Power Audio Amplifier IC LM 380:

Introduction:

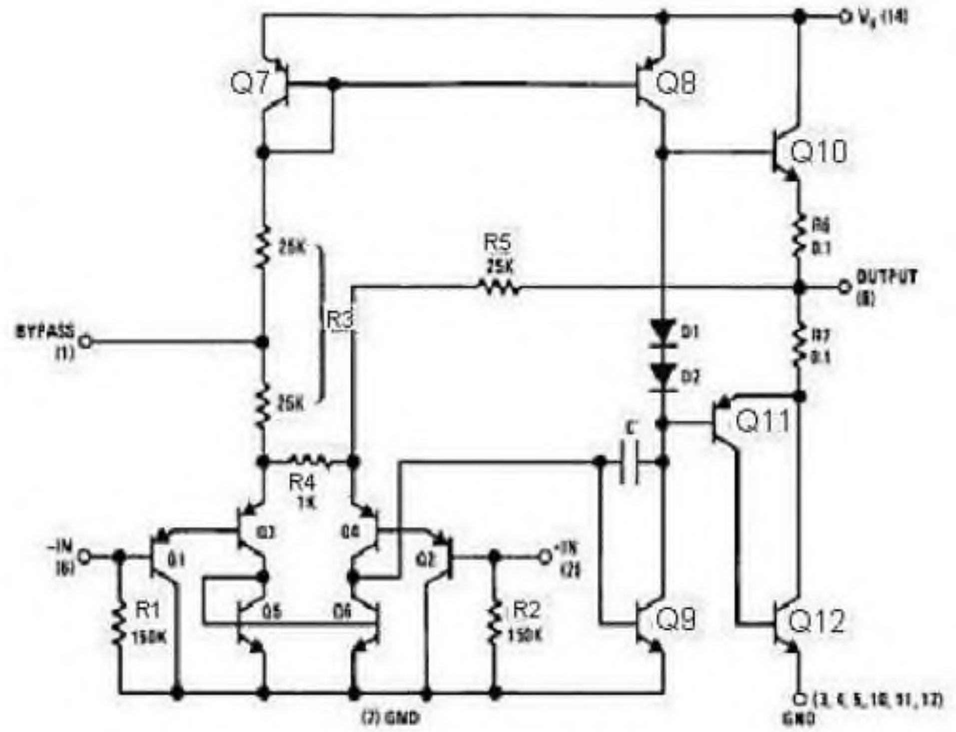
Small signal amplifiers are essentially voltage amplifier that supplies their loads with larger amplifier signal voltage.On the other hand, large signal or power amplifier supply a large signal current to current operated loads such as speakers & motors.

In audio applications, however, the amplifier called upon to deliver much higher current than that supplied 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 op-amps. To handle it following is done

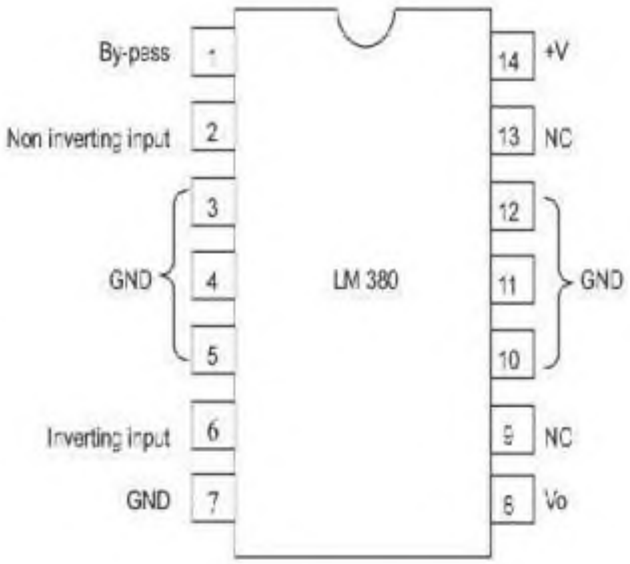
- To use discrete or monolithic power transistors called power boosters at the output of the op-amp
- To use specialized ICs designed as power amplifiers like LM 380.

