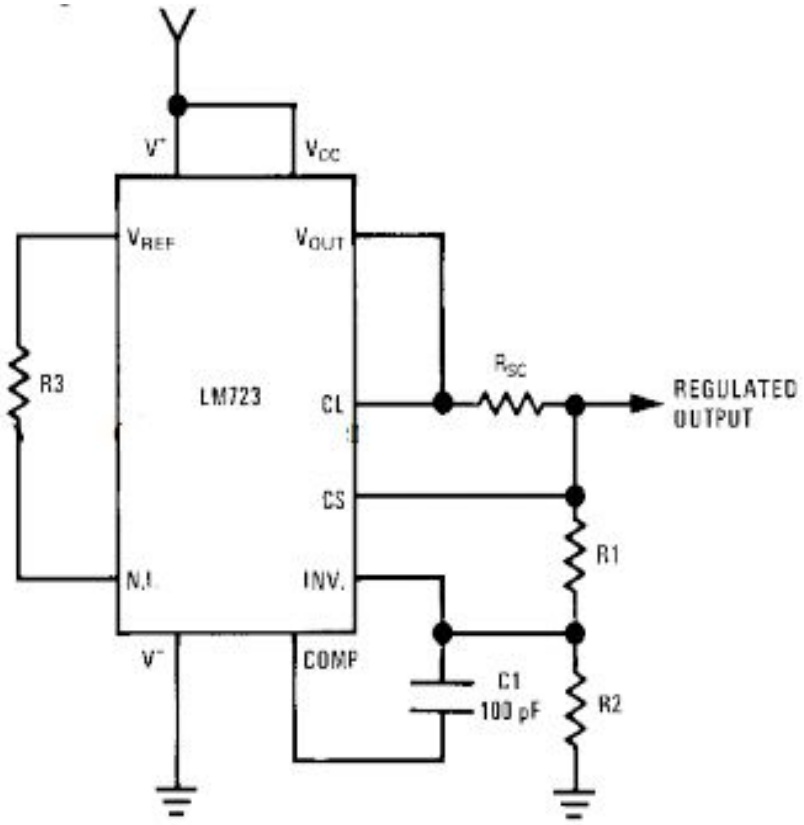
LM723 Voltage Regulator

- Can be either 14-pin DIP or 10-pin TO-100 can
- May be used for either +ve or -ve, variable or fixed regulated voltage output
- Using the internal reference (7.15 V), it can operate as a high-voltage regulator with output from 7.15 V to about 37 V, or as a low-voltage regulator from 2 V to 7.15 V
- Max. output current with heat sink is 150 mA
- Dropout voltage is 3 V (i.e. $V_{CC} > V_{o(max)} + 3$)

