Physics 173 / BGGN 266 Primer on Nonlinear OpAmp Circuits
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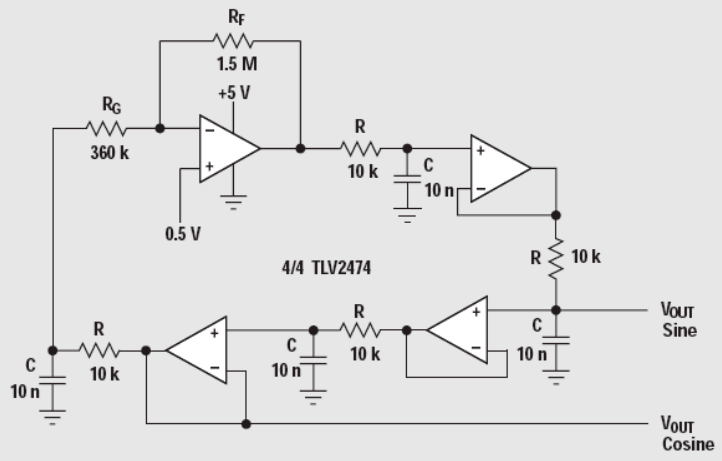
Simple Oscillator

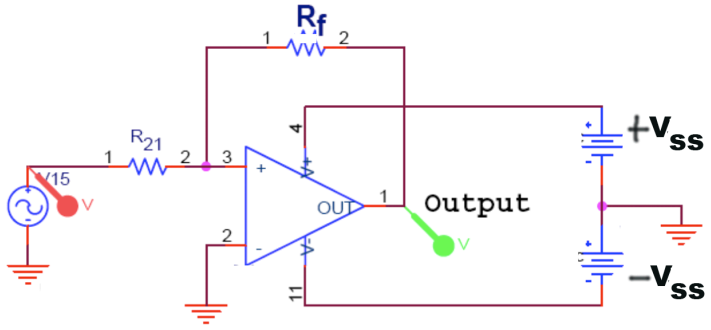
This is a phase-shift oscillator. Four RC sections require 45° phase shift per section to reach a total, unstable shift of 180°. The total gain, R_F/R_G, must be sufficiently large to counter the collective loss from each RC divider or else the positive feedback is tool weak for an oscillation to occur. In particular, we want $R_F/R_G > (1/\sqrt{2})^{-4} = 4$. Rather than have all of the gain in one step, as below, it can be distributed across each OpAmp.



Schmitt Trigger

With positive feedback, Op-Amp circuits lose stability. The Schmitt trigger is one of them. **Here**, the input voltage that causes a transition of the output from $-V_{SS}$ to $+V_{SS}$ (or *vice versa*) is $|V_{trans}| = \frac{R_{12}}{R_f}|V_{ss}|$. Thus positive inputs must exceed $\frac{R_{12}}{R_f}|V_{ss}|$ and negative inputs must be smaller than $-\frac{R_{12}}{R_f}|V_{ss}|$.

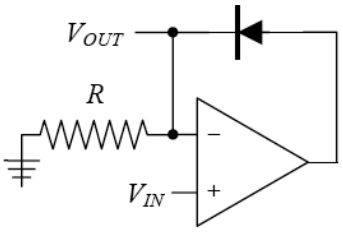
Schmitt Trigger



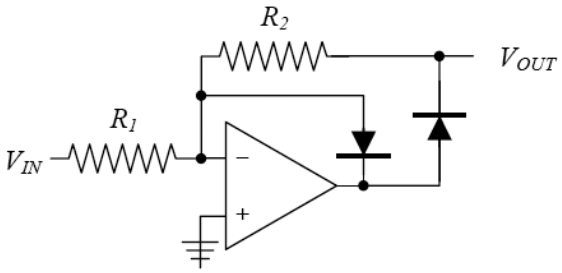
The addition of an offset to V_ allows the band of $2\frac{R_{12}}{R_f}|V_{ss}|$ to be centered around an arbitrary voltage and thus provides hysteresis. One application of Schmitt Trigger is to make the trigger level for an event immune to jitter, as may occur in physiological recording.

Rectifier(s)

These can be used to take the magnitude of a signal when followed by a low-pass filter.



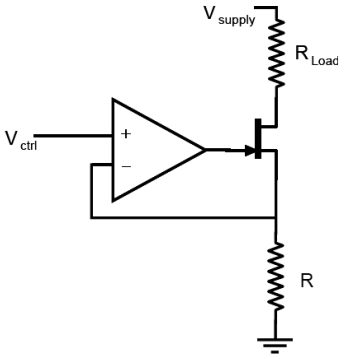
Op amp rectifier.



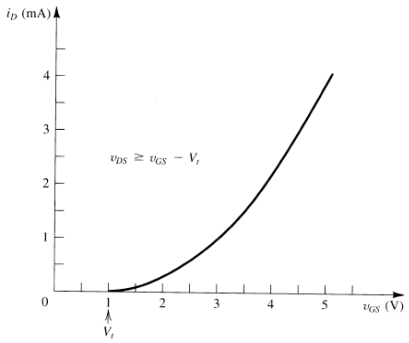
Improved op amp rectifier.

Current Source

This is used to drive a coil, or a high-power LED, with I = $V_{control}$/R. The use of a FET as the current driver surmounts the typical 10 mA maximum current of an OpAmp.



N-JFET constant current source



Plot of i_D versus v_{GS} in the active regime

Hopfield Network (modified for sequential state generation).

Feedback links all Op-Amps to produce stable states that, through a second set of feedback connections that act on a slower time-scale (or after a delay), adiabatically switch the system between states. The flip-flop constructed from two OpAmps (4 with inverters) is the minimal manifestation.