Amplifiers with Negative and Positive Feedback

Team 2: Energon

Presented to -
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Presenter 1

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Area Covered

1. Introduction to Amplifiers and Feedback
2. Negative Feedback Basics, Principle and Gain
3. Positive Feedback Basics and Gain of Voltage
4. Mathematical Problems
5. Advantages of Negative Feedback in Amplifiers
6. Comparison between Positive and Negative Feedback
7. Conclusion

Introduction to Amplifiers and Feedback

What is an Amplifier?

- A device that boosts weak input signals to a higher output level.
- Widely used in audio systems, communication devices, and signal processing.

Feedback in Amplifiers

- Feedback occurs when a portion of the output is returned to the input.
- Purpose: Helps control and improve amplifier performance.

Introduction to Amplifiers and Feedback

Types of Feedback

Negative Feedback:

- Reduces the overall gain of the amplifier.
- Increases stability, reduces distortion, and widens bandwidth.

Positive Feedback:

- Increases the amplifier’s gain.
- Can lead to oscillations, useful for creating oscillators in circuits.

Importance of Feedback

- Essential in designing stable and efficient amplifier circuits.
- Choice of feedback type impacts the amplifier's functionality and application.

Presenter 2

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Negative Feedback Basics

Negative feedback occurs when the feedback energy (voltage or current) opposes the input signal. This happens because the feedback signal is out of phase with the input signal.

How it Works:

- The amplifier creates a phase shift of 180° in the circuit.
- The feedback network is designed with no additional phase shift (0°), so the feedback signal is 180° out of phase with the input, effectively reducing the input signal.

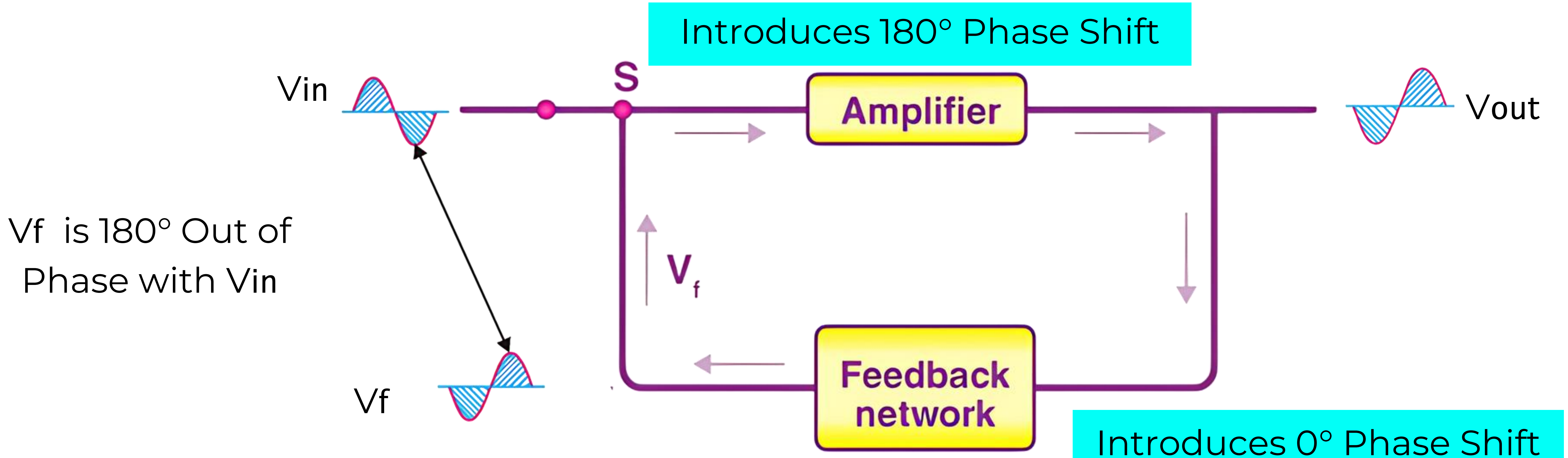

Fig. 1

Principles of Negative Voltage Feedback

In a negative voltage feedback amplifier, a portion of the output (e.g., 100 mV from a 10 V output) is fed back to the input through a feedback circuit, typically made of resistors. When combined with the input signal (101 mV), the effective input becomes 1 mV due to the negative feedback. This stabilizes the amplifier by reducing fluctuations at the input.

