Unit - 4

555 Timer:

Introduction:

→ The 555 Timer is a highly Stable device for generating accurate time delay or oscillation.

→ It contains two 555 times & is a 14 Pin DIP.

→ Supply voltage is +5V to +18 V & can drive load upto 200mA.

Applications:

→ oscillator

→ pulse generator

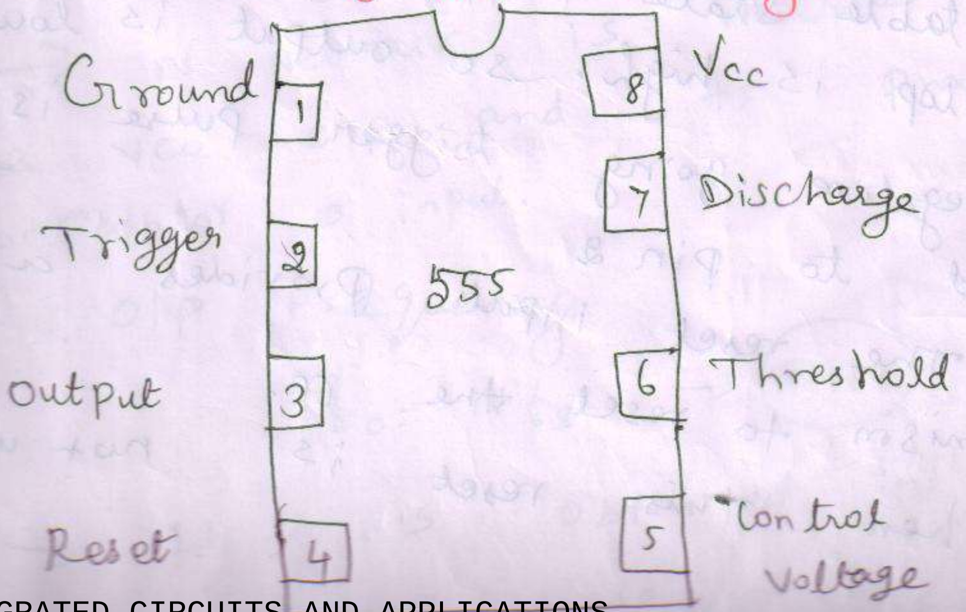
→ ramp & square wave generator

→ Mono-shot Multivibrator

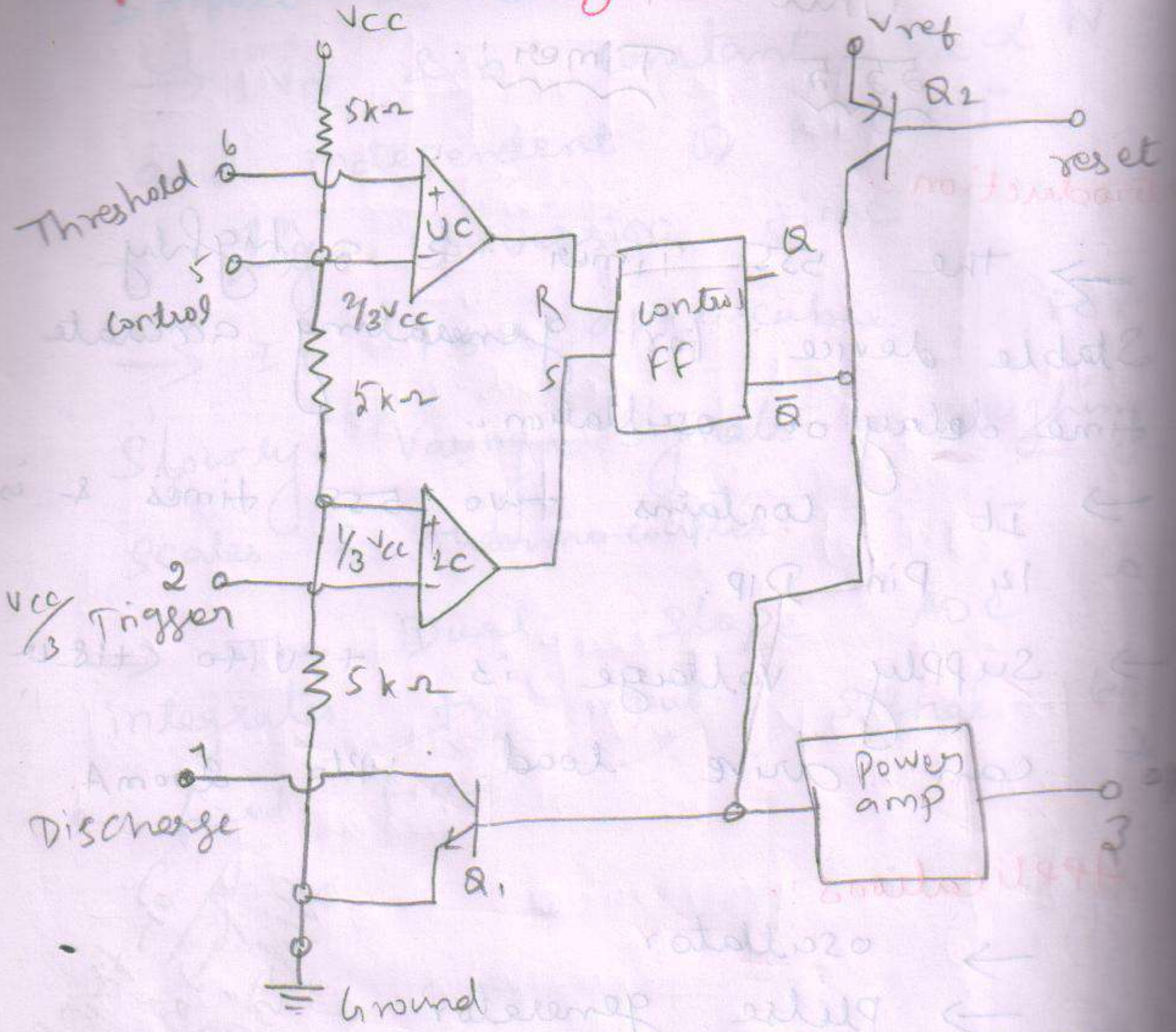
→ traffic light control

→ Voltage Monitor

8 Pin Package



Functional Diagram



→ Three 5kΩ iternal resistors act as voltage divider.

→ Upper comparator $\frac{2}{3}V_{cc}$

→ Lower comparator $\frac{1}{3}V_{cc}$

→ Stable state, O/P $\bar{Q}$ of the control flip flop is high. so output is low

→ negative going trigger pulse is applied to pin 2

→ The reset input provides a mechanism to reset the FF.

→ when this reset is not

returned to V_{cc}.

→ The transistor Q_2 is driven by an internal ref voltage V_{ref} obtained from supply voltage V_{cc}

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PLL Applications :-

⇒ Output from a PLL can be obtained either as the voltage signal $V_c(t)$ to the error voltage in the f/b loop.

Some typical applications of PLL are.

1) Frequency Multiplication / Division
2) Frequency translation
3) FM DeModulation
4) Frequency shift keying Demodulation.

1) Frequency Multiplication / Division

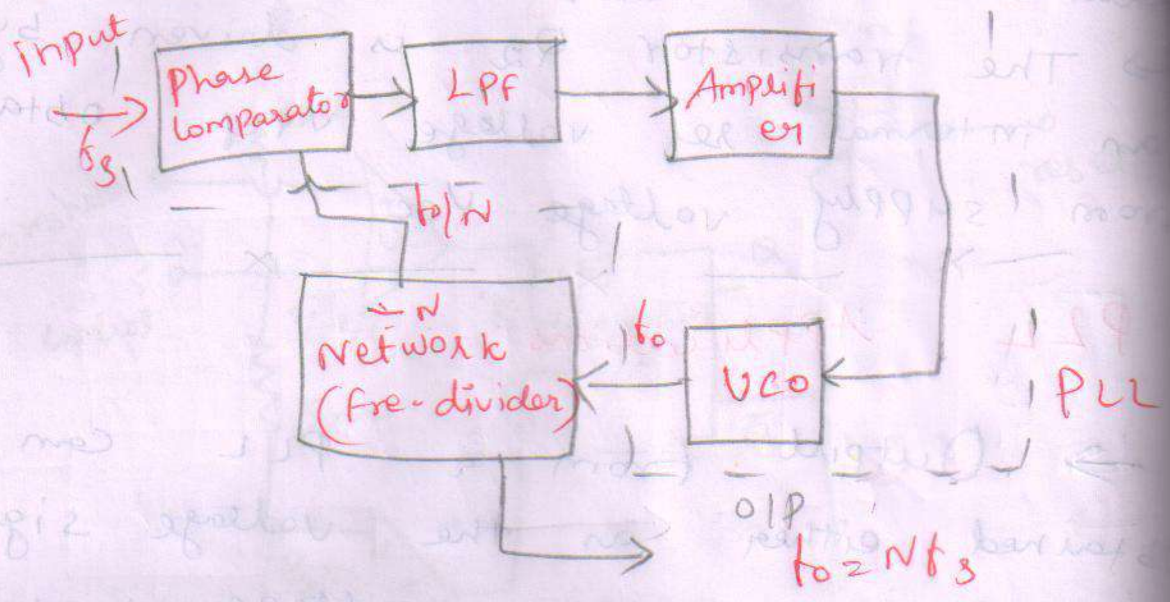
→ N network is inserted b/w the VCO O/P and the phase comparator ϕ input.

O/P Frequency

$$f_o = N f_s \rightarrow (9.42)$$

→ It is obtained in its

Frequency multiplier using IC PLL



→ If I/P signal is rich in harmonics, then the VCO can be directly locked to the n^{th} harmonic

→ without connecting any frequency divider in between.

→ This PLL circuit is used for frequency division

The O/P f_o of VCO is given by $= f_o = f_n/m$.

Frequency Translation:

→ The low pass filter & externally multiplier are connected to the PLL.

