# TIMER IC 555 :

IC 555 Timer is a monolithic IC used for timing applications, setting delays and used as an oscillator. This IC was available in 8 and 14 pin DIP (Dual-in-line) package and 8-pin TO (Top Hat or Transistor Outline). The features of this IC are as follows:

## FEATURES:

1. It operates on +5V to +18V power supply.
2. It has two modes of operation : Astable mode and Monostable mode.
3. Time delay from microseconds to hours with adjustable duty cycle output.
4. Compatible with TTL and CMOS circuits.
5. High output current with source or sink current of 200mA.
6. Very good temperature stability of 50 ppm (parts per million) or equivalently 0.005%/°C.
7. It is reliable, easy to use and low cost.

Although there were numerous applications available for this IC, some of them are listed here:

## APPLICATIONS:

1. Waveforms generators.
2. Analog frequency meters.

3. Oscillator

4. Pulse generator

5. Square wave generator

6. Linear ramp generator

7. DC to DC converters.

8. Burglar Alarm

9. Toxic gas alarm.

10. Water level controller

11. Temperature measurement and control devices.

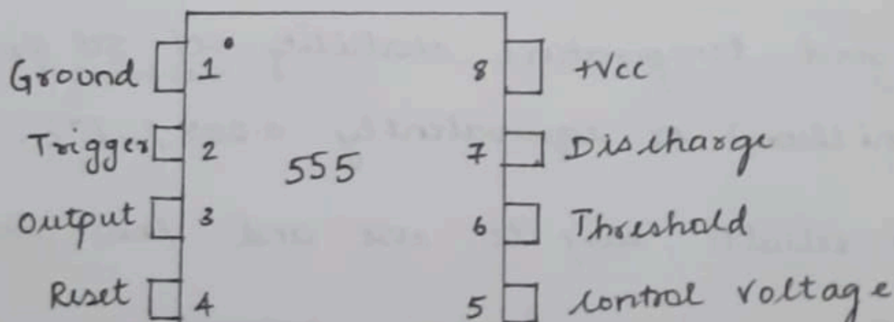
12. Traffic light controller

13. Voltage regulators

14. Electric eyes and many more.

## PIN DIAGRAM AND PIN DESCRIPTION:

8-pin mini-DIP package of 555 Timer IC:




## BLOCK DIAGRAM COMPONENTS:

(i) Potential divider

(ii) Comparators

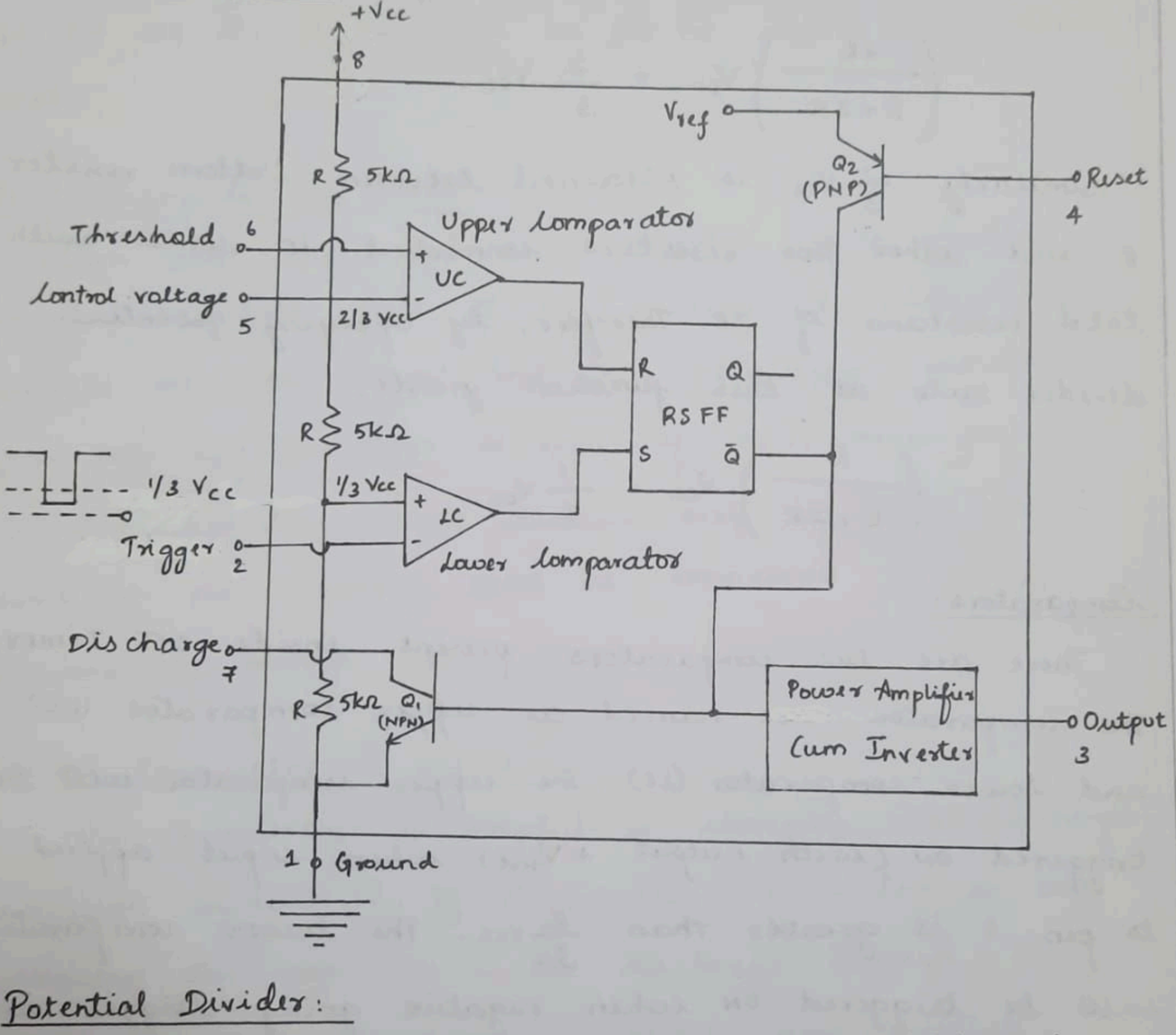
(iii) RS flip-flop

(iv) Reset transistors (PNP)

(v) Control transistor (NPN) and

(vi) Power Amplifier cum Inverter.