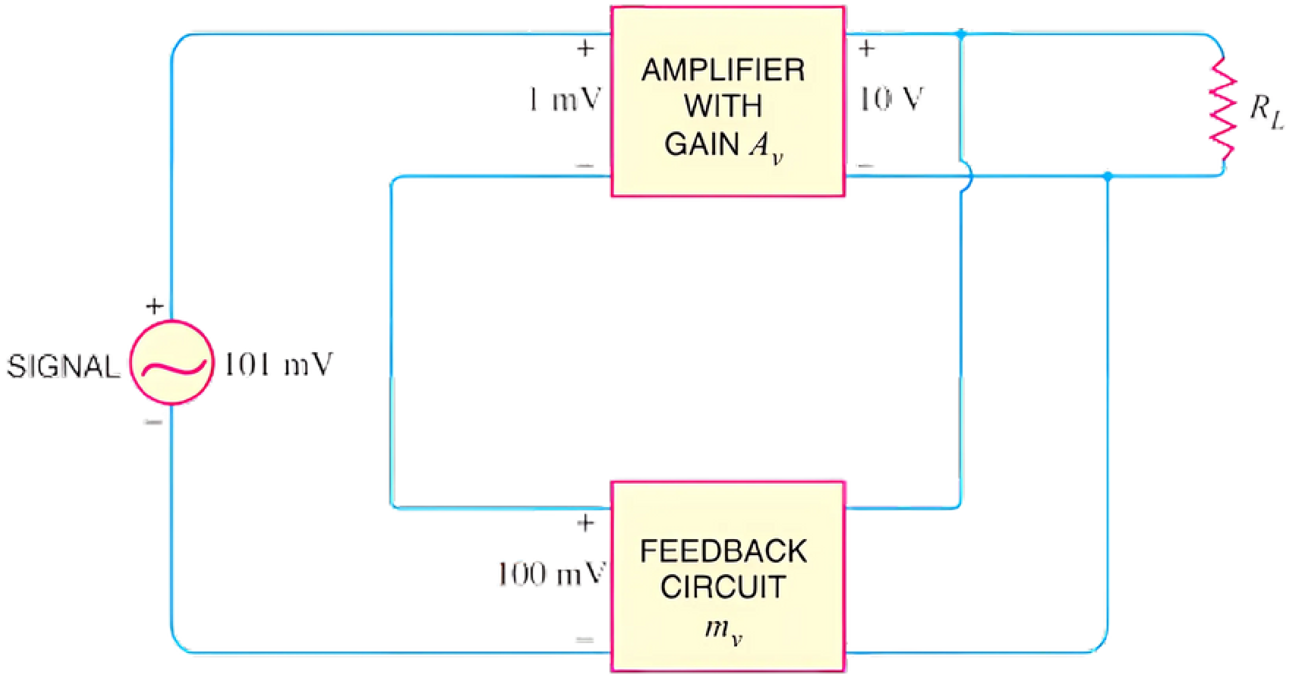

Fig. 2

Referring to Fig. 2, we have,

Gain of amplifier without feedback,

$$A_v = \frac{10\text{ V}}{1\text{ mV}} = 10{,}000$$

Fraction of output voltage feedback, $m_v = \dfrac{100\text{ mV}}{10\text{ V}} = 0.01$

Gain of amplifier with negative feedback, $A_{vf} = \dfrac{10\text{ V}}{101\text{ mV}} = 100$

Presenter 3

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Gain of Negative Voltage Feedback Amplifier