IC723 as a LOW voltage LOW current



IC723 as a HIGH voltage LOW current



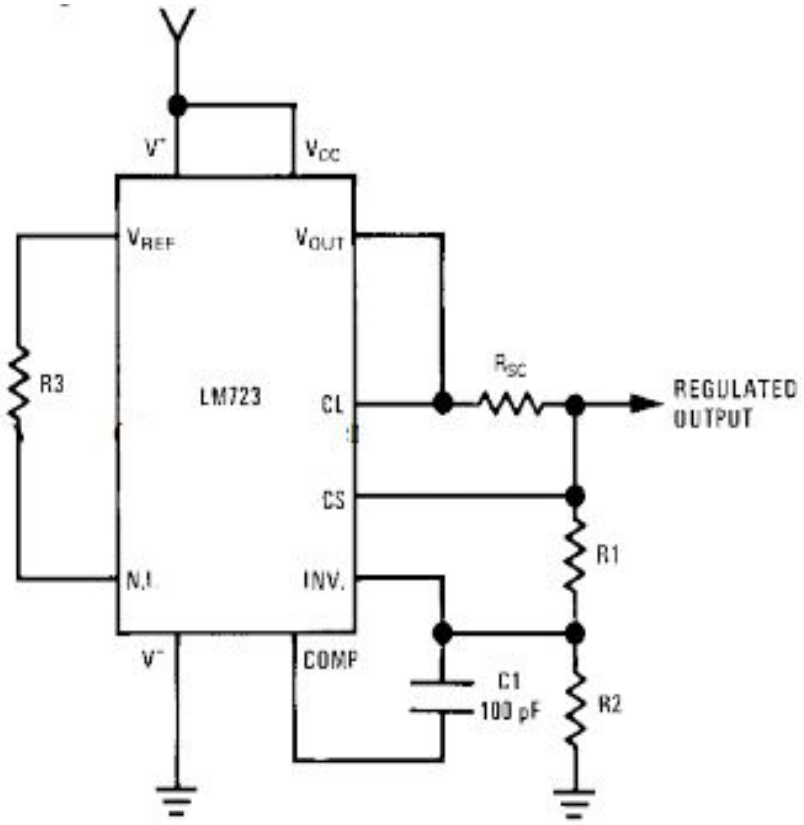
$$Vin = Vref = \frac{R2}{R1+R2} Vo$$

$$Vo = \frac{R1+R2}{R2} Vref$$

Or

$$Vo = [1 + \frac{R1}{R2}] Vref$$

IC723 as a HIGH voltage HIGH current



$$Vin = Vref = \frac{R2}{R1+R2} Vo$$

$$Vo = \frac{R1+R2}{R2} Vref$$

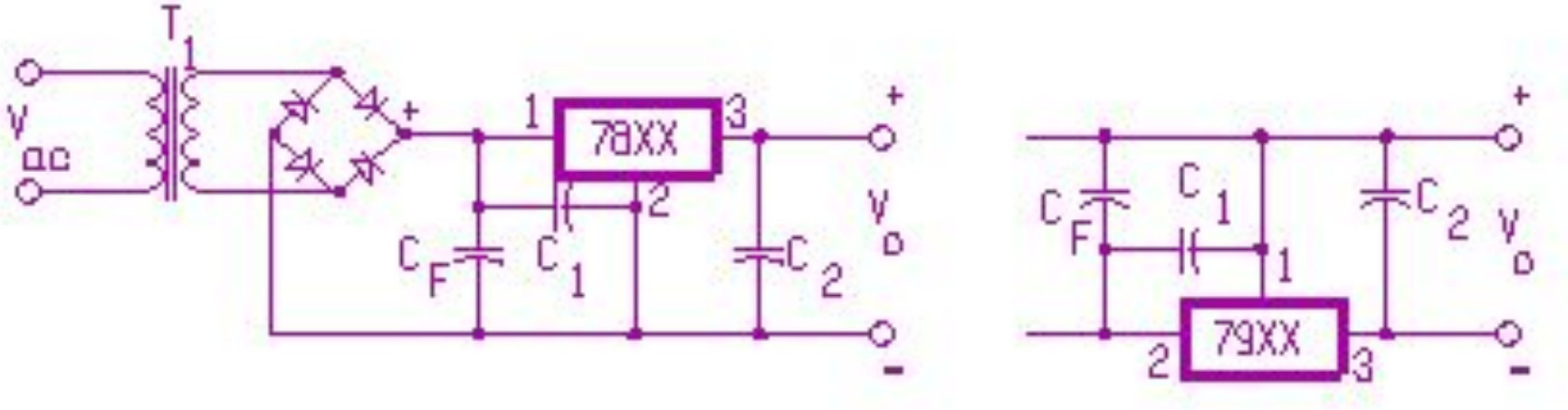
Or

$$Vo = [1 + \frac{R1}{R2}] Vref$$

Three-Terminal Fixed Voltage Regulators

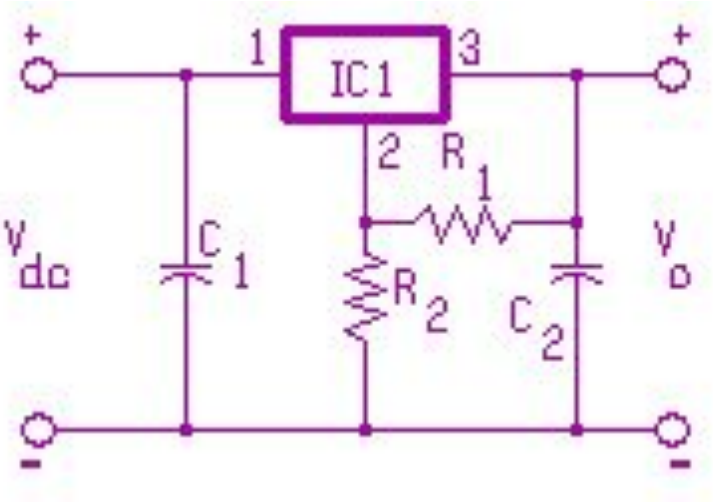
- Less flexible, but simple to use
- Come in standard TO-3 (20 W) or TO-220 (15 W) transistor packages
- 78/79XX series regulators are commonly available with 5, 6, 8, 12, 15, 18, or 24 V output
- Max. output current with heat sink is 1 A
- Built-in thermal shutdown protection
- 3-V dropout voltage; max. input of 37 V
- Regulators with lower dropout, higher in/output, and better regulation are available.

Basic Circuits With 78/79XX Regulators



- Both the 78XX and 79XX regulators can be used to provide +ve or –ve output voltages
- C_1 and C_2 are generally optional. C_1 is used to cancel any inductance present, and C_2 improves the transient response. If used, they should preferably be either 1 μF tantalum type or 0.1 μF mica type capacitors.

78XX Floating Regulator



- It is used to obtain an output > the V_{reg} value up to a max.of 37 V.
- R_1 is chosen so that $R_1 \leq 0.1\ V_{reg}/I_Q$, where I_Q is the

$$V_o = V_{reg} + \left(\frac{V_{reg}}{R_1} + I_Q\right) R_2$$

or

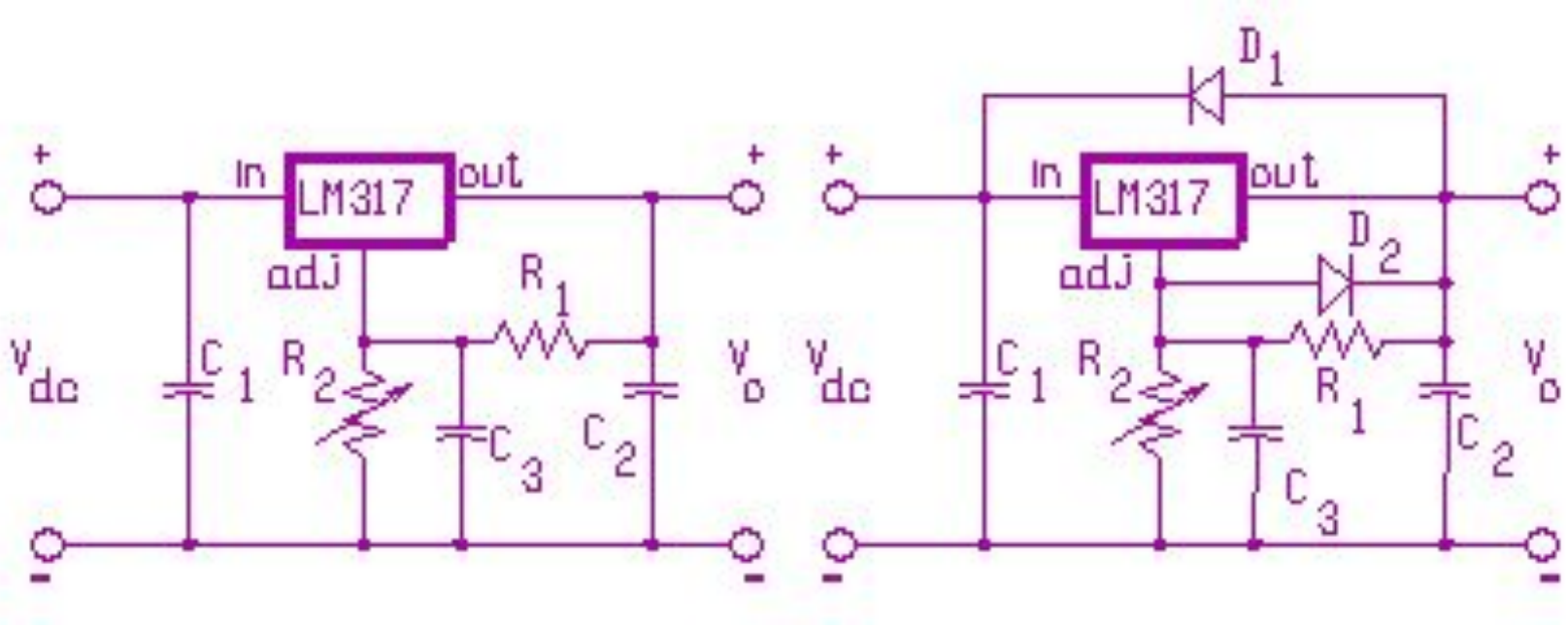
$$R_2 = \frac{R_1(V_o - V_{reg})}{V_{reg} + I_Q R_1}$$