BLOCK DIAGRAM:




## Potential Divider:

The potential divider formed by three internal resistors of each 5kΩ is used to derive two threshold voltages from supply voltage $+V_{cc}$. They are $\frac{2}{3}V_{cc}$ and $\frac{1}{3}V_{cc}$. The IC is named as 555 because of these three 5kΩ resistors. $\frac{2}{3}V_{cc}$ is obtained between top resistor R and other two resistors connected in series with total resistance of 2R. Therefore, by applying potential divider rule at junction yields

$$\left(\frac{2R}{R+2R}\right)V_{cc} = \frac{2}{3}V_{cc}.$$

Similarly, $\frac{1}{3}V_{cc}$ is obtained between bottom resistor R and other two resistors connected in series with total resistance of 2R. Therefore, by applying potential divider rule at this junction yields.

$$\left(\frac{R}{R+2R}\right)V_{cc} = \frac{1}{3}V_{cc}.$$

Comparators:

There are two comparators present inside 555 Timer. The comparators are named as upper comparator (UC) and Lower comparator (LC). The upper comparator will be triggered ON (with output $+V_{sat}$) when input applied to pin 6 is greater than $\frac{2}{3}V_{cc}$. The lower comparator will be triggered ON when negative going trigger is more negative than $\frac{1}{3}V_{cc}$ (This happens due to trigger input applied to inverting or minus terminal of LC).

## RS Flip-Flop:

When UC is ON, reset input $R=1$, producing $Q=0$ and $\bar{Q}=1$. When LC is ON, set input $S=1$, producing $Q=1$ and $\bar{Q}=0$. Note that, both comparators should not be ON at the same time as RS FF enters forbidden state.

## Reset transistor $Q_2$ (PNP):

When reset input (pin 4) is supplied with negative voltage, it enters base of $Q_2$, making the collector to emitter resistance small and thus allowing current to flow from $V_{ref}$ (emitter) to input of power amplifier cum inverter. Thus the output becomes zero. If intentional reset is not required, reset is connected to $+V_{cc}$, making $Q_2$ always OFF.

## Control Transistor $Q_1$ (NPN):

This transistor is helpful in charging and discharging external capacitor c. If $\bar{Q}=1$, this transistor is ON allowing the capacitor c to discharge through the low resistance path between collector and emitter (to ground). Suppose, if $\bar{Q}=0$, $Q_1$ is off and collector and emitter open circuits allowing the capacitor c to charge with current coming from supply voltage $+V_{cc}$.

## Power Amplifier cum Inverter:

The power amplifier increases the driving capability of Timer and inverter provides inverted output of $\bar{Q}$. If $\bar{Q} = 0$, then output $= 1$ at pin 3. If $\bar{Q} = 1$, then output $= 0$ at pin 3.

## Modes of Operation of 555 Timer:

There are two modes of operation available for 555 Timer. They are Astable Mode and Monostable Mode.

## IC Voltage Regulator:-

It is an integrated circuit whose basic purpose is to regulate the unregulated input voltage and provide with the constant regulated o/p voltage.

There are two Types of IC voltage regulators

* Fixed Voltage Regulator
* Adustable Voltage Regulator

These two comes under Linear Voltage Regulator.

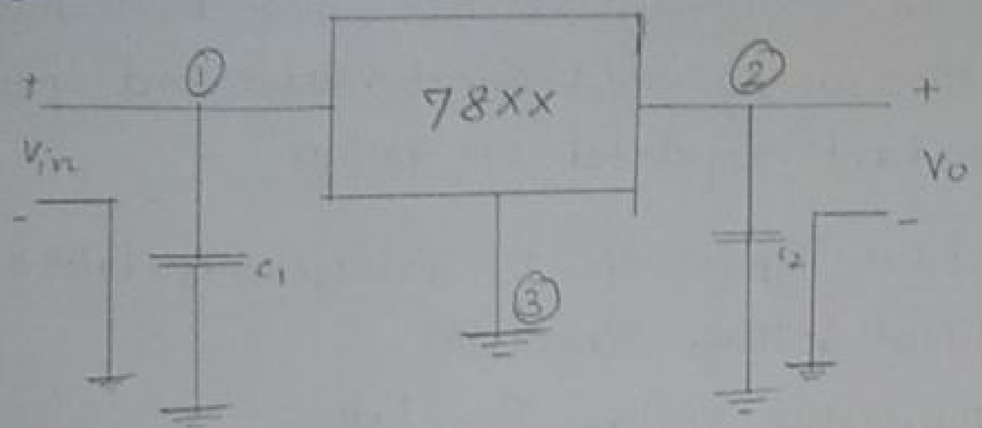
## Fixed Voltage Regulator:-

* It is a 3-terminal Voltage Regulator which provides a fixed output voltage for an unregulated input.
* There are two types of fixed Voltage Regulator.
  (i) positive fixed Voltage Regulators Ex: 78xx
  (ii) negative fixed Voltage Regulators Ex: 79xx

## (i) Positive Voltage Regulator:-

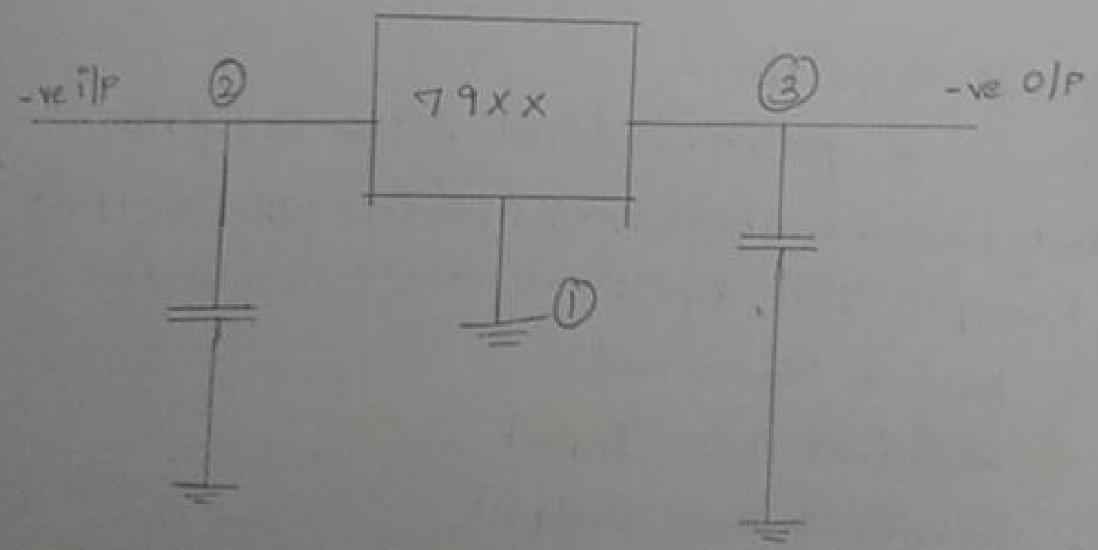
* 78xx is a positive fixed Voltage Regulator.
* The last two numbers (xx) indicate the output voltage. For Example 7815 represents a +15 V regulator.
* 78xx has 3 terminals
  (i) Terminal 1 — Input
  (ii) Terminal 2 — Output
  (iii) Terminal 3 — Ground.

