

Research Migration Project

<https://esim.fossee.in/research-migration-project>



The Research Migration Project is an initiative of FOSSEE, IIT Bombay that promotes the use of eSim for reproducing published research circuits originally implemented using proprietary simulation tools. The objective is to migrate these validated designs to eSim to build an open source resource database.

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Title of the circuit: *Amplitude-Stabilized Wien Bridge Oscillator Using AGC*

Theory/Description: The circuit is a Wien bridge sine wave oscillator with automatic gain control (AGC) implemented using an operational amplifier. The Wien bridge network, consisting of a series RC and parallel RC combination, provides frequency-selective positive feedback and determines the oscillation frequency, which is given by

$$f_0 = \frac{1}{2\pi RC}$$

At the oscillation frequency, the bridge produces zero phase shift and an attenuation factor of one-third. To satisfy the Barkhausen criterion for sustained oscillations, the amplifier gain is set slightly greater than three during startup.

Amplitude stabilization is achieved using a nonlinear AGC loop formed by a diode, a JFET, and an RC smoothing network. During startup, excess loop gain allows oscillations to build up. As the output amplitude increases, the diode conducts and charges the AGC capacitor, altering the JFET's channel resistance. This increases negative feedback, reducing the effective gain until the loop gain stabilizes at unity, thereby producing a steady-state sinusoidal output with controlled amplitude.

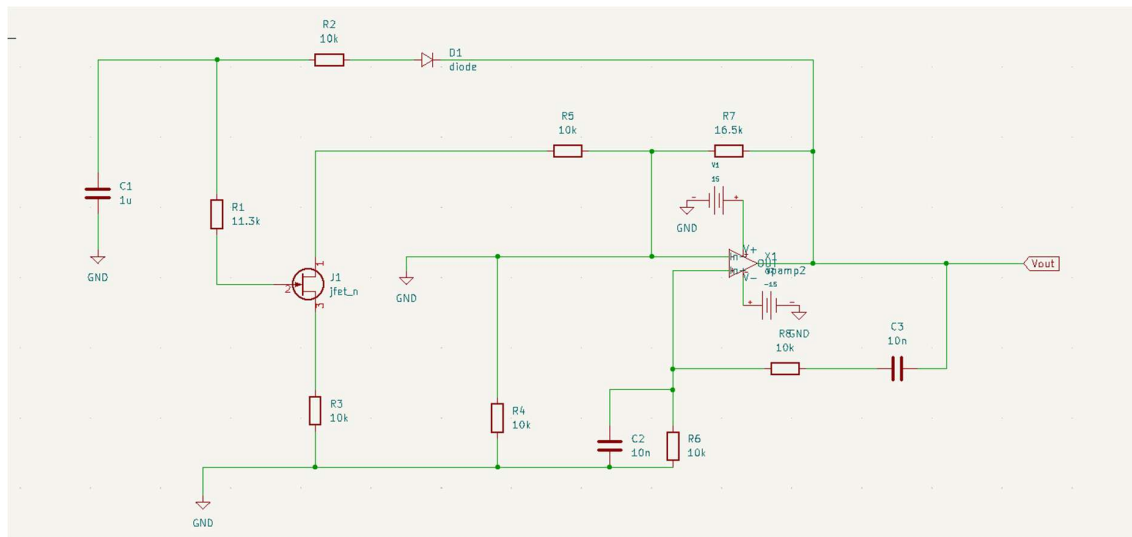
The operational amplifier provides the necessary loop gain and phase characteristics, while the RC components define the oscillation frequency and stability. When powered from a split supply, the circuit operates around ground reference, producing a symmetric sinusoidal output.

Reason to reproduce with eSim: The circuit is well suited for simulation and reproduction using eSim due to its use of standard analog components and clear theoretical foundation. As an open-source EDA platform, eSim allows easy verification of oscillation frequency,