Features of LM380:

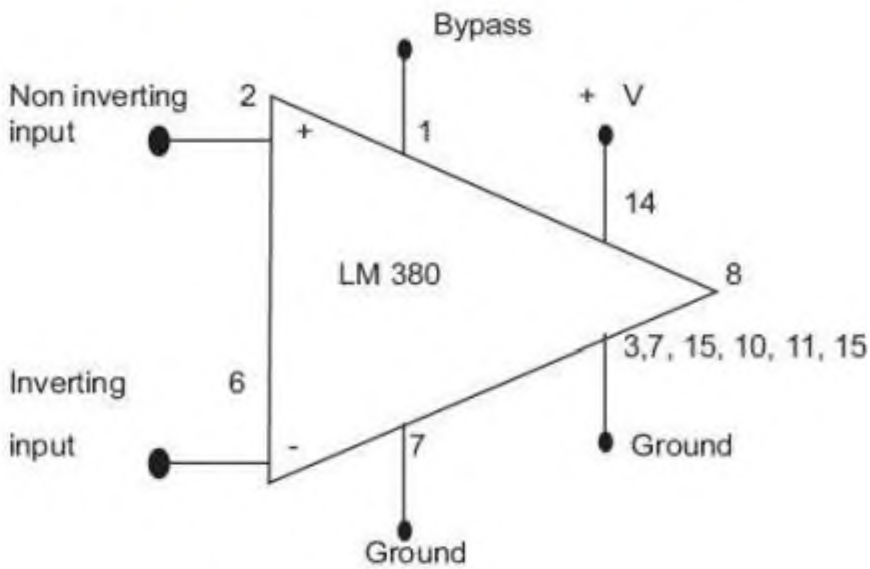
1. Internally fixed gain of 50 (34dB)
2. Output is automatically self centering to one half of the supply voltage.
3. Output is short circuit proof with internal thermal limiting.
4. Input stage allows the input to be ground referenced or ac
5. Wide supply voltage range (5 to 22V).
6. High peak current capability.
7. High impedance.



Functional block diagram of Audio Power Amplifier



Pin diagram Of Power amplifier LM380



Block diagram of LM380

LM380 circuit description:
It is connected of 4 stages,

i. PNP emitter follower
ii. Different amplifier
iii. Common emitter
iv. 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.

(ii) Differential Amplifier:

- 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.

(iii) Common Emitter amplifier stage:

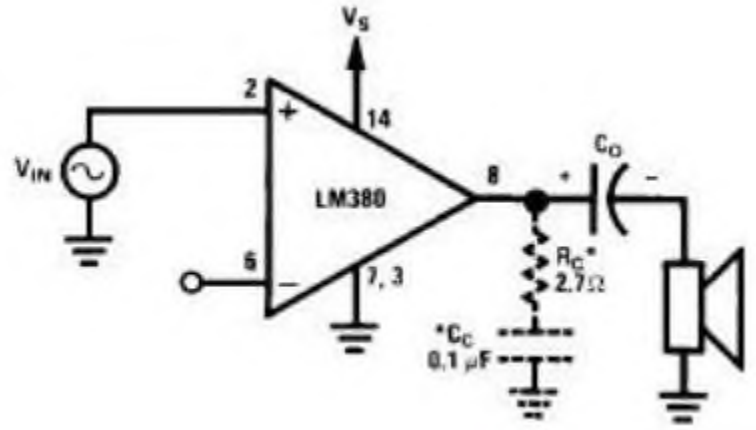
- Common Emitter amplifier stage is formed by transistor Q9 with D1, D2 & Q8 as a current source load.
- The capacitor C between the base & collector of Q9 provides internal compensation & helps to establish the upper cutoff frequency of 100 KHz.
- Since Q7 & Q8 form a current mirror, the current through 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 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 bypass 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.