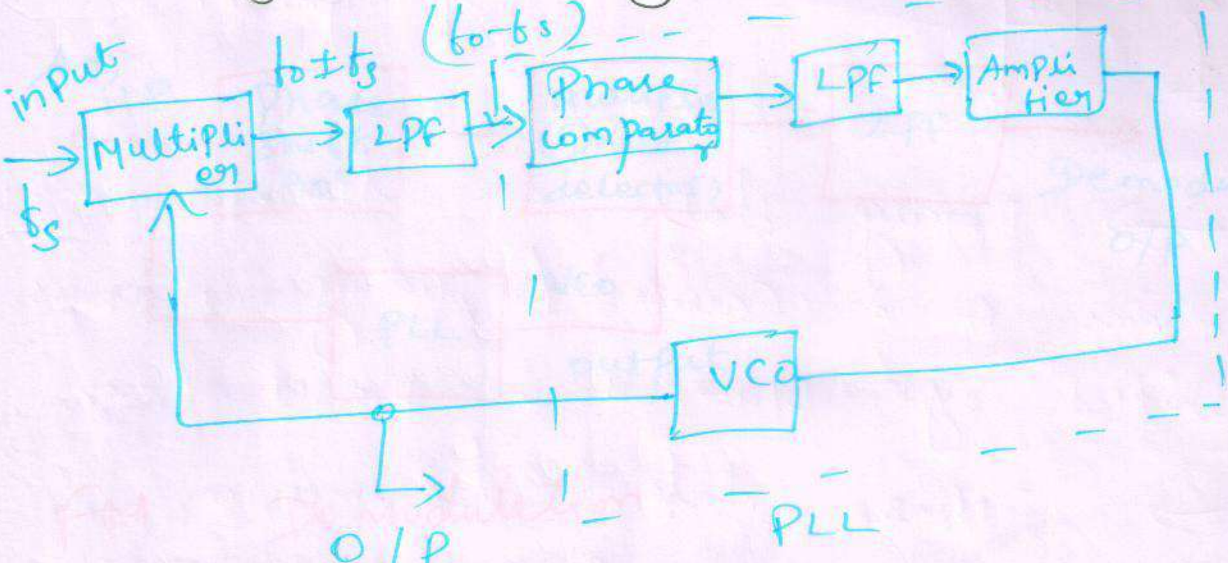
→ f_s has to be shifted & f_o of the VCO are applied as inputs to the mixer.

→ when PLL is a locked state,

$$f_o - f_s = f_1$$

$$f_o = f_s + f_1$$

it is possible to shift the incoming frequency f_s by f_1



$f_o = f_s + f_1$

PLL used as a frequency translator.

AM Modulation:

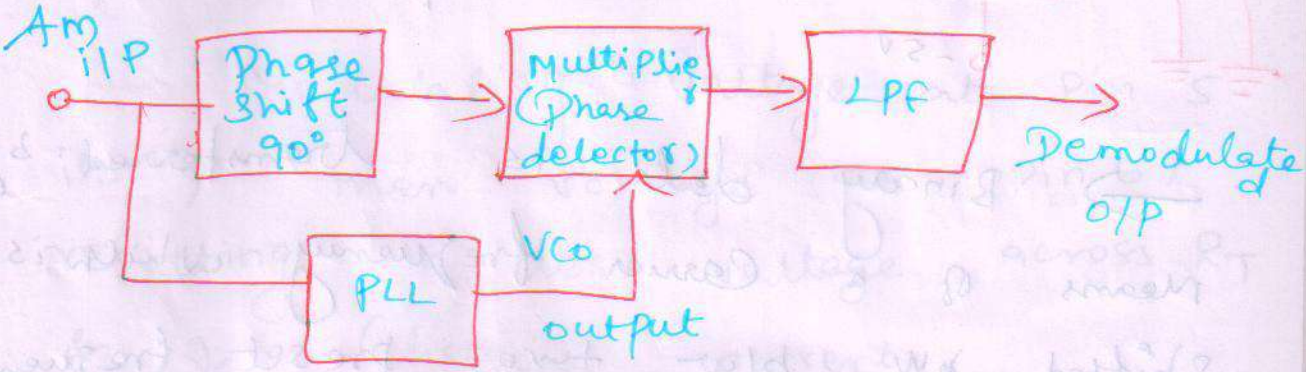
→ PLL is locked to the carrier frequency of the incoming AM signal

→ VCO O/P is same frequency as the carrier, but unmodulated

→ VCO o/p is always shift of phase by 90° before fed to multiplier.

→ The o/p of multiplier contains both the sum & difference signals.

→ The PLL AM detector exhibits a high degree of selectivity & noise immunity.



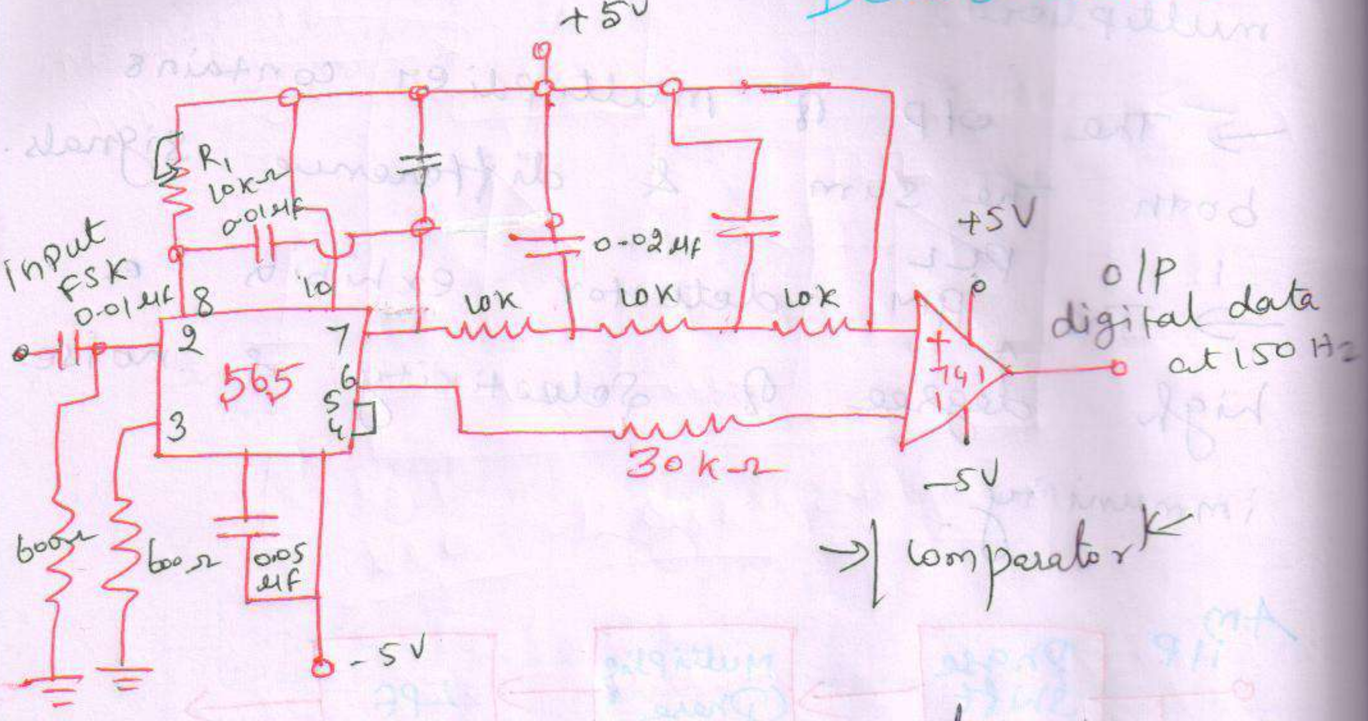
FM Demodulation:

→ If PLL is locked to a FM signal, the VCO tracks the instantaneous frequency of the input.

→ Filtered error voltage which controls the VCO & maintains lock with the input signal.

→ VCO used in ICPLL is highly linear, it is possible to realize highly linear FM demodulators.

Frequency Shift keying FSK Demodulator :-



→ comparator

→ Binary data is transferred by means of a carrier frequency which is shifted by b/w two preset frequencies.

→ This data transmission is called frequency shift keying technique.

Use :-

The 567 PLL is very usefull as FSK demodulator.

→ A three stage filter removes the carrier component and the O/P signal is made logic compatible by a voltage comparator.

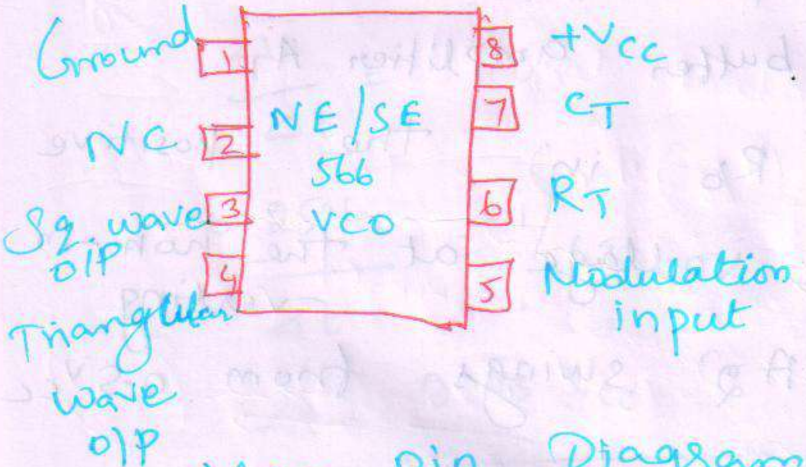
Voltage Controlled Oscillator (VCO)

→ Common type of VCO available in IC form is signetics NE/SE566.

