Oscillators

Oscillators

Role of oscillators:

*oscillators are used to generate signal

*it converts power from the dc power supply into an ac power

Harmonic oscillators → sinusoidal wave form

Relaxation oscillators →produce non sinusoidal

They are used in :

1. Electronic Communication Devices .
2. Lab.

Oscillators

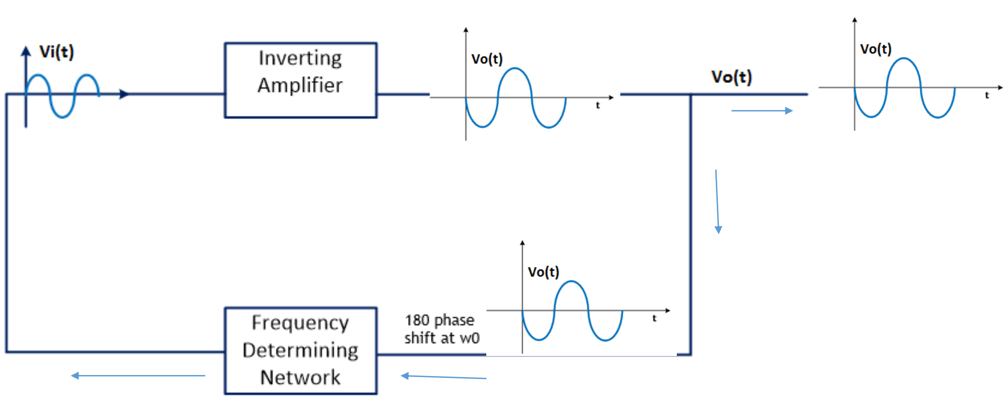
For the circuit to operate as an oscillator it must satisfy the Barkhausen criterial for sustained oscillation.

#1-The feedback must be positive ,this means that the feedback signal must be phased so that it adds to the amplifiers input signal .

#2-The loop gain (AB) must be greater than unity to allow oscillation to build up and equal to unity to sustain the oscillation .

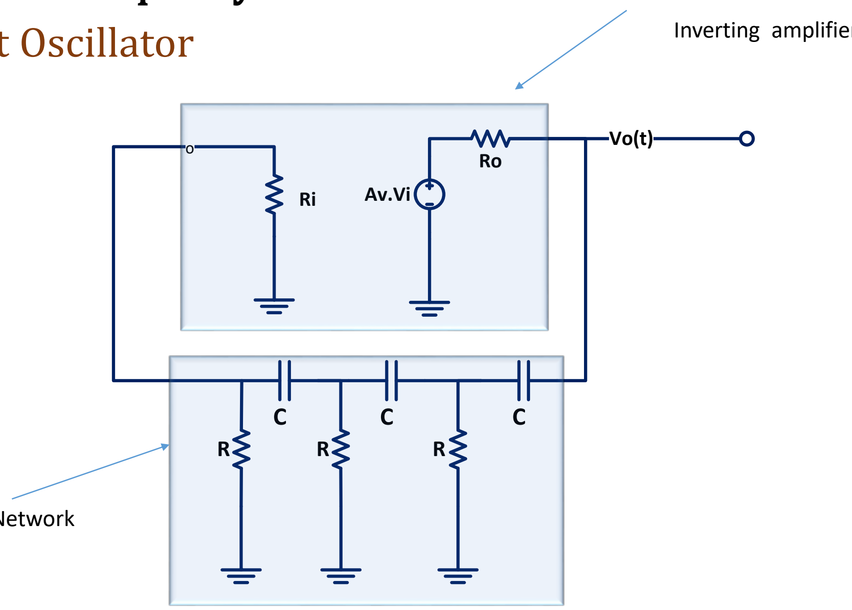
Audio frequency Oscillators

1) Phase-shift Oscillator



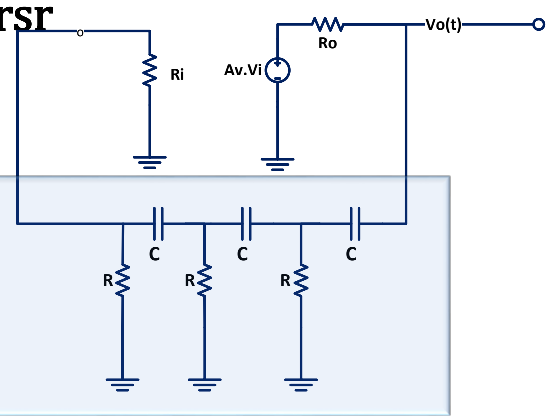
Audio frequency Oscillators

1) Phase-shift Oscillator



Oscillatorsr

1) Phase-shift Oscillator



To find β(jω) = $\frac{V_O(j\omega)}{V_i(j\omega)}$

$$(R - j\frac{1}{\omega C})\, I_1 - RI_2 = V_i$$

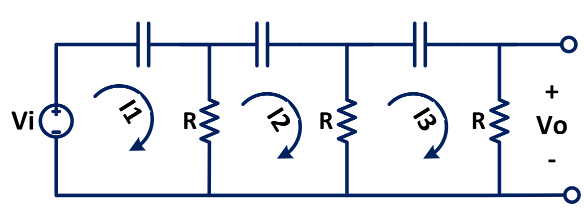
$$-RI_1 + (2R - j\frac{1}{\omega C})\, I_2 - RI_3 = 0$$

$$-RI_3 + (2R - j\frac{1}{\omega C})\, I_3 = 0$$

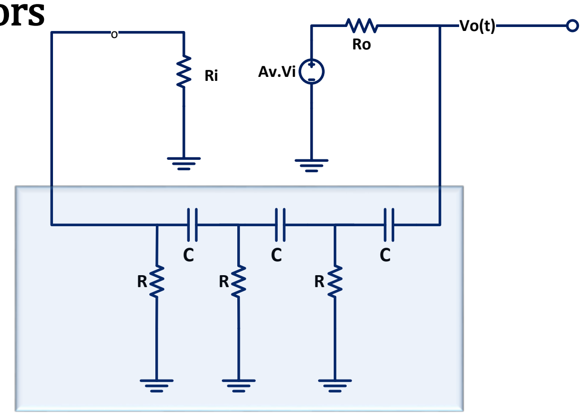
$$I_3 = \frac{R^{2V_i}}{R^3 - \frac{5R}{\omega^2 C^2} + j(\frac{1}{\omega^3 C^3} - \frac{6R^2}{\omega C})}$$

1/jwc 1/jwc 1/jwc

$R_i >> R$



Oscillators

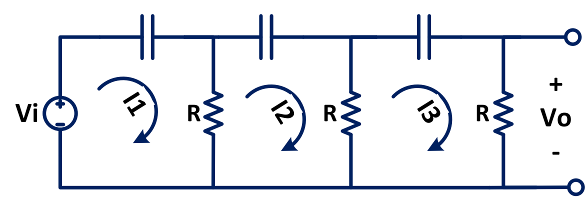


1) Pase-shift Oscillator

To find β(jω) = $\frac{V_O(j\omega)}{V_i(j\omega)}$

$$I_3 = \frac{R^2 V_i}{R^3 - \frac{5R}{\omega^2 C^2} + j\left(\frac{1}{\omega^3 C^3} - \frac{6R^2}{\omega C}\right)}$$

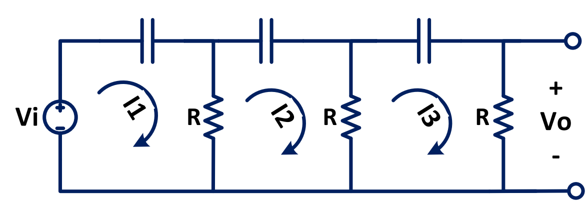
$$Vo = \frac{R^3 V_i}{R^3 - \frac{5R}{\omega^2 C^2} + j\left(\frac{1}{\omega^3 C^3} - \frac{6R^2}{\omega C}\right)}$$



Audio frequency Oscillators

1) Phase-shift Oscillator

To find β(jω) = $\frac{V_O(j\omega)}{V_i(j\omega)}$



$$\beta = \frac{V_O(j\omega)}{V_i(j\omega)}$$

$$\beta(j\omega) = \frac{1}{\left(1 - \frac{5}{\omega^2 C^2 R^2}\right) + j\left(\frac{1}{\omega^3 C^3 R^3} - \frac{6}{\omega C R}\right)}$$

At ω_o ; β(jω) must be real and negative

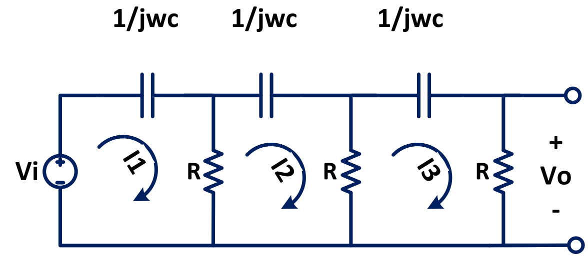
$$\frac{1}{\omega^3 C^3 R^3} - \frac{6}{\omega C R} = 0$$

$$\therefore \quad \omega_O = \frac{1}{\sqrt{6}\,RC}$$

Audio frequency Oscillators

1) Phase-shift Oscillator

To find $\beta(j\omega) = \frac{V_O(j\omega)}{V_i(j\omega)}$



$$\beta(j\omega) = \frac{1}{(1-\frac{5}{\omega^2 C^2 R^2})+j(\frac{1}{\omega^3 C^3 R^3}-\frac{6}{\omega CR})}$$

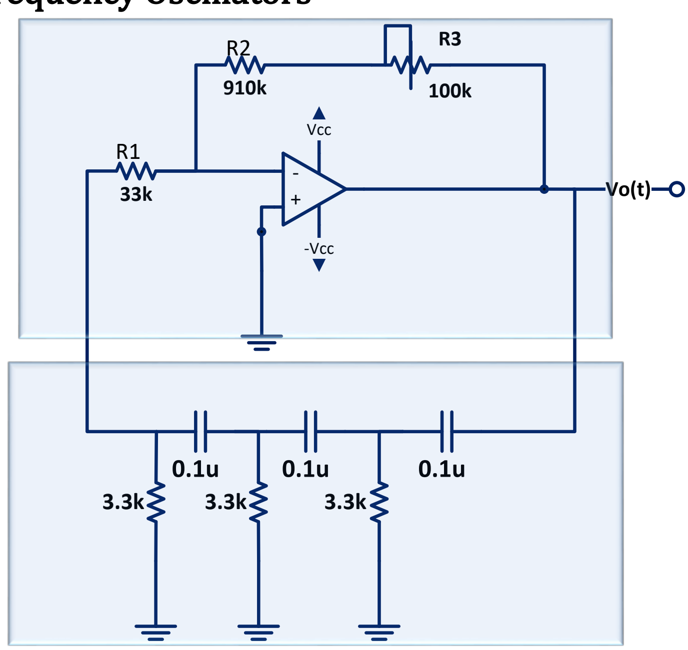
At ω_O $\beta(j\omega) = -\frac{1}{29} = \frac{1}{29}\angle 180$