Applications:

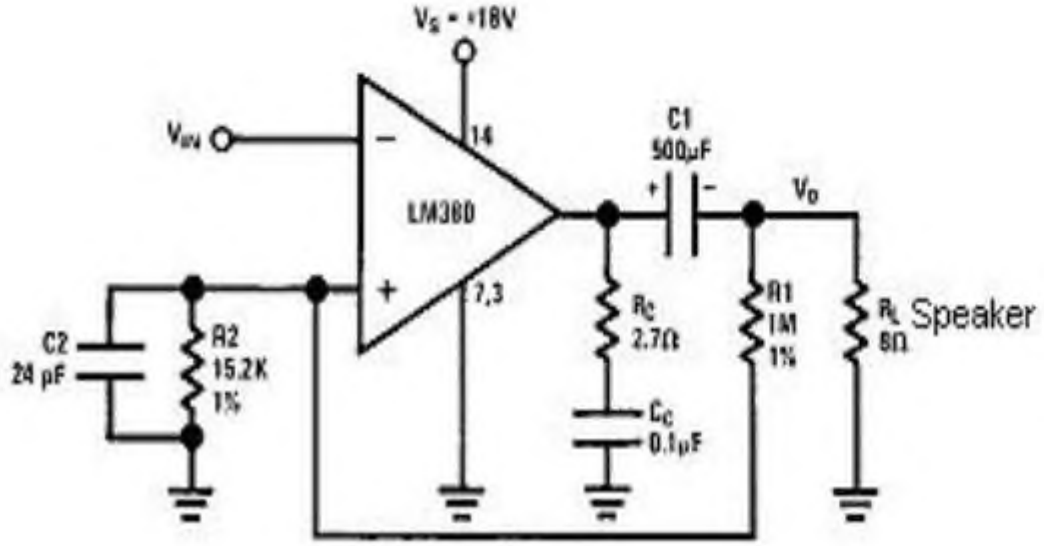
(i) Audio Power Amplifier:



Connections of audio power amplifier

- Amplifier requires very few external components because of the internal biasing, compensation & fixed gain.
- When the power amplifier is used in the non inverting configuration, the inverting terminal may be either shorted to ground, connected to ground through resistors & capacitors.
- Similarly when the power amplifier is used in the inverting mode, the non inverting terminal may be either shorted to ground or returned to ground through resistor or capacitor.
- Usually a capacitor is connected between the inverting terminal & ground if the input has a high internal impedance.
- As a precautionary measure, an RC combination should be used at the output terminal (pin 8) to eliminate 5-to-10 MHz oscillation.
- C1 is coupling capacitor which couples the output of the amplifier to the 8 ohms loud speaker which acts as a load. The amplifier will amplify the Vin applied at the non-inverting terminal.

(ii) LM 380 as a High gain amplifier:

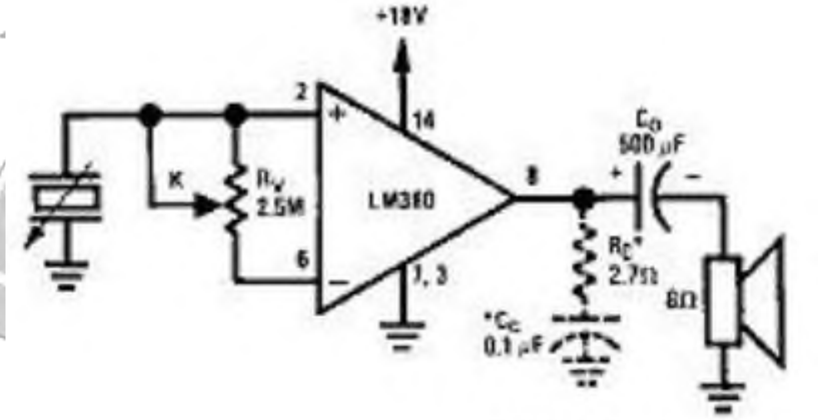


Circuit connections

- The gain of LM380 is internally fixed at 50. But it can be increased by using the external components.
- The increase in gain is possible due to the use of positive feedback, this setup to obtain a gain 200.