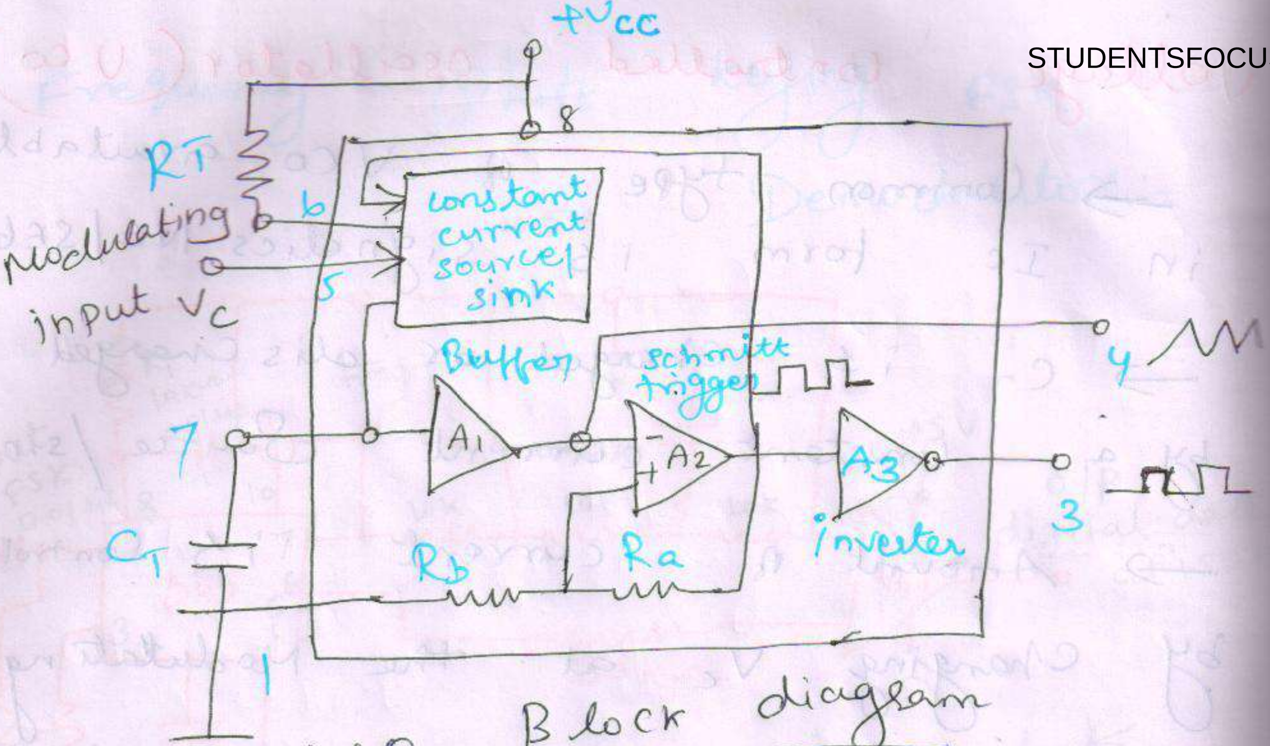
→ C_T is charged or discharged by a constant current source/sink.

→ Amount of current is controlled by changing V_c at the modulating input.

→ Modulating voltage at pin 5 is ↑ then voltage at pin 6 ↑ resulting in less voltage across R_T & ↓ charging current.



VCO pin Diagram.



VCO Block diagram

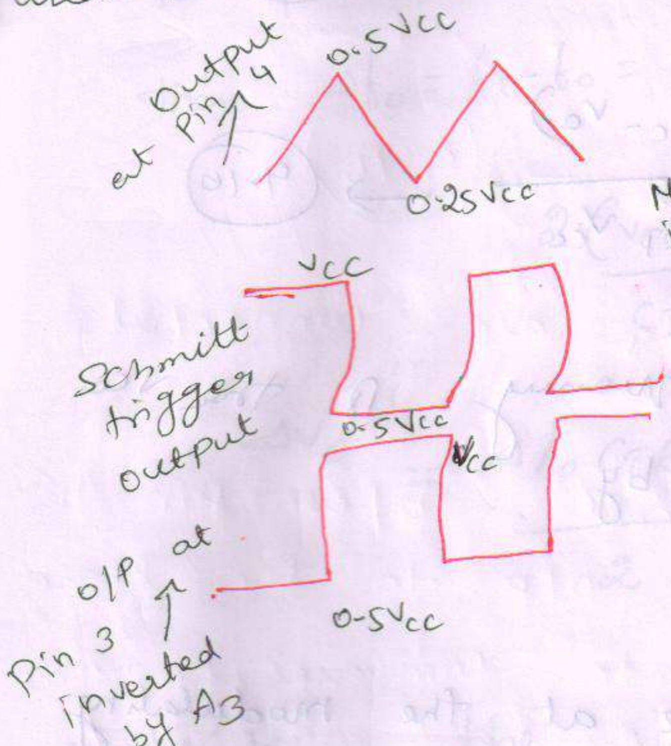
→ It is used in converting low frequency signals such as EEGs, EKG into an audio frequency range

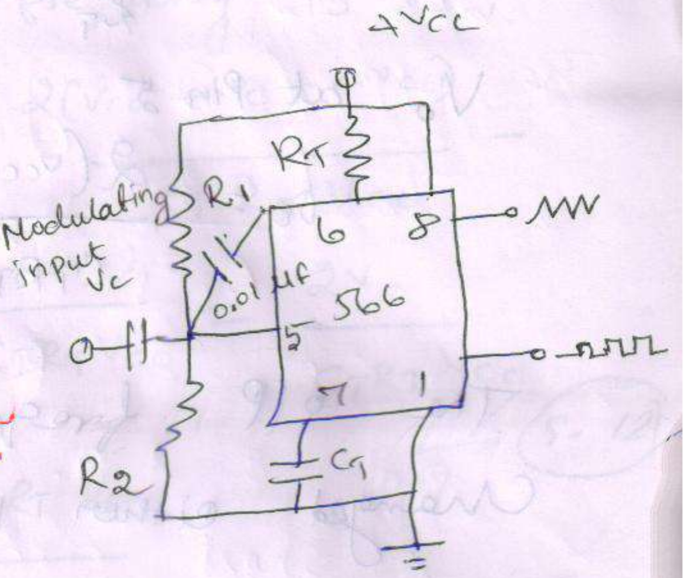
→ Voltage across C_T is applied to the inverting input terminal Schmitt trigger A_2 via buffer amplifier A_1

→ If $R_a = R_b$ in the positive f/b loop, the voltage at the non-inverting interminal of A_2 swings from $0.5V_{cc}$ to $0.25V_{cc}$.

→ Voltage across C_T exceeds $0.5V_{cc}$ during Charging, the output of the Schmitt trigger goes Low.

→ Inverter A_3 is a current Amplifier used to to drive the load.





→ Total voltage across the capacitor changes from 0.25 Vcc to 0.5 Vcc. Thus $\Delta V = 0.25 V_{CC}$,

$$\frac{\Delta V}{\Delta t} = \frac{i}{C_T}$$

$$\frac{0.25 V_{CC}}{\Delta t} = \frac{i}{C_T}$$

$$\Delta t = \frac{0.25 V_{CC} \, C_T}{i} \quad \rightarrow (9.8)$$

The frequency of oscillator f_0 is

$$f_0 = \frac{1}{T} = \frac{1}{2\Delta t} = \frac{i}{0.5 V_{CC} \, C_T}$$

$$i = \frac{V_{CC} - V_C}{R_T} \rightarrow (9\text{-}9)$$

V_o at Pin 5

$$f_o = \frac{2(V_{CC} - V_o)}{C_T R_T V_{CC}} \rightarrow (9.10)$$

The o/p frequency of the VCO Changed either by

(i) R_T
(ii) C_T
(iii) The voltage at the modulating input terminal Pin 5.

→ Now Modulating input voltage is usually varied from $0.75\,V_{CC}$ to V_{CC}

→ It can produce a frequency variation of about 10 to 1.

$$f_o = \frac{2(V_{CC} - (7/8)V_{CC})}{C_T R_T V_{CC}} = \frac{1}{4R_T C_T}$$

$$= \frac{0.25}{R_T C_T} \rightarrow (9\text{-}11)$$

Voltage to frequency conversion factor:-

→ K_V is defined as

$$K_V = \frac{\Delta f_o}{\Delta V_C}$$

Monostable operation:-

→ stand by state, FF holds transistor Q_1 on, thus clamping the external timing capacitor C to ground.

→ $\bar{Q} = 0$ then Q_1 off

→ The upper comparator resets the FF, R = 1, S = 0.