Here $C_1$ and $C_2$ act as line fiters(i.e) helps to reduce AC ripples.




Negative fixed Voltage Regulator:-

* 79xx is a negative fixed voltage Regulator.
* 79xx is same as the 78xx in design and operation except for the variation in pin configuration.
  * Terminal 1 - Ground
  * Terminal 2 - Input
  * Terminal 3 - Output.



Positive fixed Voltage Regulators 78xx series.

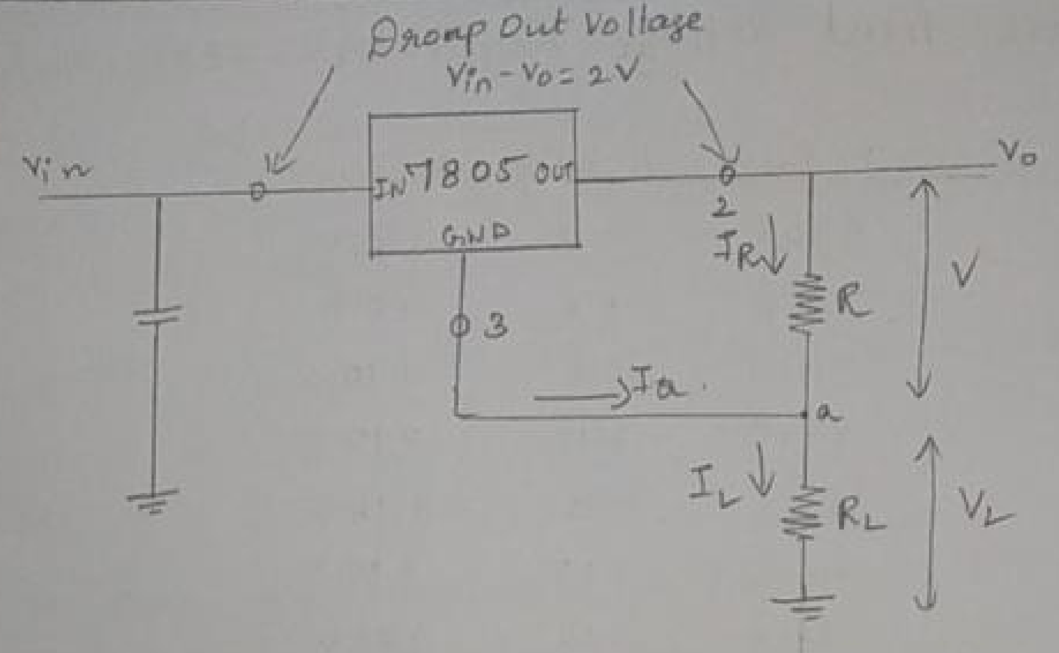
| IC Part | O/P Voltage $V_o$ | Minimum $V_i$ |
|---|---|---|
| 7805 | +5 | +7.3 |
| 7806 | +6 | +8.3 |
| 7808 | +8 | +10.5 |
| 7810 | +10 | +12.5 |
| 7812 | +12 | +14.5 |
| 7815 | +15 | +17.7 |
| 7818 | +18 | +21.0 |
| 7824 | +24 | +27.1 |

Negative fixed Voltage Regulators 79xx series

| IC Part | O/P Voltage $V_o$ | Minimum $V_i$ |
|---|---|---|
| 7905 | -5 | -7.3 |
| 7906 | -6 | -8.4 |
| 7908 | -8 | -10.5 |
| 7909 | -9 | -11.5 |
| 7912 | -12 | -14.6 |
| 7915 | -15 | -17.7 |
| 7918 | -18 | -20.8 |
| 7924 | -24 | -27.1 |

Voltage Regulator as a Current Source :-

* Fixed Voltage Regulator can also be used to provide the require output current, so it can act as a current source also
* This can be achieved by using appropriate resistor across the output which is connected in series with Load Resistor.




* 7805 is a positive fixed voltage Regulator which provides a constant output voltage of +5 V
* A load of 10 Ω is connected to the circuit.
* The voltage difference between input and output is about 2V
* Here $I_Q$ is the Quiescent current which is defined as the current level at which the amplifier produces output = 0.
* So here $I_Q$ value of 7805 is 4.2 mA.
* We have to choose the value of R such that the circuit produces a current of 1A.

From circuit

Applying KCL at node a.