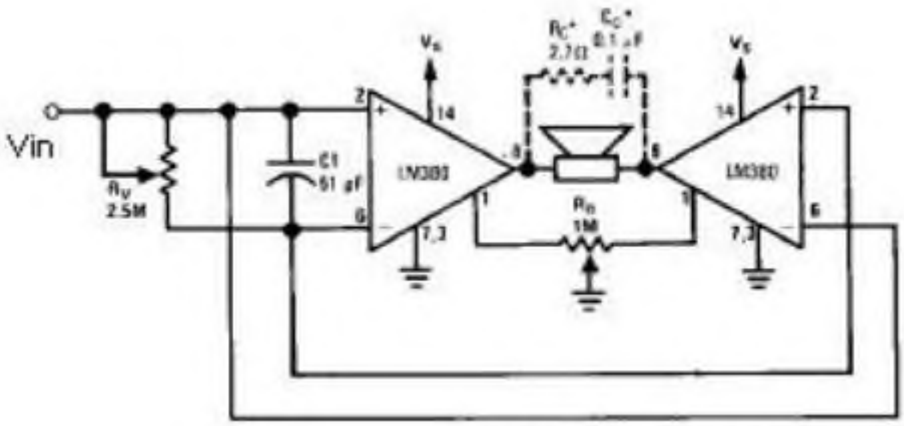
(iii) LM 380 as a variable Gain:

- Instead of getting a fixed gain of 50, it is possible to obtain a variable gain up to 50 by connecting a potentiometer between the input terminals.



Circuit connections

(iv) LM 380 as a Bridge Audio Power Amplifier:

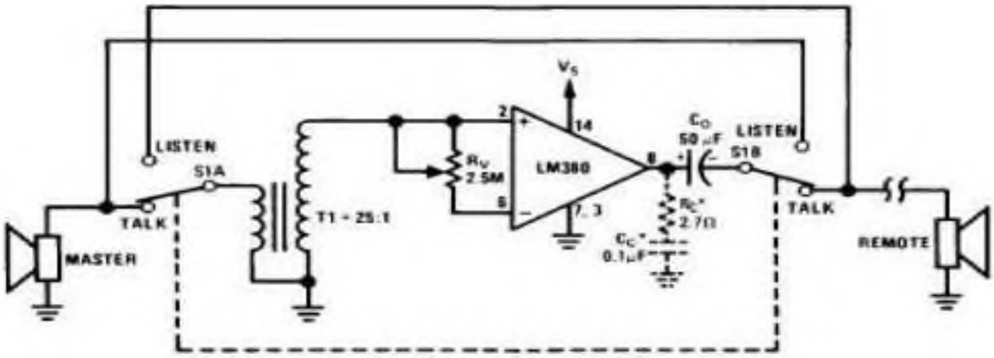


Circuit connections

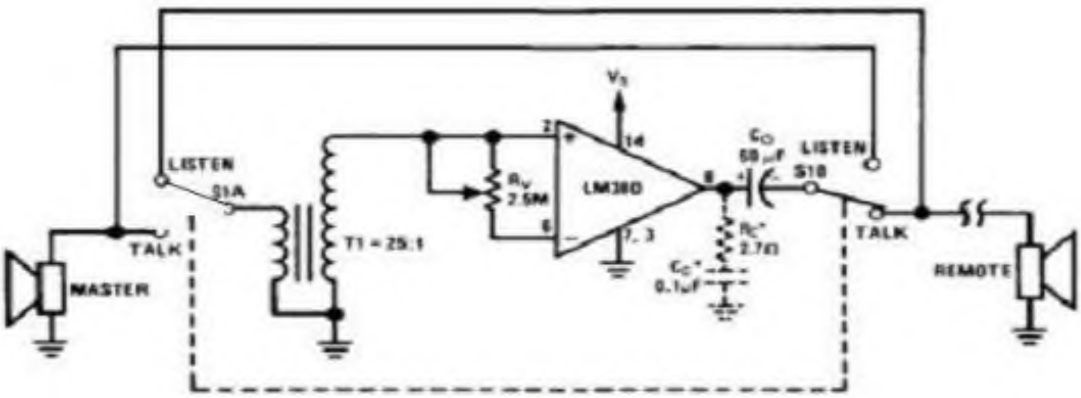
- If a certain application requires more power than what is provided by a single LM380 amplifier, then 2 LM380 chips can be used in the bridge configuration.
- With this arrangement we get an output voltage swing which is twice that of a single LM380 amplifier.
- As the voltage is doubled, power output will increase by four times that of a single LM380 amplifier. The pot R4 is used to balance the output offset voltages of the two chips.

