Module - 4

Feedback

Concept of Feedback

The process of combining a fraction of output energy back to the Input is called the feedback.

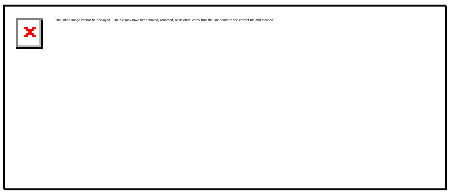
Positive and Negative feedback

When the feedback is in phase with the Input signal, it is called positive or regenerative feedback. Positive feedback causes excessive distortion and Instability.

The capability of Increasing the power of the original signal it is used in oscillator Circuits.When the feedback is inphase opposition to the Input signal, it is called Negative feedback or degenerative feedback.

Negative feedback reduces amplifier gain but it has numerous advantages (gain stability,reduction in non-linear distortion, Reduction in noise, Increase in bandwidth, Increase in Input Impendence and decrease in output Impedance) and is frequently used in amplifier circuits.

Negative feedback Amplifier



An Amplifier has a voltage gain A and output voltage V_{out} is applied to a feedback network which reduce V_{out} by a factor A to give a feedback voltage V_f, The feedback network also ensures that feedback voltage V_f is in phase opposition to Input Signal voltage V_s.

$V_{in} = V_s - Vf$

A feedback amplifier consists of two parts. An Amplifier and a feedback network is to return a fraction of the output energy to the Input of the Amplifier.

The feedback may be classified as voltage feedback and current feedback. In voltage feedback the energy feedback to the Input terminal is proportional to the Output voltage. while in Current feedback, the energy feedback to the Input terminal is proportional to the Current through load.

Both voltage and Current Can be feedback to the Input either in series or in parallel resulting in four basic feedback connections

1. **Voltage Series feedback**
2. **Voltage Shunt feedback.**
3. **Current Series feedback.**
4. **Current Shunt feedback**

Voltage refers to connecting the output voltage as input to the feedback network and current through the feedback network. Series refers to connecting the feedback signal in series with the input signal voltage and shunt refers to connecting the feedback signal in parallel with an Input Current source.

Effect of feedback on Amplifiers

For an ordinary Amplifier, (without feedback) the voltage gain equals the ratio of output voltage and input voltage.

voltage gain, $A = \frac{Vout}{Vin}$ **This gain is called open - loop gain**

Let the fraction of the output voltage V_{out} be supplied back to the Input and the open loopgain ($A = \frac{V_{out}}{Vin}$).

Now the Input voltage becomes

$$V_{in} = V_s + V_f = V_s + BV_o \text{ (Positive feedback)}$$

$$V_{in} = V_s - Vf = V_s - B\,V_o \text{ (Negative feedback)}$$

i.e $Vin = V_s \pm BVo$ (depending on whether the feedback voltage is in phase or out of phase to the Input signal voltage).

Voltage gain, $A = \frac{Vout}{Vin}$

$Vout = AVin$

Sub $Vin = Vs - BVo$ (negative feedback)

$Vout = A\,(Vs - BVo)$

$Vo = AVs - ABVo$

$Vo + ABVo = AVs$

$Vo\,(1+AB) = AVs$

$$\frac{Vo}{Vs} = \frac{A}{1+AB}$$

Voltage gain with Negative feedback , $Af = \frac{Vout}{Vs}$

$$Af = \frac{A}{1+AB}$$

Similary voltage gain with positive feedback, $Af = \frac{A}{1-AB}$

The term AB is called feedback factor where as B is known as feedback ratio.

Advantages of Negative feedback

There are numerous advantages of negative feed back

1. **Gain Stabilility**
2. **Reduced Non - linear Distortion.**
3. **Reduced Noise.**
4. **Increased Bandwidth**
5. **Increased Input Impedance.**
6. **Reduced Output Impedance.**

Explanation

1) Stabilization of Gain with Negative feedback

The variation of temperature supply voltage ageing of Components or variation in Transistor parameters with replacement are some of the factors that affects the gain of an amplifier and cause it to change. The over all gain Independent of these variations if negative feedback is used.

