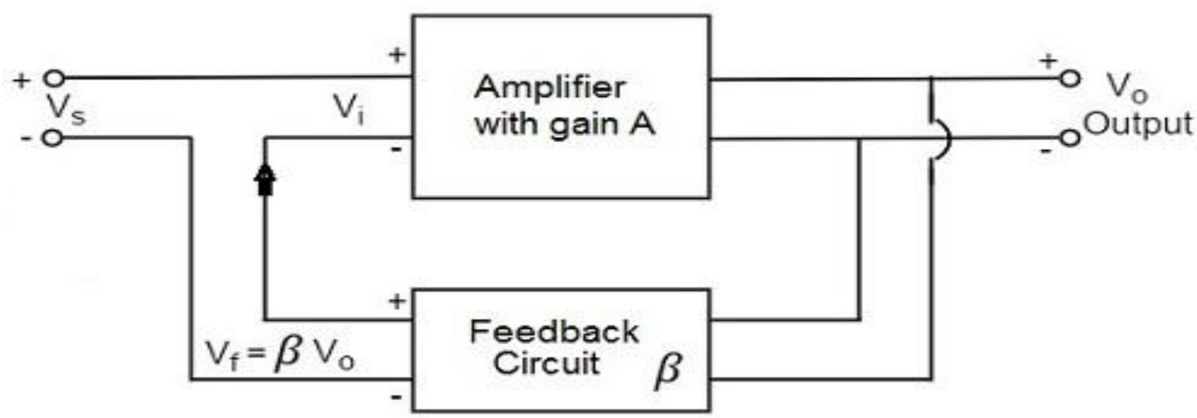
FEEDBACK AMPLIFIER

An amplifier circuit simply increases the signal strength. But while amplifying, it just increases the strength of its input signal whether it contains information or some noise along with information. This noise or some disturbance is introduced in the amplifiers because of their strong tendency to introduce hum due to sudden temperature changes or stray electric and magnetic fields. Therefore, every high gain amplifier tends to give noise along with signal in its output, which is very undesirable. The noise level in the amplifier circuits can be considerably reduced by using negative feedback done by injecting a fraction of output in phase opposition to the input signal.

PRINCIPLE OF FEEDBACK AMPLIFIER

A feedback amplifier generally consists of two parts. They are the amplifier and the feedback circuit. The feedback circuit usually consists of resistors. The concept of feedback amplifier can be understood from the following figure.



From the above figure, the gain of the amplifier is represented as A. the gain of the amplifier is the ratio of output voltage V_o to the input voltage V_i. The feedback network extracts a voltage $V_f = \beta V_o$ from the output V_o of the amplifier.

This voltage is added for positive feedback and subtracted for negative feedback, from the signal voltage V_s.

$V_i = V_s + V_f = V_s + \beta V_o$

$V_i = V_s - V_f = V_s - \beta V_o$

The quantity $\beta = V_f / V_o$ is called as feedback ratio or feedback fraction.

Let us consider the case of negative feedback. The output V_o must be equal to the input voltage $(V_s - \beta V_o)$ multiplied by the gain A of the amplifier.

Hence,

$$(V_s - \beta V_o) A = V_o$$

Or $$AV_s - A\beta V_o = V_o$$

Or $$AV_s = V_o (1+A\beta)$$

Therefore, $$\frac{\boldsymbol{Vo}}{\boldsymbol{Vs}} = \frac{\boldsymbol{A}}{\boldsymbol{1+A\beta}}$$

Let A_f be the overall gain (gain with the feedback) of the amplifier. This is defined as the ratio of output voltage V_o to the applied signal voltage V_s, i.e.,

$$A_f = \frac{Output\ Violtage}{Input\ Signal\ Voltage} = \frac{V_o}{Vs}$$

The equation of gain of the feedback amplifier, with negative feedback is given by

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

The equation of gain of the feedback amplifier, with positive feedback is given by

$$A_f = \frac{A}{1 - A\beta}$$

These are the standard equations to calculate the gain of feedback amplifiers.