$$I_L = I_Q + I_R$$

$$= I_Q + \frac{V_R}{R}$$

Since $I_L = 1A$ $I_Q = 4.2$ mA which is very very less than $I_L$

neglecting $I_Q$,

$$1 = \frac{V_R}{R}$$

$$R = V_R = 5\,\Omega$$ where $V_R$ is the output voltage which is 5V

So we need a Resistor of 5 Ω to deliver 1A current to load of 10 Ω

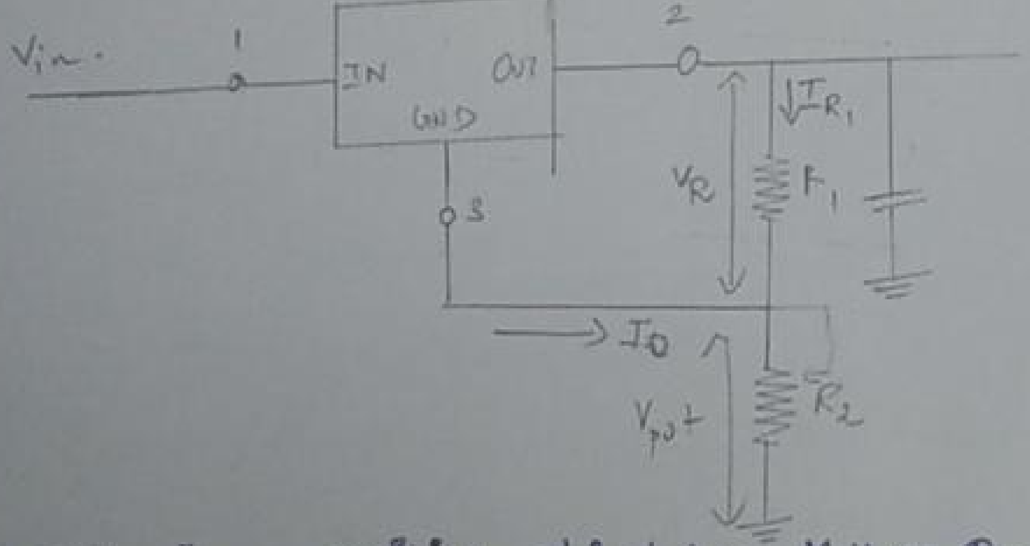
## Adjustable Voltage Regulator:-

* In laboratory, one may need variable regulated voltages or a voltage that is not available as a standard fixed voltage Regulator.

* So we go for Adjustable Voltage Regulator which is a kind of Regulator whose regulated output voltage can be varied over a Range.

* There are two types of Adjustable Voltage Regulator.
  - (i) positive adjustable voltage Regulator. Ex: LM 117, LM 317, LM 217
  - (ii) negative adjustable voltage Regulator. Ex: LM 337, LM 137, LM 237

* It has 3 terminals
  - (i) terminal 1 – Input
  - (ii) terminal 2 – Output
  - (iii) terminal 3 – Ground which is floating.




* LM 317 is a positive adjustable Voltage Regulator which is used to produce a varied range of output voltage from between 1.2 to 37V

* In order to produce this range the value of variable resistor $R_2$ is adjusted.

* The voltage across this $R_2$ is given by $V_{pot}$, where $V_R$ is the o/p voltage given by the circuit taken across $R_V$
  $V_R$ is the regulated voltage diff b/w OUT and GND terminal. It's value is 1.25V which is constant

The Output Voltage of LM 317 is given by

$$V_0 = V_R + V_{pot}$$

$$= V_R + (I_{R_1} + I_Q)R_2$$

$$= V_R + I_{R_1} R_2 + I_Q R_2$$

$$= V_R + I_Q R_2 + \left(\frac{V_R}{R_1}\right) R_2$$

$$= V_R + \frac{V_R}{R_1} + I_Q R_2$$

$$= V_R\left(1 + R_2/R_1\right) + I_Q R_2$$

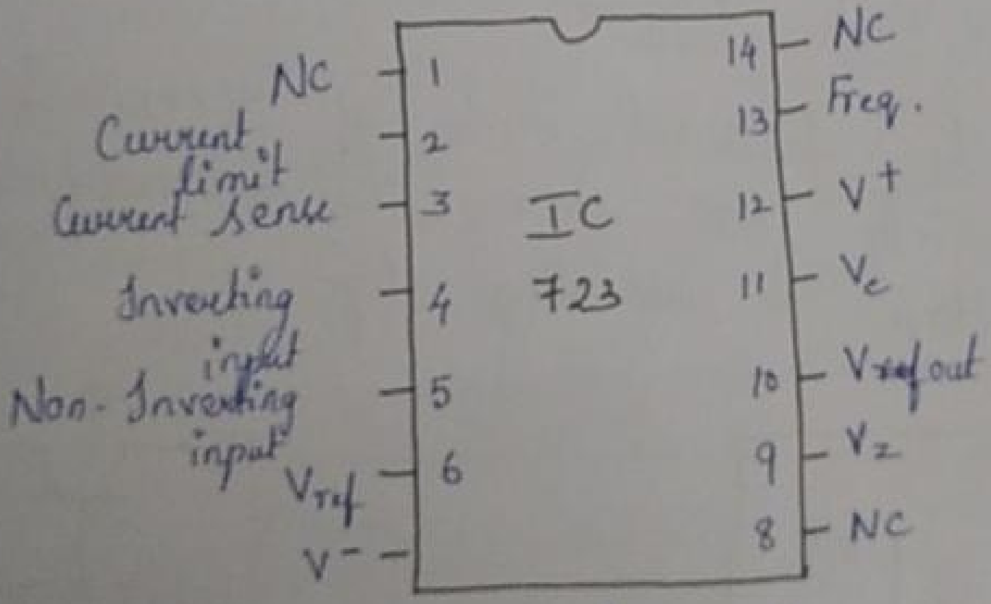
$\therefore$ By variying $R_2/R_1$ (or) value of $R_2$ resistor we can get different range of output.

Thus it is possible to adjust the output voltage from 1.2 V to 40 V and current upto 1.5 A.

## IC723 General purpose Regulator:-

IC723 is a general purpose voltage regulator used to provide variable output voltage with positive and negative polarity. It overcomes the drawbacks of three terminal regulators, (ie) [(i) No short circuit protection and (ii) output voltage is fixed (positive (or) Negative) → 2 drawbacks of three Terminal voltage Regulator]

## Pin diagram



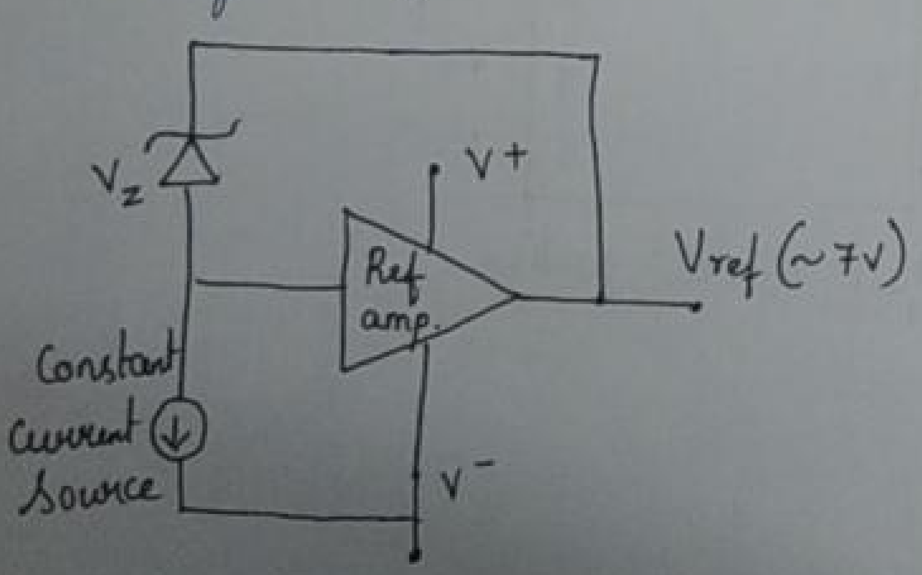

Dual-in-line package.