(v) Intercom system using LM 380:

- When the switch is in Talk mode position, the master speaker acts as a microphone.
- When the switch is in Listen position, the remote speaker acts as a microphone.
- In either phone the overall gain of the circuit is the same depends on the turns of transformer T.



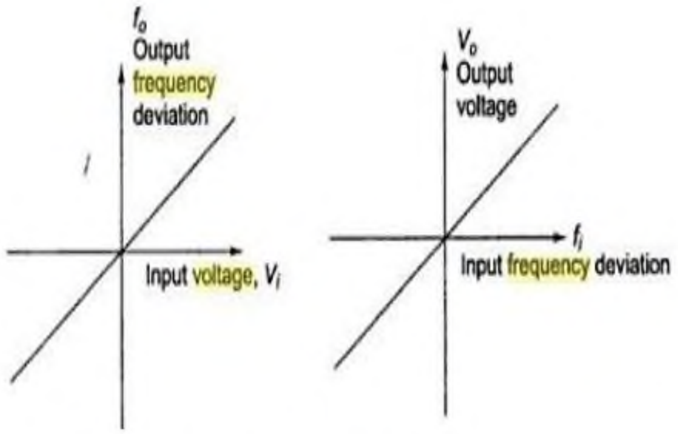
Talk mode



Listen mode

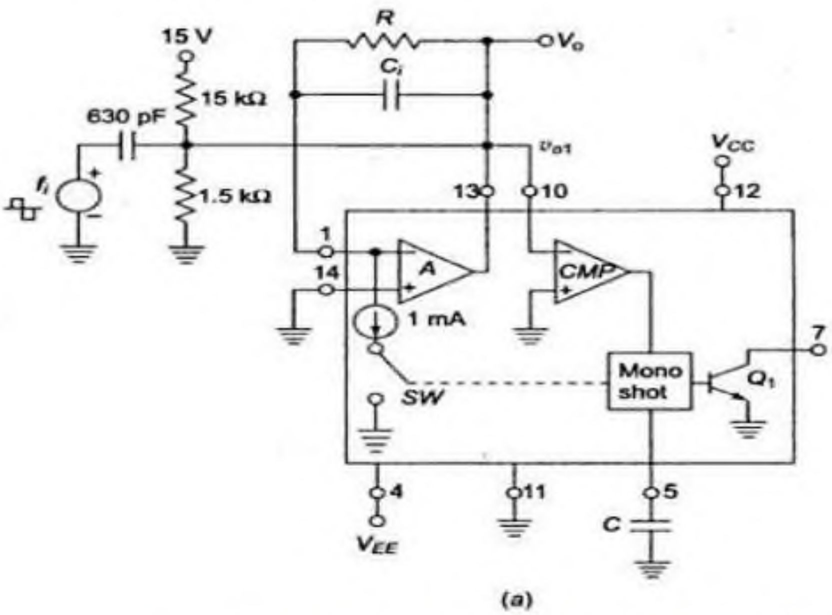
Frequency to Voltage convertors (F-V)

- F-V convertors applications: Tachometer in motor speed control Rotational speed measurement.
- Two types of it: Pulse integrating Phase locked loop