$\therefore A_V \geq 29\angle 180$

$A_V\beta \geq 1\angle 0$

Audio frequency Oscillators

1) Phase-shift Oscillator



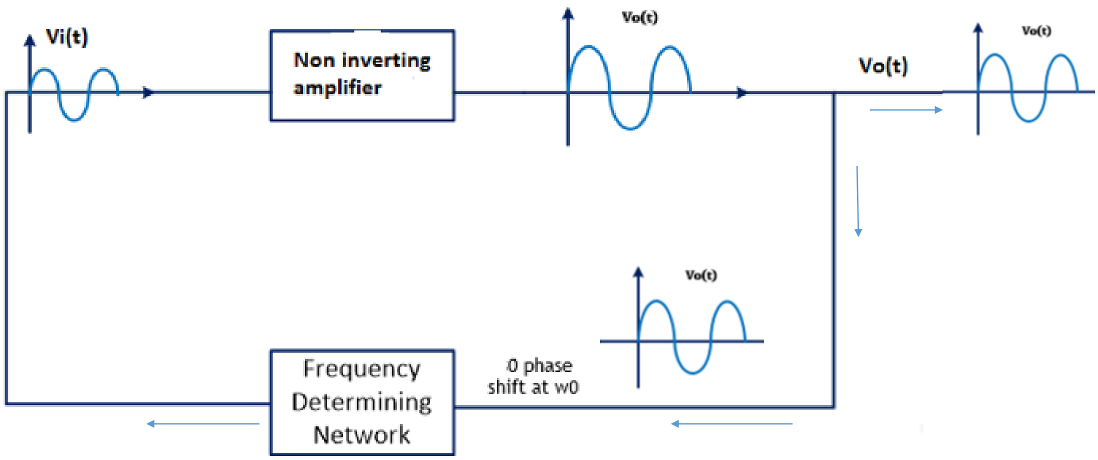
$$f_O = \frac{1}{2\pi\sqrt{6}RC} = 197\text{Hz}$$

$$A_V = -\left(\frac{R_2+R_3}{R_1}\right) = \begin{cases}-33.9\\-27.6\end{cases}$$

$A_V \leq -29$

Audio frequency Oscillators

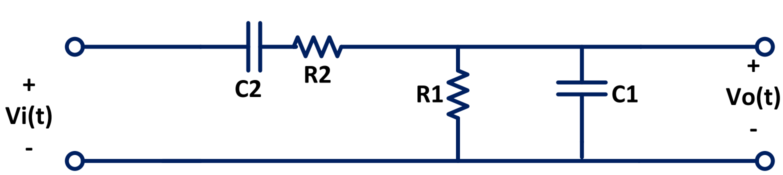
2- Wien Bridge Oscillator

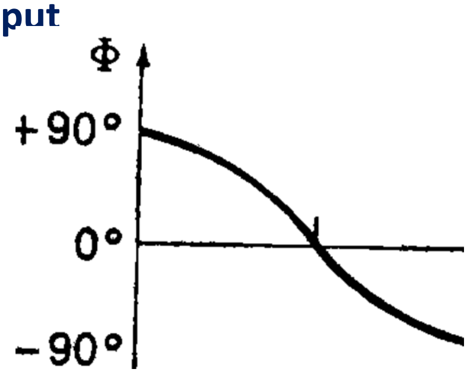


Audio frequency Oscillators

2- Wien Bridge Oscillator

- **The Wien bridge oscillator employs a lead -lag network.**
- **At one particular frequency , the phase shift across the network is 0 , therefore the feedback network is connected to the Op.Amp's noninverting input terminal.**





Audio frequency Oscillators

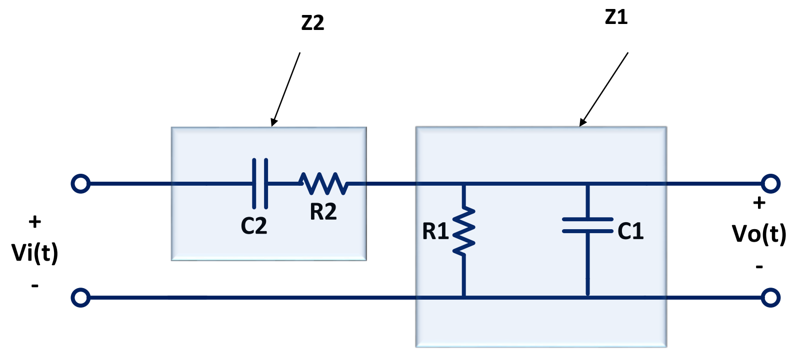
2- Wien Bridge Oscillator

- $Z_1 = R_1 \parallel \frac{1}{j\omega c_1} = \frac{R_1}{1+jR_1\omega c_1}$

- $Z_2 = R_1 + \frac{1}{j\omega c_2}$

- $\beta(j\omega) = \frac{V_o(j\omega)}{V_i(j\omega)} = \frac{Z_1}{Z_1+Z_2}$

- $\beta(j\omega) = \frac{\omega R_1 C_2}{\omega(R_1 C_1+R_2 C_2+R_1 C_2)+j(\omega^2 R_1 R_2 C_1 C_2-1)}$



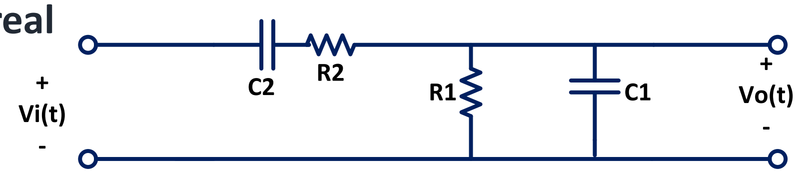
At ω_o ; β(jω)must be real and positive

- $\therefore \quad \omega^2 R_1 R_2 C_1 C_2 - 1 = 0$

Audio frequency Oscillators

2- Wien Bridge Oscillator

At ω_o ; β(jω)must be real and positive



- $\therefore \omega_o = \frac{1}{\sqrt{R_1 R_2 c_1 c_2}}$

- At ω_o ; $\beta(j\omega) = \frac{1}{1+\frac{R_2}{R_1}+\frac{C_1}{C_2}}$

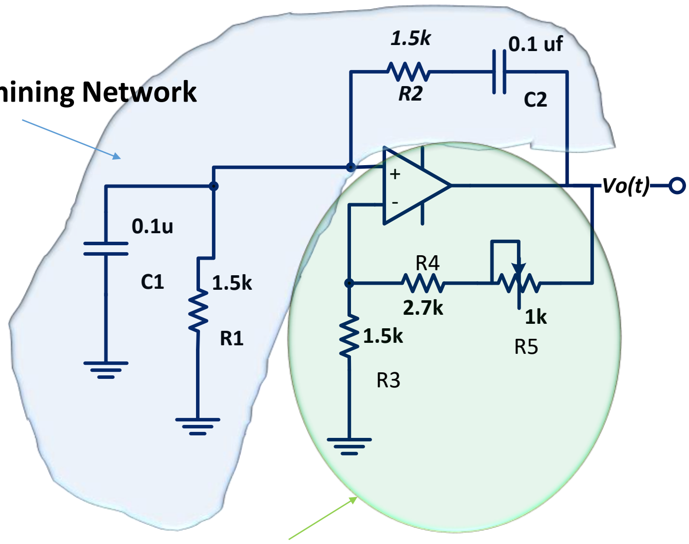
- If R_1=$R_2 = R$; and $C_1 = C_2 = C$

- $\omega_o = \frac{1}{RC}$
- $\beta = \frac{1}{3} = \frac{1}{3}\angle 0$
- $\therefore A_v \geq 3\angle 0$
- $A_v\,\beta \geq 1\angle 0$

Audio frequency Oscillators

2- Wien Bridge Oscillator

Frequency Determining Network



Since C1 = C2 and R1 = R2

- $f_o = \frac{1}{2\pi RC} = 1.06KHz$

$$\beta = \frac{1}{3}$$

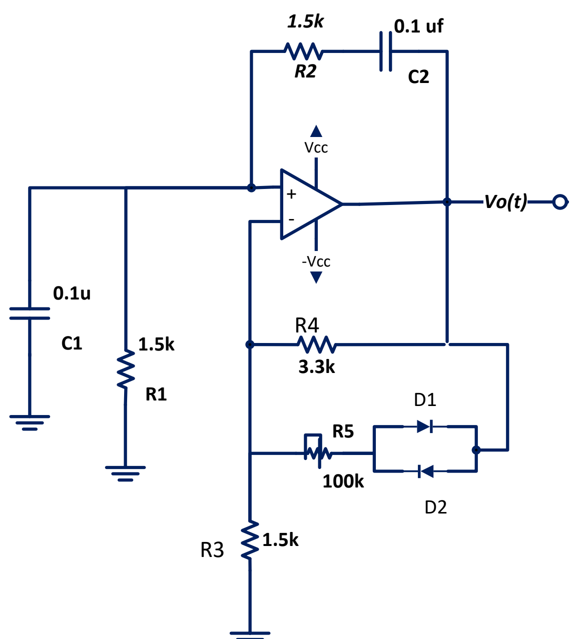
$$\therefore \; A_v \geq 3$$

$$A_v = 1 + \frac{R_4 + R_5}{R_3} = \begin{cases} 2.8 \\ 3.47 \end{cases}$$

Non Inverting Amplifier

Audio frequency Oscillators

Adaptive Negative Feedback



At the beginning

$A_v = 1 + \frac{R_4}{R_3} = 3.2 > 3$

D1,D2 are off to build up the oscillation

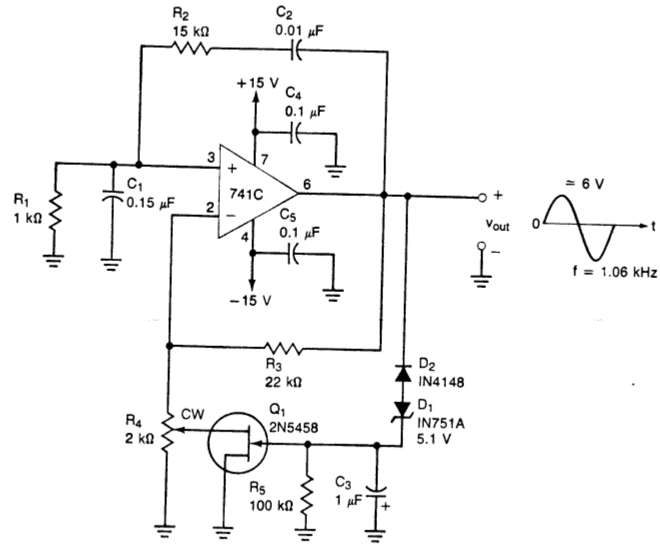
Later on D1,D2 are on

$A_v = 1 + \frac{R_4 /\!/ R_5}{R_3} = 3$

Audio frequency Oscillators

Amplitude stabilized Wien bridge oscillation using VVR (voltage variable resistor)

- The RDS of the JFET is used to control the voltage gain of the noninverting amplifier.



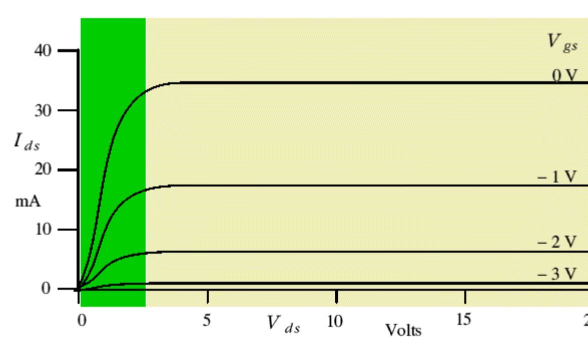
Audio frequency Oscillators

JFET as a voltage variable resister

In the pinch of region

$$I_{DS} = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2$$

$$|V_{DS}| > |V_P| - |V_{GS}|$$



'Characteristic curves for a typical N-channel JFET.

