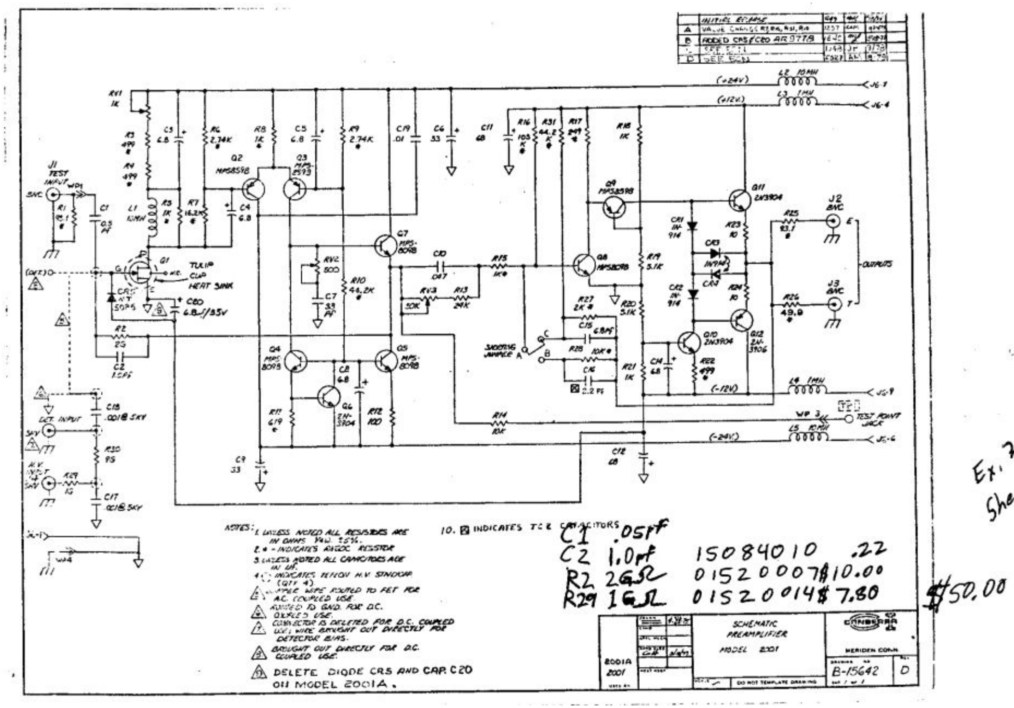
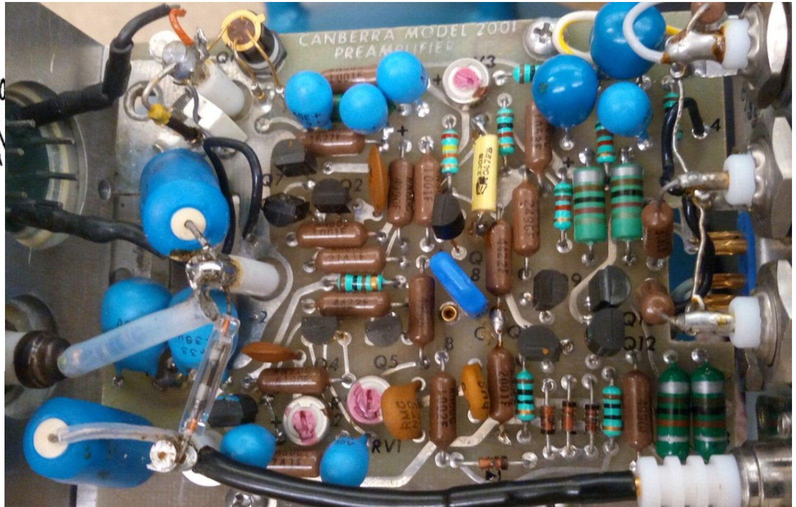
PHY405-L09

Fun ?