TYPES OF FEEDBACKS

The process of injecting a fraction of output energy of some device back to the input is known as Feedback. It has been found that feedback is very useful in reducing noise and making the amplifier operation stable. Depending upon whether the feedback signal aids or opposes the input signal, there are two types of feedbacks used.

- **Positive Feedback**

The feedback in which the feedback energy i.e., either voltage or current is in phase with the input signal and thus aids it is called as Positive feedback. Both the input signal and feedback signal introduces a phase shift of 180^o thus making a 360^o resultant phase shift around the loop, to be finally in phase with the input signal. Though the positive feedback increases the gain of the amplifier, it has the disadvantages such as:

- Increasing distortion
- Instability

It is because of these disadvantages the positive feedback is not recommended for the amplifiers. If the positive feedback is sufficiently large, it leads to oscillations, by which oscillator circuits are formed. This concept will be discussed in oscillator's tutorial.

- **Negative Feedback**

The feedback in which the feedback energy i.e., either voltage or current is out of phase with the input and thus opposes it, is called as negative feedback.

In negative feedback, the amplifier introduces a phase shift of 180^o into the circuit while the feedback network is so designed that it produces no phase shift or zero phase shift. Thus the resultant feedback voltage V_f is 180° out of phase with the input signal V_{in}. Though the gain of negative feedback amplifier is reduced, there are many advantages of negative feedback such as

- Stability of gain is improved
- Reduction in distortion
- Reduction in noise
- Increase in input impedance
- Decrease in output impedance
- Increase in the range of uniform application

It is because of these advantages negative feedback is frequently employed in amplifiers.

AMPLIFIERS NEGATIVE FEEDBACK

Negative feedback in an amplifier is the method of feeding a portion of the amplified output to the input but in opposite phase. The phase opposition occurs as the amplifier provides 180° phase shift whereas the feedback network doesn't. While the output energy is being applied to the input, for the voltage energy to be taken as feedback, the output is taken in shunt connection and for the current energy to be taken as feedback, the output is taken in series connection.

There are two main types of negative feedback circuits. They are:

- Negative Voltage Feedback
- Negative Current Feedback

➢ NEGATIVE VOLTAGE FEEDBACK

In this method, the voltage feedback to the input of amplifier is proportional to the output voltage. This is further classified into two types:

- Voltage-series feedback
- Voltage-shunt feedback

➢ NEGATIVE CURRENT FEEDBACK

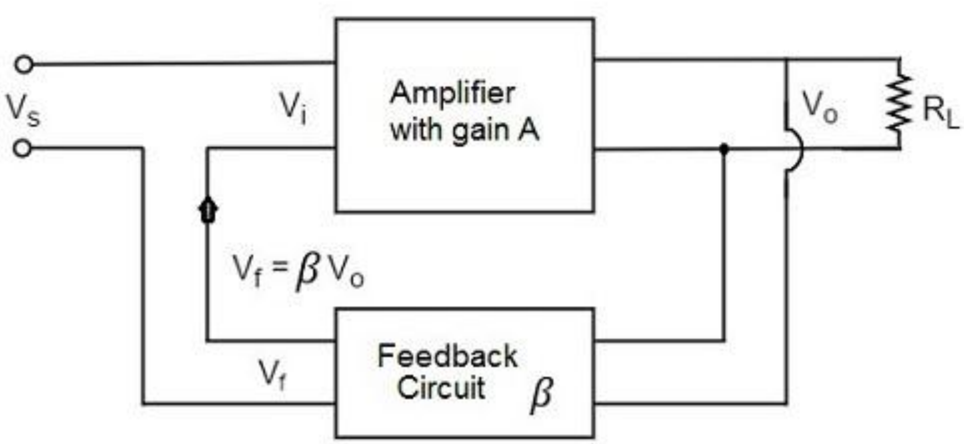
In this method, the voltage feedback to the input of amplifier is proportional to the output current. This is further classified into two types:

- Current-series feedback
- Current-shunt feedback

I. VOLTAGE-SERIES FEEDBACK

In the voltage series feedback circuit, a fraction of the output voltage is applied in series with the input voltage through the feedback circuit. This is also known as shunt-driven series-fed feedback, i.e., a parallel-series circuit.