In the ohmic region

$$I_{DS} = \frac{2I_{DSS}}{V_P}\left(V_{GS} - V_P - \frac{V_{DS}}{2}\right) V_{DS}$$

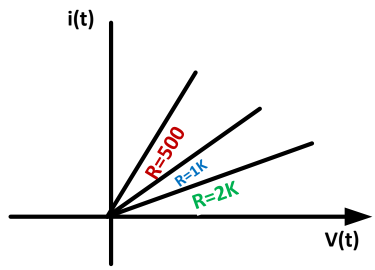
$$|V_{DS}| < |V_P| - |V_{GS}|$$

Audio frequency Oscillators

JFET as a voltage variable resister

- In the ohmic region , the V-I characteristics are fairly Linear, and their slopes are controlled by the magnitude of VGS .
- The smallest value of drain to source resistance occur when VGS=0.

$$r_{DS,(on)} = \frac{\Delta V_{DS}}{\Delta I_{DS}} \Big|_{V_{GS}} = 0$$



Audio frequency Oscillators

JFET as a voltage variable resister

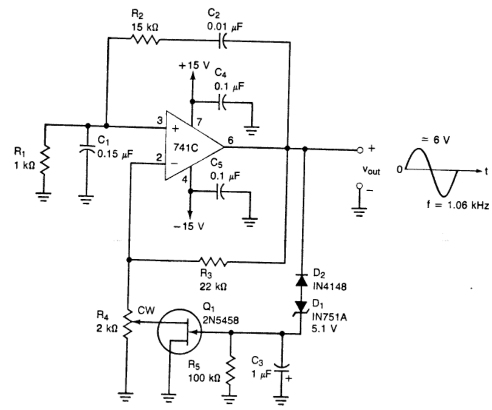
For a 2N5458 n - channel to be used A VVR V_{DS} must be kept vary small $|V_{DS}| < |V_P|$ -$|V_{GS}|$

V_{GS}	r_{DS}
0	667Ω
-0.4V	833Ω
-0.8V	1.11KΩ
-1.2V	1.97KΩ
-1.6V	3.33KΩ
-1.999V	1.33MΩ

Audio frequency Oscillators

Amplitude-Stablized Wien Bridge Oscillator using a VVR

- The RDS of the JFET is used to control the voltage gain of the noninverting amplifier.
- Diodes D_1 and D_2 are used to form a half – wave rectifier.
- When the output voltage become sufficiently large , it is converted to negative pulsating dc
- C_3 is used as a filter to smooth the pulsating dc to provide a constant dc bias voltage VGs



Audio frequency Oscillators

Building up – Oscillation

Initially D1 and D2 are off

And $V_{GS} = 0$

$\therefore r_{DS} = 667\Omega$

$A_v = 1 + \frac{22k}{R_T}$

$R_T = 209\Omega + 1791\Omega // r_{DS}$

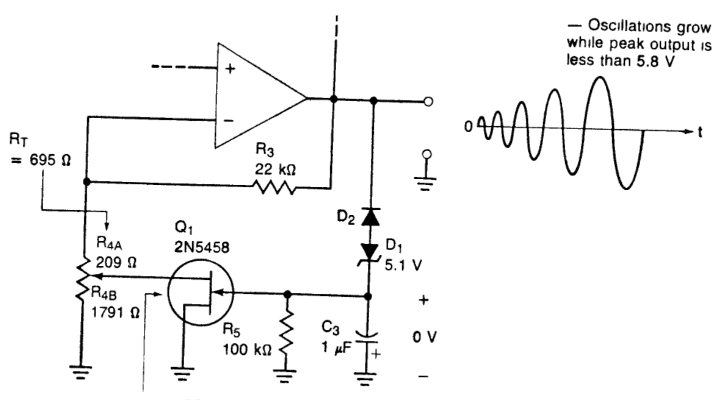
$R_T = 209\Omega + 486\Omega = 695\Omega$

$\therefore A_v = 32.65$

$B = \frac{1}{1+\frac{R_2}{R_1}+\frac{C_1}{C_2}} = \frac{1}{31}$

$\therefore A_v \, \beta > 1$

Building up oscillation



Audio frequency Oscillators

Sustained- Oscillation

When the peak out put voltage reaches 5.9v , D1and D2 are on and V_{GS} =-0.1v

$\therefore r_{DS} = 741\Omega$

$A_v = 1 + \frac{22k}{R_T}$

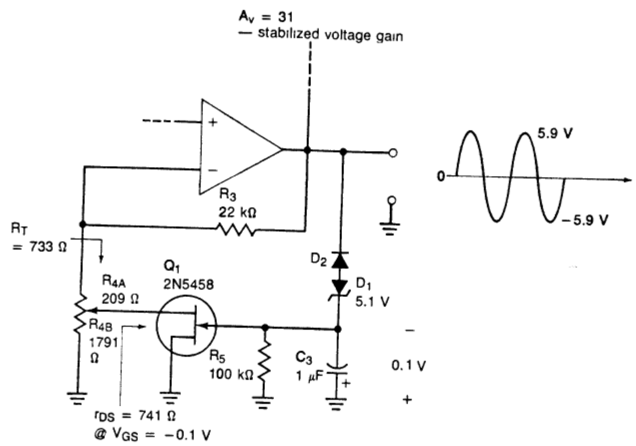
$R_T = 209\Omega + 1791\Omega /\!/ 741\Omega$

$R_T = 733\Omega$

And $A_v = 31$

$\beta = \frac{1}{31}$

$\therefore A_v \beta = 1$



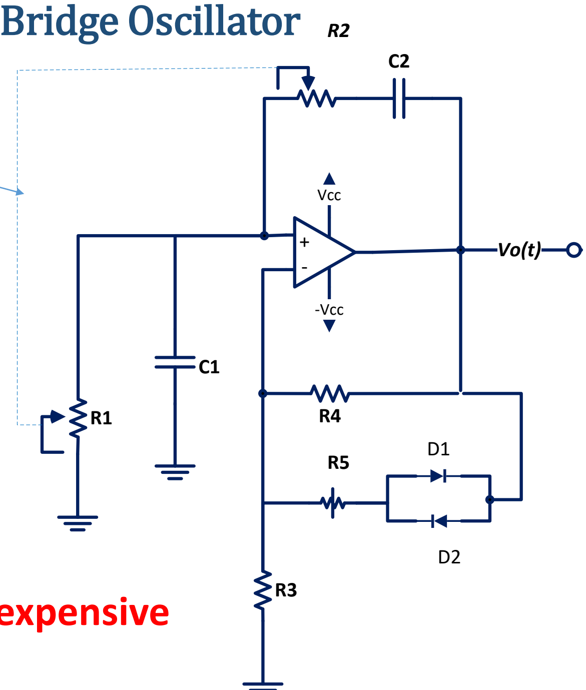
Sustained oscillation , And $f_o = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$ = 1.06KHz

Adjusting the frequency of the wien Bridge Oscillator

Ganged potentiometer

$$\omega_o = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$$

$$B = \frac{1}{1 + \frac{R_2}{R_1} + \frac{C_1}{C_2}}$$



Ganged potentiometer are relative expensive

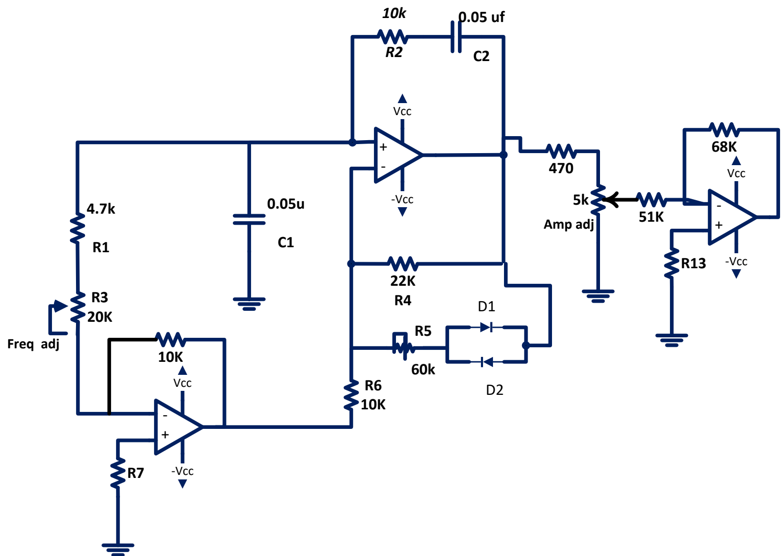
Audio frequency Oscillators

Practical Wien bridge oscillator

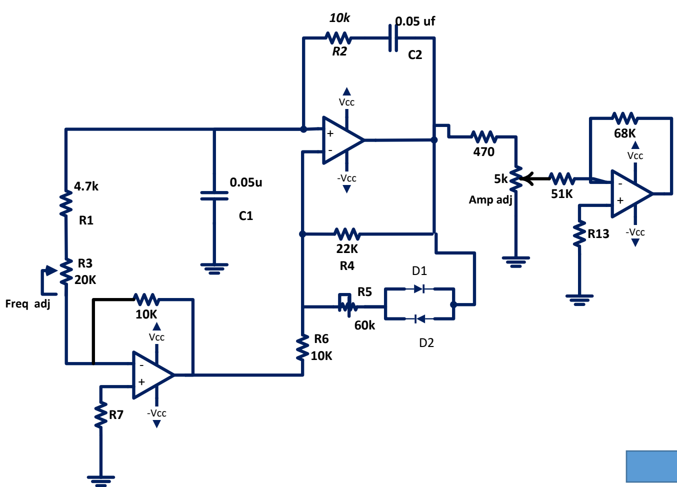
$$R_1{}'=R_1+R_3$$

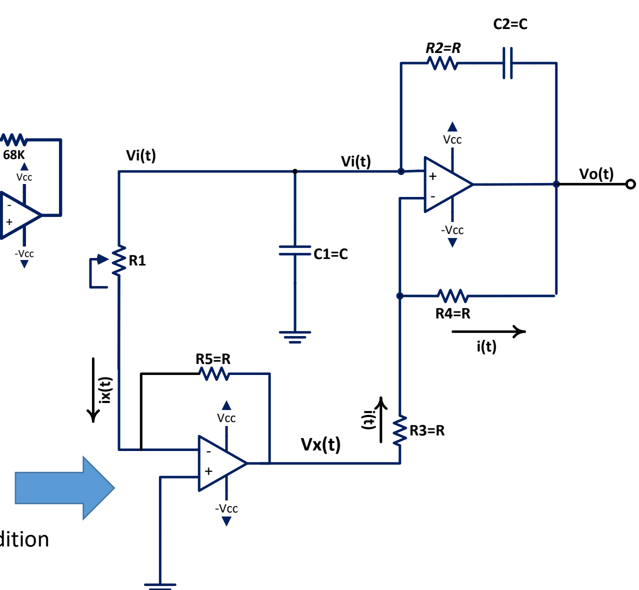
$$\omega_o=\frac{1}{\sqrt{R_1{}'R_2C_1C_2}}$$

$$B=\frac{1}{1+\frac{R_2}{R_1{}'}+\frac{C_1}{C_2}}$$



Using Active negative feedback and single potentiometer to adjust the Frequency of the Wien Bridge oscillator.





