WIEN BRIDGE OSCILLATOR

- It uses a non-inverting amplifier (does not provide any phase shift during amplifier stage).
- As total phase shift required is 0^0 or $2n\pi$ radians, in wien bridge type no phase shift is necessary through feedback.
- Thus the total phase shift around a loop is 0^0.
- A Wien-Bridge Oscillator is a type of phase-shift oscillator which is based upon a Wien-Bridge network comprising of four arms connected in a bridge fashion.
- Here two arms are purely resistive while the other two arms are a combination of resistors and capacitors.
- In particular, one arm has resistor and capacitor connected in series (R_1 and C_1) while the other has them in parallel (R_2 and C_2).
- Two arms of the bridge R_1 , C_1 in series and R_2 , C_2 in parallel are frequency sensitive.
- In this circuit, at high frequencies, the reactance of the capacitors C_1 and C_2 will be much less due to which the voltage V_0 will become zero as R_2 will be shorted.
- At low frequencies, the reactance of the capacitors C_1 and C_2 will become very high. However even in this case, the output voltage V_0 will remain at zero only, as the capacitor C_1 would be acting as an open circuit.
- This kind of behavior exhibited by the Wien-Bridge network makes it a lead-lag circuit in the case of low and high frequencies, respectively

Transistorised wien bridge oscillator:

- In this circuit two stage common emitter transistor amplifiers is used.
- Each stage contributes 180^0 phase shift hence the total phase shift due to the amplifier stage becomes 360^0 which is necessary as per the oscillator conditions.
- The bridge consists of R and C in series, R and C in parallel, R_3 and R_4.
- The feedback is applied from the collector of Q_2 through the coupling capacitor, to the bridge circuit.
- The two stage amplifier provides a gain much more than 3 and it is necessary to reduce it.

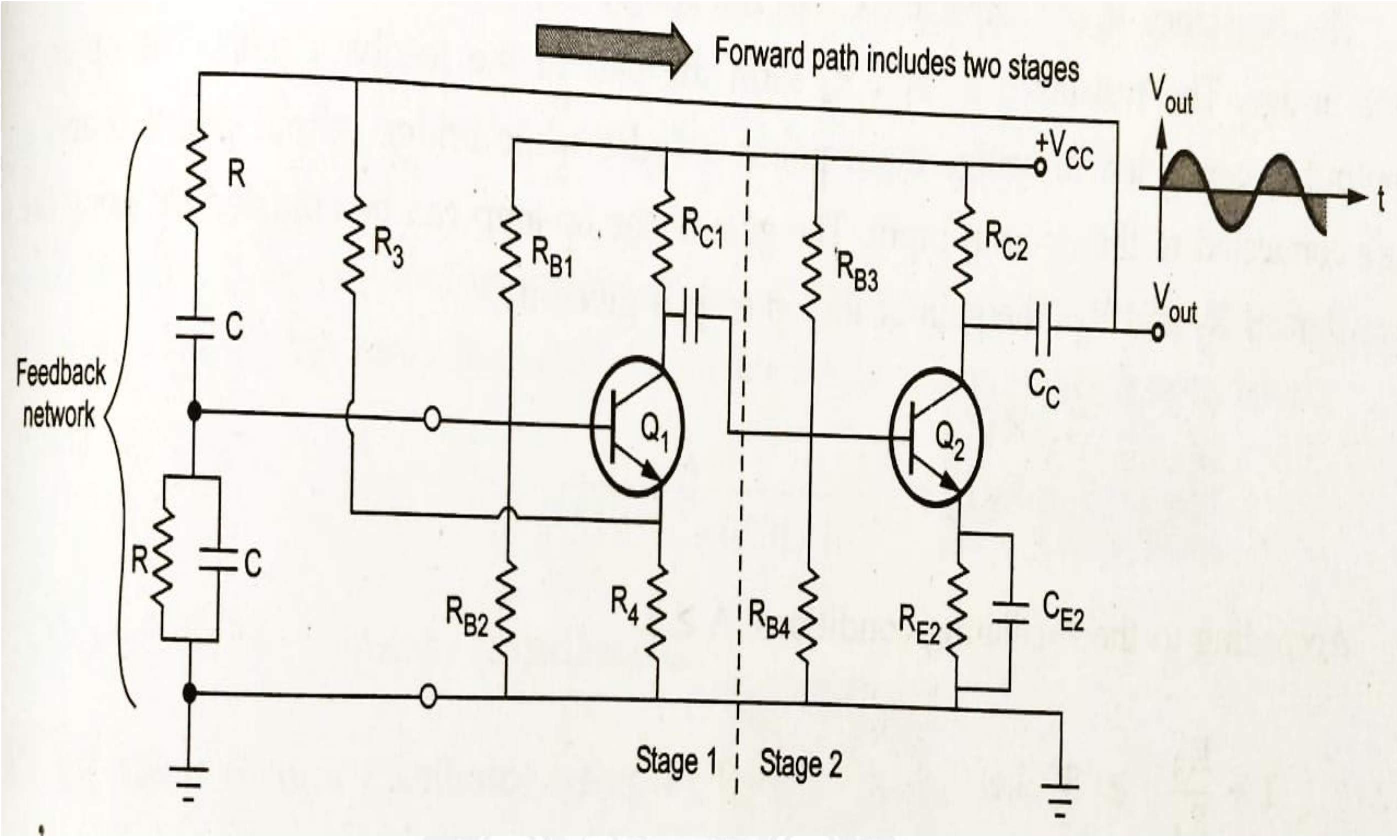
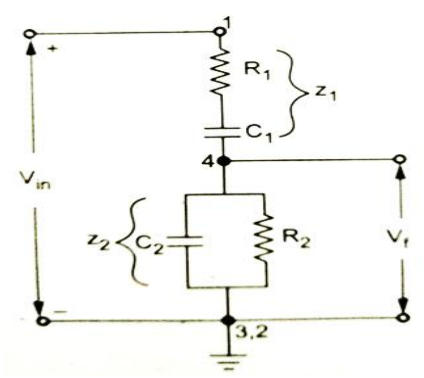