The following figure shows the block diagram of voltage series feedback, by which it is evident that the feedback circuit is placed in shunt with the output but in series with the input.

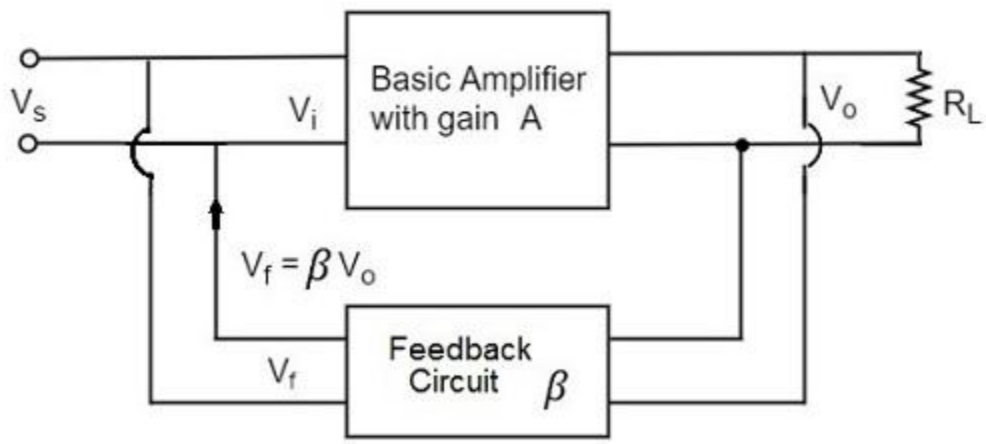


As the feedback circuit is connected in shunt with the output, the output impedance is decreased and due to the series connection with the input, the input impedance is increased.

II. VOLTAGE-SHUNT FEEDBACK

In the voltage shunt feedback circuit, a fraction of the output voltage is applied in parallel with the input voltage through the feedback network. This is also known as shunt-driven shunt-fed feedback i.e., a parallel-parallel proto type.

The below figure shows the block diagram of voltage shunt feedback, by which it is evident that the feedback circuit is placed in shunt with the output and also with the input.

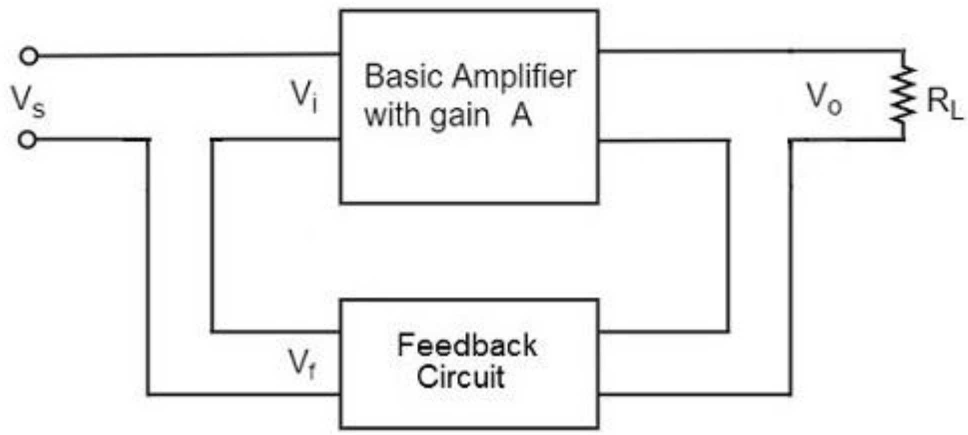


As the feedback circuit is connected in shunt with the output and the input as well, both the output impedance and the input impedance are decreased.

III. CURRENT-SERIES FEEDBACK

In the current series feedback circuit, a fraction of the output voltage is applied in series with the input voltage through the feedback circuit. This is also known as series-driven series-fed feedback i.e., a series-series circuit.

The following figure shows the block diagram of current series feedback, by which it is evident that the feedback circuit is placed in series with the output and also with the input.