In the sustained condition

Audio frequency Oscillators

to find $A_v = \frac{V_o(t)}{V_i(t)}$

$$A_v = \frac{V_o(t)}{V_i(t)}$$

$$V_o(t) = -R\, i(t) + V_i(t)$$

$$i(t) = \frac{V_x(t) - V_i(t)}{R}$$

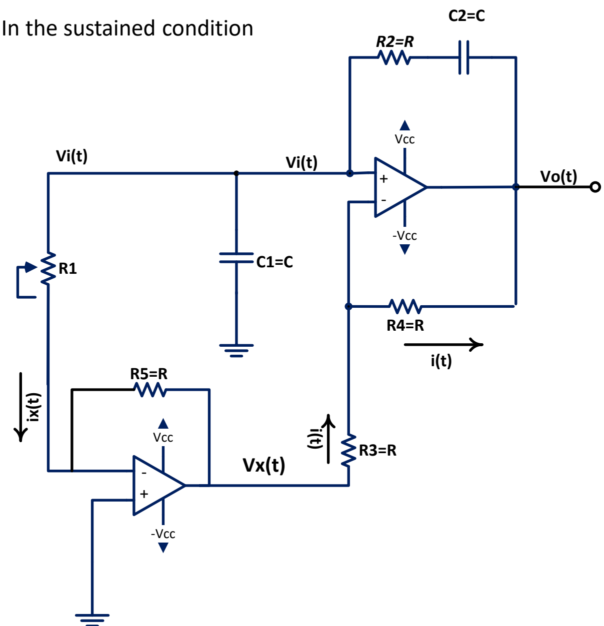
$$V_X(t) = -\frac{R}{R_1} V_i(t)$$

$$\therefore A_v = \frac{V_o(t)}{V_i(t)} = \left(2 + \frac{R}{R_1}\right)$$

$$\beta = \frac{1}{1 + \frac{R}{R_1} + 1} = \frac{1}{2 + \frac{R}{R_1}}$$

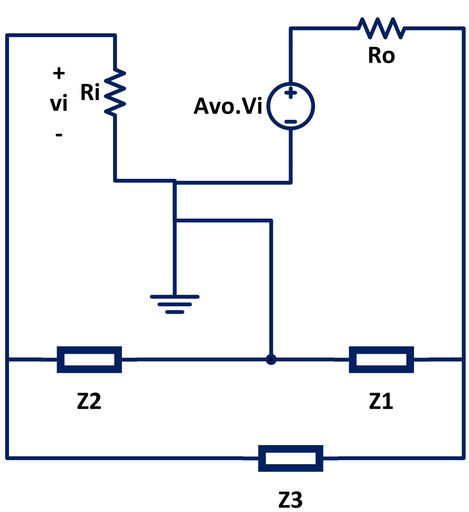
$$\therefore A_v\, \beta = 1$$

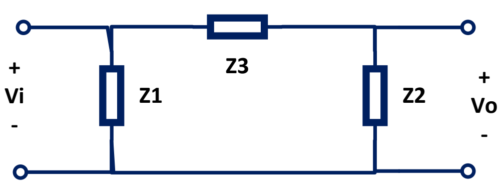
In the sustained condition



High Frequency Harmonic Oscillators

General LC Oscillator

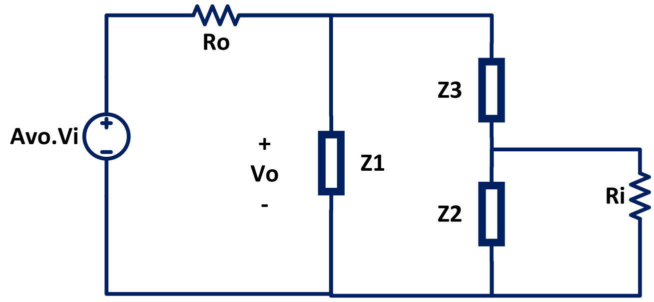




$$\beta(j\omega) = \frac{V_o(j\omega)}{V_i(j\omega)} = \frac{Z_2}{Z_2 + Z_3}$$

High Frequency Harmonic Oscillators

General LC Oscillator



To determine A_v

$$A_v(j\omega) = \frac{V_o(j\omega)}{V_i(j\omega)} = \frac{Z_l}{Z_l+R_o} A_{vo} V_i$$

$$Z_l = Z_1 \,/\!/\, (Z_2 + Z_3)$$

$$\therefore A_v(j\omega) = \frac{Z_1\,(Z_2+Z_3)A_{vo}}{Z_1\,(Z_2+Z_3)+R_o(Z_1+Z_2+Z_3)}$$

$$A_v\beta = \frac{Z_1\,Z_2 A_{vo}}{Z_1\,(Z_2+Z_3)+R_o(Z_1+Z_2+Z_3)}$$

$Z_1, Z_2 and Z_3$ are pure reactances

$R_i >> Z_2$

$\therefore$ At ω_o

1. $Z_1 + Z_2 + Z_3 = 0$
2. $A_v\beta = -\frac{Z_2}{Z_1} A_{vo}$

$A_v\,\beta \geq 1\angle 0$

$\therefore A_{vo} \leq -\frac{Z_1}{Z_2}$

High Frequency Harmonic Oscillators

Example of LC Oscillators

Oscillator type	Z1	Z2	Z3	Amplifier
Hartley	L	L	C	Inverting
	L	C	L	Follower
Colpitts	C	C	L	Inverting
	L	C	C	Non-Inverting
Clapp	C	C	LC	Inverting
Pierce crystal	C	C	XTAL	Inverting

High Frequency Harmonic Oscillators

Colpitts Oscillator

C1 = 330pF
C2 = 680pF
L = 110μH

At ω_o:

$$Z_1 + Z_2 + Z_3 = 0$$

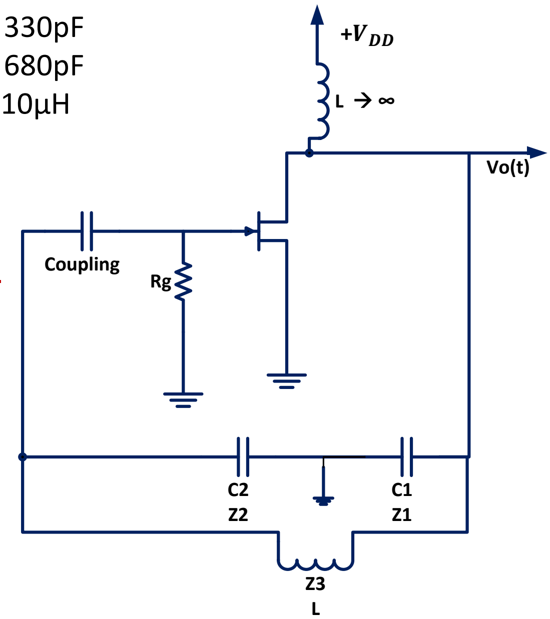
$$-j\frac{1}{\omega_o\ C_1} - j\frac{1}{\omega_o\ C_2} + j\omega_o L = 0$$

$$\therefore\ \omega_o = \frac{1}{\sqrt{LC_T}} \quad , \quad C_T = \frac{C_1 C_2}{C_1\ + C_2}$$

$$f_o = \frac{\omega_o}{2\pi} = 1.02\text{MHz}$$

$$A_{vo} \le -\frac{Z_1}{Z_2} = -\frac{C_2}{C_1}$$

$$A_{vo} \le -2.06$$



High Frequency Harmonic Oscillators

Clapp Oscillator

At ω_o

$$Z_1 + Z_2 + Z_3 = 0$$

$$-j\frac{1}{\omega_o\ C_1} - j\frac{1}{\omega_o\ C_2} - j\frac{1}{\omega_o\ C_3} + j\omega_o L = 0$$

$$\therefore\ \omega_o = \frac{1}{\sqrt{LC_T}}$$

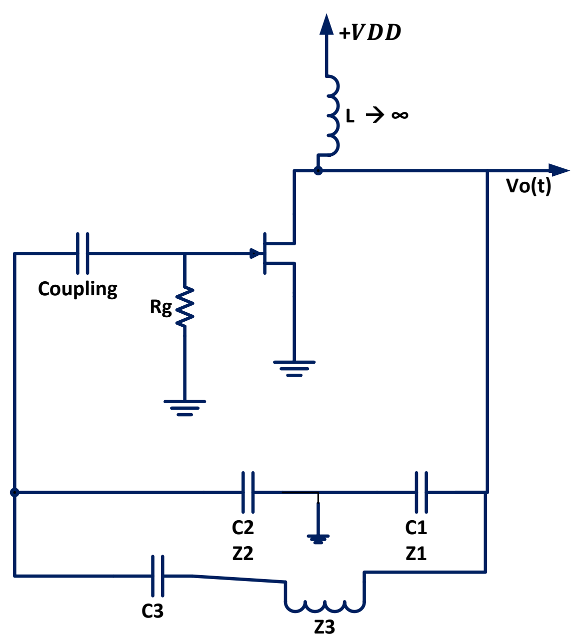
$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$C_T = 212.7\text{PF}$$

$$f_o = \frac{\omega_o}{2\pi} = 1.04\text{MHz}$$

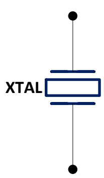
$$A_{vo} \le -\frac{Z_1}{Z_2} = -\frac{C_2}{C_1}$$

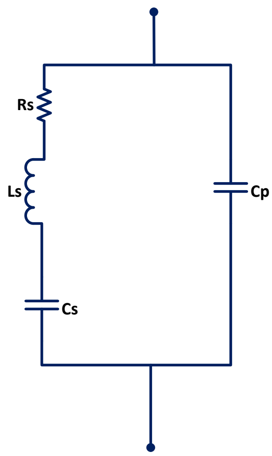
C1 = 680pF
C2 = 1500pF
C3 = 390pF
L = 110μH

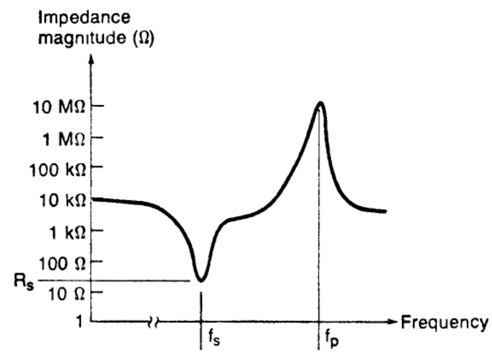


High Frequency Harmonic Oscillators

The Crystal





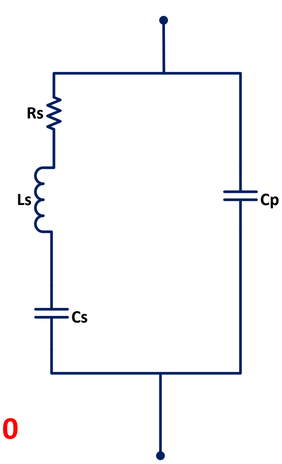


Oscillators

High Frequency Harmonic Oscillators

The Crystal

R_s is very small



$$Z(j\omega)= \frac{\left(j\omega L_s + \frac{1}{j\omega C_3}\right)\frac{1}{j\omega C_p}}{j\omega_o L_s + \frac{1}{j\omega C_3} + \frac{1}{j\omega C_p}}$$

$$Z(j\omega)= \frac{-j}{\omega C_p}\,\frac{\omega^2 - \frac{1}{L_s C_s}}{\omega^2 - \frac{C_s + C_p}{L_s C_s C_p}}$$

$$\omega^2 - \frac{1}{L_s C_s} = 0$$

$$\therefore \omega_s = \frac{1}{\sqrt{L_s C_s}}$$

Series resonance

$$\omega^2 - \frac{C_s + C_p}{L_s C_s C_p} = 0$$

$$\therefore \omega_p = \frac{1}{\sqrt{L_s\left(\frac{C_s C_p}{C_s + C_p}\right)}}$$