Figure: 2.3.1 wien bridge oscillator

[Source: Microelectronics by J. Millman and A. Grabel, Page-388]

- To reduce the gain, the negative feedback is used without bypassing the resistance R_4.
- The amplitude stability can be improved using a nonlinear resistor for R_4.
- Increase in the amplitude of the oscillations, increases the current through nonlinear resistance, which results into an increase in the value of non linear resistance R_4.

Derivation of wien bridge oscillator



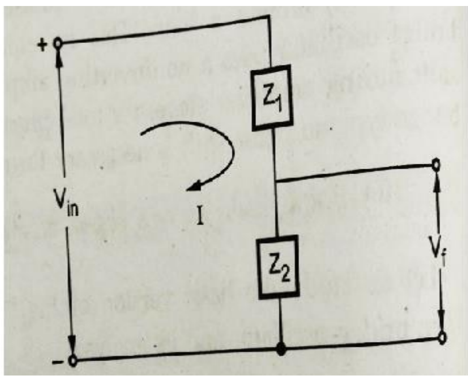


Figure: 2.3.2 feedback network of wien bridge oscillator

[Source: Microelectronics by J. Millman and A. Grabel, Page-389]

- From figure 2.3.2

$$ {}_1 = R_1 + \frac{1}{j\omega C_1} = \frac{1 + j\omega R_1 C_1}{j\omega C_1} $$

$$ {}_2 = R_2 || \frac{1}{j\omega C_2} = \frac{R_2}{1 + j\omega R_2 C_2} $$

Replaing jω = s,

$$ {}_1 = \frac{1 + sR_1 C_1}{sC_1} $$

$$ {}_2 = \frac{R_2}{1 + sR_2 C_2} $$

$$ I = \frac{V_{in}}{{}_1 + {}_2} $$

And $V_f = IZ_2$

$$ V_f = \frac{V_{in}\ {}_2}{{}_1 + {}_2} $$

$$ \beta = \frac{V_f}{V_{in}} = \frac{{}_2}{{}_1 + {}_2} $$

- Substituting the value of Z_1 and Z_2

$$ \beta = \frac{\frac{R_2}{1+sR_2C_2}}{\frac{1+sR_1C_1}{sC_1} + \frac{R_2}{1+sR_2C_2}} $$

- Replacing s by jω, $s^2 = -\omega^2$ and rationalizing simplifying the expression

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

- To have zero phase shift of the feedback network, its imaginary part must be zero

$$ \omega C_1 R_2 (1 - \omega^2 R_1 R_2 C_1 C_2) = 0 $$

$$ \omega^2 = \frac{1}{R_1 R_2 C_1 C_2} $$

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

$$ f = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}} $$

- This is the frequency of the oscillator and it shows that the components of the frequency sensitive arms are the deciding factors for the frequency.
- In practice R_1=R_2=R and C_1=C_2=C

  $= \frac{1}{2\pi RC}$; $\omega = \frac{1}{RC}$

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

- The positive sign of β indicates that the phase shift by the feedback network is 0^0

$$|A\beta| \geq 1$$

$$|A| \geq \frac{1}{|\beta|} \geq \frac{1}{\frac{1}{3}}$$

$$|A| \geq 3$$

- This the required gain of the amplifier stage without any phase shift.
- If $R_1 \neq R_2$ and $C_1 \neq C_2$ then

$$= \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$

$$\beta = \frac{C_1 R_2}{R_1 C_1 + R_2 C_2 + C_1 R_2}$$

$$A \geq \frac{R_1 C_1 + R_2 C_2 + C_1 R_2}{C_1 R_2}$$

Advantages:

1. Mounting the two capacitors on common shaft and varying their values, the frequency can be varied as per the requirement.
2. The stability high
3. The frequency range can be selected simply by using decade resistance box
4. High gain