Canberra Model 2001 Preamplifier

https://groups.nscl.msu.edu/nscl_library/manuals/canberra/can_2001A.pdf



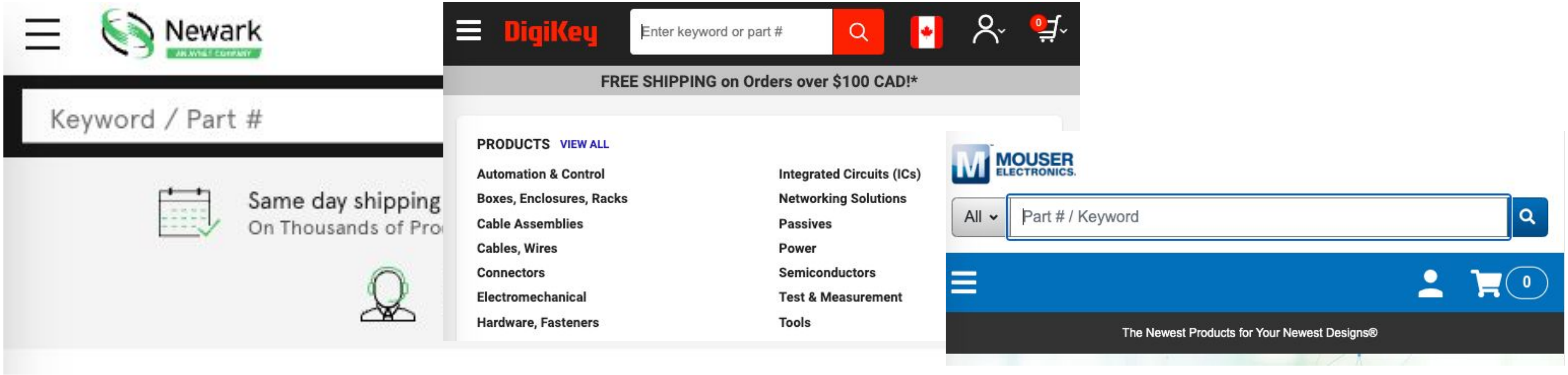


Logistics -- Final project

- Last regular lab to go, final project afterwards.
  - See the project guidelines for more information.
- Coordinate with this OneNote page
- We'll follow the steps of
  1. Conceptual design -- due last week
  2. Technical design -- due **today**
     a. Try to use in-house components as much as possible
     b. Part list finalized by the end of this day
     c. Order will go out **next Monday**
     d. Usually takes 3 days to get back
  3. Realization -- the two weeks following

Logistics -- Final project

- I have left a few comments on the onenote page
- **Note again: Part order will go out first thing next Monday**
- **Provide part links via Newark, Digikey or Mouser**



Project

- Report + Video due by 11:59pm on Friday April 4
  - Last lab session with TA support is Mar. 31
- Select a reasonably advanced circuit, build it, and demonstrate that you understand the circuit and that it works.
  - You may choose a published circuit.
  - The circuit should be conceptually clear and technically accessible.
  - We are more impressed by analog than digital
  - e.g. Points may be lost if the device depends too much on software and not enough on hardware.
  - This is a Physics Lab, so a nice well analyzed physics measurement with a relatively simple circuit can also impress us.

Grading Scheme

  - 25% for effort
  - 25% for clarity
  - 25% for understanding
  - 25% for difficulty X quality of project
- Notes
  - If project does not work, but student deals well with unforeseen problems, and well documents and explain their efforts, an excellent grade is still possible.
    - e.g. demonstrate a clear understanding of why the project did not work and that the reasons were not trivial to anticipate.
  - simpler projects are expected to be better done, including a beautiful breadboard layout

Written Report

- Each student must submit an individual Report.
- This report should be concise and include:
  - Title & Abstract
  - Description of circuit and how it works
  - Test Procedure & Data Analysis
  - Conclusion & References
- Notes
  - There is no length requirement, but 4 to 8 pages would be typical.
  - Longer reports DO NOT get higher grades
  - All source material must be cited and any help received (from Instructor, TA, Technologist, Student, …) acknowledged.
  - **DO NOT PLAGIARIZE!!** This includes copying from your partner…

