UNIT III

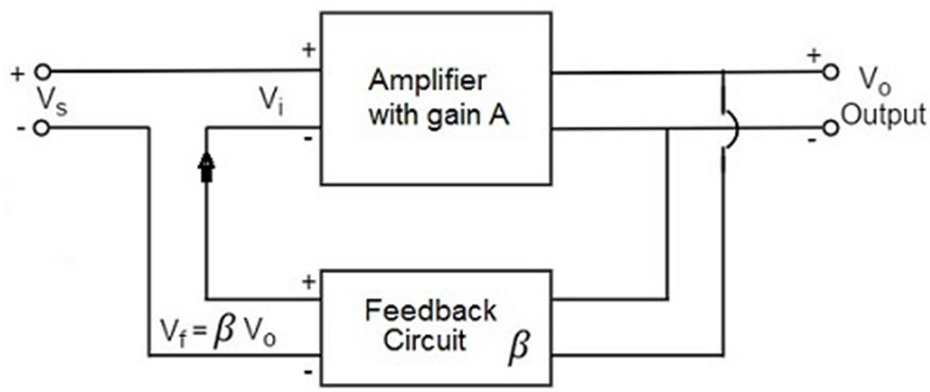
Amplifiers Feedback

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. Now,

$Vi=Vs+Vf=Vs+\beta Vo$ $Vi=Vs+Vf=Vs+\beta Vo$

$Vi=Vs-Vf=Vs-\beta Vo$ $Vi=Vs-Vf=Vs-\beta Vo$

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,

(Vs−βVo)A=Vo$(Vs-\beta Vo)A=Vo$

Or

AVs−AβVo=Vo$AVs-A\beta Vo=Vo$

Or

AVs=Vo(1+Aβ)$AVs=Vo(1+A\beta)$

Therefore,

VoVs=A1+Aβ$VoVs=A1+A\beta$

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.,

Af=OutputvoltageInputsignalvoltage=VoVs$Af=OutputvoltageInputsignalvoltage=VoVs$

So, from the above two equations, we can understand that,

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

Af=A1+Aβ$Af=A1+A\beta$

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

Af=A1−Aβ$Af=A1-A\beta$

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 OSCILLATORS 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^o 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^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.

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

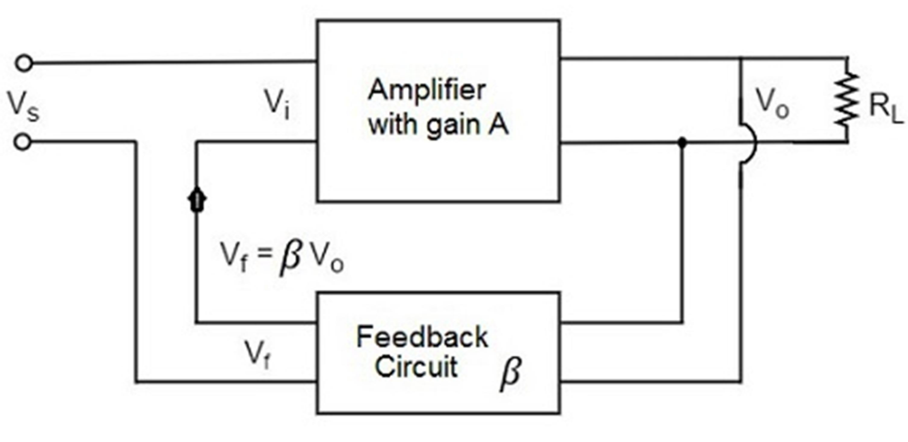
In this method, the voltage feedback to the input of amplifier is proportional to the output current. This is further classified into two types.

- Current-series feedback
- Current-shunt feedback

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.

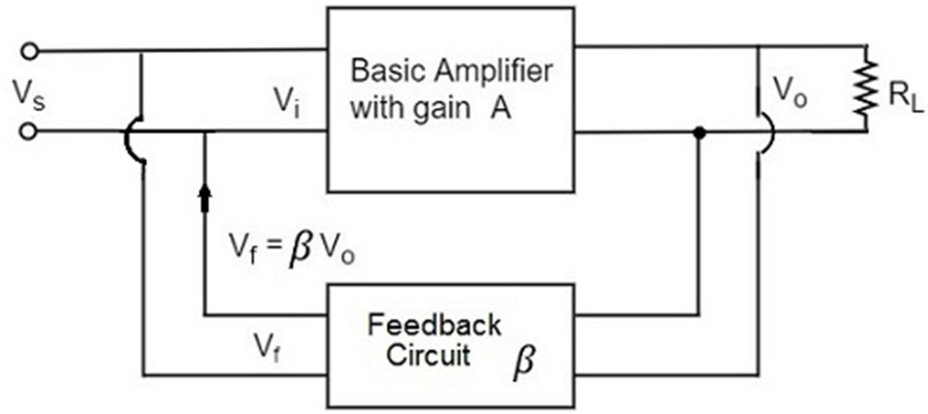


As the feedback circuit is connected in shunt with the output, the output impedance is decreased and due to the series connection with the input, the input impedance is increased.

