Oscillators & Timers

Oscillators

- Relaxation oscillators
- Square wave oscillators
- Sine wave oscillators
- 555 timer circuits
  - One shot
  - Time delays
  - Pulse trains
Relaxation oscillator

capacitor alternately charges and discharges

Neon lamp lights at 60 V, goes out at 40 V.

The unijunction transistor behaves similarly to the neon lamp and will also make a relaxation oscillator. See the textbook.

Comparator made into square wave oscillator

Let $V_+ = -V_-$
Assume $V_{\text{out}}$ is high.
$C$ charges toward $V_+$.
$V_B$ is 0.5 $V_+$ or 0.5 $V_-$.  
Output goes low when $C$ charged above 0.5 $V_+$.
Then $C$ discharges toward $V_-$.
Output goes high when $C$ charged below 0.5 $V_-$.  

Square waves to triangle waves

Put the square wave from the comparator into an op amp integrator to get a triangle wave. Don’t forget that the integrator is inverting.

Rounded triangle waves look like sine waves

Diodes have nonlinear current-voltage characteristics which can be used to round off a triangle wave.
Sine wave oscillator

Sine wave oscillators are difficult to build because the top of the sine wave is usually “clipped” off at $V_+$ and $V_-$. 

Solution to clipping: continuously tweak the gain so that it does not clip.

Clipping causes music distortion!

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Sine wave oscillator with gain tweaking

The tungsten lamp $R_1$ gets more resistive when the filament is hot and this reduces the gain $(R_2/R_1)$ so that the sine wave does not clip.

With positive feedback loop, the signal amplifies itself resulting in “unstable” oscillations.

The Wien bridge has zero phase delay only when $\omega = 1/RC$. Here, positive feedback is strongest for the sine wave with $\omega = 1/RC$ and this sets the frequency.
Mathcad shows that Wien bridge has zero phase change at $\omega = RC$

The Wien bridge

$Z_1(\omega) := R + \frac{1}{\frac{1}{iC\omega}}$

$Z_2(\omega) := \frac{1}{R + \frac{1}{iC\omega}}$

$180 \cdot \arg \left( \frac{Z_2(\omega)}{Z_1(\omega) + Z_2(\omega)} \right)$

Sine wave oscillator on a chip

• Just buy one.
  For example ICL8038 by Intersil.
  See D&H, ch. 10-6.

• Some chips will do sine and cosine simultaneously. See H & H ch. 5.16.
ICL8038 wiring

The sine wave is created by feeding the triangle wave into a nonlinear network (sine converter). This network provides a decreasing shunt impedance as the potential of the triangle moves toward the two extremes.

555 Timer chip

See D & H ch. 10-5 or H & H ch. 5.14

The 555 generates
1. Single rectangular pulses with a given width (one-shot multivibrator)
2. Pulse trains with controllable frequency and duty cycle (astable multivibrator).
The comparators change state when the capacitor charging voltage is 1/3 and 2/3 of the supply voltage.

Internally, there are comparators and a flip-flop memory.
555 as a “one-shot”

The trigger transition from high to low starts the timer (not the low value). The end of the output pulse of this timer can start a second timer.

\[ \tau_{\text{high}} = 1.1 \, R \, C \]