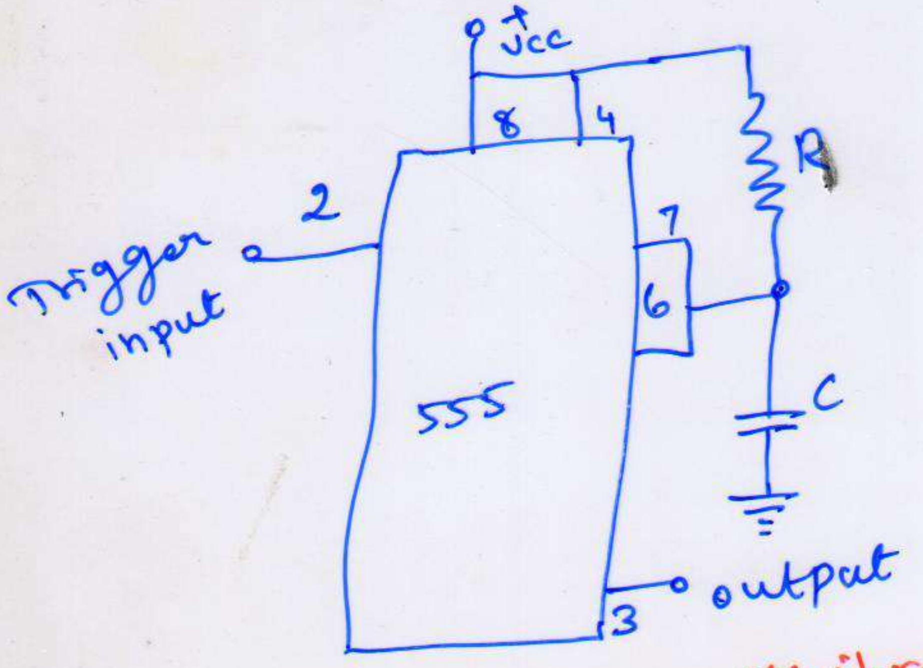
The voltage across the capacitor,

$$V_c = V_{cc} (1 - e^{-t/(RC)})$$

$$V_c = 2/3 \, V_{cc}$$

$$T = RC \ln 1/3$$

$$T = 1.1 RC \text{ (sec)}.$$



Monostable multivibrator

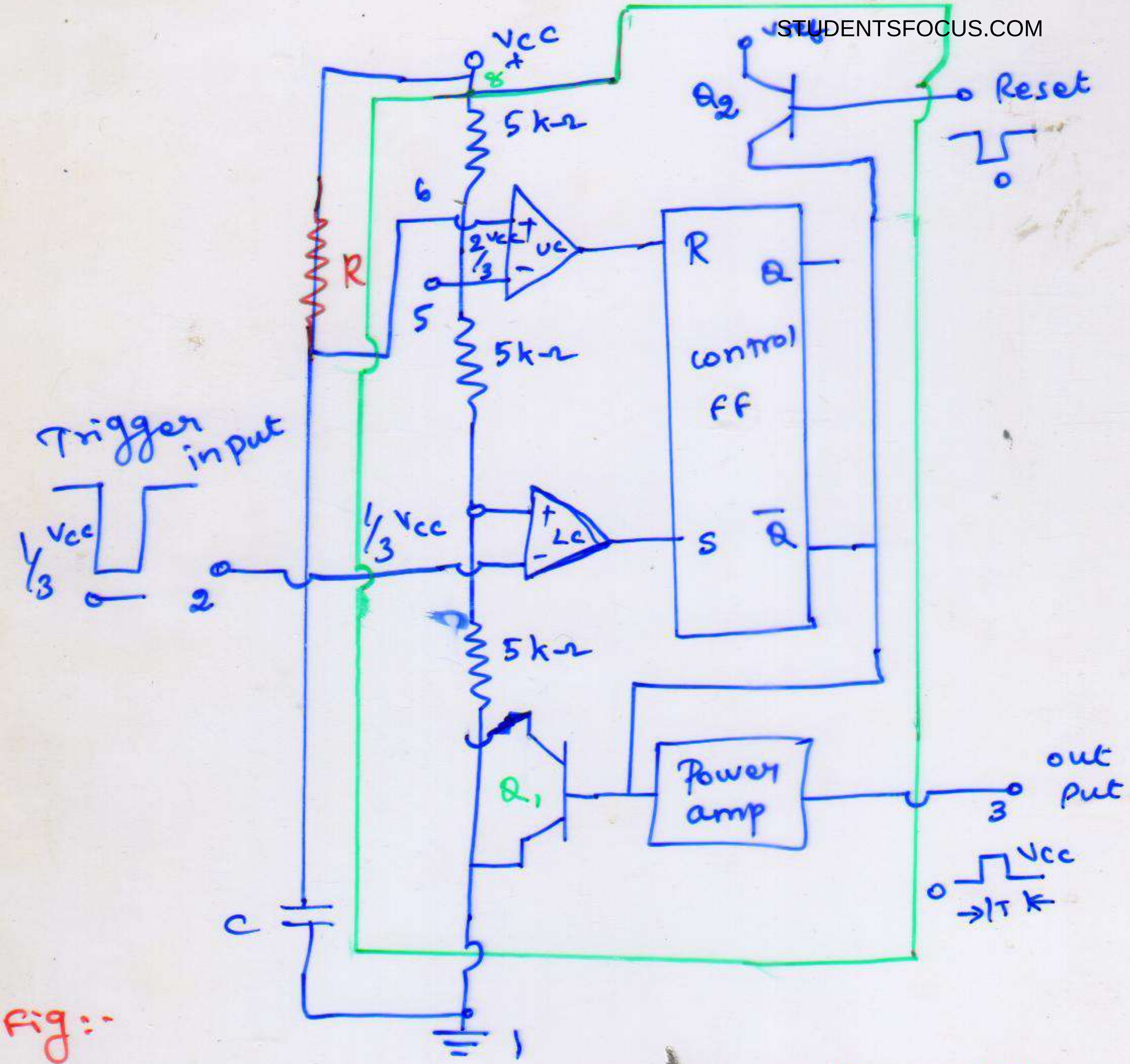


Fig:-

Time in monostable operation with functional diagram

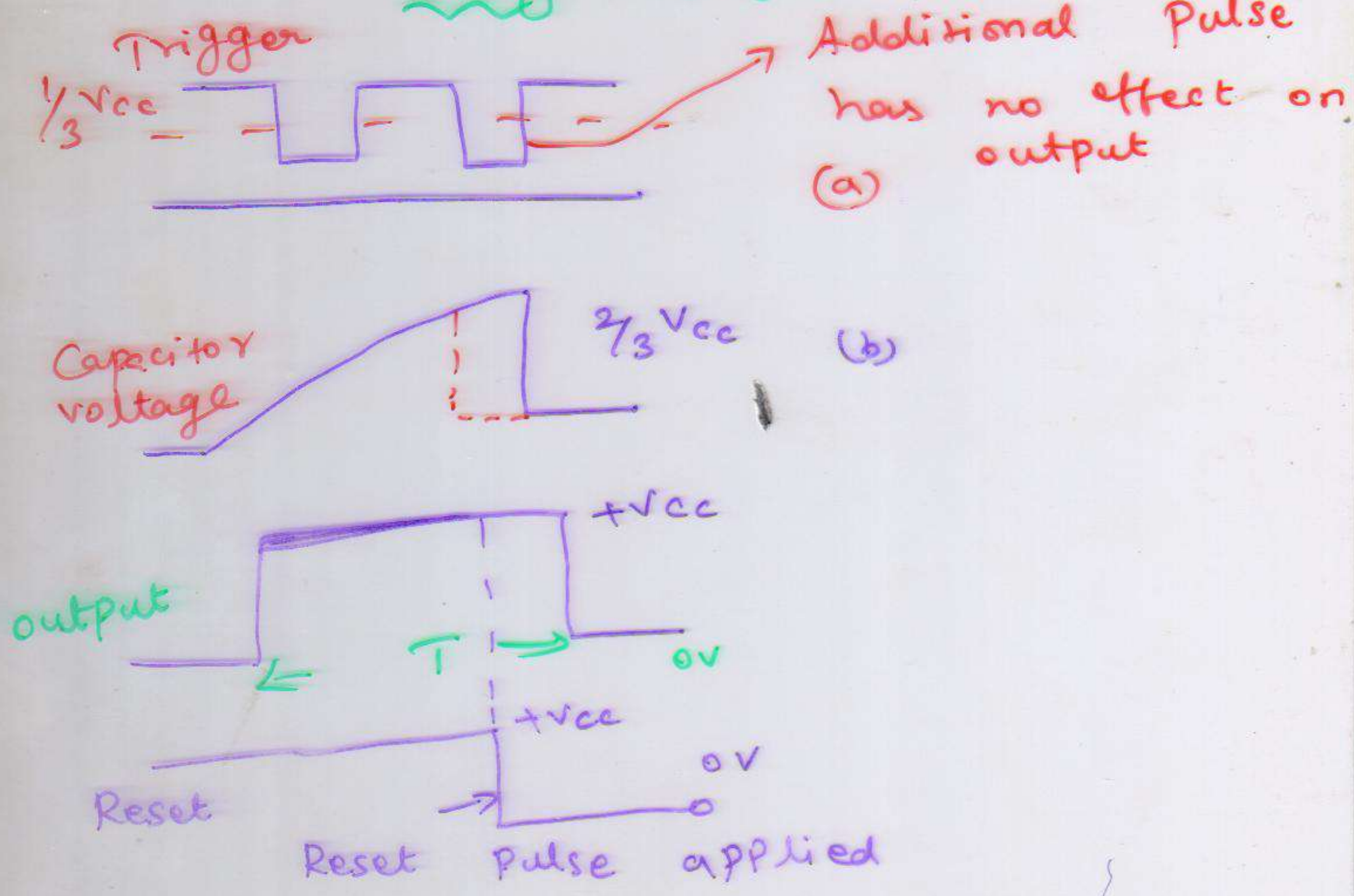
→ Timing interval is independent of supply voltage.

→ It is once trigger, the o/p remains in the high state until time T elapse. which depends on R & C.

→ The negative reset pulse is applied to the reset terminal, Q_2 goes off, Q on, capacitor c is immediately discharged.

→ If reset is released, the o/p will still remain low untill a negative going trigger pulse is again applied at pin 2.

Timing pulses



Applications of 555 Timer :-

Missing pulse detector :-

→ The input trigger is low, the emitter diode of the transistor Q is forward biased.

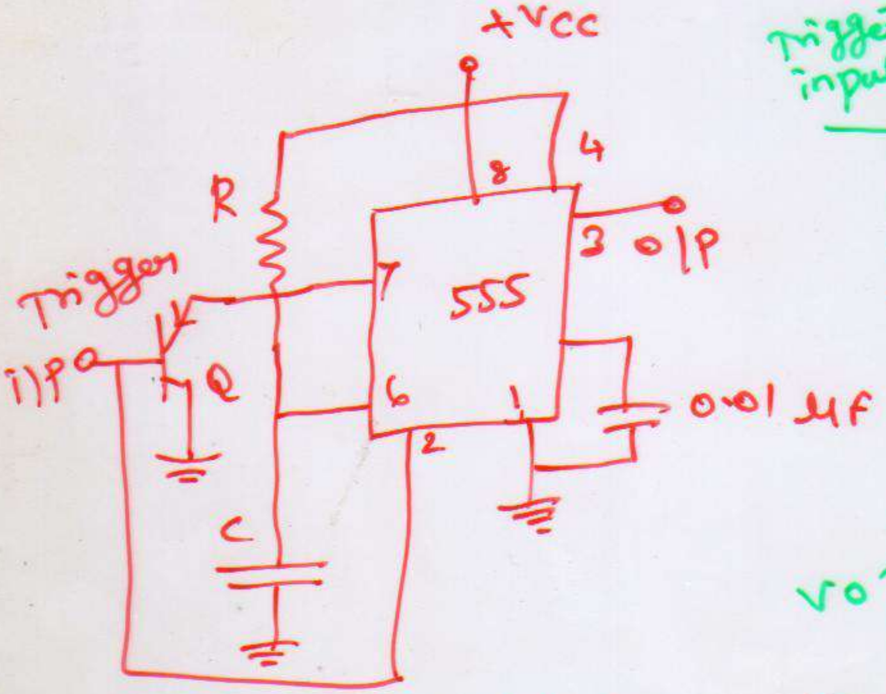
→ C gets clamped to few tenths of a volt ~0.7 V

→ Output of timer goes high.