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.

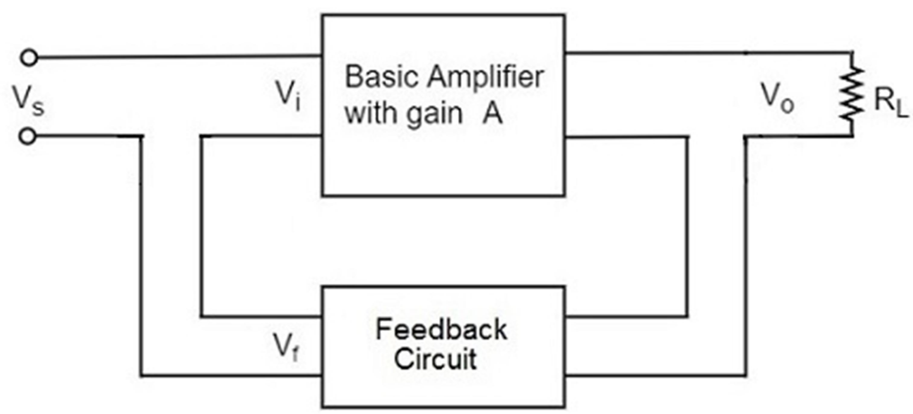


As the feedback circuit is connected in shunt with the output and the input as well, both the output impedance and the input impedance are decreased.

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.

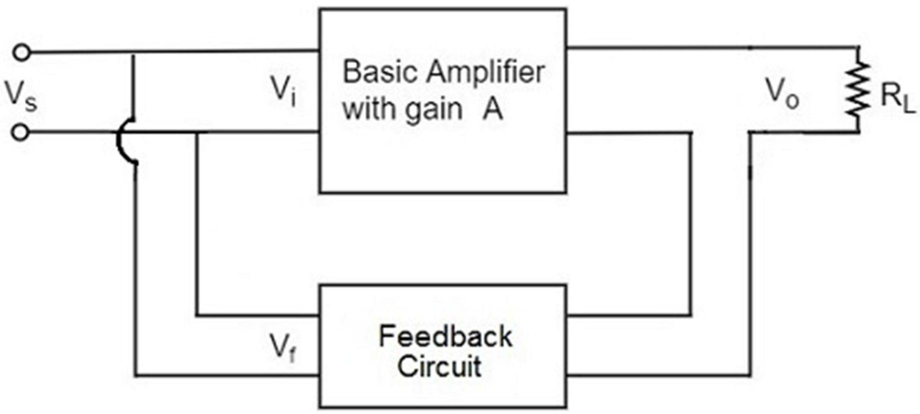


As the feedback circuit is connected in series with the output and the input as well, both the output impedance and the input impedance are increased.

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.

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

Characteristics	**Types of Feedback**			
	Voltage-Series	**Voltage-Shunt**	**Current-Series**	**Current-Shunt**
Voltage Gain	Decreases	Decreases	Decreases	Decreases
Bandwidth	Increases	Increases	Increases	Increases
Input resistance	Increases	Decreases	Increases	Decreases
Output resistance	Decreases	Decreases	Increases	Increases
Harmonic distortion	Decreases	Decreases	Decreases	Decreases

Noise	Decreases	Decreases	Decreases	Decreases

Advantages of Feedback Amplifier

- Feedback improves general stability by reducing sensitivity to shifts in component parameters.
- Negative feedback boosts the amplifier's bandwidth through extending its frequency response.
- By reducing distortion caused by harmonics, negative feedback generates a signal that is cleaner and easier to reproduce.
- Feedback makes it possible to precisely control the amplifier's gain, which facilitates achieving the intended performance.
- By maintaining an increasingly linear relationship between input and output, negative feedback improves linearity.

Disadvantages of Feedback Amplifier

- Feedback makes the circuit more complicated and difficult to fix and design.
- Feedback has the potential to amplify noise in system due to which SNR reduces.
- The cost of production is high due to complexity of circuit.
- Feedback amplifiers may have a small phase margin, which increases stability problems.
- Excessive feedback may lead to a reduction in overall gain.

Applications of Feedback Amplifier

Feedback amplifiers have various real life applications such as :

- Used in amplifiers for speakers and headphones to ensure clear and high-quality sound.
- Utilized in medical equipment like ECG ,machines to improve signal accuracy and reliability.
- Integrated in control systems for automation and robotics to regulate processes.
- Used in video amplifiers to improve the quality of signals transmitted to TVs and monitors.

- Used in testing equipment to amplify and analyse signals during circuit testing and debugging.