Parallel resonance

Oscillators

High Frequency Harmonic Oscillators

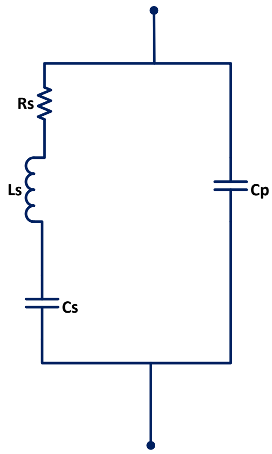
The Crystal

$C_s = 0.0060\text{PF}$

$L_s = 0.165609\text{H}$

$R_s = 10\Omega$

$C_P = 13.0\text{PF}$



$$f_s = \frac{1}{2\pi\sqrt{L_s C_s}}$$

$f_s = 5.048967\text{MHz}$

$$\omega_p = \frac{1}{\sqrt{L_s\left(\frac{C_s C_p}{C_s + C_p}\right)}}$$

$f_p = 5.050145\text{MHz}$

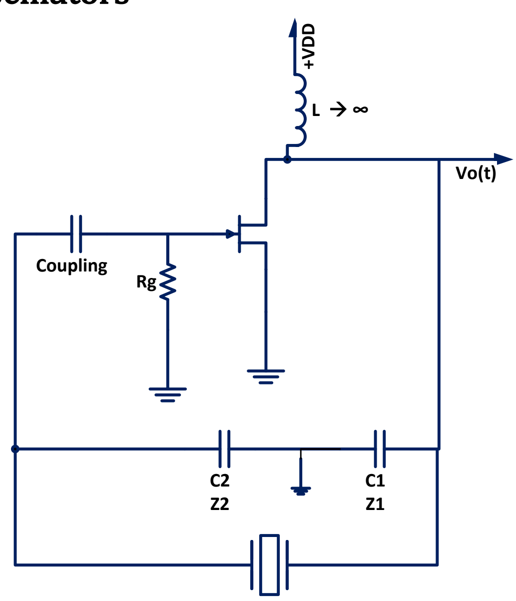
$$f_p - f_s = 1.179\text{KHz}$$

Oscillators

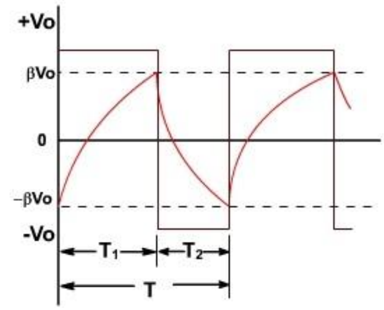
High Frequency Harmonic Oscillators

Pierce crystal oscillator.

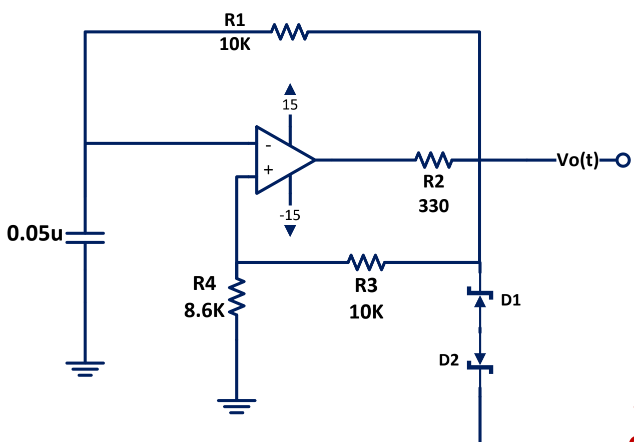
$$w_p > w_o > w_s$$



Oscillators



An OP Relaxation Oscillator



V_z = 9.1V $f_o = 1KhZ$

-The Op. Amp relaxation oscillator shown is a square _wave generator .

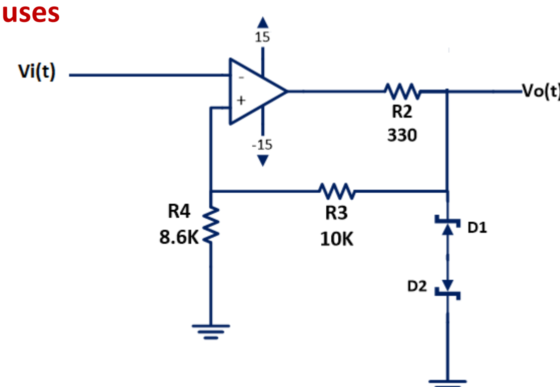
-The circuit's frequency of oscillation is dependent on the charge and discharge of a capacitor C_1 through a resistor R_1.

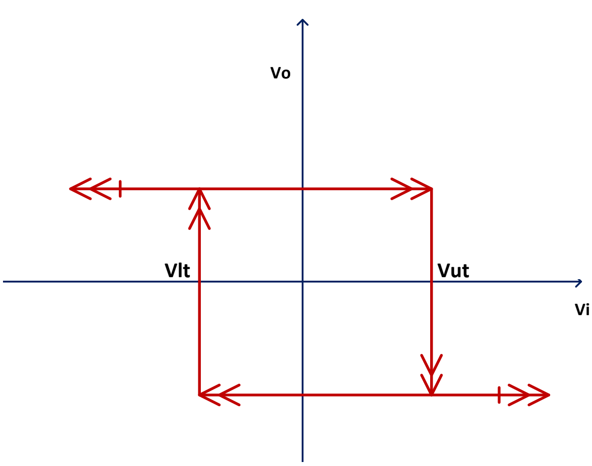
- The "heart" of the oscillator is an inverting Op. Amp comparator . the comparator uses positive feedback .

An OP Relaxation Oscillator

Oscillators

- The "heart" of the oscillator is an inverting Op. Amp comparator . the comparator uses positive feedback .

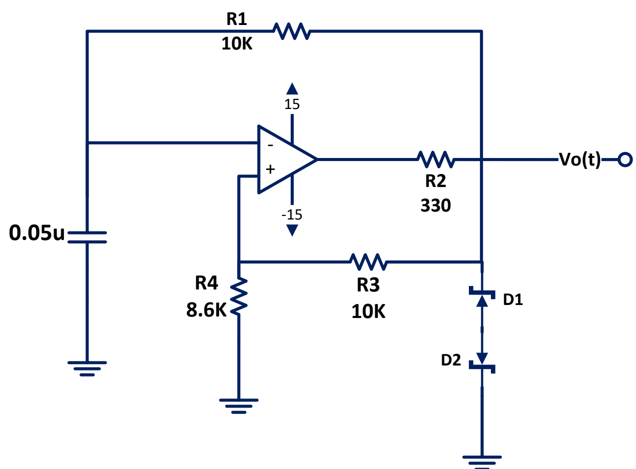


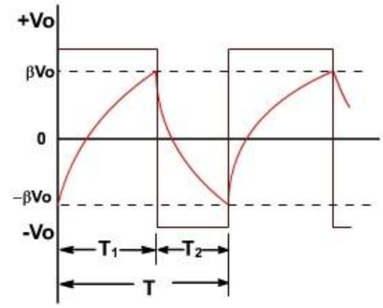


- $V_{UT} = \frac{R_4}{R_4+R_3}(V_z + 0.7) = \beta(V_z + 0.7)$
- $V_{LT} = -\frac{R_4}{R_4+R_3}(V_z + 0.7) = -\beta(V_z + 0.7)$

Oscillators

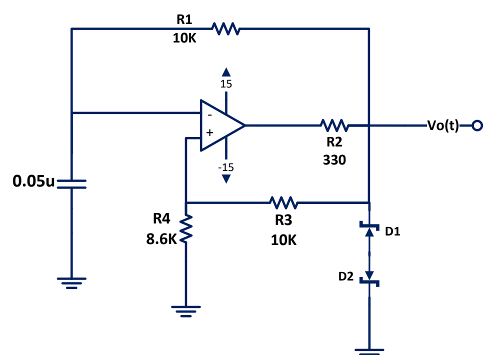
An OP Relaxation Oscillator





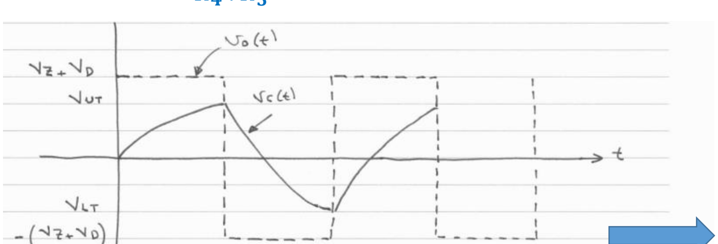
- $V_{out} = \pm(V_z + 0.7)$
- $V_{UT} = \frac{R_4}{R_4+R_3}(V_z + 0.7)$ = $\beta(V_z + 0.7)$
- $V_{LT} = -\frac{R_4}{R_4+R_3}(V_z + 0.7)$ = $-\beta(V_z + 0.7)$

Oscillators

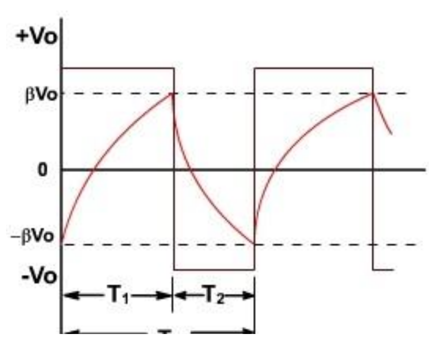


An OP Relaxation Oscillator

- $V_{out} = \pm(V_z + 0.7)$
- $V_{UT} = \frac{R_4}{R_4+R_3}(V_z + 0.7)$ = $\beta(V_z + 0.7)$
- $V_{LT} = -\frac{R_4}{R_4+R_3}(V_z + 0.7)$ = $-\beta(V_z + 0.7)$

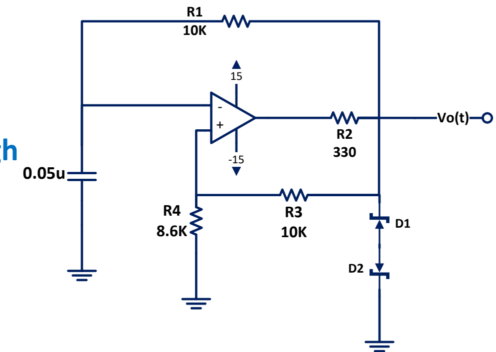


In the steady state



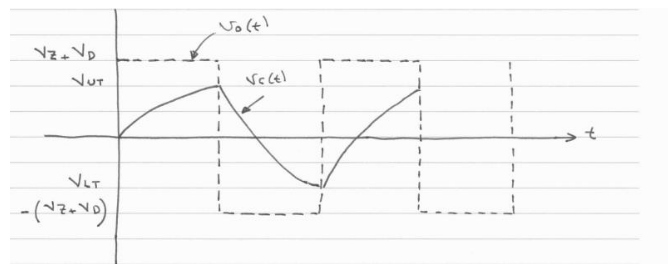
An OP Relaxation Oscillator

Oscillators

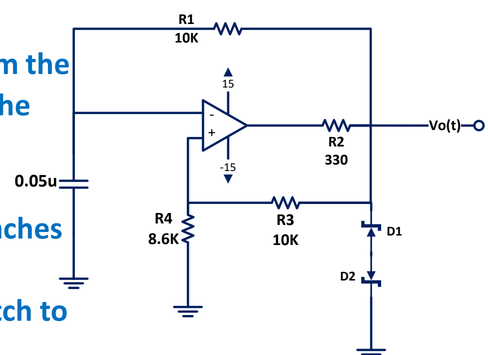


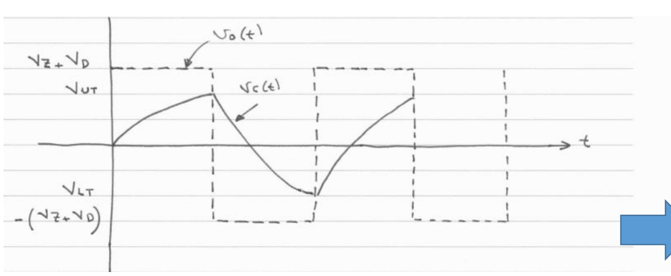
- When the output of the comparator is positive ,capacitor C_1 will charge through resistor R_1.
- The capacitor will attempt to charge to V_{out}=V_z+ 0.7.
- When the voltage a cross the capacitor reaches the upper threshold voltage V_{UT} ,the comparators output will immediately switch to

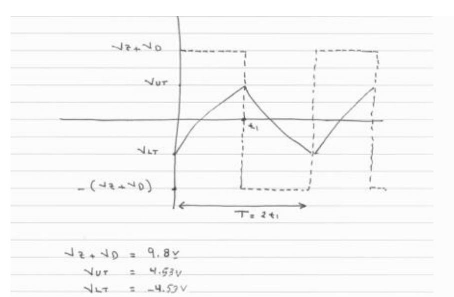
  V_{out}= - (V_z+ 0.7).