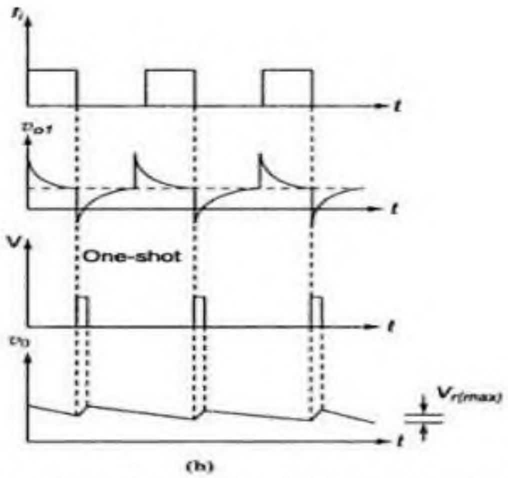
Ideal characteristics of V-F convertor and F-V convertor

- F-V convertor produces an output voltage whose amplitude is a function of input signal frequency.
- $V_0=k_f f_i$ kf is sensitivity of F-V convertor
- It is basically a FM discriminator.



(a)

Frequency To Voltage Convertor using VFC32 (V-F)



F-V Convertor using VF32 and input and output characteristics

- Input frequency is applied to comparator A.
- Resistor R acts as feedback element.
- Capacitor Ci enables charge-balancing,
- High pass network conditions input signal

For negative spike of V 01, comparator COMP triggers one shot multivibrator with threshold 7.5V The output of multivibrator closes the switch SW, for a time TH, this causes voltage Vo to build up and inject thru R and this continues until current out of summing input of opamp is equal to that injected by Vo through R continuously.

$$Vo=10^{-3} * T_H * R * fi \qquad \text{as } T_H = 7.5\ C / 1X10^{-3}$$

Ripple Voltage, Vr(max) =7.5 C /Ci

Voltage to frequency convertor

Principle: Charge balancing technique-the process of charging and discharging results in frequency proportional to input signal F0= k Vi

Operation: Op-amp A converts input V_i to current $I_i = V_i/R$ into summing junction.When switch SW is open the current flows into capacitor Ci and charges it, and node voltage V_{o1} produce ramp down.When V_{01} =0 CMP triggers and sends a triggering signal to one shot multivibrator that closes the switch SW and turns transistor Q ON for time T_H.

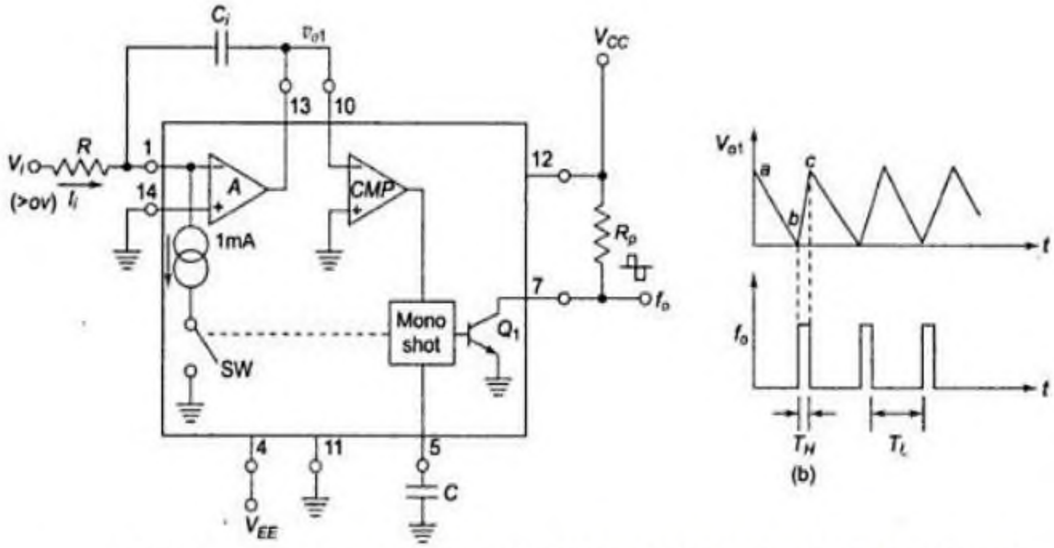
The threshold of mono shot = 7.5 V and T_H= 7.5 C/10^{-3}