The voltage gain with negative feedback

$$Af = \frac{A}{1 + AB}$$

2) Feedback

Noise in an amplifier is reduced in the same way as distortion. distorition is usually Introduced in the last stage of the amplifier. The noise can be reduced by negative feedback only if its source the with in the feedback loop after the first stage.

3) Effect of Negative feedback on Gain and Bandwith

In practical amplifiers the open - loop gain drops off at higher frequencies due to the device and Circuit Capacitance.

The Amplifier with negative feedback has a larger bandwidth. Negative feedback in amplifier has indeed the effect of maintaining the gain gets reduced, the band width is Increased.

4) Effect of feedback on Impedance

1. **Input Impedance**

Effect of voltage series feedback

$$\frac{Vs}{Ii} = Zi\,(1+AB)$$

$$\therefore \ \mathbf{Zif = Zi\,(1+AB)}$$

Effect of voltage shunt feedback

$$Z_{if} = \frac{Vi}{Is} = \frac{Vi}{Ii + If}$$

$$\therefore \ \mathbf{Z_{if} = \frac{Zi}{1 + AB}}$$

Out put Impedance

Effect of voltage Series feedback

$$Z_{of} = \frac{V}{I}$$

$$Z_{of} = \frac{Zo}{1 + AB}$$

5) Stability in feedback Amplifiers

In Negative feedback, the feedback Signal is subtracted from the applied signal. The Amplifier must process a signal which is the sum of the Input and feedback signal causing the output to be become quite large

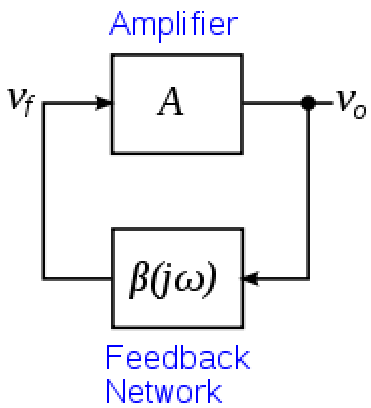
$$A_f = \frac{A}{1 + AB}$$

This unbounded Output results in a Condition called Instability, which must be avoided in feedback Amplifiers.

Oscillators

An oscillator is a type of feedback Amplifier in which part of the output is fedback to the Input via a feedback Circuit. In the signal fedback is of proper magnitude and phase, the circuit produces a periodic waveform on its output with Oscillator block Diagram only dc power supply voltage as an Input

The feedback is positive most Oscillator use positive feedback. The closed loop gain of the Amplifier is denoled by Av.



$V_d = V_f + V_{in}$

$V_o = A_v V_d$

$V_f = BV_o$

For positive feedback

$$\frac{V_o}{V_{in}} = \frac{A_v}{1 - A_v B}$$

Vin = 0 & Vo# 0

AvB =1 **This is the condition for Oscillation**.

