OPAMP oscillators

- Oscillators are amplifiers with positive feedback.
- They are intentionally unstable.
- Two basic kinds of oscillators:
  - Relaxation oscillators have triangular, sawtooth or square wave outputs
  - Sinusoidal oscillators produce 1 frequency. External components determine the frequency. External components can include inductors, capacitors, quartz crystals resistors.
- We can also create oscillators digitally (DDS) by using counters, comparators and a sine table lookup in memory.

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- OPAMP oscillators are typically restricted to frequencies less than about 10Mhz.
- OPAMPs do not have sufficient gain at higher frequencies to maintain oscillation.
- At higher frequencies they also begin to contribute considerably to the phase shift.

OPAMP oscillators

- Here we see the progression from a feedback amplifier to an oscillator.

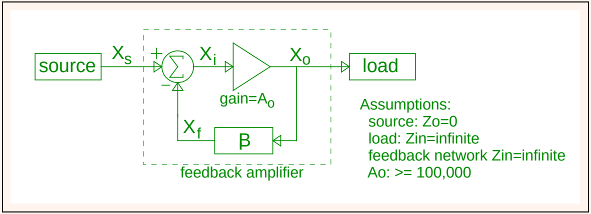

Figure: An Amplifier with Negative Feedback

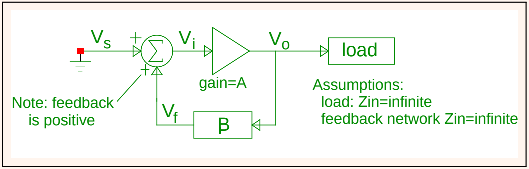

Figure: Oscillator Block Diagram

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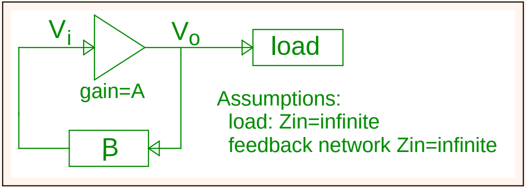


Figure: Oscillator Block Diagram

- The oscillator looks similar to the amplifier but without an input signal
- If $A > \beta$ the signal at the input to the amplifier is continuously regenerated.
- IOW, if the loop gain $A\beta \geq 1$, and there is a phase shift of a multiple of zero or 360 degrees, we produce an oscillator.
- The output of the amplifier eventually reaches the power supply rails where the gain decreases which limits the output amplitude.

OPAMP oscillators

- Here's an oscillator with some parts you might recognize.

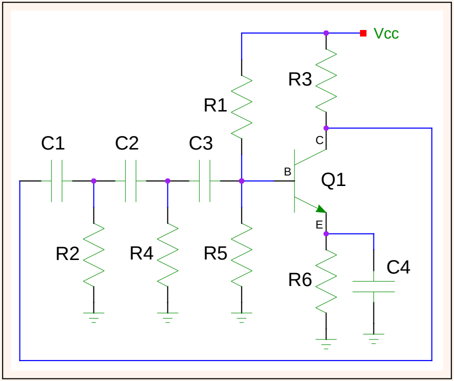


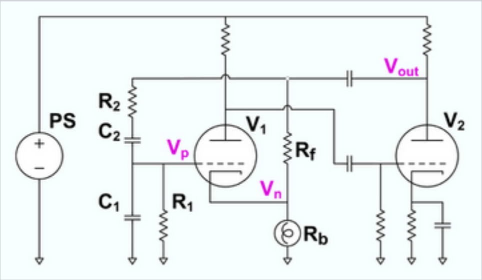
Figure: BJT phase shift oscillator

- The BJT amplifier provides the necessary gain and 180 degree phase shift while the RC sections each provide a phase shift of 60 degrees.

OPAMP oscillators

- In a phase shift oscillator, as phase shift approaches an integer multiple of 0° or 360° and $|AB| \Rightarrow 1$, the output voltage will head towards ∞. This will be limited by the power supply. As the signal magi nude increases the amplifier will begin to saturate lowering its gain.
- Negative feedback within the oscillator can stabilize the amplitude as David Packard and Bill Hewlett found in 1939 that produced their first successful project, the HP200A, precision audio oscillator.

OPAMP oscillators



Simplified schematic of a Wien bridge oscillator from Hewlett's US patent 2,268,872. Unmarked capacitors have enough capacitance to be considered short circuits at signal frequency. Unmarked resistors are considered to be appropriate values for biasing and loading the vacuum tubes. Node labels and reference designators in this figure are not the same as used in the patent. The vacuum tubes indicated in Hewlett's patent were pentodes rather than the triodes shown here.

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- The same technique can be used with modern components if you can find the light bulb!

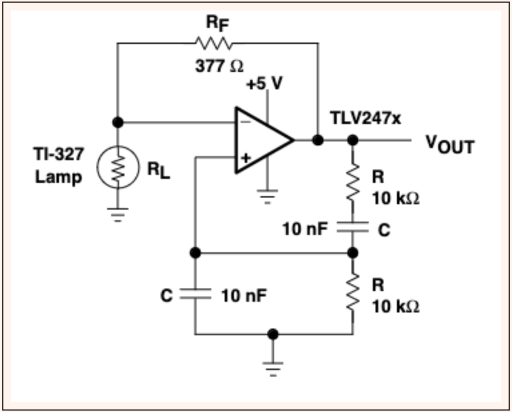

Figure: A modern HP200a Schematic (Thanks TI!)

OPAMP oscillators

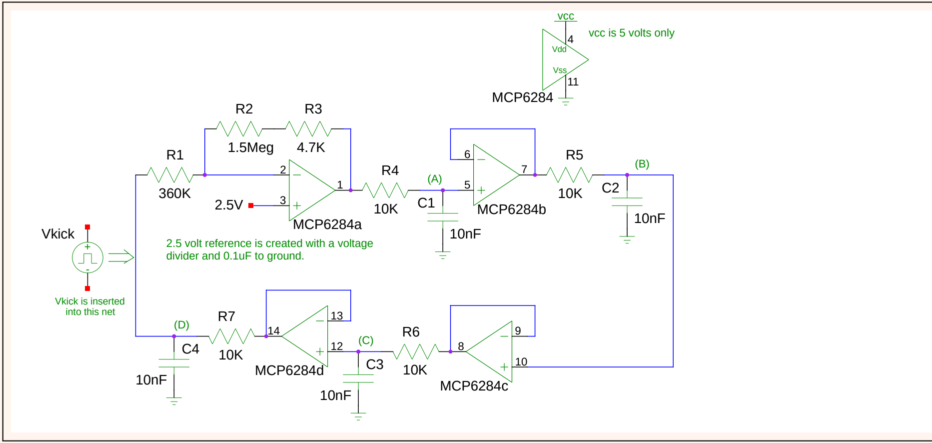

Figure: The Bubba Oscillator