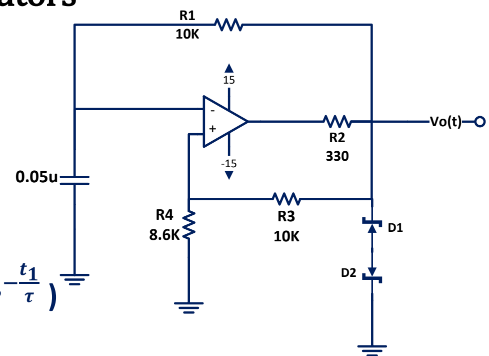
- The capacitor will than start to charge from the positive upper threshold voltage toward the negative output voltage .
- When the voltage across the capacitor reaches the lower threshold voltage V_{LT} , the comparators output will immediately switch to V_{out}= + (V_z+ 0.7).





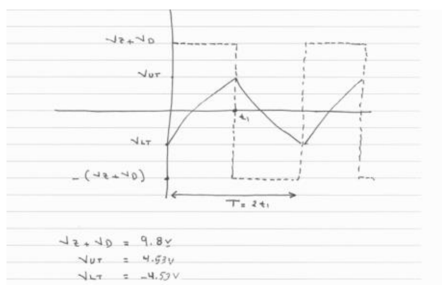


Oscillators



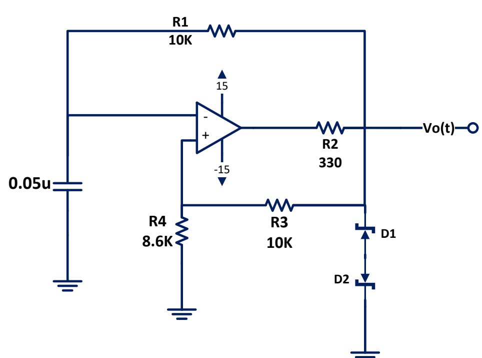
To determine the frequency of oscillation

- $V_c(t) = V_I + (V_f - V_I)(1 - e^{-\frac{t}{\tau}})$
- At t_1 $\quad V_c(t) = \beta V_{out}$ $\qquad \frac{R_4}{R_4+R_3} = \beta$
- $\beta V_{out} = -\beta V_{out} + (V_{out} - (-\beta V_{out}))(1 - e^{-\frac{t_1}{\tau}})$
- dividing both side by V_{out}
- $\beta = -\beta + (1+\beta)(1 - e^{-\frac{t_1}{\tau}})$
- $2\beta = (1+\beta)(1 - e^{-\frac{t_1}{\tau}})$
- $\frac{2\beta}{(1+\beta)} = (1 - e^{-\frac{t_1}{\tau}})$



- $e^{-\frac{t_1}{\tau}} = \frac{1-\beta}{1+\beta}$
- $\frac{t_1}{\tau} = ln\frac{1-\beta}{1+\beta}$
- $t_1 = \tau\, ln\frac{1-\beta}{1+\beta} = R_1 C_1\, ln\frac{1+\beta}{1-\beta}$
- $T = 2t_1 = 2R_1 C_1 \ln(\frac{1+\beta}{1-\beta})$

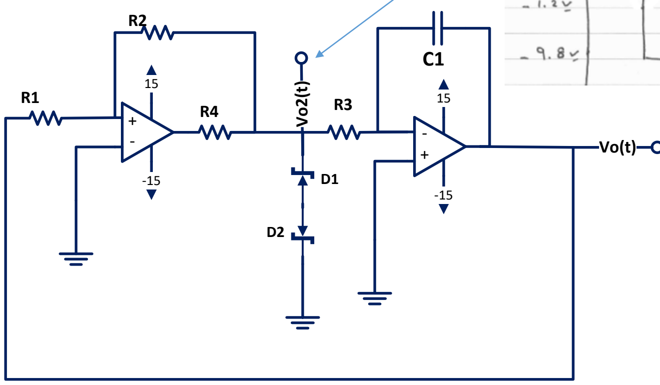
  $f_o = \frac{1}{T}$
- $\therefore\ f_o = \frac{1}{T} = \frac{1}{2R_1 C_1\ ln(\frac{1+\beta}{1-\beta})}$

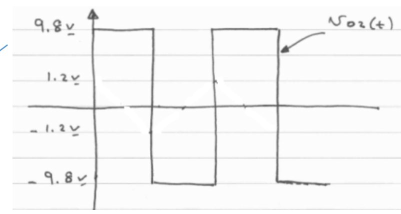


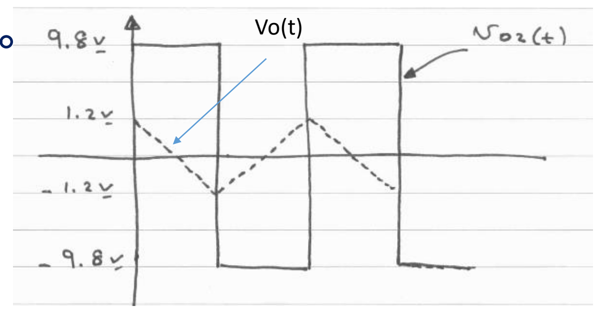
- If $R_4 = 0.859 R_3$ $\quad \rightarrow \quad \beta = 0.462$ $\qquad \therefore f_o = \frac{1}{2R_1 C_1}$
- $\ln(\frac{1+\beta}{1-\beta}) = 1$

Oscillators

An Op-Amp Triangle Generator







V_Z = 9.1v

R_1 = 100KΩ

R_2 = 820 KΩ

$V_Z + V_D$ = 9.8v

$\frac{R_1}{R_2}(V_Z + V_D)$ = 1.2v

Oscillators

An Op-Amp Triangle Generator

It consists of two stages

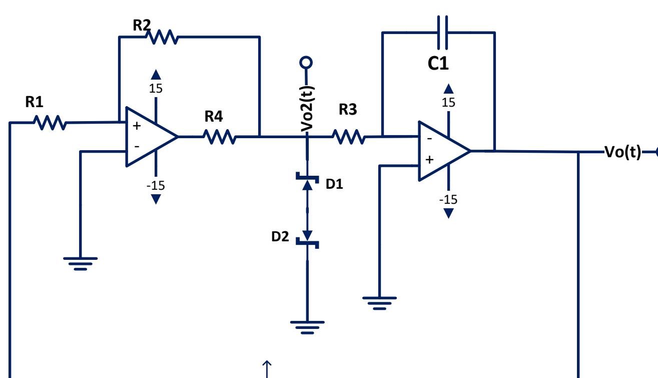
a) Non inverting Schmitt trigger comparator
b) Inverting integrator

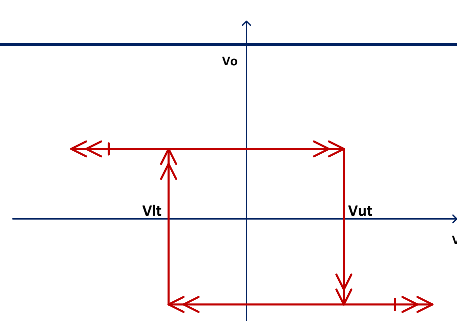
It provide two different output waveforms

a) Square wave
b) Triangle wave

$V_{UT} = \frac{R_1}{R_2}(V_Z + V_D)$ = 1.2v

$V_{LT} = -\frac{R_1}{R_2}(V_Z + V_D)$ = -1.2v

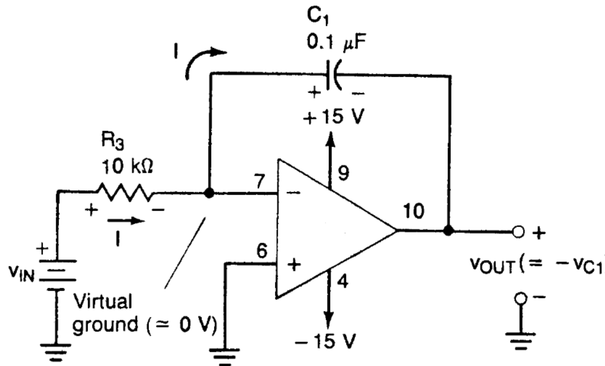




Oscillators

Inverting Integrator

Assuming that Vc(0⁻) = 0

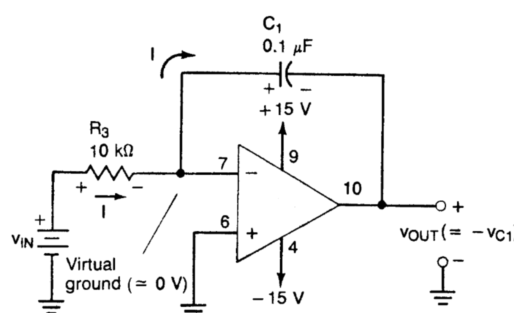


$$V_{out} = -\frac{1}{R_3 C_1} \int_0^t v_{in} dt$$

$$V_{out} = -\frac{v_{in}}{R_3 C_1} t$$

Oscillators

Inverting Integrator



Assuming that V_i = -10mv , find V_o (t) at 0.1s and 0.2s

$$V_{out} = -\frac{v_{in}}{R_3 C_1} t = -\frac{v_{in}}{(10k\Omega)(0.1\mu F)} t = -1000 v_{in}$$

If v_{in} is -10mv and t is 0.1s

$V_{out} = -1000 v_{in}$t = -(1000)(-10mv)(0.1s)

= 1v

And in 0.2s

$V_{out} = -1000 v_{in}$t = -(1000)(-10mv)(0.2s)

=2v

Assuming that $+V_{sat}$ is 13 v we may solve the time to reach saturation

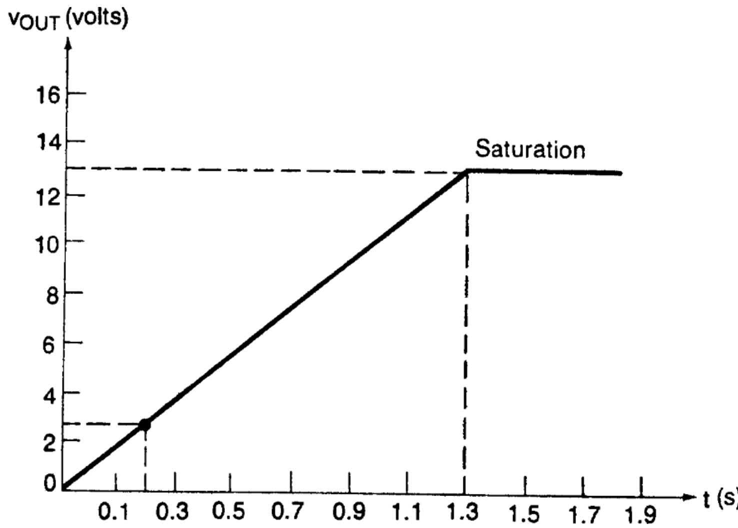
$$V_{out} = -\frac{v_{in}}{R_3 C_1} t = +V_{sat}$$

t= $\frac{+V_{sat}}{-v_{in}} R_3 C_1$= $\frac{13v}{-(-10mv)}$(10kΩ)(0.1μf)