Video Report

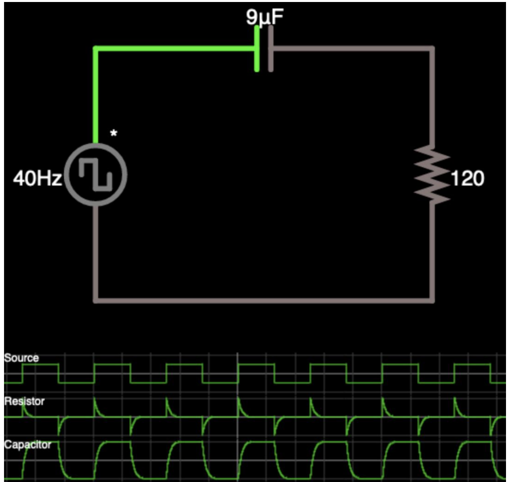
- Each student must also make a short (< 4 minute) video to demonstrate their project.
  - State the point of the project.
  - Show it working.
  - Illustrate any interesting features.
- Notes
  - The video's audio would normally simply describe and explain what is being demonstrated
  - Descriptive subtitles are an allowed alternative

A few more circuits
And how I usually study them

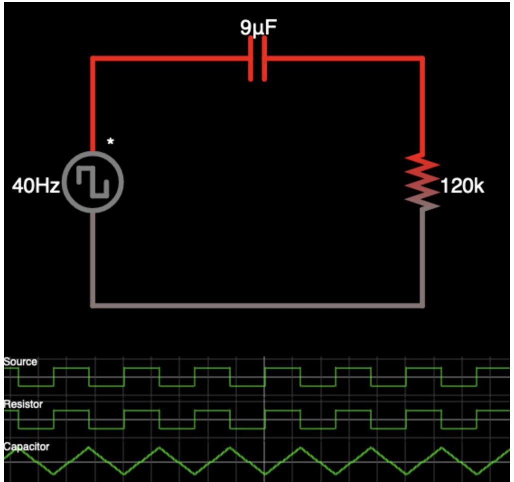
Differentiators and Integrators, passive vs active

- Simple RC or LR circuits can passively differentiate or integrate their input
- Rely on the source to have negligible output impedance

$$V_{out} \propto \frac{dV_{in}}{dt}$$

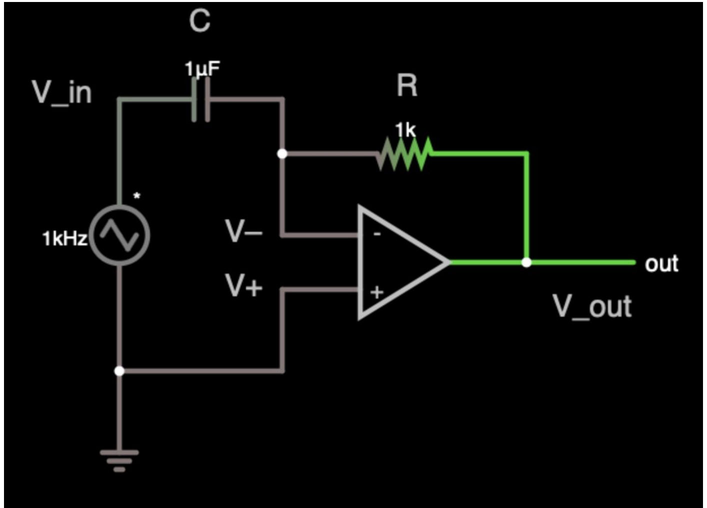


$$V_{out} \propto \int_0^t V_{in}(t')dt'$$



Simple Op Amp Differentiator

- An ideal op amp has infinite input impedance and draws no current
- Active differentiator and integrator doesn’t depend on output impedance of upper stream circuit



