Electronics II

Lecture 22
Oscillators I

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Previous Lecture

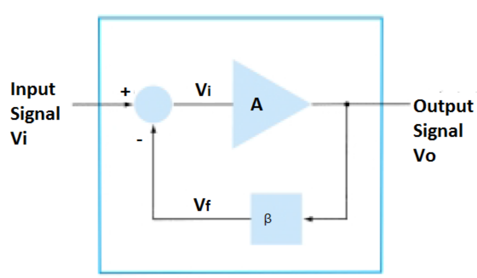
- Classic Filter Functions
  - Butterworth.
  - Chebyshev I & II.
  - Elliptic.
  - Bessel.

Session Overview

Topic	Oscillators.
Concepts	Positive Feedback, Negative Feedback, Oscillators, Barkhausen Criterion, RC Phase Shift Oscillator.
Recommended Reading	Section 17.1, 17.2 & 17.5 of [1]. Section 12-3 of [2].
Keywords	Feedback, Amplifiers, Oscillators, Positive Feedback, Negative Feedback, Oscillator, Barkhausen, Loop Gain, RC Phase Shift.

Feedback

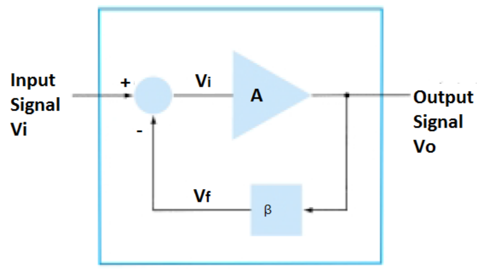
- Feedback is *'returning a portion of the output signal to the input so as to change the performance characteristics of the device'*.
- There are two types of feedback, depending upon the relative polarity of the of the signal being fed back.
  - Negative Feedback.
  - Positive Feedback.
- Negative Feedback
  - When the feedback causes the changes to reduce, it is referred to as the negative feedback. For amplifiers with negative feedback, the gain reduces as a result of feedback.
- Positive Feedback
  - Positive feedback drives a circuit into oscillations.



Robert L. Boylestad, *Electronic Devices and Circuit Theory*, 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.

Negative Feedback

- If the feedback signal is of opposite polarity to the input signal, the feedback is termed as *'negative feedback'*.
- With the negative feedback certain improvements are achieved which include
  - Higher Input Impedance.
  - Better Stabilized Voltage Gain.
  - Improved Frequency Response.
  - Lower Output Impedance.
  - Reduced Noise.
  - More Linear Operation.
- Negative feedback reduces the overall voltage gain.
- For amplifiers, negative feedback is used.



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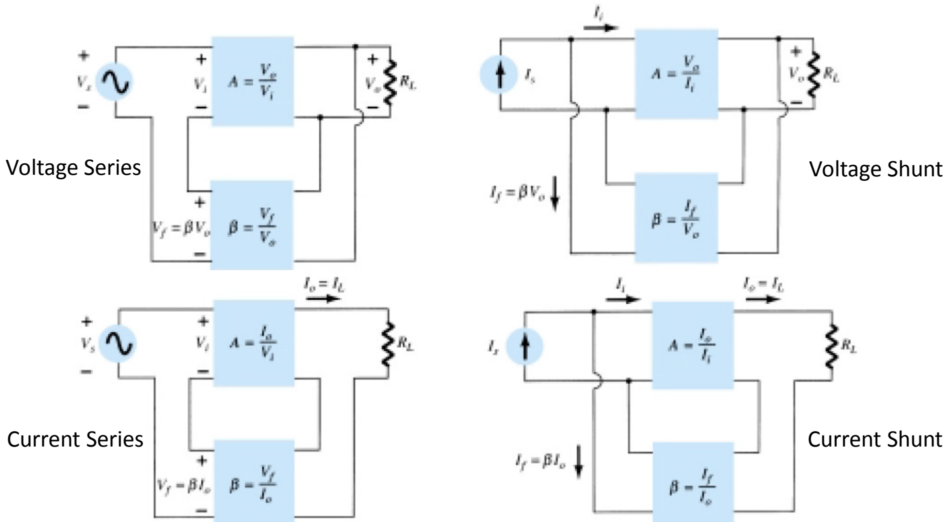
Feedback Connection Types