## Features of IC723

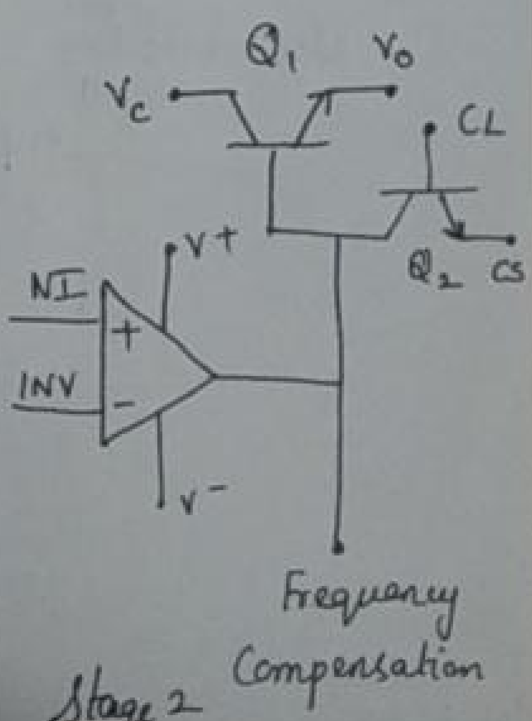
1) Output voltage magnitude & polarity can be varied.
2) Load current can be improved up to 5A (or) even more with external components.
3) Current sensing and current limiting capability.
4) Available in Dual-in-line (DIP) & metal can packages.
5) In-built frequency compensation.

## Functional Block diagram:

The functional block of IC723 is splitted into two stages. They are reference voltage stage & regulating stage.