t of

3-Terminal Variable Regulator

- The floating regulator could be made into a variable regulator by replacing R_2 with a pot. However, there are several disadvantages:
  - Minimum output voltage is V_{reg} instead of 0 V.
  - I_Q is relatively large and varies from chip to chip.
  - Power dissipation in R_2 can in some cases be quite large resulting in bulky and expensive equipment.
- A variety of 3-terminal variable regulators are available, e.g. LM317 (for +ve output) or LM 337 (for -ve output).

Basic LM317 Variable Regulator Circuits



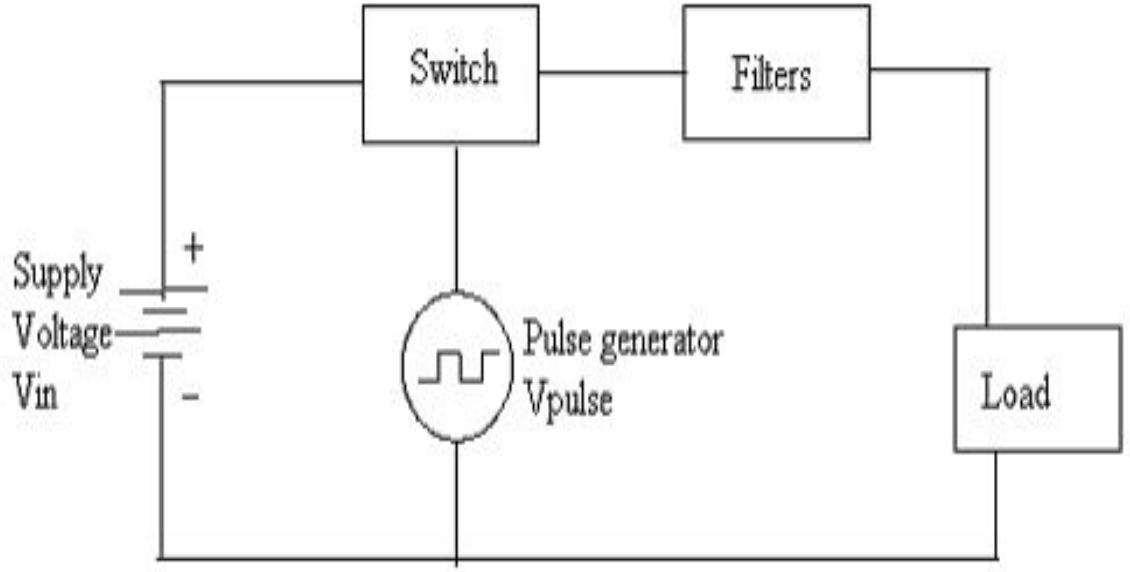
(a)

Circuit with capacitors to improve performance

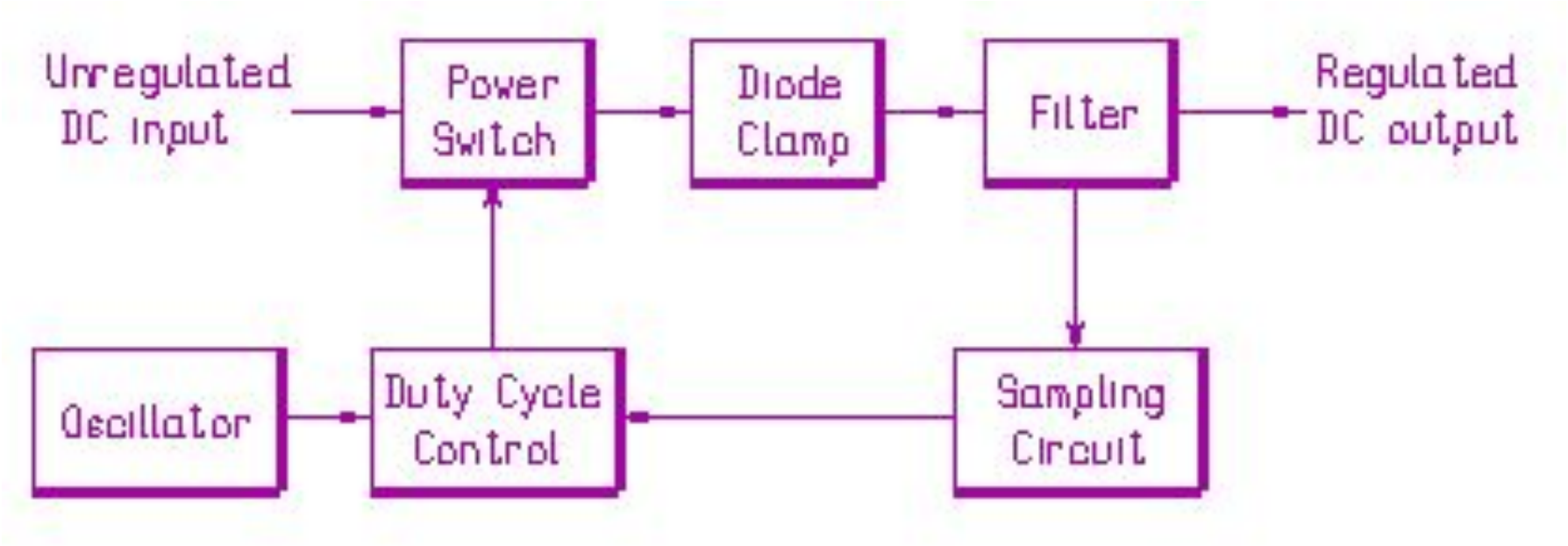
(b)

Circuit with protective diodes

Switching Regulator



Block Diagram of Switch-Mode Regulator



It converts an unregulated dc input to a regulated dc output. Switching regulators are often referred to as dc to dc converters.