Considering the negative voltage feedback amplifier shown in the Fig. The gain of the amplifier without feedback is Av. Negative feedback is then applied by feeding a fraction mv of the output voltage e_0 back to amplifier input. Therefore, the actual input to the amplifier is the signal voltage eg minus feedback voltage mve_0

Actual input to amplifier = eg − mv e_0

The output e_0 must be equal to the input voltage eg − mv e_0 multiplied by gain Av of the amplifier -

$$(eg - mv\, e_0)\, Av = e_0$$

$$\text{or,} \quad Aveg - Avmve_0 = e_0$$

$$\text{or,} \quad e_0\,(1 + Avmv) = Aveg$$

$$\text{or,} \quad \frac{e_0}{eg} = \frac{Av}{1 + Avmv}$$

But e_0/eg is the voltage gain of the amplifier with feedback.

∴ Voltage gain with negative feedback is

$$Avf = \frac{Av}{1 + Avmv}$$

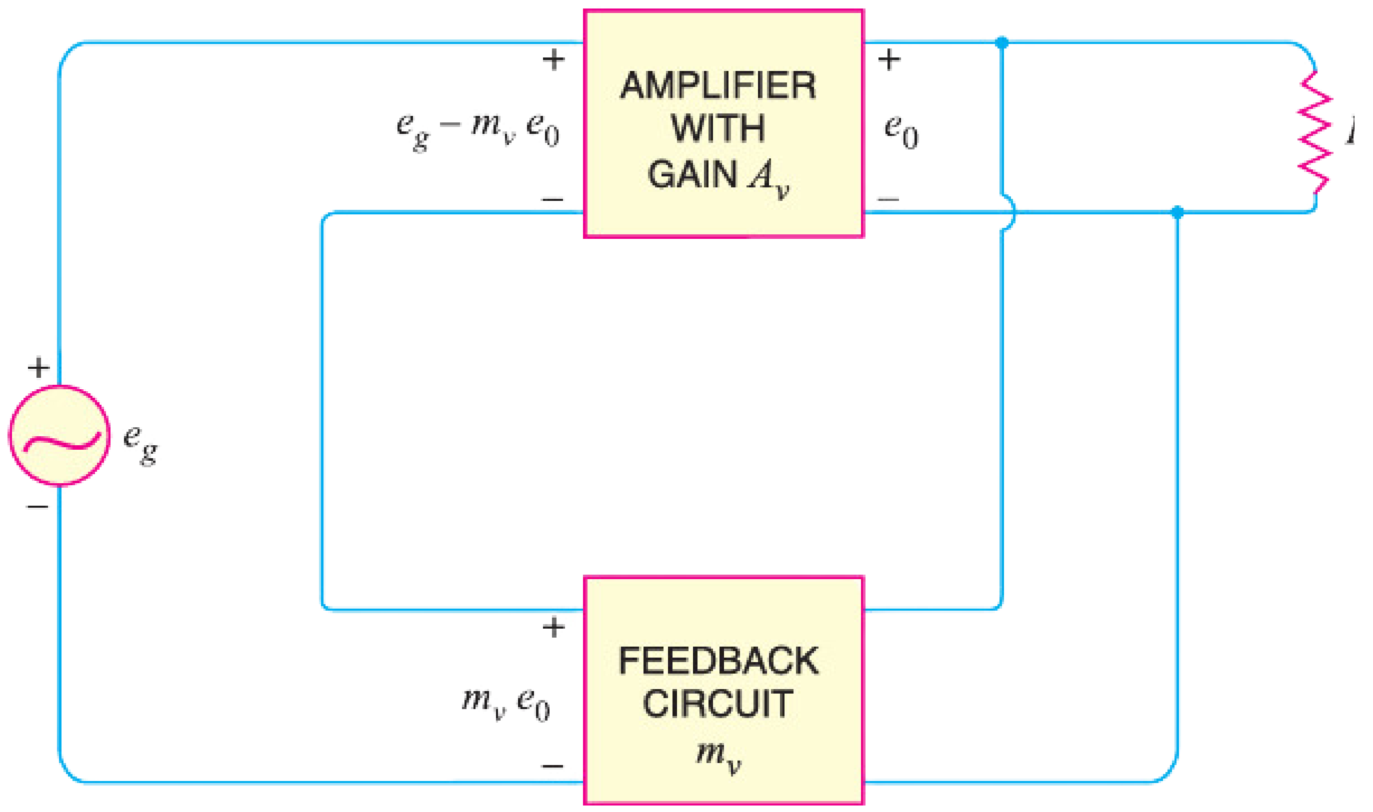

Fig. 5

Presenter 4

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Positive Feedback Basics