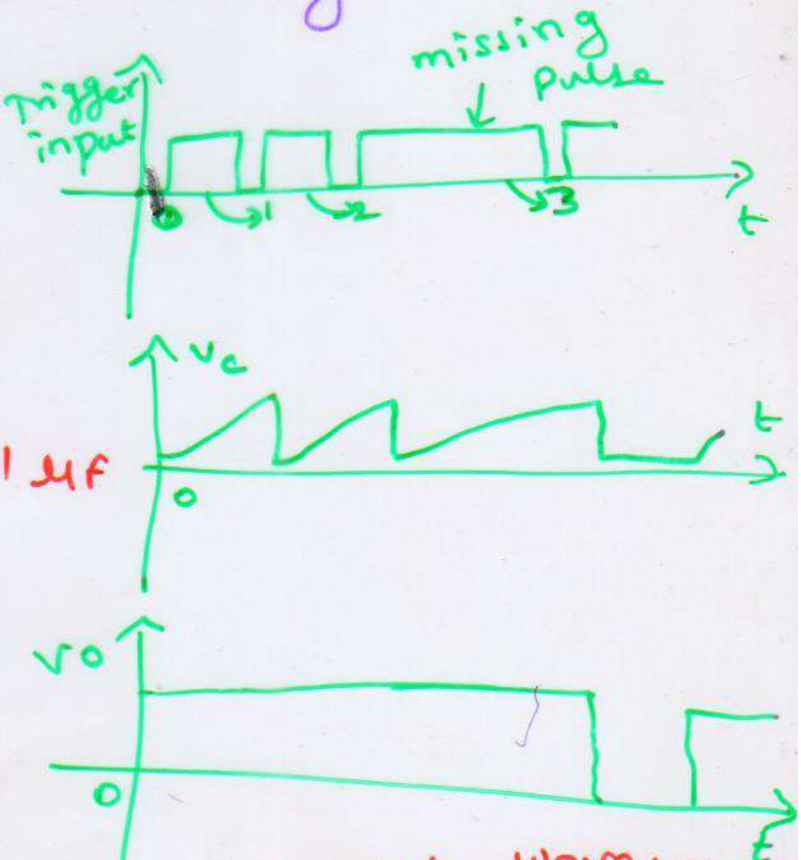
→ If a pulse misses, the trigger i/p is high & Q is cut off

→ Timer enters into normal state of monostable operation.

→ used to detect missing heart beat.



Missing pulse detector monostable circuit



output waveforms

Linear ramp Generator :-

→ In linear ramp generator, the resistor R of the Monostable circuit is replaced by constant current source.

The capacitor voltage

$$V_C = \frac{1}{C}\int_0^t i\,dt \rightarrow (8.3)$$

KVL law

$$\frac{R_1}{R_1+R_2} V_{CC} - V_{BE} = (\beta+1) I_B R_E \simeq \beta I_B R_E$$

$$= I_C R_E = i R_E \rightarrow (8.4)$$

I_B, I_C → base, collector currents

β → current amplification factor.

So

$$i = \frac{R_1 V_{CC} - V_{BE}(R_1+R_2)}{R_E(R_1+R_2)} \rightarrow (8.5)$$

Putting the value of current 'i'

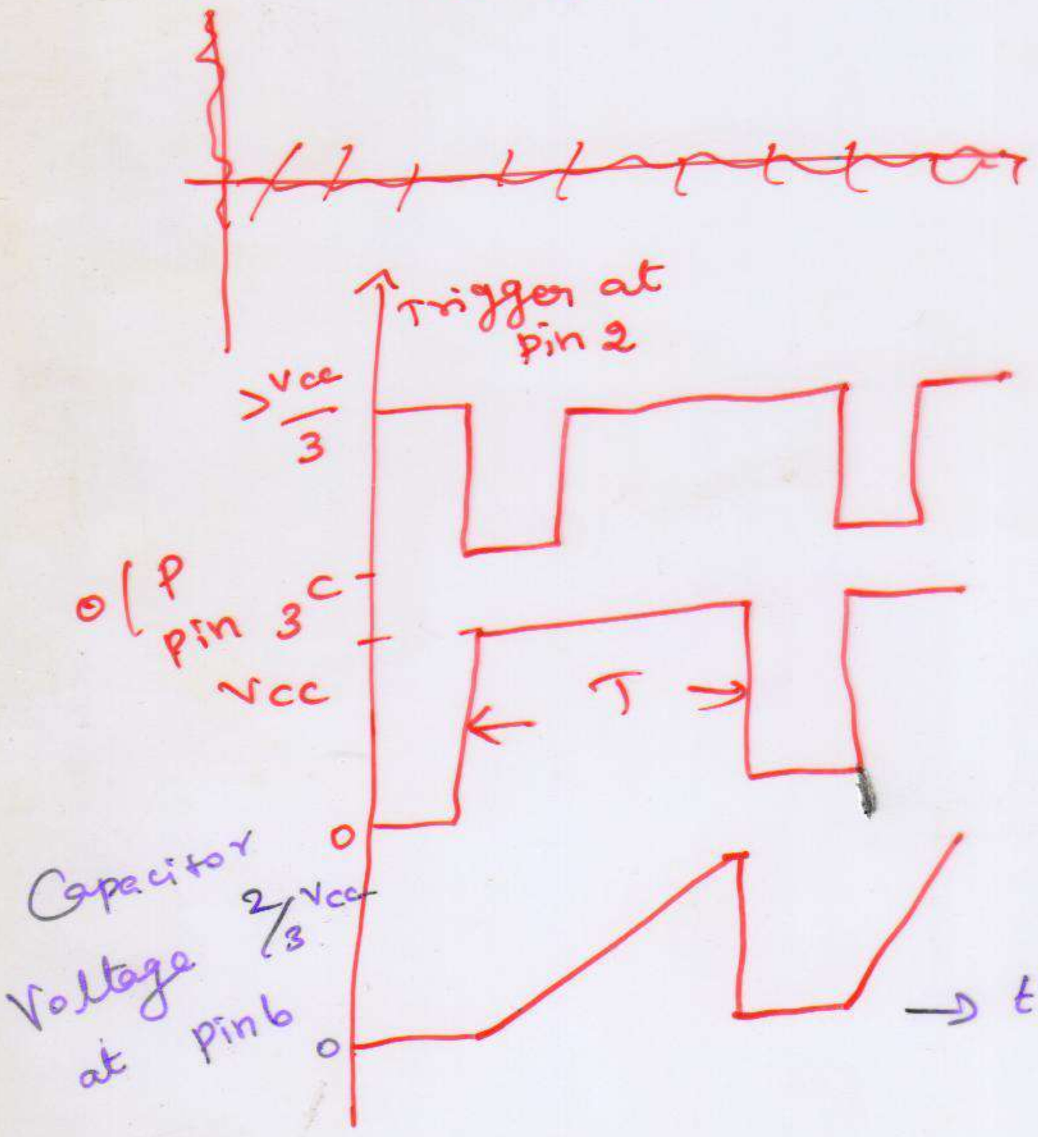
$$V_C = \frac{R_1 V_{CC} - V_{BE}(R_1+R_2)}{C R_E (R_1+R_2)} \times t \quad (8.6)$$

$t = T$, $V_C = \frac{2}{3} V_{CC}$

$$\frac{2}{3}V_{cc} = \frac{R_1 V_{cc} - V_{BE}(R_1+R_2)}{R_E (R_1+R_2) C} \times T \rightarrow (8.7)$$

$$T = \frac{\frac{2}{3}V_{cc} R_E (R_1+R_2) C}{R_1 V_{cc} - V_{BE}(R_1+R_2)} \rightarrow (8.8)$$

O/P waveforms

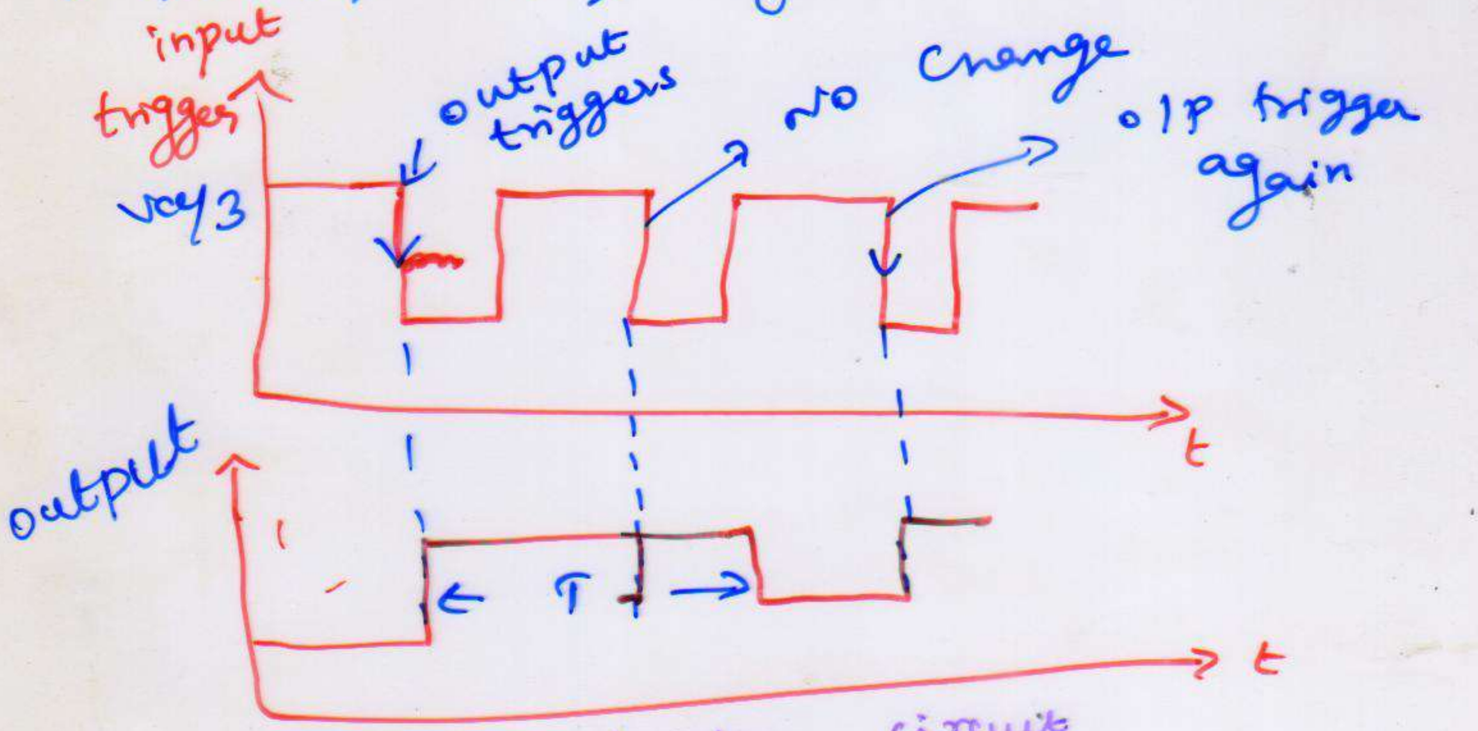


Frequency divider :-

→ Continuously triggered Mono Stable circuit, triggered by a square wave generator.