$$I_R = \frac{V^- - V_{out}}{R} = I_C = C\frac{d(V_{in} - V^-)}{dt}$$

$$V^- = V^+ = 0$$

$$V_{out} = -RC\frac{dV_{in}}{dt}$$

Simple Op Amp Integrator

- An ideal op amp has infinite input impedance and draws no current
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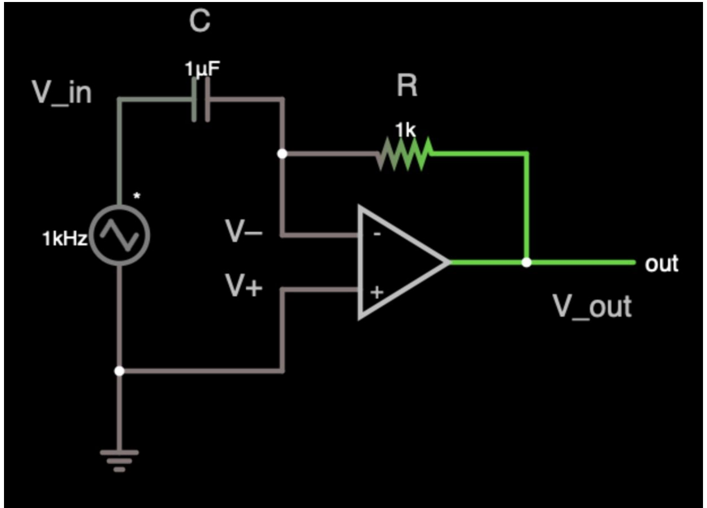


$$I_C = C\frac{d(V^- - V_{out})}{dt} = I_R = \frac{V_{in} - V^-}{R}$$

$$V^- = V^+ = 0$$

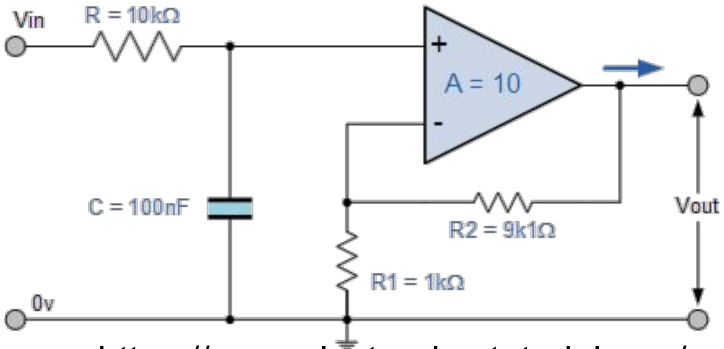
$$V_{out} = -\frac{1}{RC}\int_0^t V_{in}(t')dt$$

Filters, passive vs active

https://www.wevolver.com/article/difference-between-active-and-passive-filters

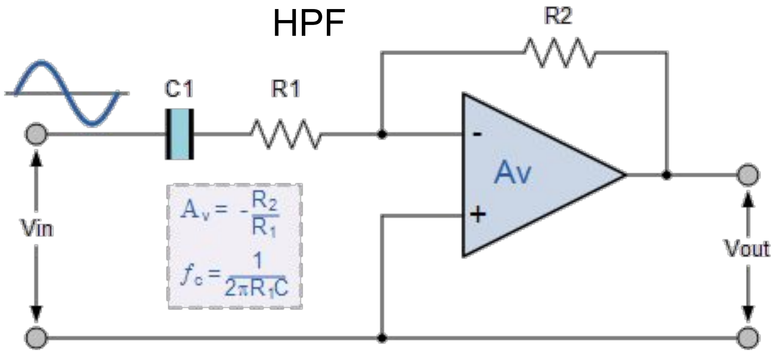
- Can also use op-amps to build active filters
- Benefits:
  - Output of passive filters depends on the load
  - Active filters maintain their performance irrespective of the load