The Two requirement for oscillation

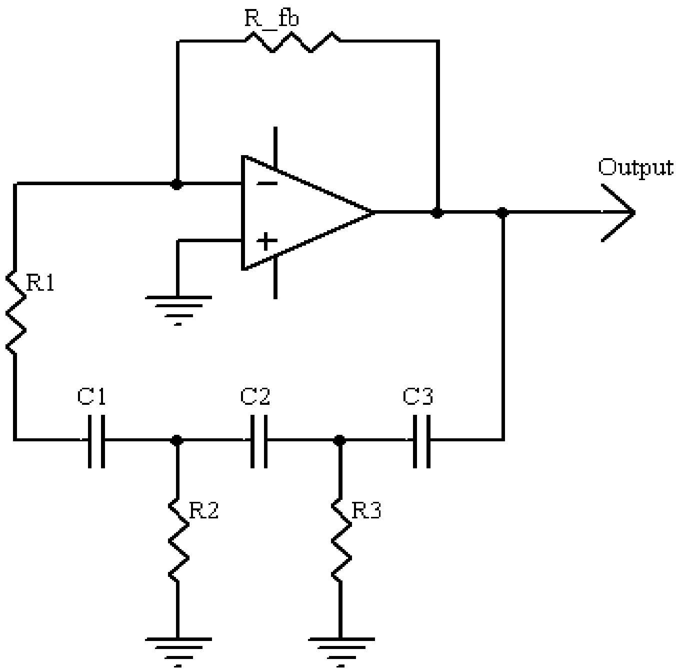
(1) The Magnitude of the loop gain AvB must be at least 1

(2)The total phase shift of the loop gain AvB must be equal to 0or 360 degree. This condition is known as **Barkhausen Condition for Oscillation**.

Frequency Stability

The ability of the Oscillator Circuit to Oscillate at one exact frequency is called **frequency stability**. A number of factors may cause change in oscillator frequency. They are Temperature change, change in the dc power supply.

RC - phase shift Oscillator



Working

The circuit consist of an op- Amp and three RC network.

The Op-amp Provides a phase shift becouse op-Amp the inverting mode configuration of 180^{o} and An Additional 180^{0} phase shift is provided by the Three RC. The feedback gain

$$B = \frac{1}{29}$$

So the circuit will Oscillate if A >29

Wein bridge Oscillator

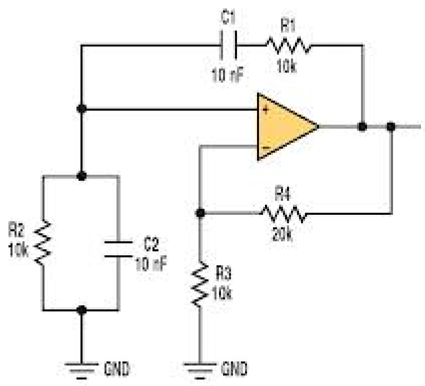


Figure 1

Working

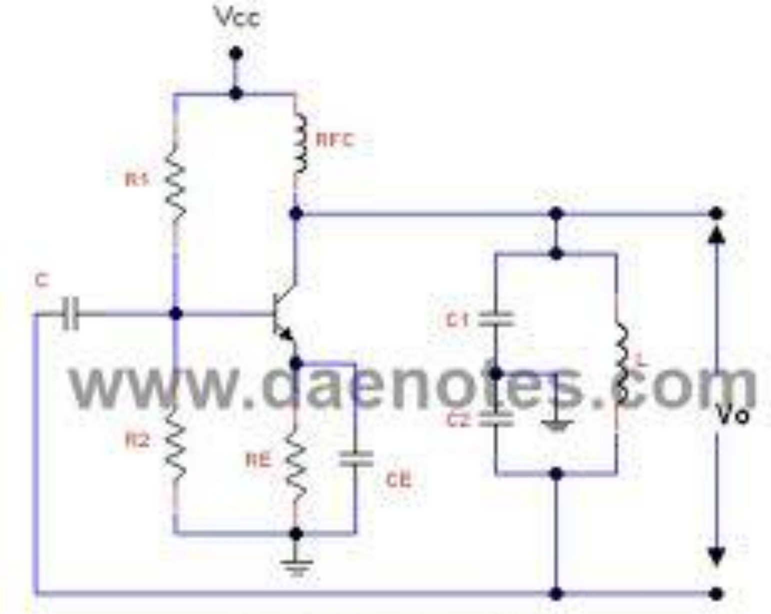
Wein bridge Oscillator can be viewed as a non inverting amplifier configuration with the Input signal fed backfrom the Output through the feedback Circuit. The Circuit to produce a sinusoidal output the phase shift around the feedback loop must be equal to unity. The frequency of Oscillation.