→ i/p first '−' going edge then o/p will remain high

→ O/p can be made integral fractions of the input frequency



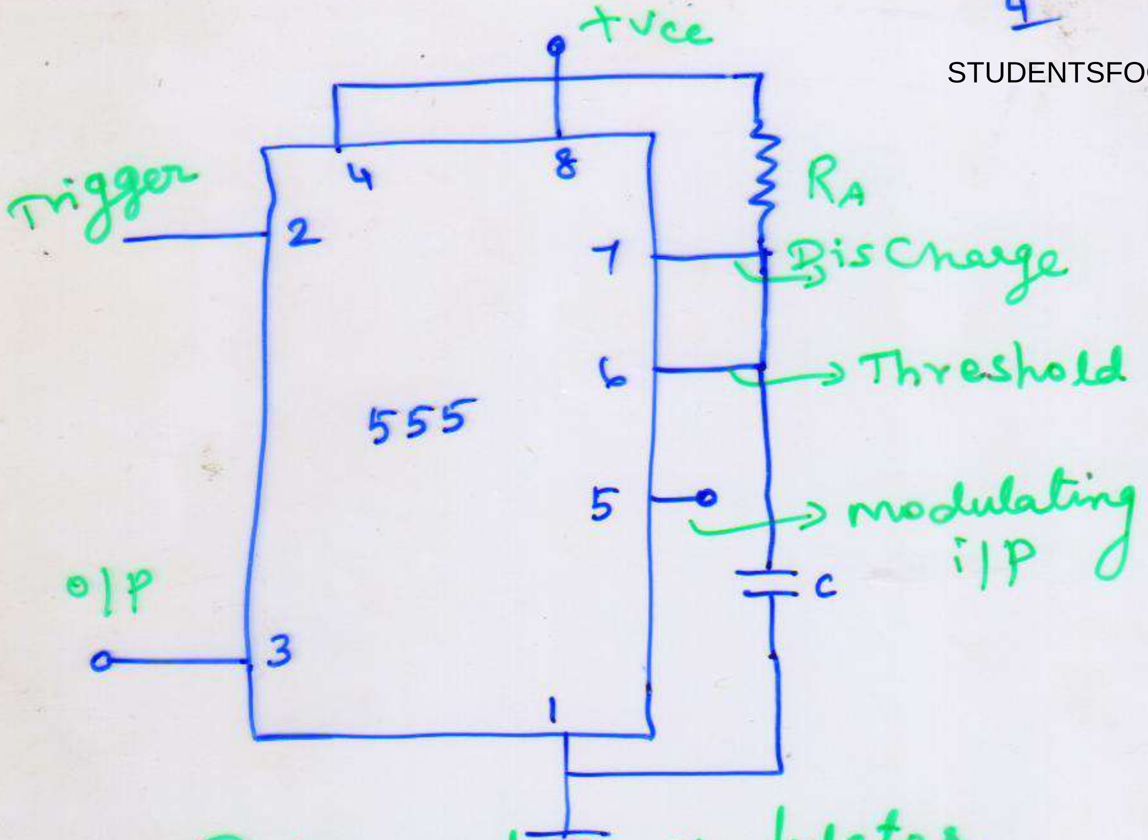
Frequency divider circuit

Pulse width Modulation:-

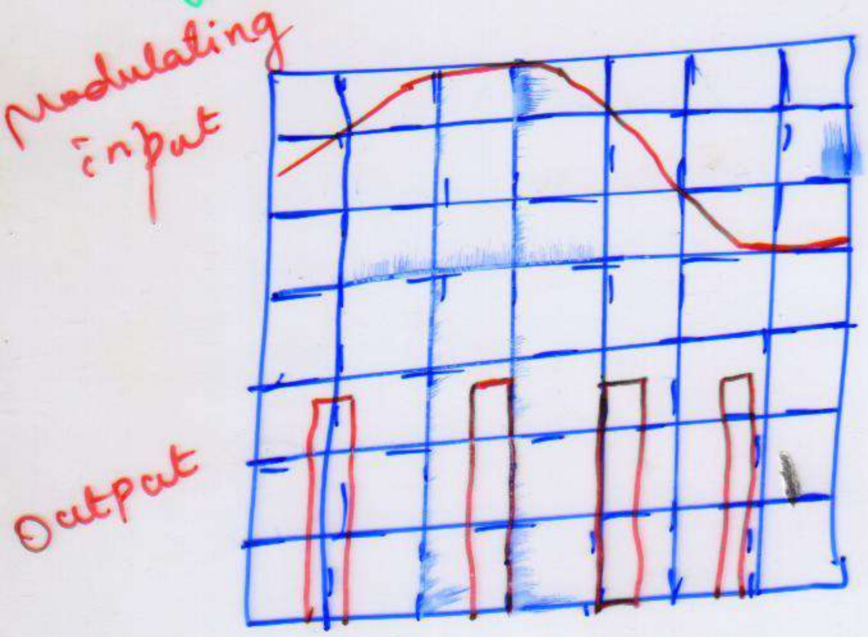
→ Modulating i/p signal applied at pin 5.

→ This signal superimposed upon the already existing voltage $\frac{2}{3}V_{cc}$

→ In output waveform that the pulse duration, the duty cycle only varied keeping the frequency same.



Pulse width Modulator



$\Delta V_c \Rightarrow$ Modulation voltage to produce the frequency is f_1,

then $\Delta f_0 = f_1 - f_0 = \dfrac{2(V_{cc} - V_c + \Delta V_c)}{C_T R_T V_{cc}} - \dfrac{2(V_{cc} - V_c)}{C_T R_T V_{cc}} = \dfrac{2V_c}{C_T R_T V_{cc}}$ → (9.12)

$$\Delta V_c = \frac{\Delta f_0 C_T R_T V_{cc}}{2} \rightarrow (9.13)$$

Putting the value of $C_T R_T$

$$\Delta V_c = \Delta f_0 V_{cc} / 8 f_0 \rightarrow (9.14)$$

$$k_v = \frac{\Delta f_0}{\Delta V_c} = \frac{8 f_0}{V_{cc}} \rightarrow 9.15$$

Monolithic Phase locked Loop :-

→ Different building blocks of PLL are available,

→ Some important monolithic PLLS are SE / NE 560 Series introduced by signetics & LM560 series by national Semi Conductor.

IC PLL 565 :-

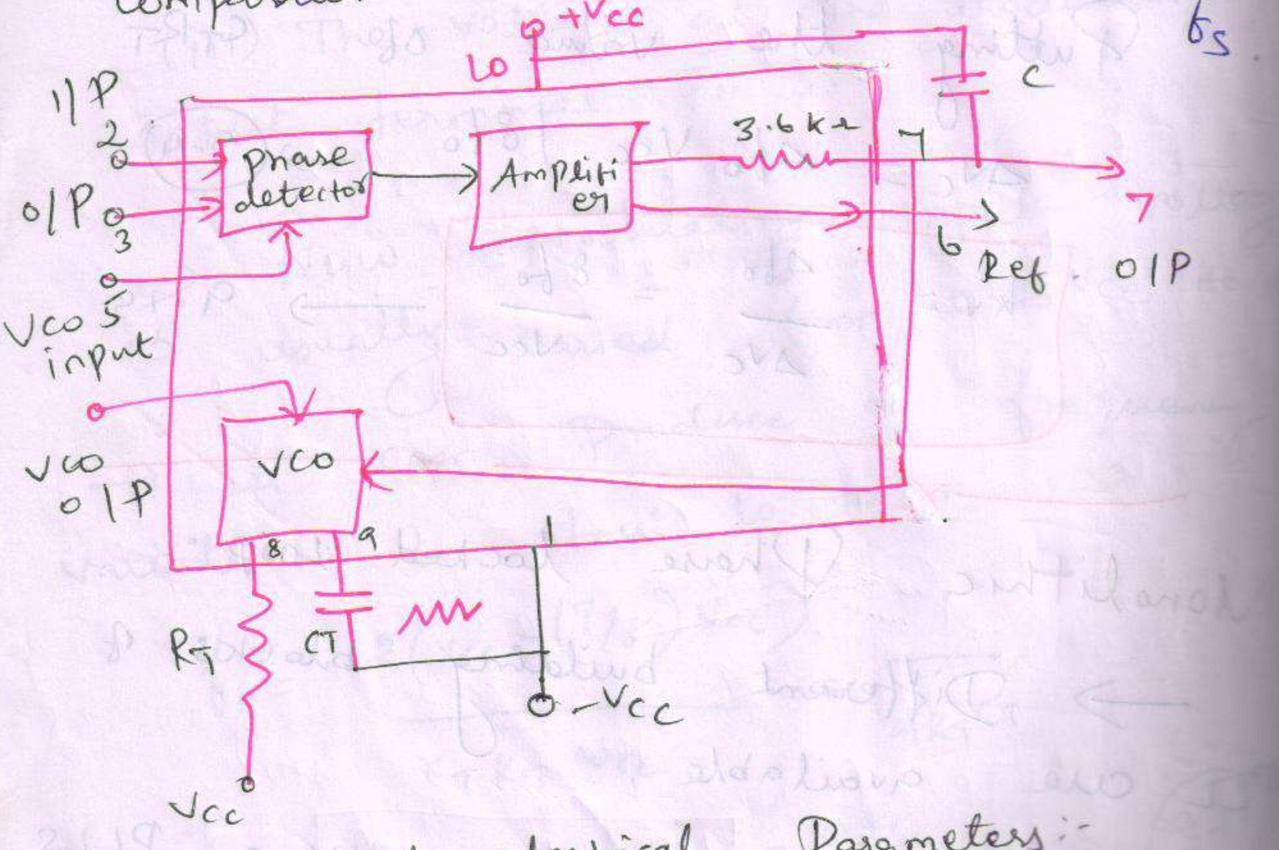
565 is a 14 pin DIP Package.

The o/p frequency

$$f_o = \frac{0.25}{C_T R_T} \text{ Hz} \rightarrow (9.16)$$

→ Where C_T & R_T are connected to pin 8 & 9.

→ A short circuit b/w pin 4 & 5 connects the VCO o/p to the Phase comparator so as to compare f_o with f_s.