= (1300)(1ms)=1.3s

Oscillators

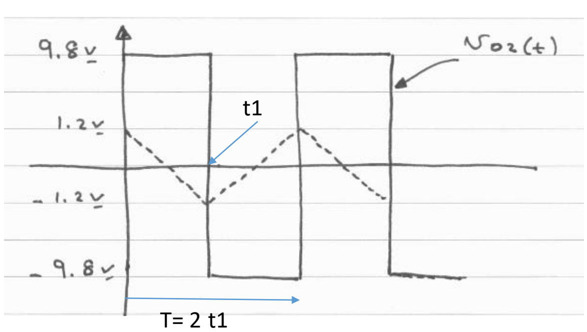
Inverting Integrator



Oscillators

Inverting Integrator

To determine f_o



For $t_1 \geq t \geq 0$

$$V_o(t) = V_{UT} - \frac{v_{in}}{R_3 C_1} t$$

$$V_o(t) = \frac{R_1}{R_2}(V_Z + V_D) - \frac{V_Z + V_D}{R_3 C_1} t$$

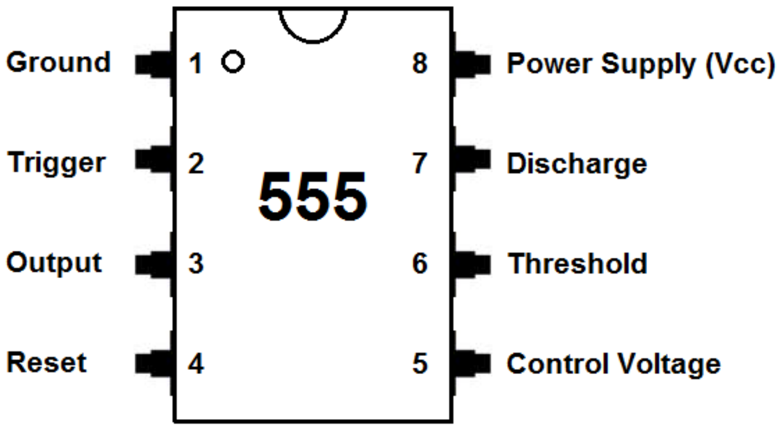
At t = t_1 ; $V_o(t_1) = -\frac{R_1}{R_2}(V_Z + V_D) = V_{LT}$

$$\therefore t_1 = \frac{2R_1 R_3 C_1}{R_2}$$

$$f_o = \frac{1}{T} = \frac{1}{2\,t_1} = \frac{R_2}{4R_1 R_3 C_1}$$

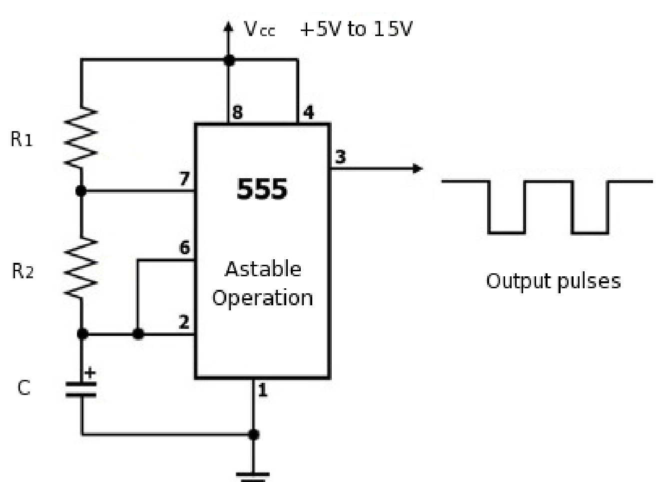
Oscillators

The 555 Timer As an Oscillator.



Oscillators

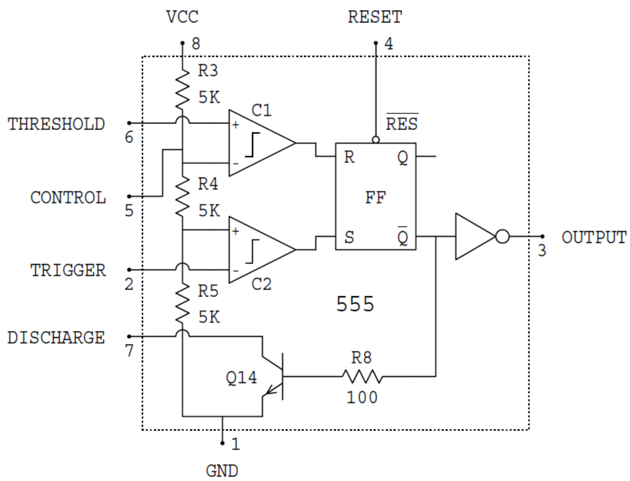
The 555 Timer As an Oscillator.



Oscillators

The 555 Timer As an Oscillator.

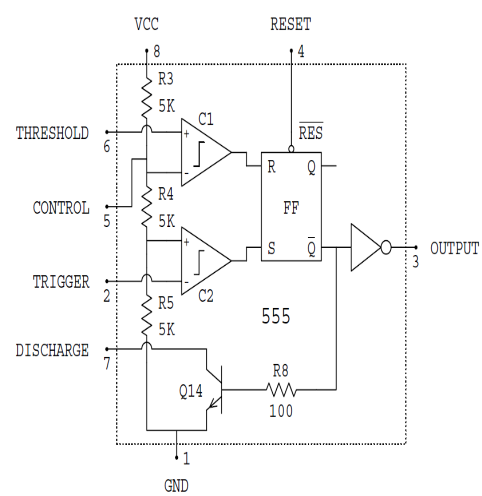
Functional block diagram of the 555 integrated circuit timer



Oscillators

The 555 Timer As an Oscillator.

Internal Component of 555



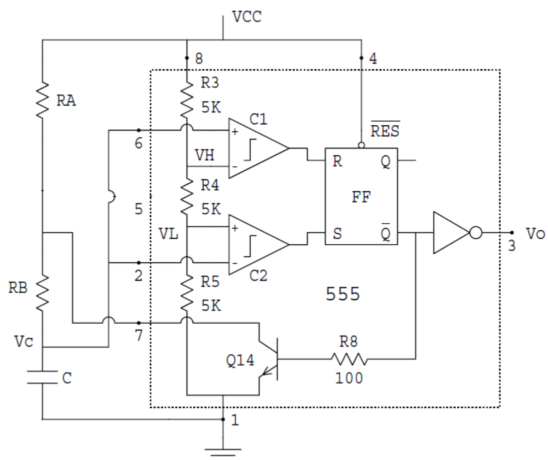
- **Two comparators**
- **Three R (5K) that set the trigger Levels**
- **Transistor that act as a switch**
- **S R Latch**
-

S	R	Q_n
0	0	Q_n no change
1	0	1
0	1	0
1	1	Forbidden

Oscillators

The 555 Timer As an Oscillator.

555 timer as an a stable circuit



Oscillators

The 555 Timer As an Oscillator.

Operation of the 555 timer oscillator.

At the beginning

$V_C(0^+) = V_C(0^-)$

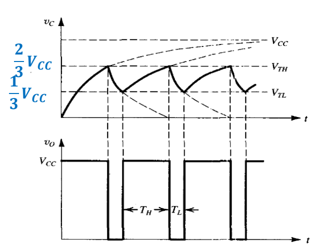
$\therefore$ R = 0 , S = 0

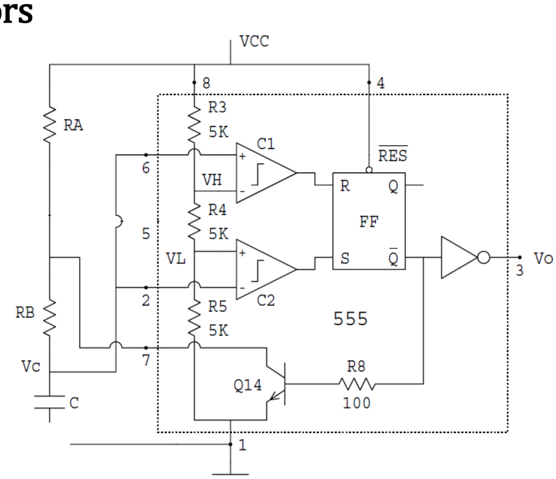
$\therefore$ Q = 1 , $\overline{Q} = 0$

$\therefore$ Transistor is off

$\therefore$ The capacitor start charging

$\tau_c = (R_A + R_B)C$



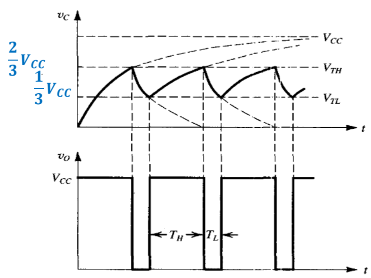


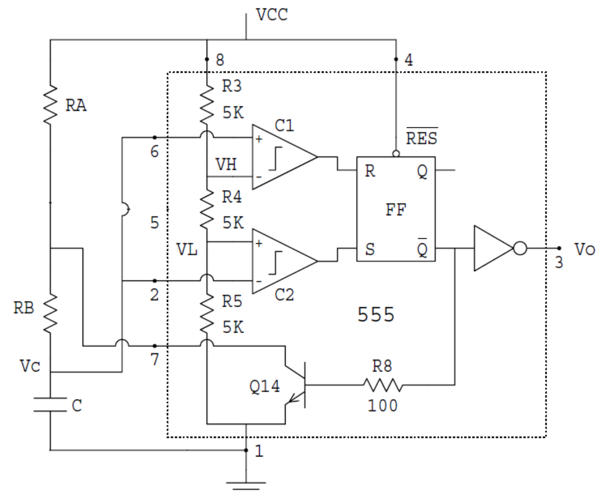
- When $V_C(t) > \frac{1}{3} V_{CC}$
- $\therefore$ R = 0 , and S = 0   No change
- $\therefore$ Q =1 ,and $\overline{Q} = 0$

$\therefore$ The transistor is still off

$\therefore$The capacitor is still charging

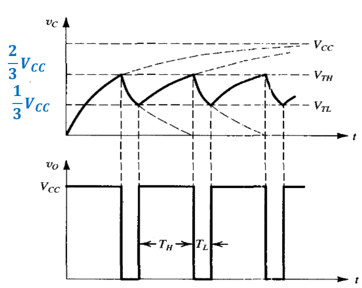
$\tau_c = (R_A + R_B)C$

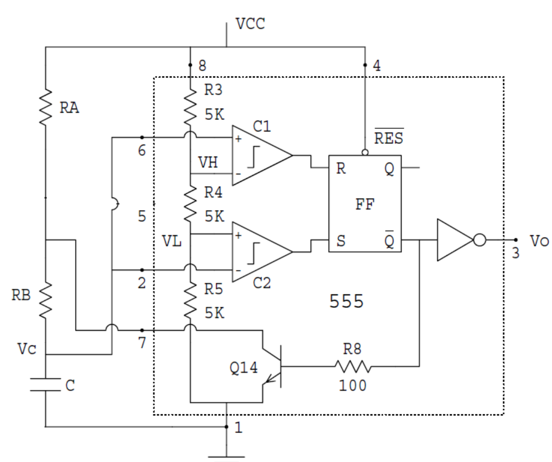




- When $V_C(t) > \frac{2}{3} V_{CC}$
- $\therefore$ R = 1 , and S = 0
- $\therefore$ Q =0 ,and $\overline{Q}$=1
- $\therefore$ The transistor turns on
- $\therefore$The capacitor starts discharging