- There are four basic types of feedback connection depending upon the feedback parameter and connection topology.
- These types include
  - Voltage Series Feedback.
  - Voltage Shunt Feedback.
  - Current Series Feedback.
  - Current Shunt Feedback.
- Feedback voltage refers to the output voltage as input to the feedback.
- Feedback current refers to tapping off some output current the feedback network.
- Series refers to connecting the feedback signal in series with the input signal voltage.
- Shunt refers to connecting the feedback signal in parallel with an input current source.
- Series feedback tends to increase the input resistance, while shunt feedback decreases the input resistance.
- Voltage feedback tends to decrease the output impedance while current feedback tends to increase the output impedance.
- Which one of the four types is preferred and why?

Feedback Connection Types



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Gain with Feedback

TABLE 18.1 Summary of Gain, Feedback, and Gain with Feedback from Fig. 18.2

		Voltage-Series	*Voltage-Shunt*	*Current-Series*	*Current-Shunt*
Gain without feedback	A	$\frac{V_o}{V_i}$	$\frac{V_o}{I_i}$	$\frac{I_o}{V_i}$	$\frac{I_o}{I_i}$
Feedback	β	$\frac{V_f}{V_o}$	$\frac{I_f}{V_o}$	$\frac{V_f}{I_o}$	$\frac{I_f}{I_o}$
Gain with feedback	A_f	$\frac{V_o}{V_s}$	$\frac{V_o}{I_s}$	$\frac{I_o}{V_s}$	$\frac{I_o}{I_s}$

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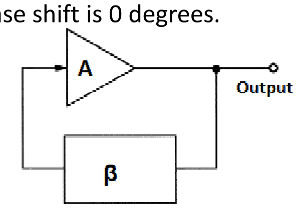
Oscillator Operation

- A device which generates a periodic ac output signal without any form of input signal.
- Oscillator is a term mostly used for sine-wave signal generator whereas a square wave generator is usually termed as a multi-vibrator.
- Desirable features of a sine wave oscillator are
  - Low distortion sinusoidal waveform
  - Adjustable frequency range.
- Oscillation is a form of instability caused by feedback that reinforces a signal that would diminish otherwise due to energy loss.
- For this feedback to be regenerative, there are certain amplitude and phase conditions that must be fulfilled.
- Oscillators are designed with the known feedback characteristics.

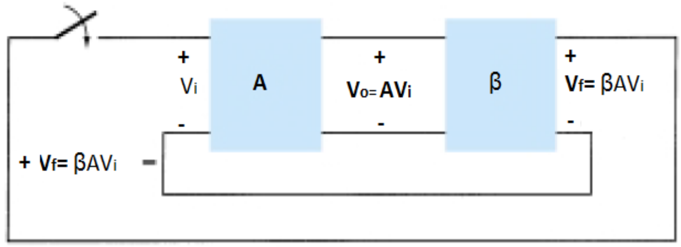
The Barkhausen Criterion

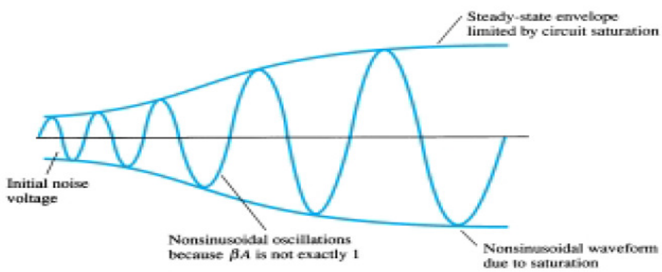
- In the block diagram, A is the amplifier gain while β is the feedback gain.
- In order to make the given system work as an oscillator, the loop gain must satisfy the Barkhausen criterion which is
  - $|A\beta| = 1$.
- It is also important to note that not only the gain magnitude must be unity but the in phase signal reinforcement must also occur.
- Reactive elements especially the capacitors cause the shift in the gain magnitude and phase shift in amplifiers/ oscillators as a function of frequency.
- In general, there exists only one frequency at which the gain magnitude is unity and total phase shift is 0 degrees.