Important electrical Parameters :-

Operating frequency range : 0.001 Hz to 500 kHz

operating voltage range : ±6V to ±12V

output level : 10mV rms min to 3V p-p

O/P sink voltage current : 1 mA

Input impedance : 10 kΩ

Drift in VCO Center frequency : 300 ppm/°C

Drift in VCO centre frequency with supply voltage : 1.5 per cent/V max

Triangle wave amplitude : 2.4 Vpp at ±6 V

Triangle wave amplitude : 5.4 Vpp at ±6 V

Bandwidth adjustment range : < ±1 to ±60%.

Derivation of lock in range :-

If φ radians is the phase difference b/w the signal & VCO, then the O/P voltage of the analog phase detector

$$V_e = K_\varphi(\varphi - \pi/2) \rightarrow (9.18)$$

$K_\varphi \rightarrow$ angle to voltage transient efficient

$$V_c = A K_\varphi(\varphi - \pi/2) \rightarrow (9.19)$$

$$f = f_o + K_v V_c \rightarrow (9.20)$$

$K_v \rightarrow$ is the voltage to frequency transfer coefficient.

$$f = f_s = f_o + K_v V_c \rightarrow (9.21)$$

Maximum o/p voltage magnitude available from the phase detector occurs for $\varphi = \pi$ & 0 radian,

$$V_{e(max)} = \pm k_\varphi \pi/2$$

$$V_{co} = \pm (\pi/2) k_\varphi A \rightarrow (9.24)$$

The maximum Vco frequency swing than can be obtained is given by,

$$(f - f_o)_{max} = K_V V_{c(max)} = K_V K_\varphi A(\pi/2) \rightarrow (9.25)$$

$$f_s = f_o \pm (f - f_o)_{max} = f_o \pm K_V K_\varphi (\pi/2)$$

$$= f_o \pm \Delta f_L \rightarrow (9.26)$$

$$2\Delta f_L = K_V K_\varphi A\pi \rightarrow (9.27)$$

$$\Delta f_L = \pm K_V K_\varphi A \pi/2 \rightarrow (9.28)$$

$$K_V = 8f_o / V$$

$$V = +V_{cc} - (-V_{cc})$$

$$K_\varphi = 1.4/\pi$$

lock in range

$$\boxed{\Delta f_L = \pm 7.8 f_o / V}$$

Derivation of Capture range:-

The low pass filter (LPF)

$$T(jf) = 1 / 1 + j(f/f_1)$$

$T(\Delta f) = f_1 / \Delta f = f_1 / (f_s - f_0)$

$V_c = V_e \times T(f) \times A \rightarrow (9.35)$

$V_{c(max)} = V_{C(max)} \times T(f) \times A$

$\pm k_\phi (\pi/2) A \; (f_1 / \Delta f) \rightarrow (9.36)$

Total capture range

$2 \Delta f_c = 2\sqrt{f_1 \Delta f_L}$

→ LPF band-width is first set for a large value

→ This will minimize the interference of undesirable signals and noise.

Analog Multiplier :-

→ There are a number of applications of analog multipliers such as (i) frequency doubling

(ii) Measurement of real power

(iii) detecting phase angle difference

(iv) diving one signal by another.

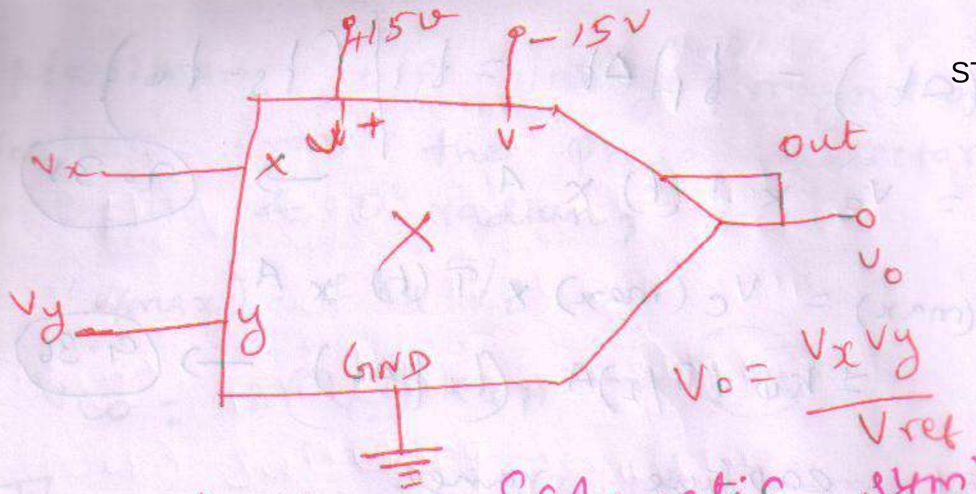
(v i) Multiplying two signals.

The o/p voltage

$$V_o = \frac{V_x V_y}{V_{ref}} \rightarrow (4.55)$$

$V_{ref} \Rightarrow 10V$

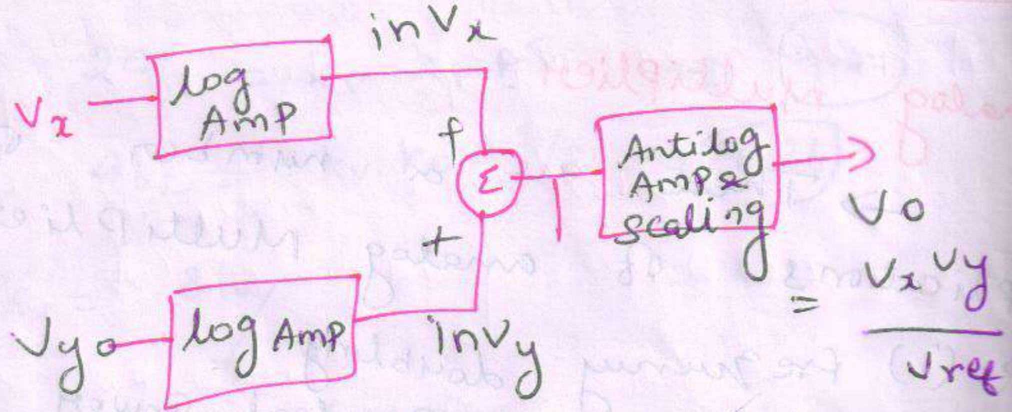
$$V_o = \frac{V_x V_y}{10}$$



Multiplier Schematic symbol

→ supply voltage can range from ±8 V to ±18 V

Block diagram of a log antilog Multiplier :-



→ This log-antilog multipliers are restricts log-antilog Multipliers.

Some of the multiplier IC Chips are AD533, AD534, AD633.

Squarer Circuit :-

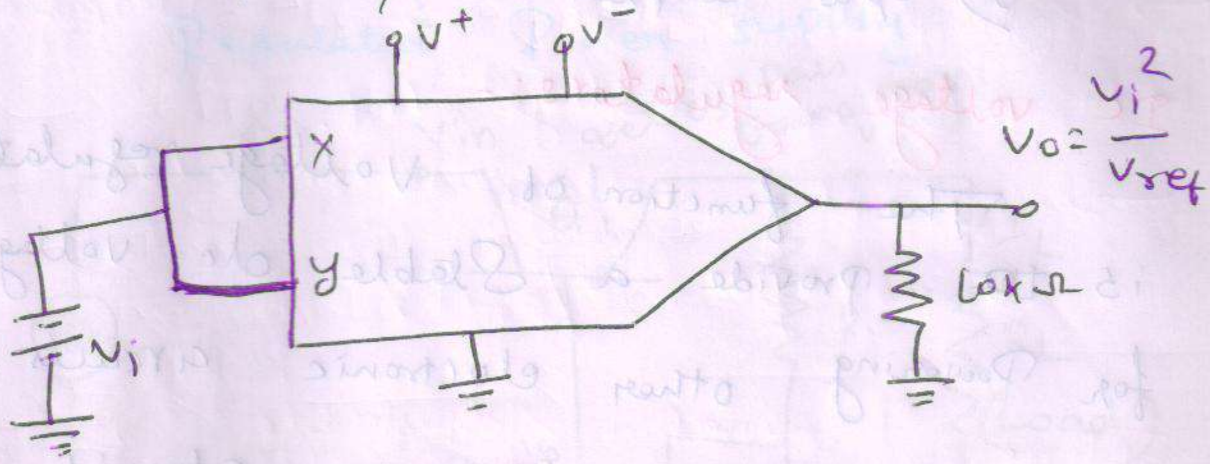
→ used to square any positive or negative number provided

→ v_i representing the ... is connected to both the inputs

$$V_o = \frac{v_i^2}{V_{ref}}$$

$v_i = 5 \sin 2\pi \times 10^4 t$ & $V_{ref} = 10V$

$$V_i = 5^2/10 \,(\sin 2\pi \times 10^4 t)^2$$



Phase angle detection :-

If the i/p signals applied to a multiplier are

$$V_x = V_{mx} \sin \omega t$$

$$V_y = V_{my} \sin(\omega t + \theta)$$

$$= \frac{V_{mx} V_{my}}{V_{ref}} \sin \omega t \; \sin(\omega t + \theta)$$

$$= \frac{V_{mx} V_{my}}{V_{ref}} \times \frac{1}{2}\left[\cos\theta - \cos(2\omega t + \theta)\right]$$

$$V_{o,dc} = \frac{V_{mx} V_{my}}{\ldots} \times \cos\theta$$

Unit 5

Application IC's

1) voltage regulator
2) Power Amplifier
3) function Generator
4) switching regulator
5) opto coupler.