Oscillator with LC feedback Circuits

The RC feedback Oscillator, wein bridge Oscilltor are suitable for frequency of about 1MHz, LC feedback elements are used in oscillator that require higher frequency of oscilltion. Several typesof LC feedback Oscilaator are used

1) **Colpitts**
2) **Harteley**
3) **Crystal oscillator**.

1) Colpitts Oscillator



Colpitts Oscillator

The Oscillator uses an LC Circuit in the feedback loop to provide the necessary phase shift and to act as a Resonant filter that phases only the desired frequency of Oscillation.

The frequency of Oscillation in the resonant frequency of LC Circuit and is established by the values of C_1, C_2 and L

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

Condition for oscillation and startup

The Attenuation B of the Resonant feedback Circuit in the Colpitt's oscillator is determined by the values of C_1 and C_2.

The voltage across C_2 is the oscillator output voltage (Vout) and the voltage developed across C_1 is the feedback voltage (V_f)

$$\text{Attenuation } B = \frac{Vf}{Vout} = \frac{IX_{C1}}{IX_{C2}}$$

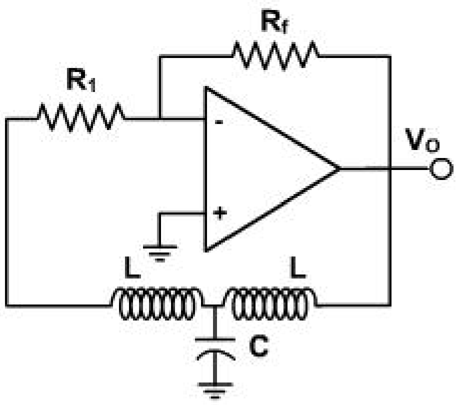
$$= \frac{X_{C1}}{X_{C2}}$$

$$B = \frac{C2}{C1}$$

The condition for oscillation AvB = 1

Hartley Oscillator

Circuit Diagram



Working

The Hartely Oscillator Consist of Two series Inductors and a parallel Capacitor.

In this Circuit, the frequency of Oscillation

The Attenuation, B of the feed back Circuit

$$B = \frac{L1}{L2}$$

To assure Start -up of oscillation Av must be greates than $\frac{1}{B}$

Crystal Controlled Oscillator

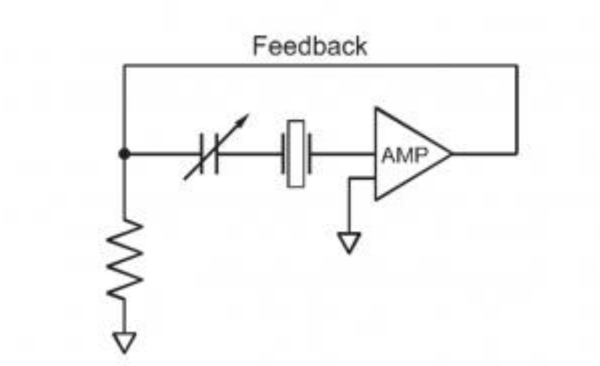
The most stable and accurate type of feedback oscillator uses a piezoelectric crystal in the feedback loop to control the frequency.

The piezoelectric Effect

When a changing mechanical stress is applied across the crystal to cause it to vibrate, a voltage develops at the frequency of mechanical vibration

eg: Quartz Crystal

When an ac voltage is applied across the Crystal it vibrates at the frequency of applied voltage.



A Great advantage of the crystal is that it exhabits a very high Q.

The Impedence of the crystal is minimum at the series resonant frequency, thus providing maximum feedback.The Fundamental frequency depends on the crystal's mechanical dimensions, type of cut. and inversely proportional to the thickness of the crystal slab

For most crystals, the upper limit is less than 20MHz. for higher frequencies the crystal must be operated in the Overtone mode.