Positive feedback occurs when the feedback energy (voltage or current) is in phase with the input signal, reinforcing it rather than opposing it.

This in-phase feedback increases the amplifier's overall gain.

How it Works:

- When the feedback energy (voltage or current) is in phase with the input signal and thus aids it, it is called positive feedback. Both amplifier and feedback network introduce a phase shift of 180°. The result is a 360° phase shift around the loop, causing the feedback voltage Vf to be in phase with the input signal Vin

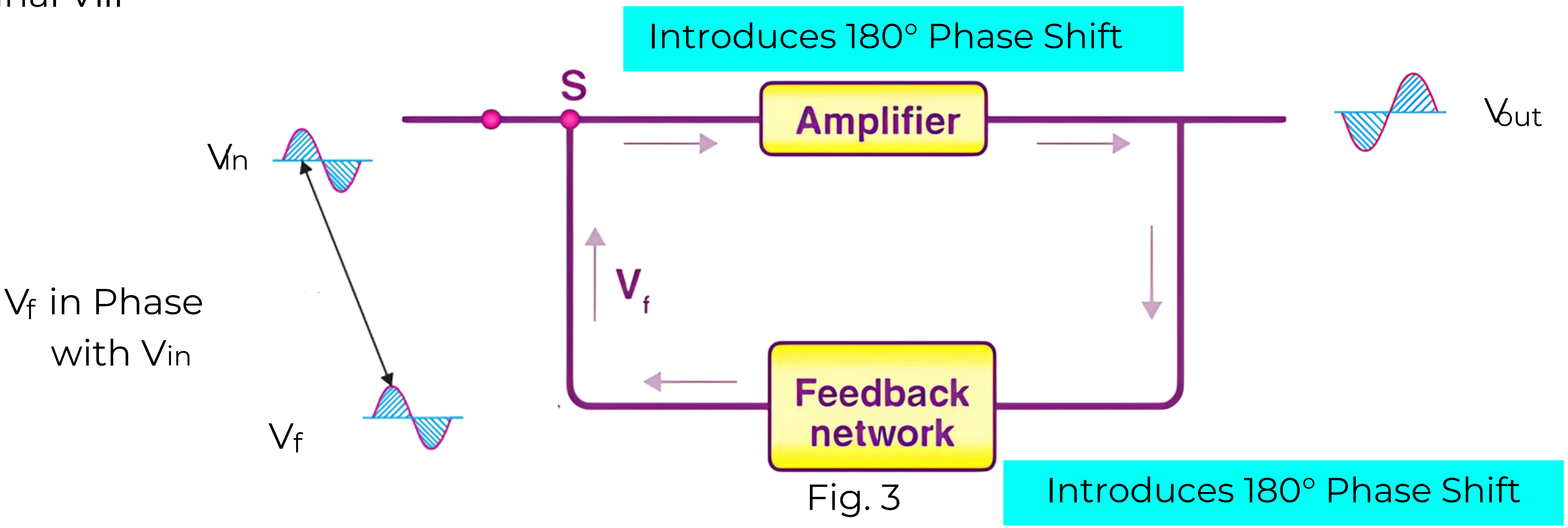

Fig. 3

Gain of Positive Voltage Feedback Amplifier

In a positive voltage feedback amplifier, a fraction (m_v) of the output (e_0) is fed back to the input, adding to the input signal (eg). This reinforces the input, increasing the overall gain of the amplifier.