During T_H , V_{01} ramps upward by amount $\Delta V_{01}=(1mA-I_i)\ T_H /C_i$

Time duration TL for vo1 to return to 0 is TL = $C\Delta V_{01}/I_i$

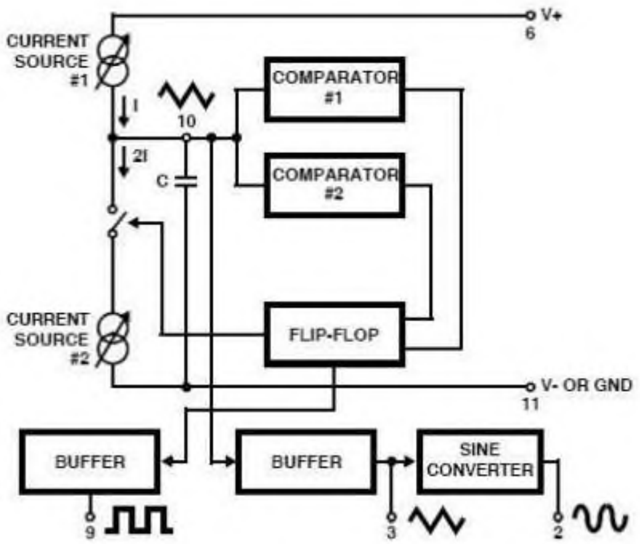
$$T_L+T_H = 1mA\ T_H /I_i \quad = T$$

$$F_0=V_i/7.5\ RC$$

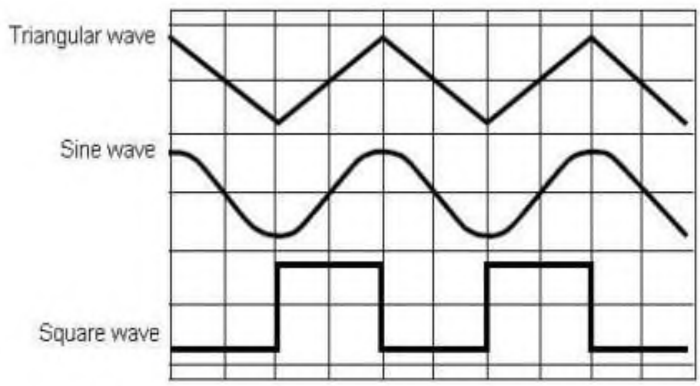


Voltage-Frequency convertor using VF32 and its input output characteristics

Function Generator IC 8038:



Functional block diagram of Function generator



Output Waveforms from Function Generator IC 8038

It 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 : -VEE 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 drifts 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 RA= RB = R & if RC is adjusted for 50% duty cycle then f0= 0.3/RC; RA = R1, RB =R3, RC= R2.

(ii) Duty cycle / Frequency Adjust : (Pin 4 & 5):

Duty cycle as well as the frequency of the output wave form can be adjusted by external resistors at pin 4 & 5.The values of resistors RA & RB 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 RA & RB 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.
- The output frequency is proportional to Vin as given by the following expression.

For RA = RB (50% duty cycle).

f0= 5 Vin/CRAVcc ; where C is the timing capacitor.

- With pin 7 & 8 connected to each other the output frequency is given by f0= 0.3/RC where R = RA = RB for 50% duty cycle.
- This is because M Sweep input (pin 8):

Vin=R1Vcc/R1+R2

- 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,

$$f_0=1.5\ V_{in}/CR_AV_{CC}$$

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