Comparing Switch-Mode to Linear Regulators

Advantages:

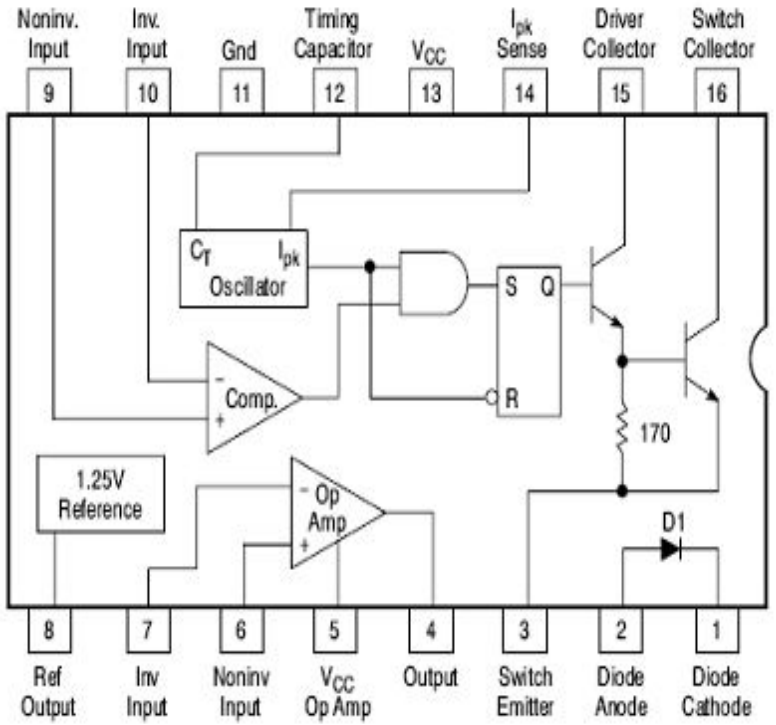
- 70-90% efficiency (about double that of linear ones)
- can make output voltage > input voltage, if desired
- can invert the input voltage
- considerable weight and size reductions, especially at high output power

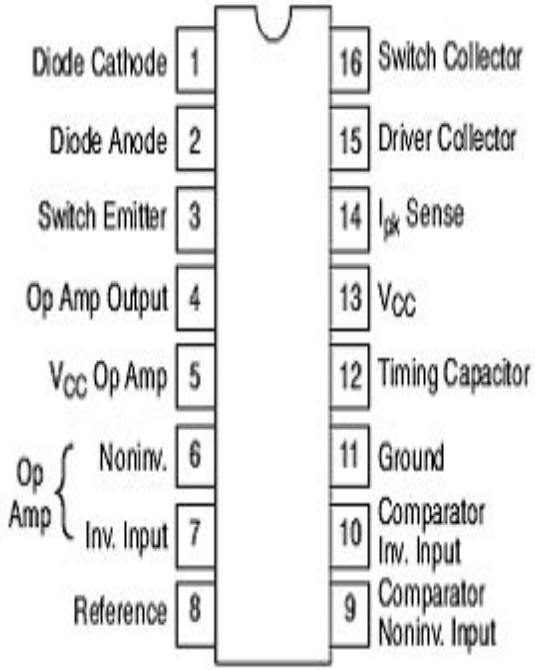
Disadvantages:

- More complex circuitry
- Potential EMI problems unless good shielding, low-loss ferrite cores and chokes are used