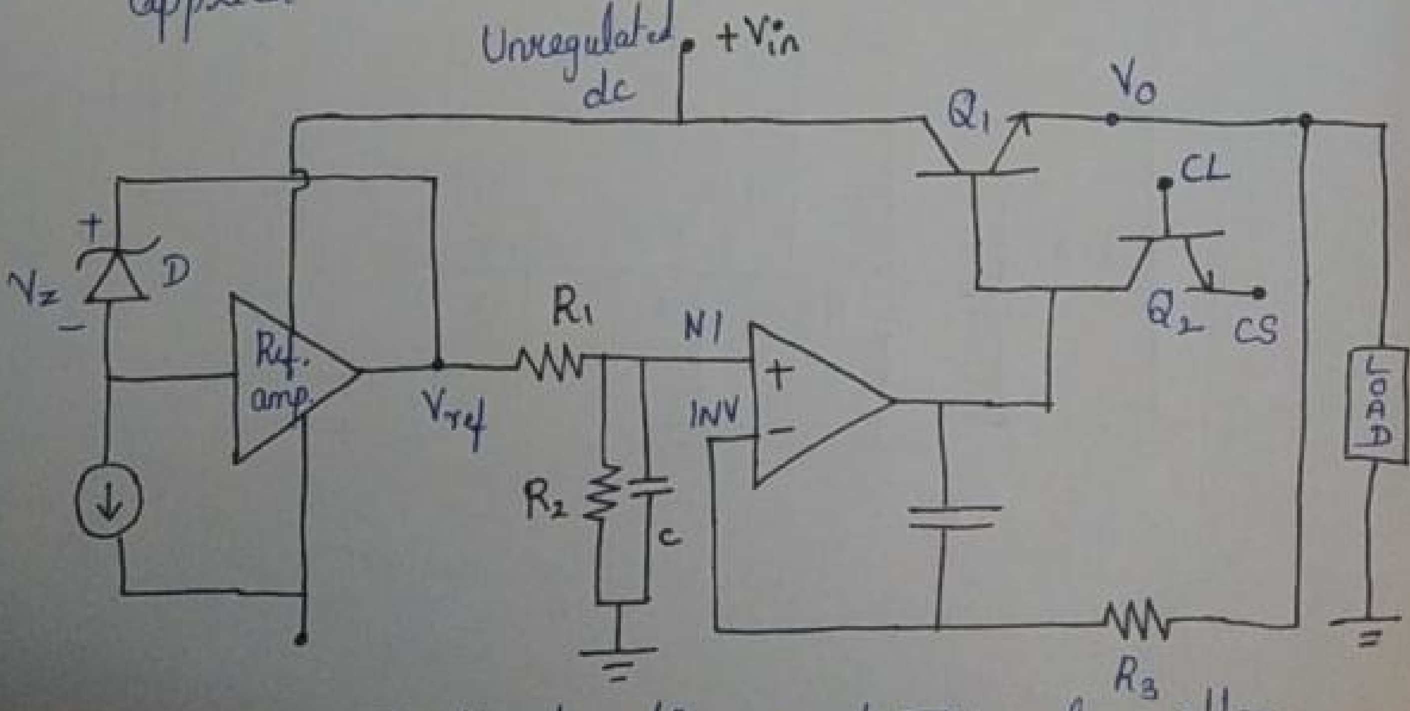



Stage 1



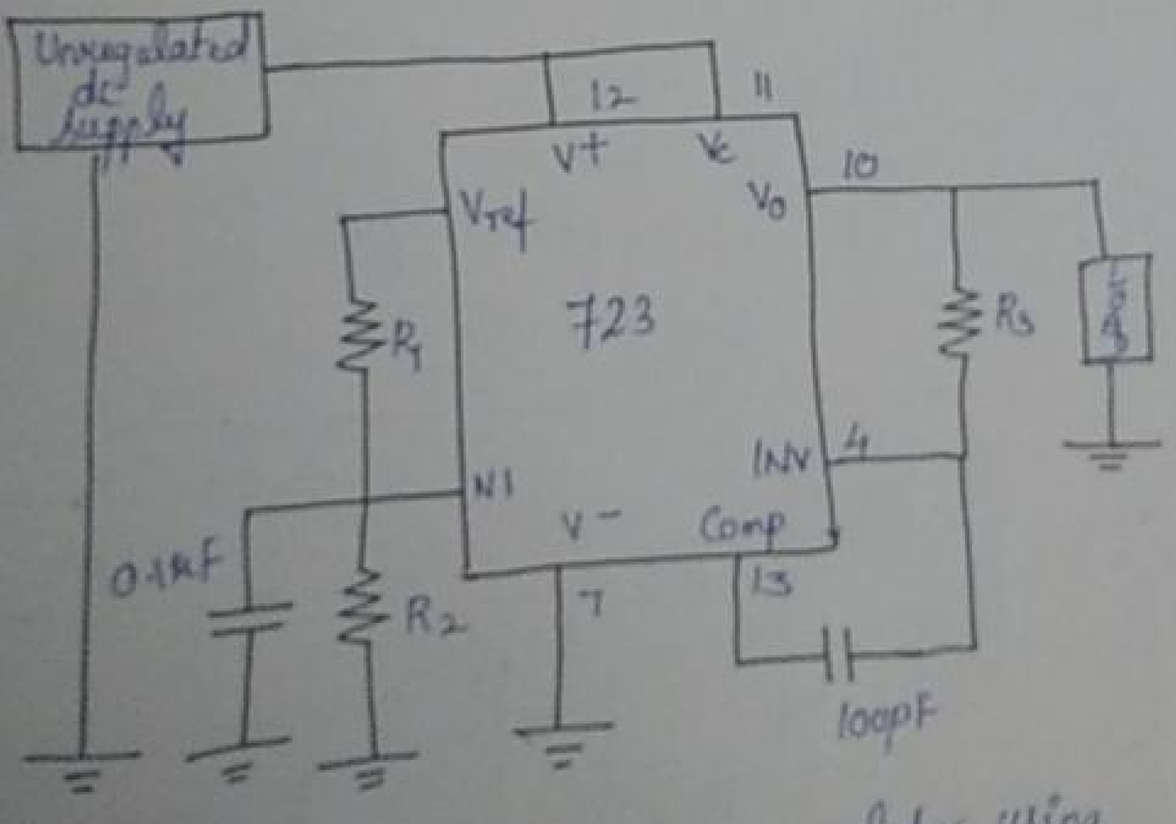

Stage 2

* The reference voltage stage consists of a zener diode D, a reference amplifier and a constant current source.
* The constant current source supplies fixed amount of current to reverse bias D and the drop across D is $V_Z$ called as zener voltage.
* The stage 1 produces a fixed voltage of about 7 volts at the terminal $V_{ref}$.
* The second stage (regulating stage) consists of an error amplifier, a series pass transistor $Q_1$ and a current limit transistor $Q_2$.
* The error amplifier compares a sample of the output voltage applied at the inverting (INV) input terminal to the reference voltage $V_{ref}$ applied at the NI input terminal.



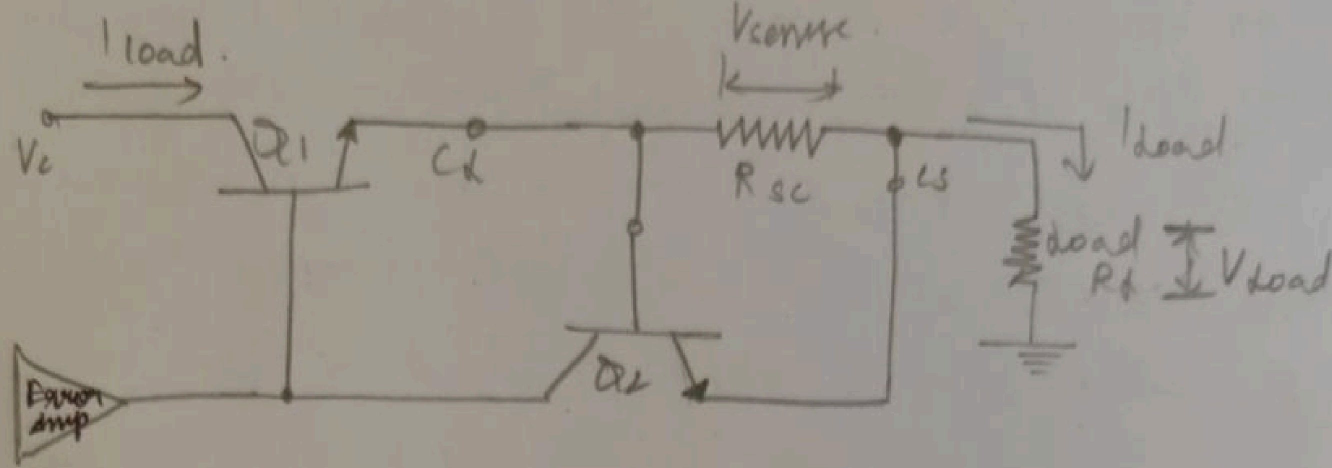

Functional diagram of IC723 low voltage regulator.

* Consider the case, if $V_o$ rises than the desired level (ie) $V_o > V_{ref}$, the error amplifier produces negative voltage since INV > NI
* This lowers the base current applied to $Q_1$, this reduces the current passing from $V_c$ to $V_o$. Now $V_o$ is reduced to the fixed level output.
* If $V_o$ drops than the desired level (ie) $V_o < V_{ref}$, error amplifier produces positive voltage which increases the base current of $Q_1$, this increases the current passing from $V_c$ to $V_o$. Now $V_o$ is increased to fixed level output.




Low voltage regulator using IC723.