Theodore F. Bogart, Jeffery S. Beasley, Guilermo Rico, Electronics Devices and Circuits, 6th Edition, Pearson Education Inc, ISBN: 978-81-775-8887-3

Oscillator Function





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The Barkhausen Criterion

- *Example 12-5 (Bogart):* The gain of a certain amplifier as a function of frequency is A(jw)= -16x 10^6 /jw. A feedback path connected around it has β(jw)= $10^3/(2\text{x}10^3+ jw)^2$. Will the system oscillate? If so, at what frequency.

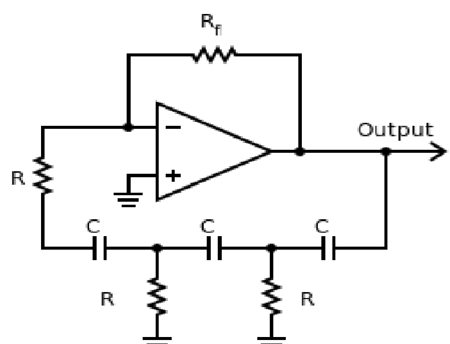
  Solution:

Types of Oscillators

- Four basic oscillator configurations will be covered which include
  - RC Phase Shift Oscillator.
  - Wien Bridge Oscillator.
  - Collpits Oscillator.
  - Hartley Oscillator.

RC Phase Shift Oscillator

- RC phase shift oscillator is the simplest oscillator using an op-amp in the inverting configuration (180^0 phase shift).
- The op-amp drives three cascaded RC sections with 180^0 phase shift. Thus the total phase shift around the loop is 360^0.
- An important point here is that the total phase shift by three cascaded RC sections is equal to 180^0.
- The loss in the RC network is compensated by the op-amp gain that is vo/vi= - (R_f/R).



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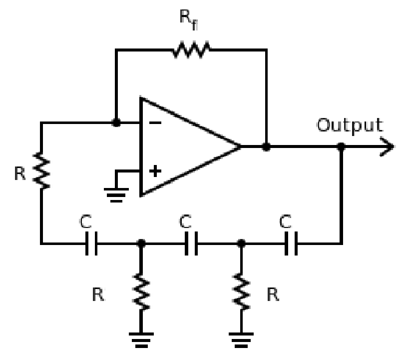
RC Phase Shift Oscillator

- $\beta = R^3/[\,(R^3 - 5RX_C^2) + j(X_C^3 - 6R^2X_C)\,]$

- $f_o = 1/\,2\pi RC\sqrt{6}$

- $R_f/R_1 = 29$



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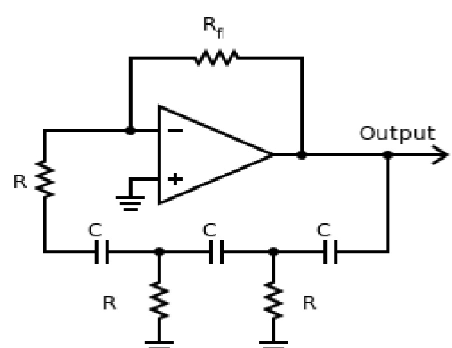
RC Phase Shift Oscillator

- *Example 12-6 (Bogart):* Design an RC Phase shift oscillator capable of oscillation at 100Hz.



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Next Lecture

- The next lecture will cover the following topics
  - Wien Bridge Oscillator.
  - Collpits Oscillator.
  - Hartley Oscillator.
  - Oscillator Applications.

References

[1] Robert L. Boylestad, *Electronic Devices and Circuit Theory,* 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.

[2] Theodore F. Bogart, Jeffery S. Beasley, Guilermo Rico, Electronics Devices and Circuits, 6th Edition, Pearson Education Inc, ISBN: 978-81-775-8887-3