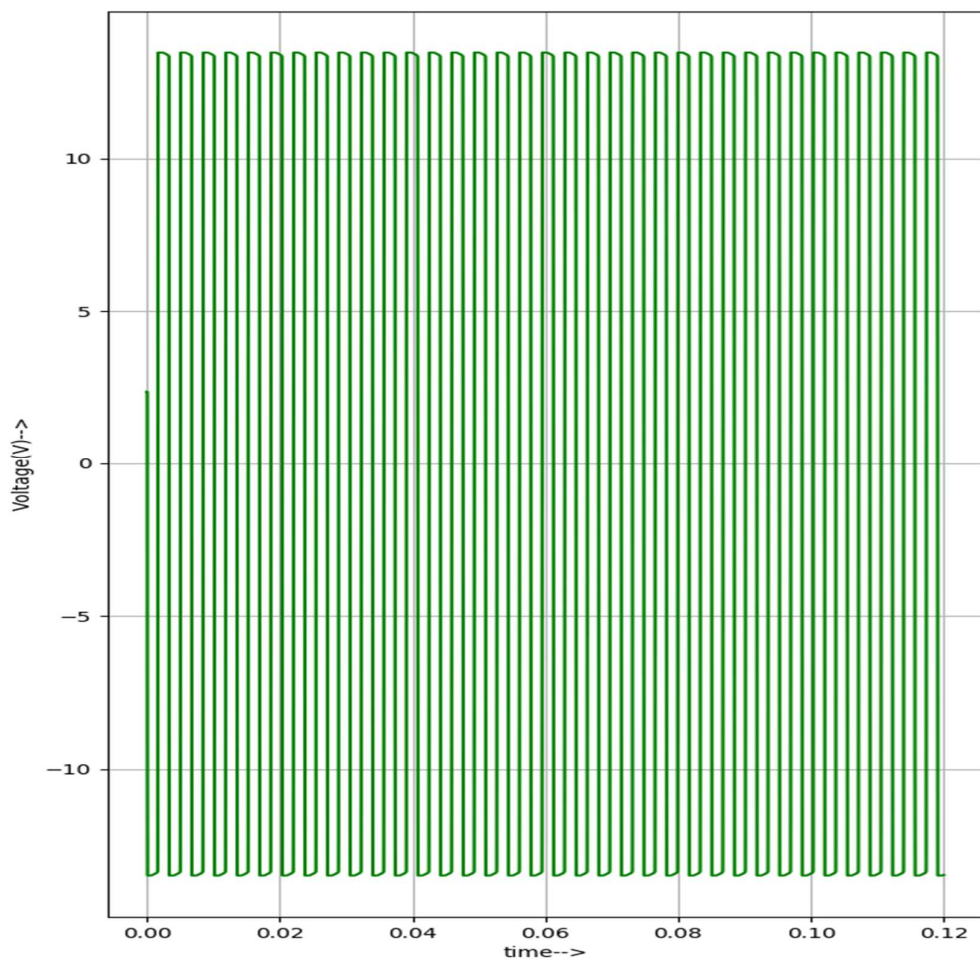
amplitude stability, and transient behaviour. The design provides strong educational value by demonstrating practical concepts such as feedback, frequency-selective networks, and automatic gain control, while also enabling further optimization and modification within the simulation environment.

Expected Outcome/outputs: Upon simulation or implementation, the circuit is expected to generate a stable sinusoidal waveform at approximately 1.6 kHz, as determined by the Wien bridge RC network. During startup, a transient increase in amplitude is observed, followed by stabilization due to the action of the automatic gain control loop. The steady-state output exhibits a near-sinusoidal waveform with minor amplitude limiting, indicating effective gain stabilization. Circuit performance can be validated by measuring the oscillation frequency, observing waveform symmetry, and confirming amplitude stability over time.

Circuit Diagram(s):



Expected Results: The circuit operates without an external input signal and self-generates oscillations due to positive feedback. The simulated output waveform is a near-sinusoidal signal with a frequency of approximately 1.6 kHz, as defined by the Wien bridge RC network. During startup, a transient offset and amplitude growth are observed, after which the waveform stabilizes due to the action of the automatic gain control circuit. The steady-state output voltage is centred around ground (for split-supply operation) and exhibits stable peak amplitude with minor flattening at the waveform extremes, indicating controlled gain and steady oscillation.



Research Paper:

Title: Design of an Amplitude-Stable Sine-Wave Oscillator

Author: B.J. Shekan

Page No.: 312–315

Link: <https://ieeexplore.ieee.org/document/1049913>

Source/Reference(s) :

1. Texas Instruments, *“Sine Wave Oscillator”*
Texas Instruments Application Report.
 2. Ramakant A. Gayakwad, *“Op-Amps and Linear Integrated Circuits,”*
Pearson Education - Chapter on sinusoidal oscillators.
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