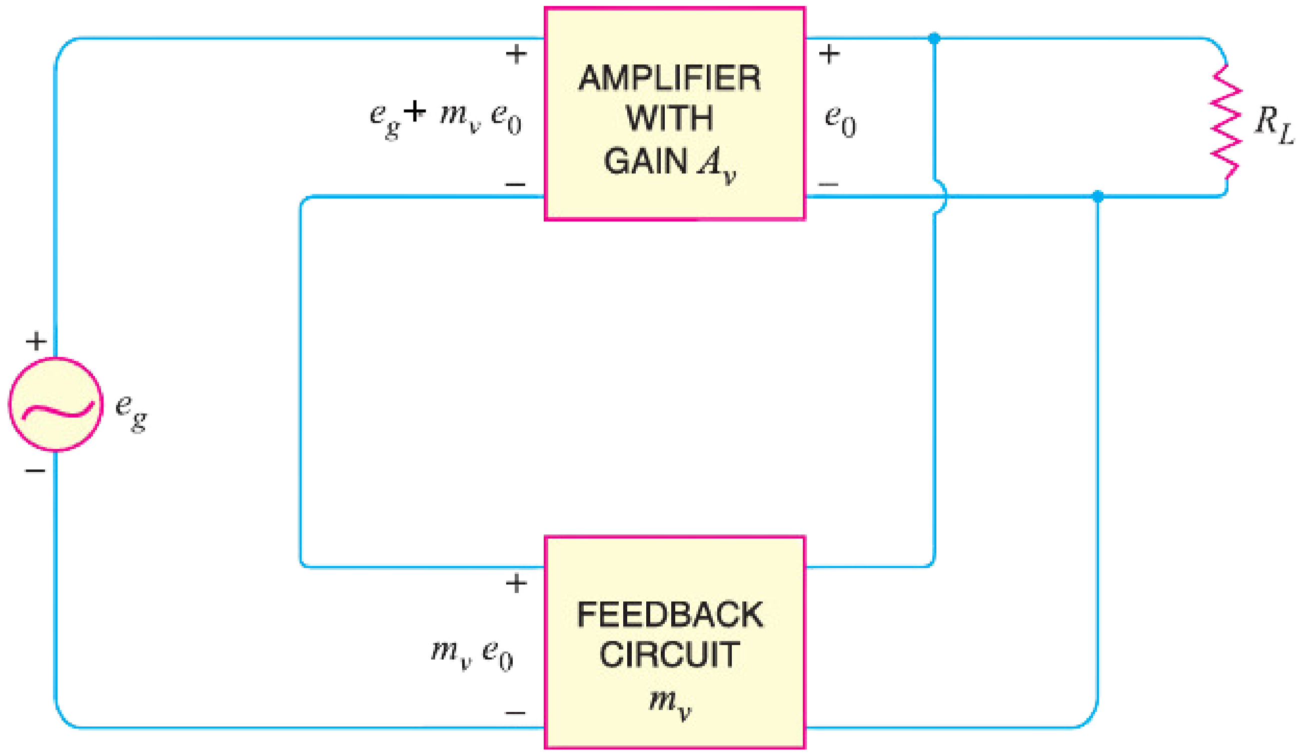

Fig. 4

Actual input to amplifier = $e_g + m_v e_0$

The output e_0 must be equal to the input voltage $e_g + m_v e_0$ multiplied by gain A_v of the amplifier -

$$(e_g + m_v e_0) A_v = e_0$$

or, $A_v e_g + A_v m_v e_0 = e_0$

or, $e_0 (1 - A_v m_v) = A_v e_g$

or, $$\frac{e_0}{e_g} = \frac{A_v}{1 - A_v m_v}$$

But e_0/e_g is the voltage gain of the amplifier with feedback.