# IC 723 current limit and current foldback protection.

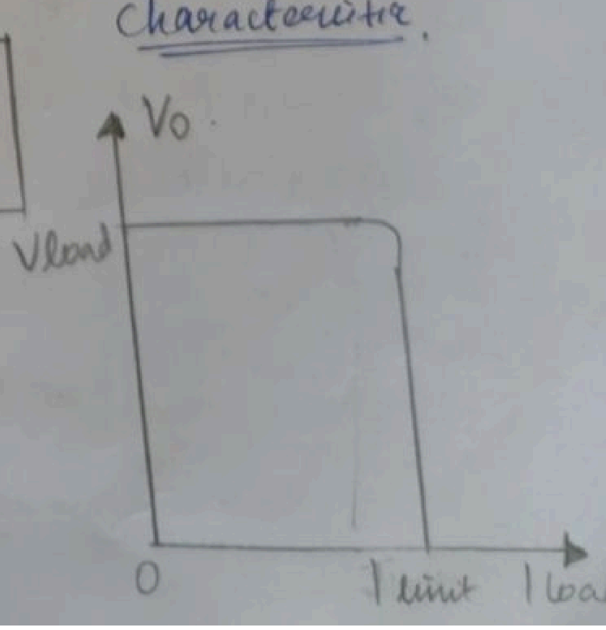



*** Current limiting:**

When the load demands large current, IC provides it by mainting constant output voltage $V_o$. This increases temperature continously and may damage the IC. Therefore, the load current will not be allowed to increase beyond a range using current limit protection circuit. The output current from error amplifier enters base of $Q_1$ reducing its collector emitter resistance. The load current now passes from collector to emitter of $Q_1$. A small voltage drope across Rsc appears as $V_{sense}$.

$$\boxed{I_{limit} = \frac{V_{sense}}{R_{sc}} = \frac{0.5V}{R_{sc}}}$$

Characteristic.

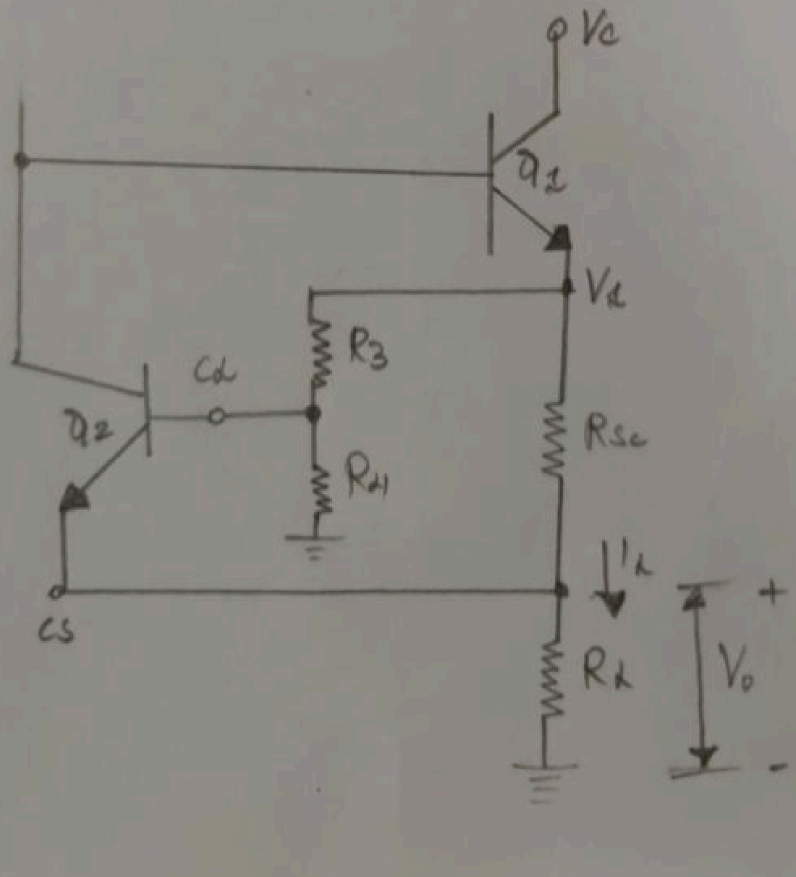


ii) Current fold back:

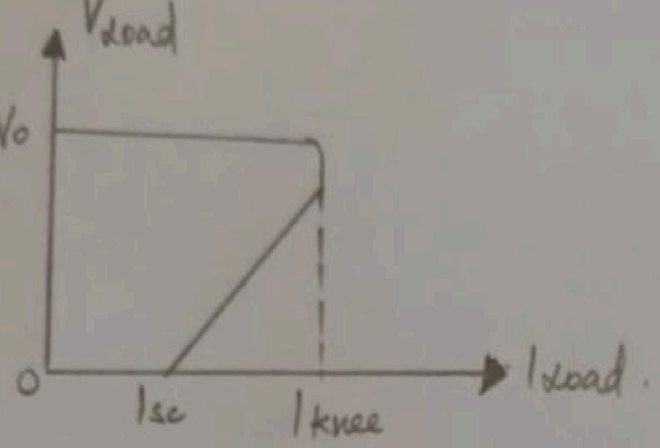
current fold back method is used to limit the short circuit current when the load is short circuited. The previous method will allow short circuited current and reduces $V_o$ to zero when load reaches $I_{limit}$. Thus, the drawback of previous technique is maximum current flows through the regulator, if load is short circuited, which is eliminated by this method.

The idea of current fold back is to reduce load voltage $V_o$ to zero and reduce the load current when it reaches a particular current called knee current.

This further reduces the conduction of $Q_1$ and thus the load current is minimized. This process continues until $V_o = 0V$.



This behaviour is shown in characteristic.



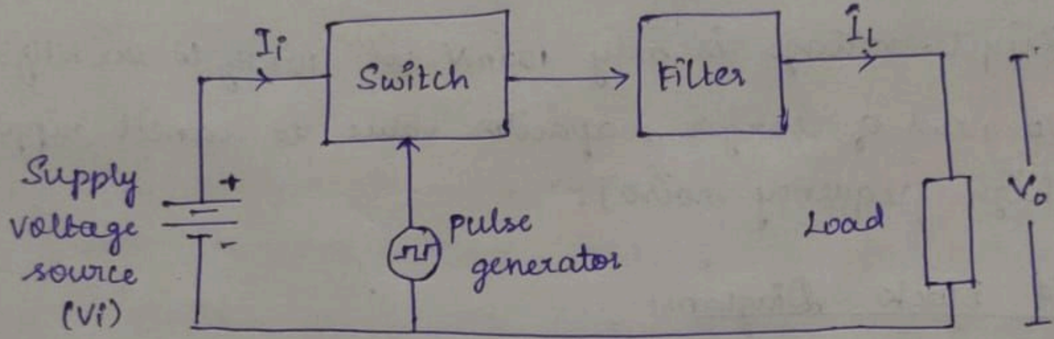

* Applications of 723 voltage regulator:

i) Low voltage regulator.
ii) High voltage regulator.
iii) Current booster.