LPF



https://www.electronics-tutorials.ws/filter/filter_5.html

HPF



https://www.electronics-tutorials.ws/filter/filter_6.html

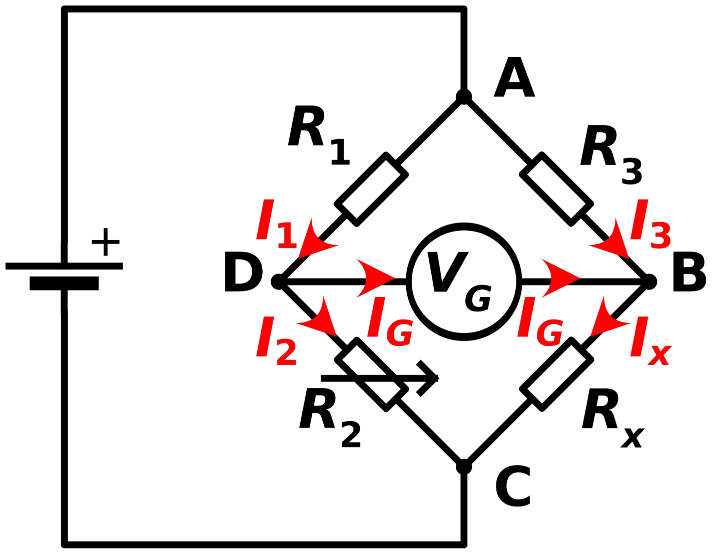
Wheatstone bridge

- Used to precisely measure unknown resistance (Rx)
- Dial R2 until $V_G = 0$
- Two voltage dividers balance, $V_B = V_D$

$$\frac{V_{DC}}{V_{AD}} = \frac{V_{BC}}{V_{AB}}$$

$$\Rightarrow \frac{I_2 R_2}{I_1 R_1} = \frac{I_x R_x}{I_3 R_3}$$

$$\Rightarrow R_x = \frac{R_2}{R_1} \cdot R_3$$

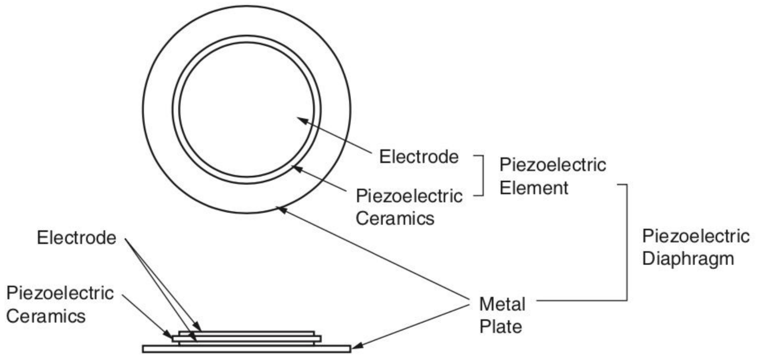


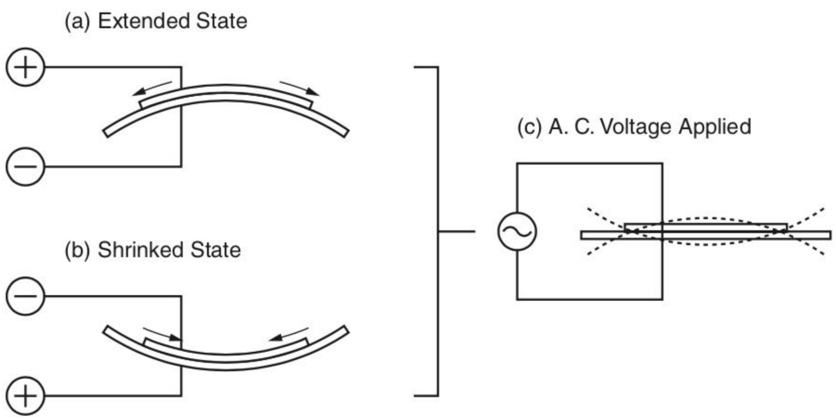
https://en.wikipedia.org/wiki/Wheatstone_bridge