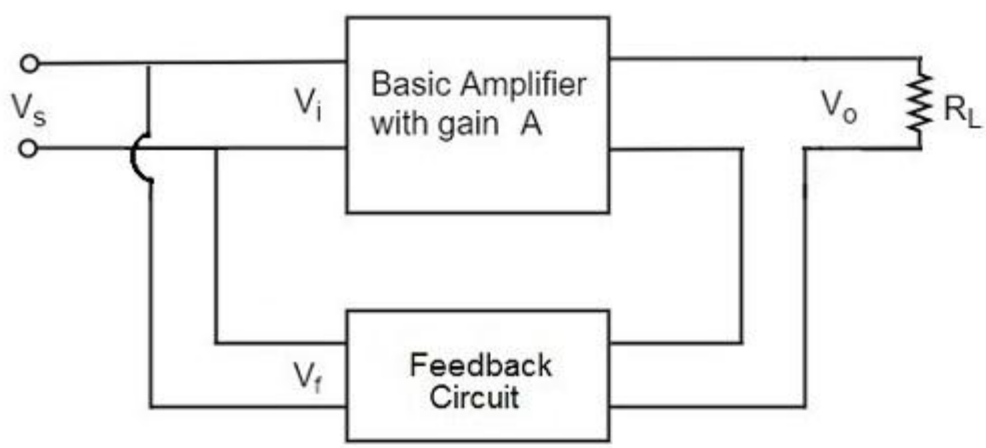


As the feedback circuit is connected in series with the output and the input as well, both the output impedance and the input impedance are increased.

IV. CURRENT-SHUNT FEEDBACK

In the current shunt feedback circuit, a fraction of the output voltage is applied in series with the input voltage through the feedback circuit. This is also known as series-driven shunt-fed feedback i.e., a series-parallel circuit.

The below figure shows the block diagram of current shunt feedback, by which it is evident that the feedback circuit is placed in series with the output but in parallel with the input.



As the feedback circuit is connected in series with the output, the output impedance is increased and due to the parallel connection with the input, the input impedance is decreased.

Negative feedback in an amplifier is the method of feeding a portion of the amplified output to the input but in opposite phase. The phase opposition occurs as the amplifier provides 180^{o} phase shift whereas the feedback network doesn't.

While the output energy is being applied to the input, for the voltage energy to be taken as feedback, the output is taken in shunt connection and for the current energy to be taken as feedback, the output is taken in series connection.

ADVANTAGES AND DISADVANTAGES

The advantages of this amplifier include the following:

- The amplifier's gain can be stabilized by the negative feedback
- The particular feedback configurations can be increased by the input resistance.
- Output resistance will be decreased for particular feedback configurations.
- The operating point is stabilized.
- The disadvantage of this amplifier is a gain reduction.

APPLICATIONS

The negative feedback amplifier applications include the following.

- Electronic Amplifiers
- RPS (regulated power supplies)
- A large bandwidth amplifiers

Thus, this is all about feedback amplifier, types, and topologies. From the above information finally, we can conclude that, when the positive feedback raises the amplifier's gain, it has some drawbacks like rising distortion as well as insecurity. Due to these drawbacks, this kind of feedback is not suggested for the amplifiers. So, when the positive feedback is adequately large, then it directs to oscillations. Similarly, when the gain of negative feedback amplifier is reduced, there will be several benefits of like Stability of gain will be improved, noise and distortion reduction, i/p impedance increment, the decrement of o/p impedance. Due to these benefits, this kind of feedback is often used in amplifiers.

As the feedback circuit is connected in series with the output, the output impedance is increased and due to the parallel connection with the input, the input impedance is decreased.

Let us now tabulate the amplifier characteristics that get affected by different types of negative feedbacks.

Feedback Topology	**Input Resistance**	**Output Resistance**
Voltage Series	Increases $R_{if} = R_i*(1+A*\beta)$	Decreases $R_{of}=R_o/(1+A*\beta)$
Current Series	Increases $R_{if} = R_i*(1+A*\beta)$	Increases $R_{of} = R_o*(1+A*\beta)$
Current Shunt	Decreases $R_{if} = R_i / (1+A*\beta)$	Increases $R_{of} = R_o*(1+A*\beta)$
Voltage Shunt	Decreases $R_{if} = R_i*(1+A*\beta)$	Decreases $R_{of}=R_o / (1+A*\beta)$