$\tau_d = R_B C$





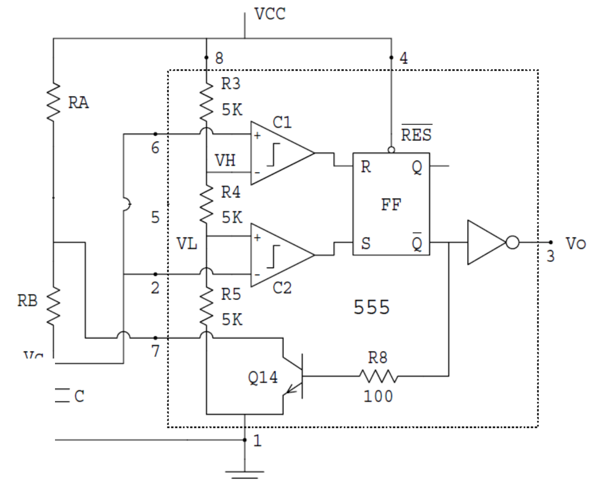
When $V_C(t) < \frac{1}{3}V_{CC}$

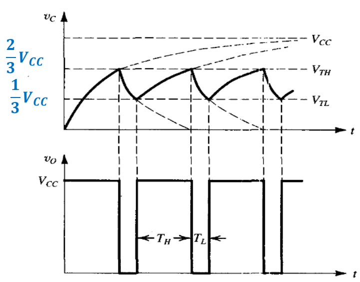
$\therefore$ S = 1 , and R = 0

$\therefore$ Q = 1 ,and $\overline{Q}$ = 0

$\therefore$ The transistor turn Off

$\therefore$The capacitor starts charging

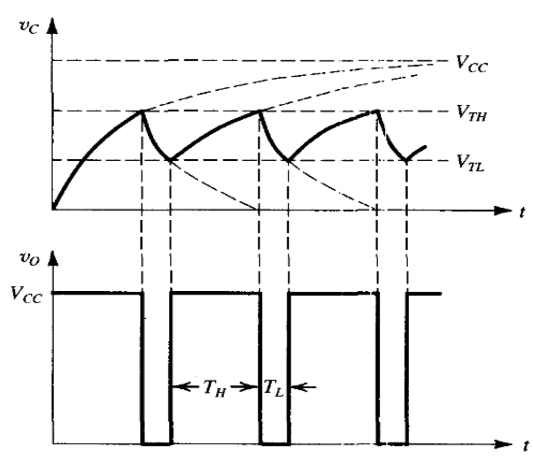


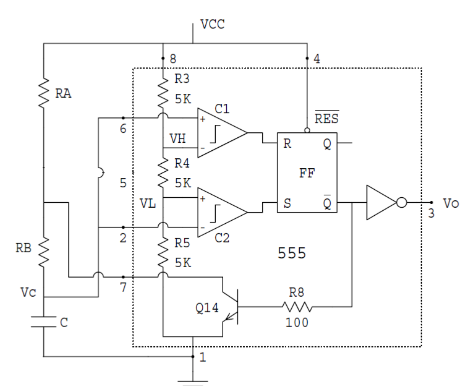


Oscillators

The 555 Timer As an Oscillator.

Operation of the 555 timer oscillator.

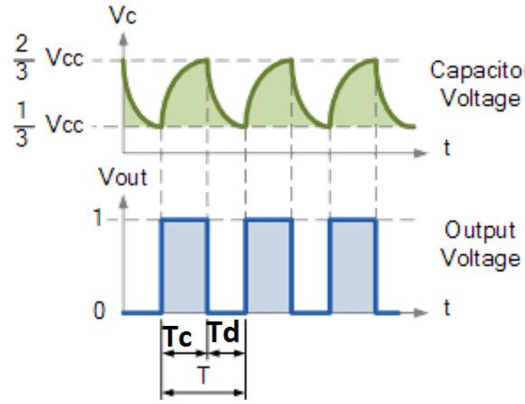




Oscillators

The 555 Timer As an Oscillator.

Operation of the 555 timer oscillator.



1. To find T_C

$$V_c(t) = V_I + (V_f - V_I)(1 - e^{-\frac{t}{\tau}})$$

$$V_c(T_C) = \frac{2}{3}V_{CC} \;;\quad V_I = \frac{1}{3}V_{CC} \;;\quad V_f = V_{CC}$$

$$\tau = (R_A + R_B)C$$

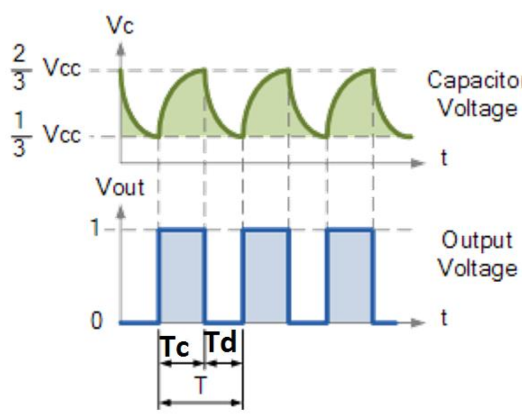
$$V_c(T_C) = \frac{2}{3}V_{CC} = \frac{1}{3}V_{CC} + (V_{CC} - \frac{1}{3}V_{CC})(1 - e^{-\frac{t}{\tau}})$$

$$T_C = \tau \ln 2 = (R_A + R_B)C \ln 2$$

Oscillators

The 555 Timer As an Oscillator.

Operation of the 555 timer oscillator.



2-To find T_d

$$V_c(t) = V_I + (V_f - V_I)(1 - e^{-\frac{t}{\tau}})$$

$$V_c(T_d) = \frac{1}{3}V_{CC} \;;\quad V_I = \frac{2}{3}V_{CC} \;;\quad V_f = 0$$

$$\tau = R_B C$$

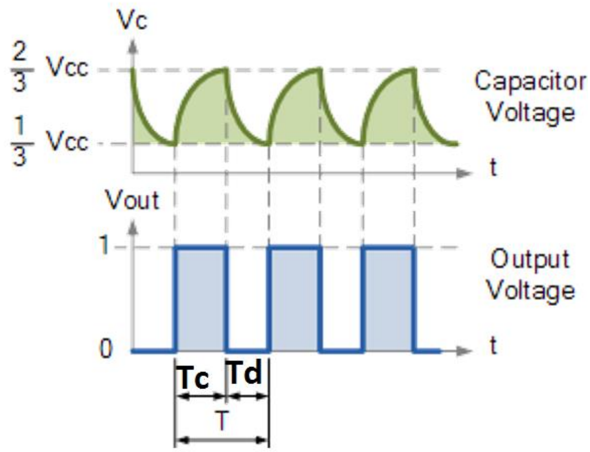
$$V_c(T_d) = \frac{1}{3}V_{CC} = \frac{2}{3}V_{CC}\,(0 - \frac{2}{3}V_{CC})\,(1 - e^{-\frac{t}{\tau}})$$

$$\therefore T_d = \tau \ln 2 = R_B C \ln 2$$

Oscillators

The 555 Timer As an Oscillator.

Operation of the 555 timer oscillator.



3- To find T

T= $T_C + T_d$ =$(R_A + 2R_B)$C $ln\,2$

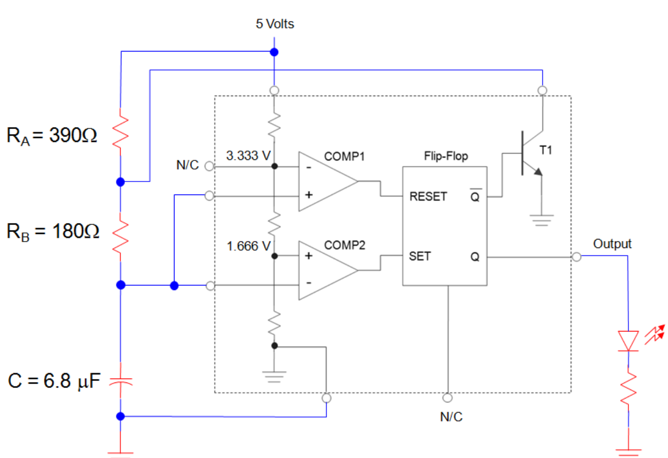
T= 0.693 $(R_A + 2R_B)$C

4- To find Duty cycle

Duty cycle = D = $\frac{T_C}{T} = \frac{R_A+R_B}{R_A+2R_B}$

Example

Calculate the period and frequency of the blinking LED.



$$T = 0.693\left(R_A + 2R_B\right)C$$

$$T = 0.693\left(390\Omega + 2\times180\Omega\right)\times 6.8\mu F$$

$$T = 3.534\,mSec$$

$$F = \frac{1}{T}$$

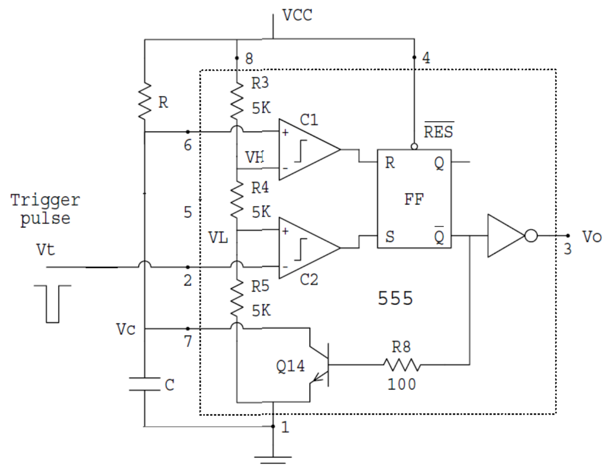
$$F = \frac{1}{3.534\,mSec}$$

$$F = 282.941Hz$$

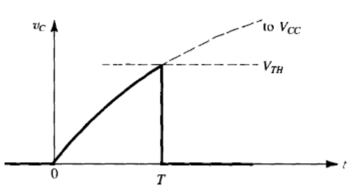
Oscillators

The 555 Timer As an Oscillator.

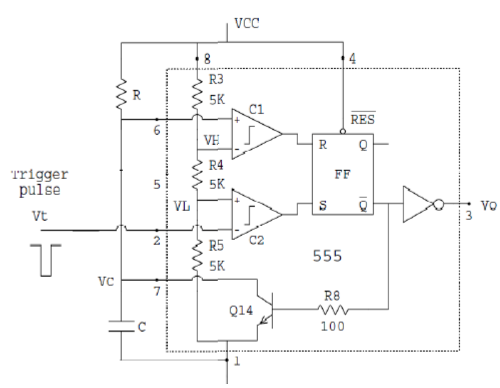
555 timer as a monostable circuit

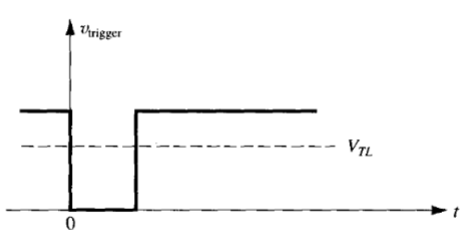


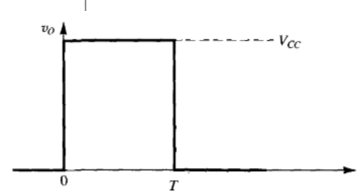
555 timer as a monostable circuit



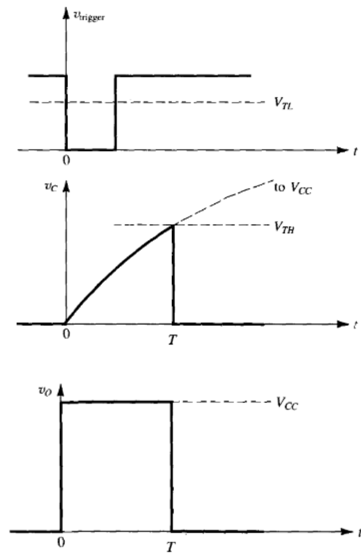
555 timer as a monostable circuit







T = RCℓn3 ≈ 1.1 RC



$T = RC\ell n3 \approx 1.1\ RC$