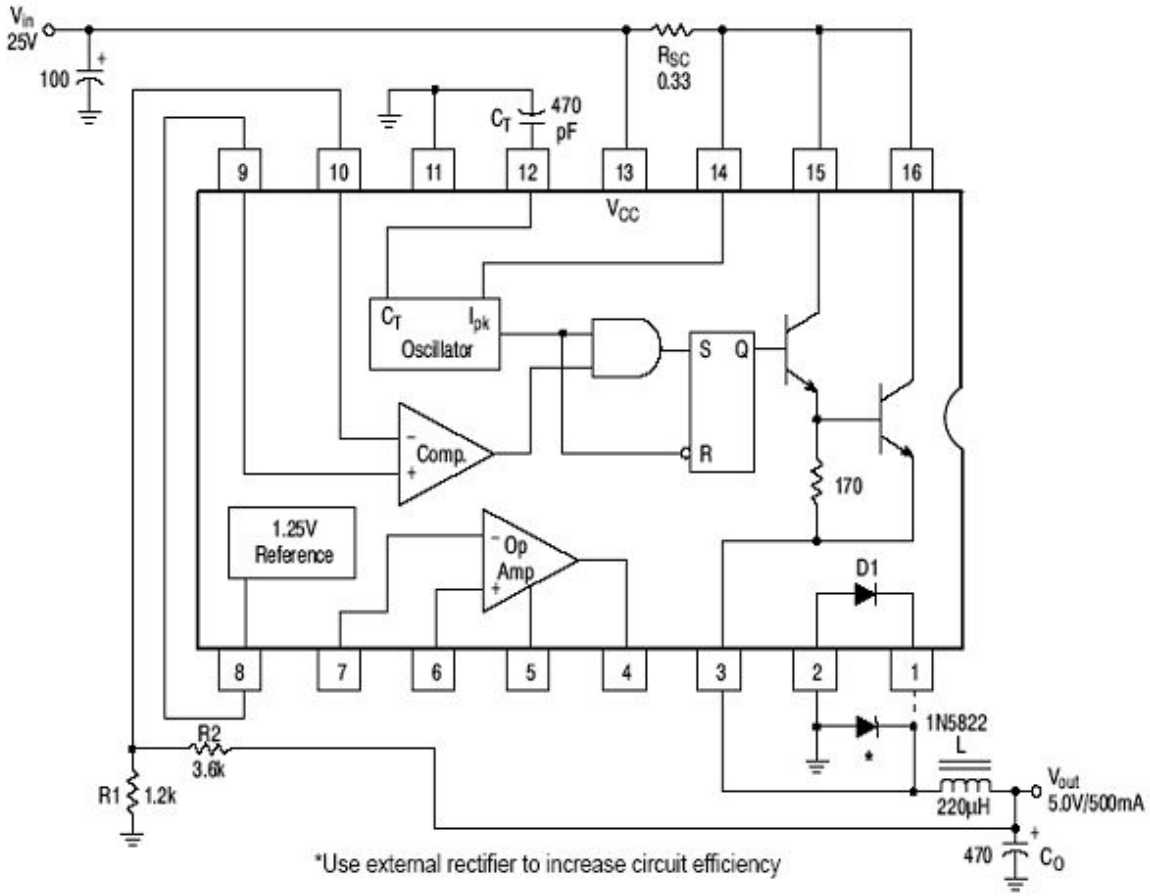
Monolithic Switching Regulator

[µA78S40]