Piezo Transducers

[Piezo Sound Components: Application Manual, P15E-8, Murata Manufacturing 2012]

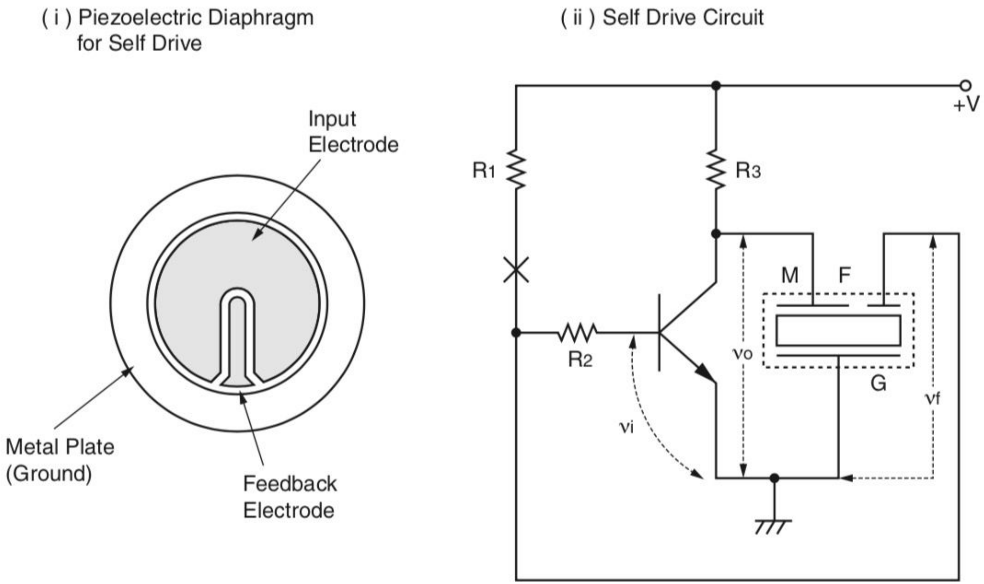
A "piezo" is a piezoelectric material with electrodes





- It produces a voltage if bent.
- It bends if a voltage is applied.
- It produces sound if an oscillating voltage is applied.

Piezo can “self drive” with feedback

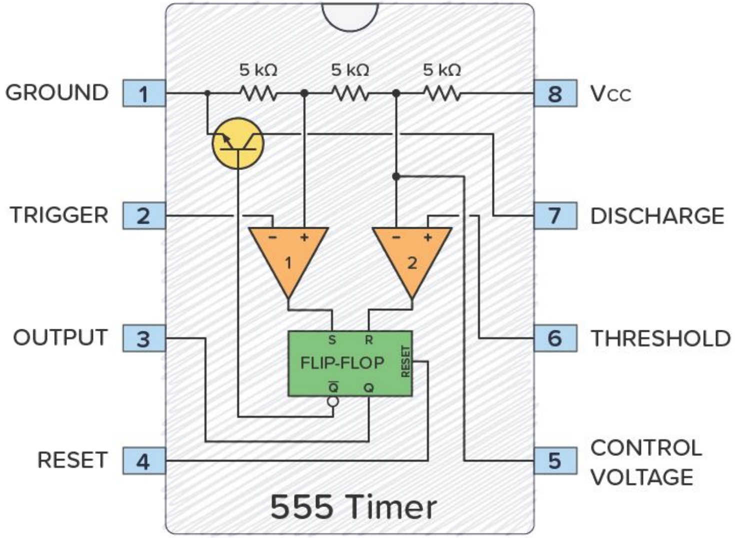


- When in self driving, it will oscillate at its natural resonance frequency.
- Feedback electrode can also be used to monitor oscillation.