∴ Voltage gain with negative feedback is

$$A_{vf} = \frac{A_v}{1 - A_v m_v}$$

Presenter 5

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Mathematical Problems

Example 1. The overall gain of a multistage amplifier is 140. When negative voltage feedback is applied, the gain is reduced to 17.5. Find the fraction of the output that is fedback to the input.

Solution.

$$A_v = 140, \quad A_{vf} = 17.5$$

Let m_v be the feedback fraction. Voltage gain with negative feedback is

$$A_{vf} = \frac{A_v}{1 + A_v m_v}$$

or $$17.5 = \frac{140}{1 + 140\, m_v}$$

or $$17.5 + 2450\, m_v = 140$$

$\therefore$ $$m_v = \frac{140 - 17.5}{2450} = \mathbf{\frac{1}{20}}$$

Mathematical Problems

Example 2. An amplifier has a voltage gain of 500 without feedback. If a negative feedback is applied, the gain is reduced to 100. Calculate the fraction of the output fed back. If, due to ageing of components, the gain without feedback falls by 20%, calculate the percentage fall in gain with feedback.

Solution.

$$A_v = 500 \; ; \; A_{vf} = 100 \; ; \; m_v = ?$$

$$A_{vf} = \frac{A_v}{1 + A_v m_v}$$

or $$100 = \frac{500}{1 + 500\, m_v}$$

$\therefore$ $$m_v = \mathbf{0.008}$$

Now $$A_v = \frac{80}{100} \times 500 = 400 \; ; \; m_v = 0.008 \; ; \; A_{vf} = ?$$

$$A_{vf} = \frac{A_v}{1 + A_v m_v} = \frac{400}{1 + 400 \times 0.008} = \frac{400}{4.2} = 95.3$$

$\therefore$ $$\%\text{ age fall in } A_{vf} = \frac{100 - 95.3}{100} \times 100 = \mathbf{4.7\%}$$

Presenter 6

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Advantages of Negative Feedback in Amplifiers

1. **Gain Stability:** Maintains a stable gain despite variations in transistor parameters or supply voltage.
2. **Reduces Non-Linear Distortion**: Decreases distortion in large-signal amplifiers by a factor of 1 + Avmv.
3. **Improves Frequency Response:** Keeps voltage gain steady across a range of frequencies, enhancing frequency response.
4. **Increases Circuit Stability:** Stabilizes output against changes in temperature, frequency, and amplitude.
5. **Increases Input Impedance & Decreases Output Impedance:** Facilitates impedance matching, benefiting practical applications.

Presenter 7

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Comparison between Positive and Negative Feedback

Aspect	Negative Feedback	Positive Feedback
Phase Relationship	Feedback signal is out of phase with the input signal (opposes it).	Feedback signal is in phase with the input signal (reinforces it).
Effect on Gain	Reduces overall gain but increases stability and accuracy.	Increases gain and can lead to oscillations if uncontrolled.
Stability	Improves stability and reduces sensitivity to component changes.	Can reduce stability, often leading to oscillations; useful in oscillators.
Distortion and Noise	Reduces distortion and filters noise; ideal for high-fidelity applications.	Can increase distortion; not typically used where clean signal output is critical.
Typical Applications	Used in audio amplifiers, control systems, and op-amp circuits for stable gain.	Applied in oscillators, Schmitt triggers, and RF amplifiers for signal generation.

Conclusion

Feedback Types:

- **Negative Feedback:** Reduces gain, stabilizes performance, and lowers distortion.
- **Positive Feedback:** Increases gain, used for oscillations and signal shaping.

Key Points:

- **Negative Feedback:** Ideal for stable, high-quality output.
- **Positive Feedback:** Useful in circuits needing oscillation, like oscillators and triggers.

Real-World Impact:

- Feedback amplifiers are essential in audio, communications, and control systems.

Thank You