IC voltage regulators:-

The function of voltage regulator is to provide a stable dc voltage for powering other electronic circuits.

voltage regulators can be classified as,

a) Series Regulator
b) Switching regulators

Series regulator:-

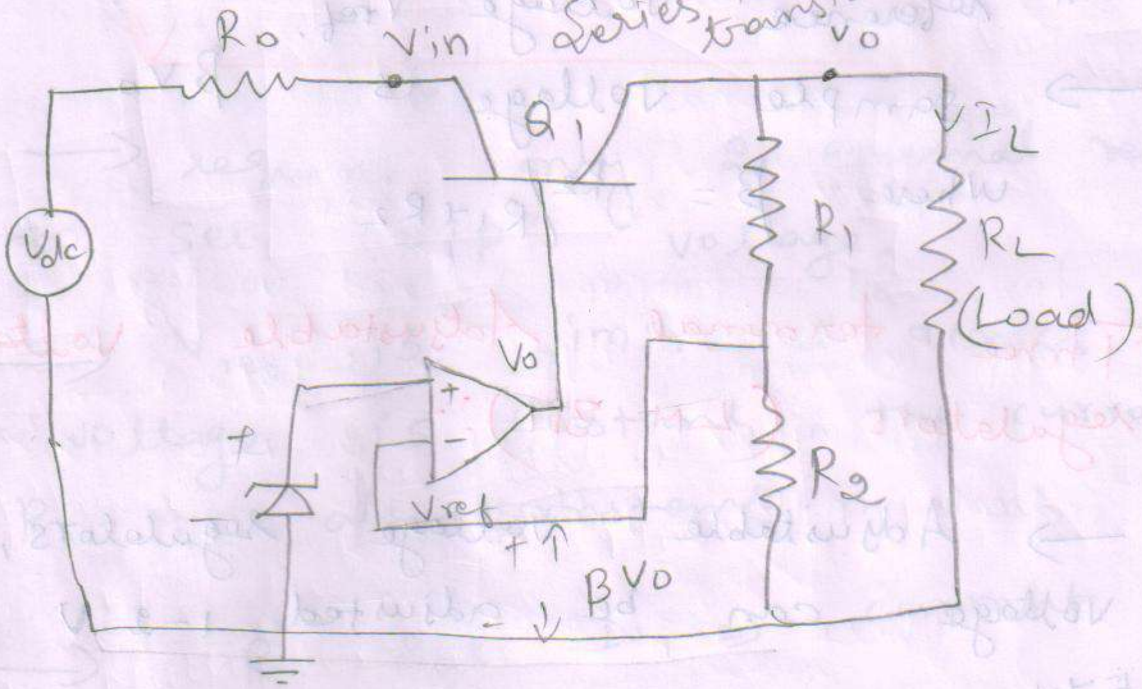
Series regulator use a Power transistor connected in series b/w the unregulated dc input and load. O/P voltage is controlled by continuous voltage drop place across series Pass transistor.

→ The transistor conducts in the active or linear region.

Switching regulators:-

Can operate power transistor as a high frequency on /off switch, so power transistor does not conduct current continuously.

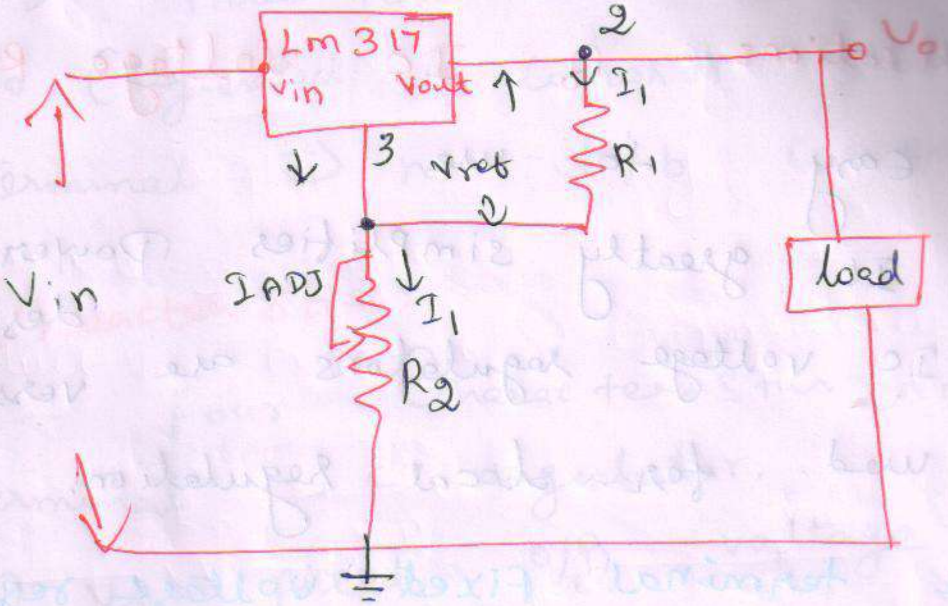
Regulated Power supply



A regulated power supply using discrete components and circuit consists of following four parts,

a) Reference voltage
b) Error Amplifier
c) Series pass transistor
d) Feed back n/w

Lm 317 regulator



→ requires only 2 external resistor, to set O/P voltage.

→ V_{ref} is impressed across R_1 & voltage is constant, the current R_1 is also constant.

→ R_1 set I_1 ⇒ current set or Program resistor.

→ O/P voltage $= R_1 I_1 + R_2 (I_1 + I_{ADJ}) \rightarrow (1)$

Where $I_1 = \frac{V_{ref}}{R_1}$

Sub (I) in equ (1)

$$V_o = R_1 \left(\frac{V_{ref}}{R_1}\right) + R_2 (I_1 + I_{ADJ})$$

$$V_o = V_{ref} + \frac{V_{ref}}{R_1} R_2 + R_2 I_{ADJ}$$

→ Power transistor Q_1 is in series with unregulated dc voltage V_{in} and regulated o/p voltage V_o.

→ Q_1 is also connected as an emitter follower.

→ Sampled voltage is compared with reference voltage V_{ref}.

→ sample voltage is βV_o

Where $\beta = R_2 / R_1 + R_2$

Three terminal Adjustable voltage regulators (LM 317):-

→ Adjustable voltage regulators, o/p voltage can be adjusted 1-2 V upto 57V.

→ LM 317 series is most commonly used general purpose adjust-able voltage regulators.

Advantages:-

→ Improved S/m performance

→ Improved overload protection

→ Improve system reliability.

where $V_{ref} = 1.25V$ = ref voltage b/w and adjustement terminals

Applications of IC Voltage Regulators

1) Easy to use
2) It greatly simplifies Power supply design,
3) IC voltage regulators are versatile
4) used for local regulation.

Three terminal fixed voltage regulators

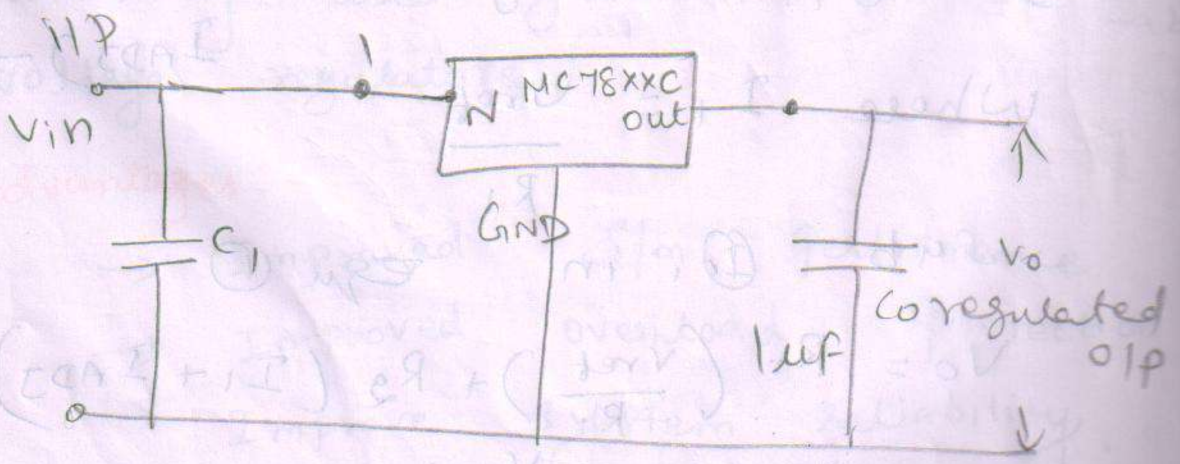
78XX series are three terminal, Positive fixed voltage regulators with screen O/P voltage,

In 78XX last 2 nos XX indicate O/P voltage.

These regulators are 2 types.

Metal Package (3type).

plastic Package (220 types)



→ Three terminal voltage regulators

→ Three terminals O/P, Vin & V_o (regulated & common ground terminal ⇒ no f/b connection.

Characteristics:-

Four characteristics of 3 terminal IC regulator.

1) V_o: fixed O/P voltage as specified by manufactures.

2) $V_{in} > V_o + 2$ volts

ie If $V_o = 7V$, $V_{in} = 5V$

3) $I_{o\,max}$, load current may vary from 0 to rated max O/P I

4) Thermal shutdown: IC has temperature sensor, which turns off IC when it becomes too hot.

IC 723 General purpose Regulator:-

limitation of 3 terminal voltage regulation

1) No short circuit protection

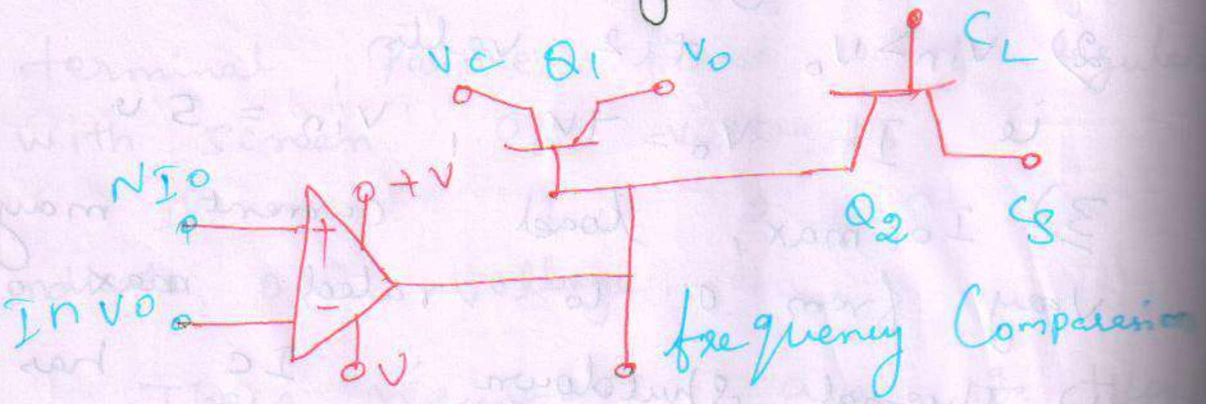
2) O/P voltage is fixed

The limitation can be overcome by 723 general purpose regulators which can be adjusted over a wide range of both positive or negative regulated voltage

Important features of IC 723 :-

→ It has good line and load regulation

→ Relative ease with which Power Supply can be designed & Provides a choice of supply voltage.



→ Two Seperate sections,

(i) Zener Diode

(ii) Error amp