1. Monolithic Switching Regulators:

Switching regulation is the advanced technique in ~~which~~ voltage regulation. It uses the controlling ~~system~~ element, the series pass transistor as switch, that operates in only 2 conditions - they are cutoff and saturation. It has improved efficiency when compared with linear regulation.

Components of switching Regulator:




$$\boxed{V_o = \frac{t_{ON}}{T} \times V_{in}}$$

If T is maintained constant and Vo is made proportional to $t_{ON}$ is called Pulse Width Modulation (PWM). On the other hand, if $t_{ON}$ is maintained constant and $V_o$ is made inversely proportional to T (or) proportional to frequency f. is called an Frequency modulation (FM). PWM method is preffered because of high current output, irrespective of being complex compared to FM method.

Advantages of switching voltage regulator compared to linear voltage regulator

1. Power dissipation is very small. And no serious heat dissipation problems and no waste of power.

2. Higher efficiency. Approximately 85%.

3. No need of heat sink.

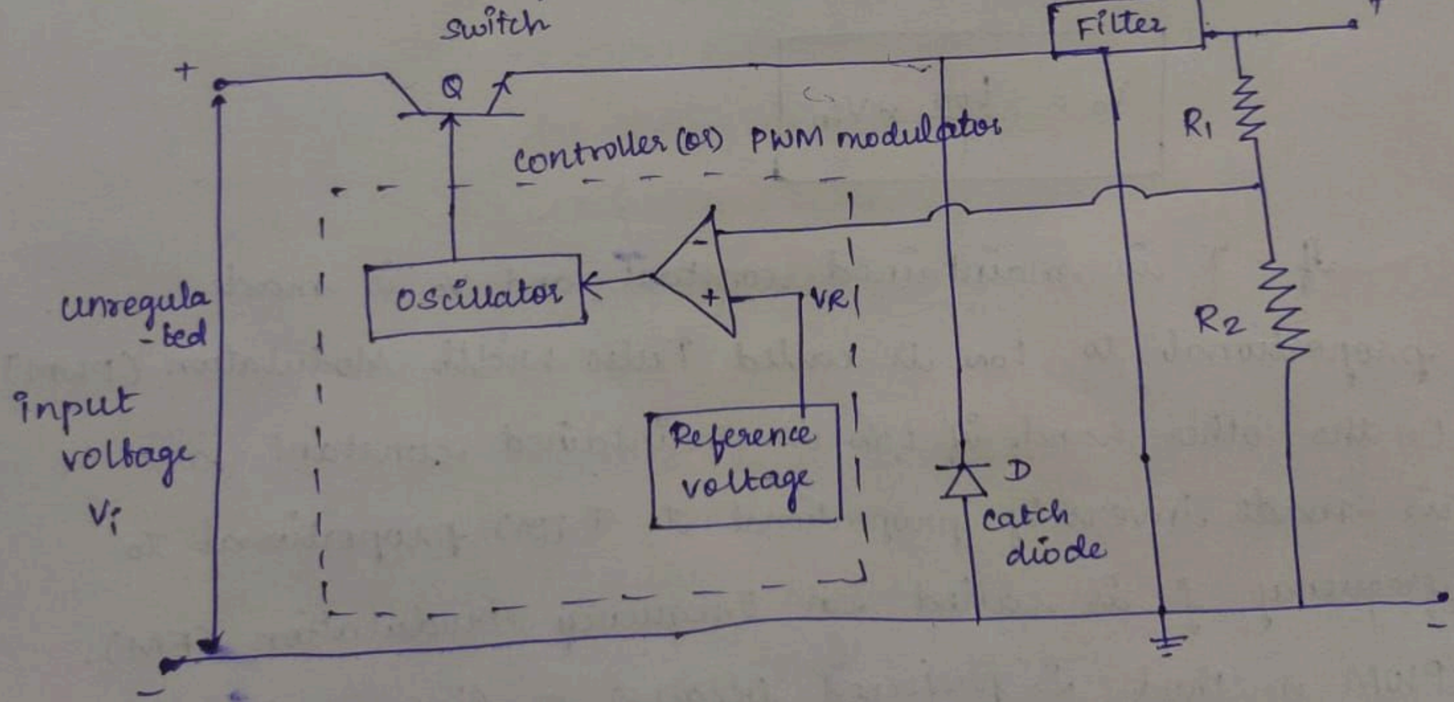
4. Bulky transformers can be avoided.

5. No condition of input voltage, always being greater than output voltage.

6. Ripple voltage is only 100mV for 10KHz to 200KHz frequency.

7. No need of larger capacitor value to cancel ripples (high frequency noise).

## Detailed Block Diagram:



The detailed block shows the arrangement of control switch Q, controller, catch diode D, filter and potential driver $R_1$ and $R_2$. Whenever the o/p voltage increases or decreases, the whole circuit is responsible for bringing the o/p voltage to a fixed desired level. The operation is so fast, that even we wont see the o/p decreasing or increasing than the desired o/p. To understand how its happening, we assume two cases.

In case 1, assume $V_o$ is decreasing than desired level. This decreasing voltage is partly taken by potential driver. The voltage across $R_2$ is given to inverting terminal of op-amp comparator. The non-inverting terminal is supplied with fixed reference voltage. Now, $V_R > V_f$. The op-amp produces positive o/p which increases the $t_{ON}$ of the oscillator's PWM o/p. This o/p from oscillator makes Q conduct for long duration. Transistor begin to turn ON (with small ~~oscillator~~ collector-Emitter resistance) allowing more current from i/p side to o/p side compensating decreasing o/p $V_o$. Thus, $V_o$ is maintained constant.

In case 2, assume $V_o$ is increasing than desired level. The operation here is just opposite to case 1. $V_R < V_f$, op-amp o/p is negative, reduces $t_{ON}$ and Q conduction is limited to short duration, passing small amout of current from i/p side to o/p side. Thus $V_o$ is reduced and compensated to produce fixed o/p.

If o/p $V_o$ remains same value then $V_R = V_f$ and zero o/p from comparator has no effect on oscillator.