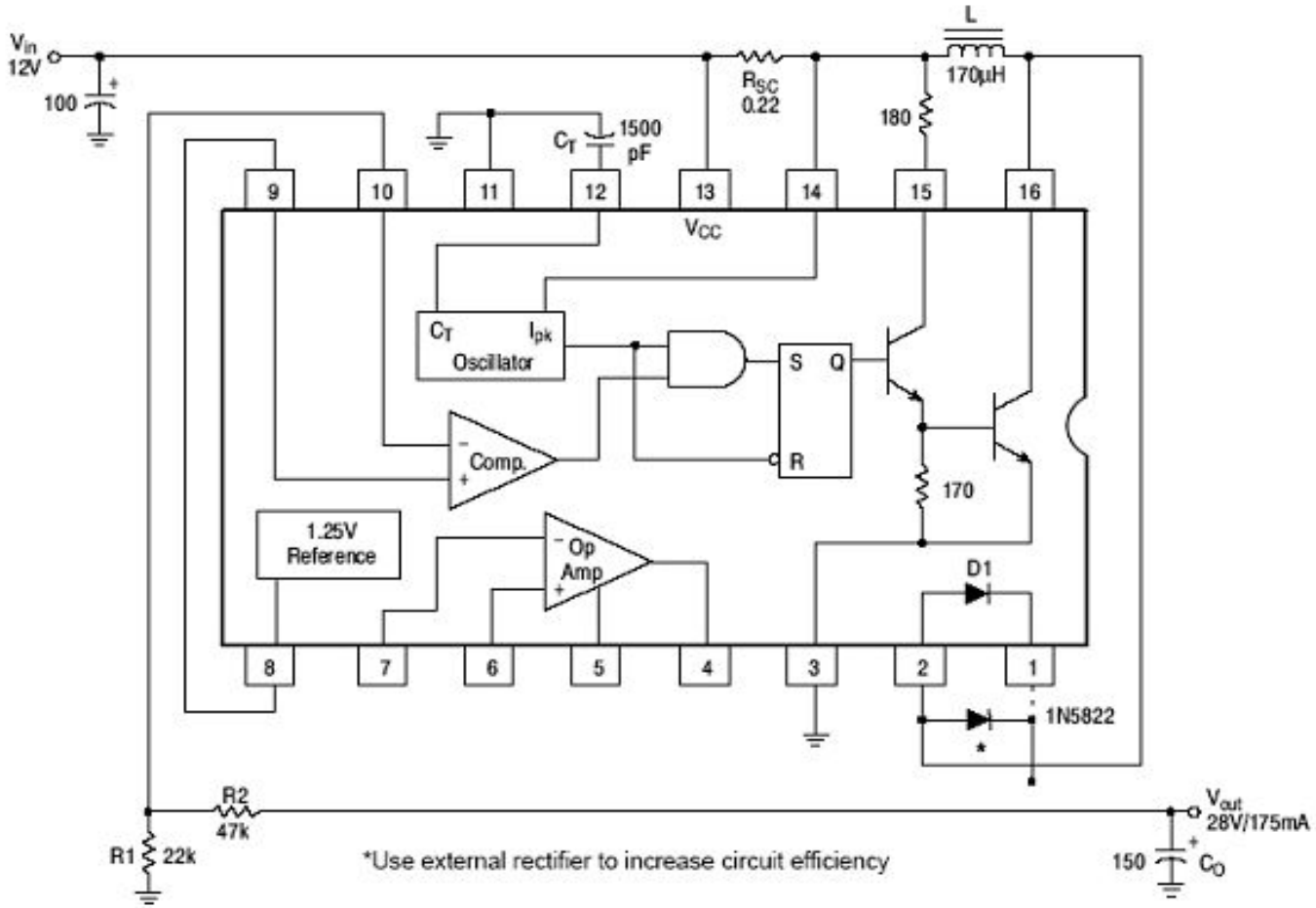




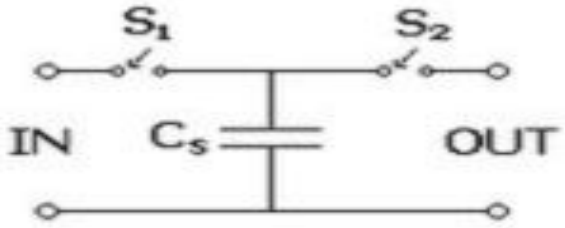
Step-Down converter



Step-Up Converter



Switched Capacitor Filter



$$q = CV$$

$$q_{IN} = C_S V_{IN}$$

$$q_{OUT} = C_S V_{OUT}$$

$$q = q_{OUT} - q_{IN} = C_S(V_{OUT} - V_{IN})$$

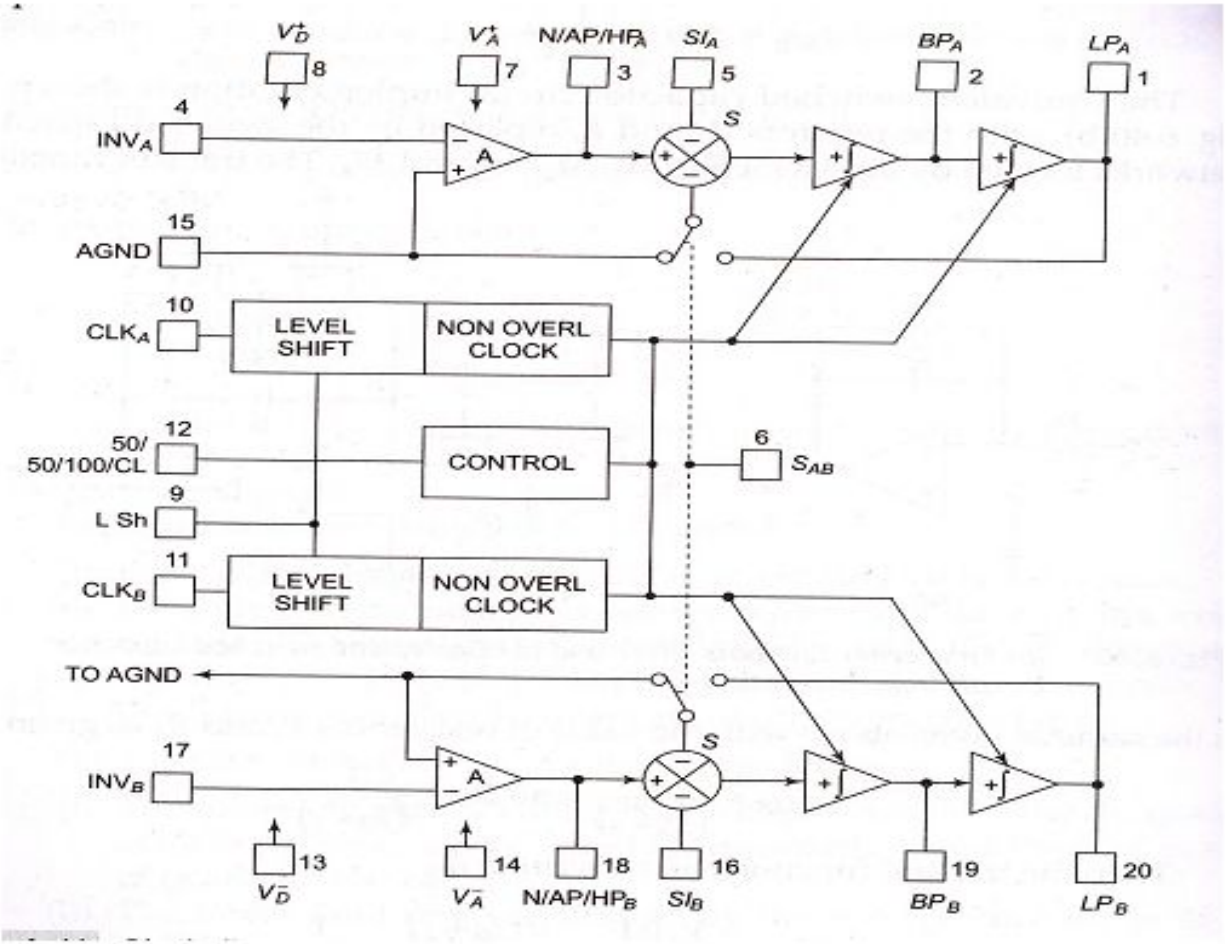
$$I = qf$$

$$I = C_S(V_{OUT} - V_{IN})f$$

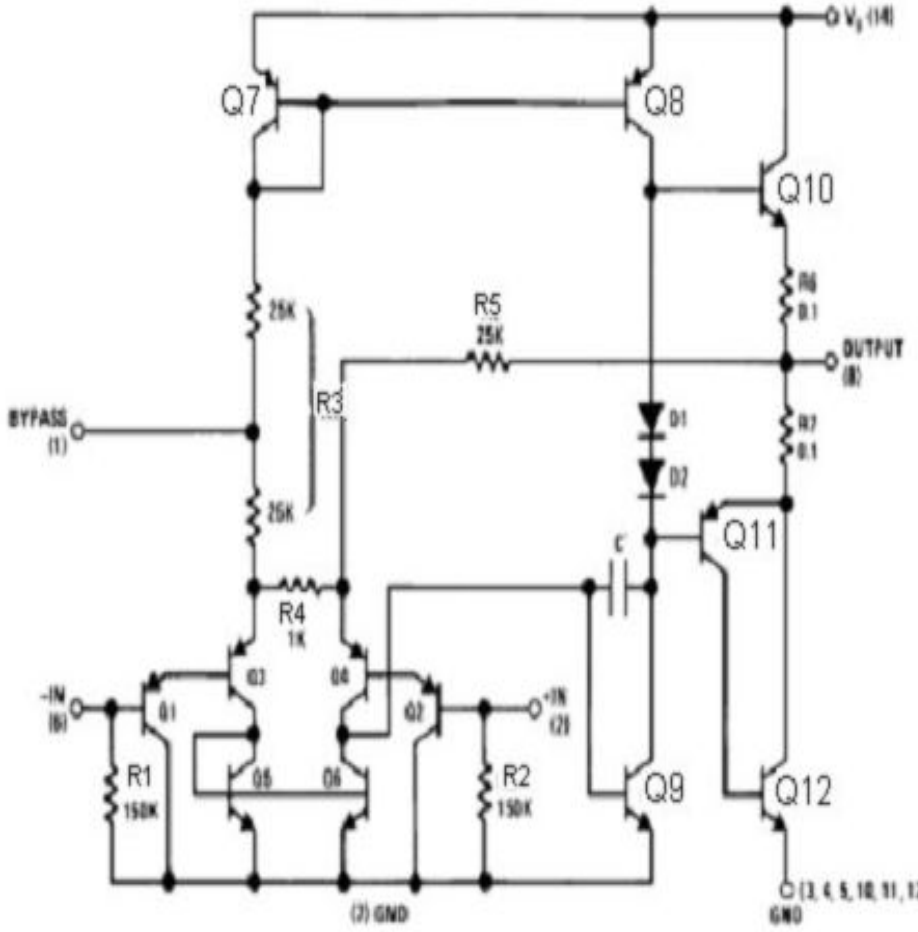
$$V = V_{OUT} - V_{IN}$$

$$R = \frac{V}{I} = \frac{1}{C_S f}$$

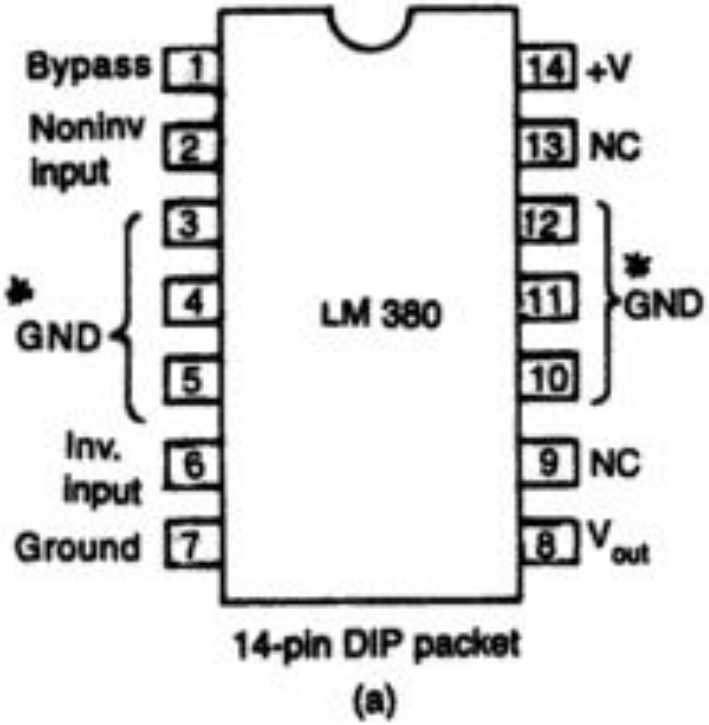
Switched Capacitor Filter–MF10

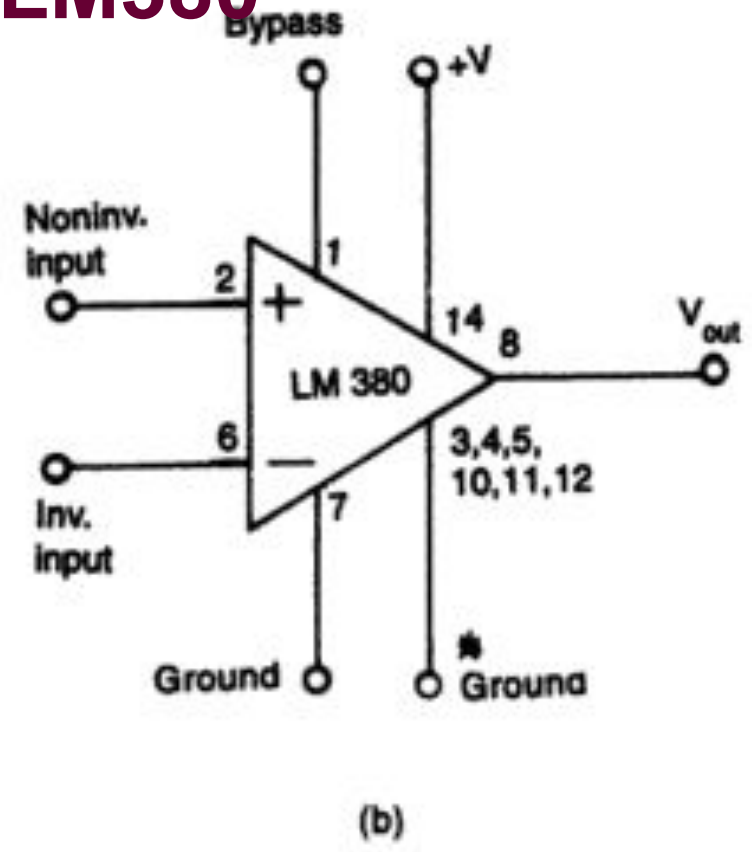


Audio Power Amplifier

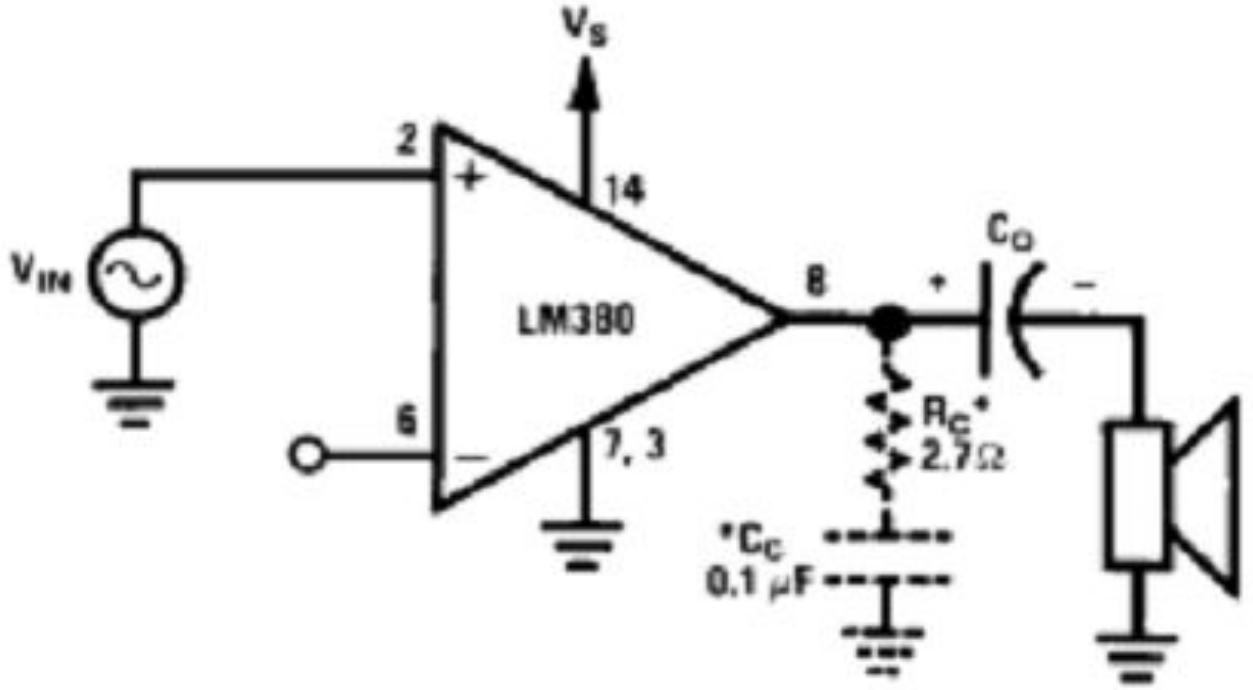


PIN DIAGRAM AND BLOCK DIAGRAM OF LM380





Audio Power Amplifier–LM380



Isolation Amplifier

- Provides a way to link a fixed ground to a floating ground.
- Isolates the DSP from the high voltage associated with the power amplifier.

ISOLATION AMPLIFIER

Purposes

- To break ground to permit incompatible circuits
- to be interfaced together while reducing noise
- To amplify signals while passing only low leakage current to prevent shock to people or damage to equipment
- To withstand high voltage to protect people, circuits, and equipment

Methods

- Power Supply Isolation : battery, isolated power
- Signal Isolation : opto-isolation, capacitive

OPTOCOUPLER

- The optocouplers provide protection and high-speed switching
- An optocoupler, also known as an opto-isolator, is an integral part of the opto electronics arena. It has fast proven its utility as an electrical isolator or a high-speed switch, and can be used in a variety of applications.
- The basic design for optocouplers involves use of an LED that produces a light signal to be received by a photodiode to detect the signal. In this way, the output current or current allowed to pass can be varied by the intensity of light.

Optoelectronic Integrated Circuits

Applications

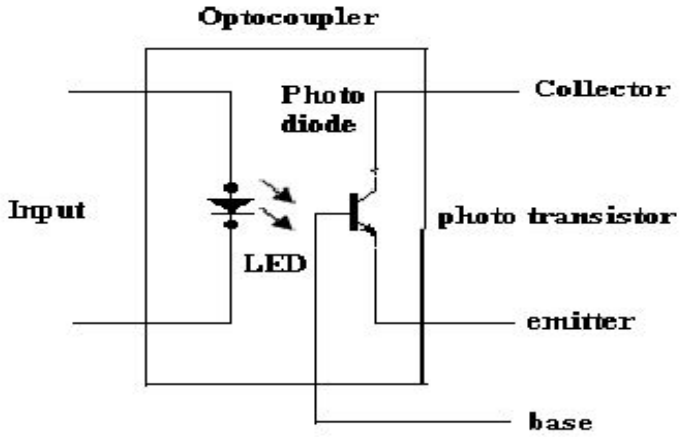
- Inter- and intra-chip optical interconnect and clock distribution
- Fiber transceivers
- Intelligent sensors
- Smart pixel array parallel processors

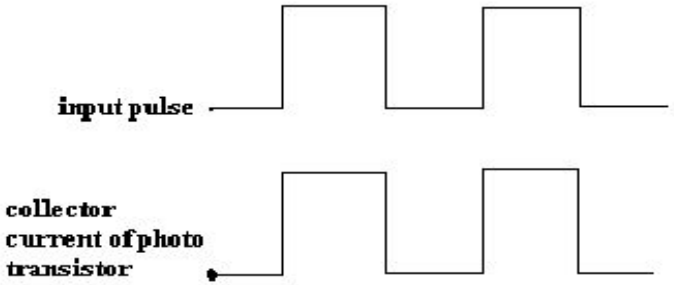
Optoelectronic Integrated Circuits

Approaches

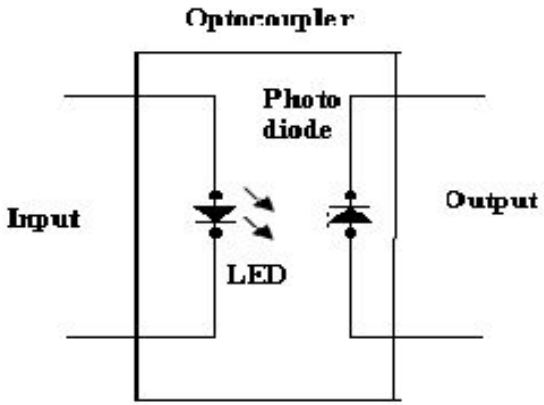
- Conventional hybrid assembly: multi-chip modules
- Total monolithic process development
- Modular integration on ICs:
- epitaxy-on-electronics
- flip-chip bump bonding w. substrate removal
- self-assembly

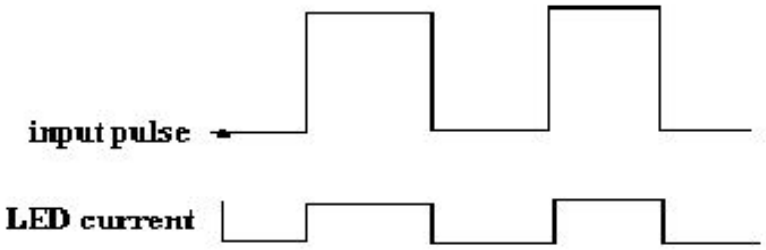
LED –Phototransistor Optocoupler





LED –Photodiode Optocoupler





Optocoupler IC