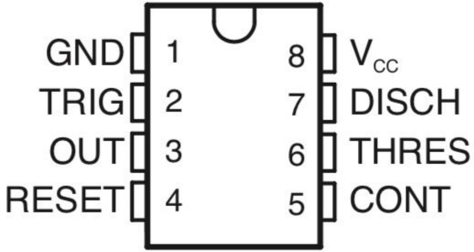
https://www.build-electronic-circuits.com/how-does-a-555-timer-work/

555 Timers

- Integrated circuit used in timer, delay pulse and oscillator circuits
  - Outputs rectangular pulses
  - Sine wave with matched LC circuit
  - Triangular wave with integrator
- Astable mode
  - Continuous rectangular oscillations
  - No external trigger required
  - Period and Duty Factor set by external R, C.
- Monostable mode
  - Triggered pulses
  - External trigger required.
  - Pulse length determined by external RC circuit.



NE555P Pin-out

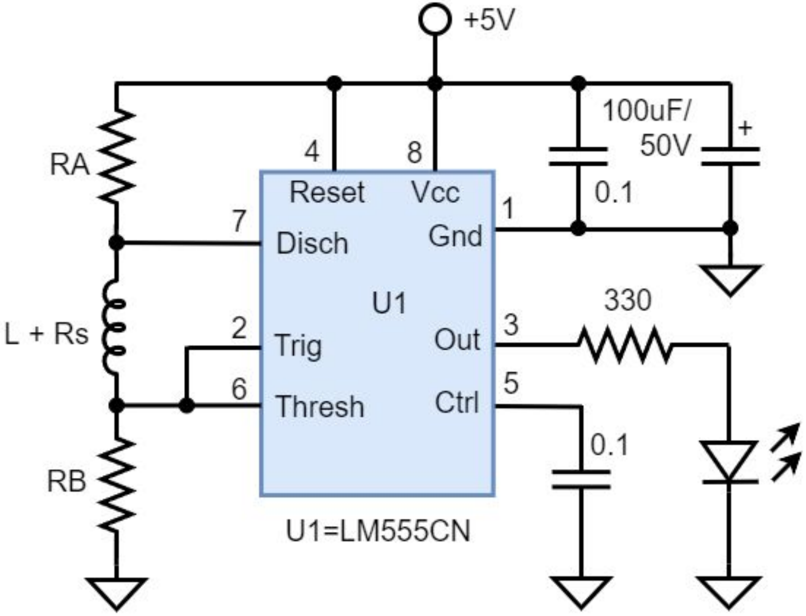


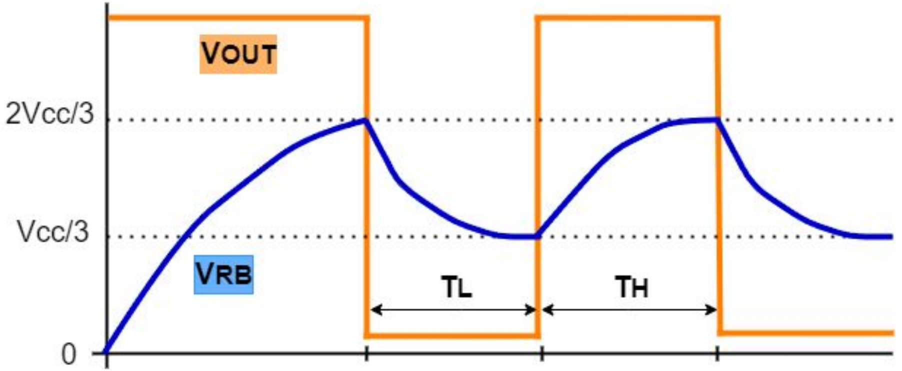
1. Ground
2. Trigger: Output (pin 3) goes high when voltage on pin 2 drops below 1/3 of supply voltage VCC (pin 8).
3. Output: VCC if triggered, 0V if not.
4. Reset: timer starts if voltage on pin 4 drops below 1/3 of VCC (pin 8), but usually connected to pin 8 unless resets needed.
5. Control: adjusts trigger voltage level, but if this capability not used, can be floating or connected to ground through a small capacitor
6. Threshold: Output (pin 3) goes low when voltage on pin 6 goes above 2/3 VCC. (pin 8).
7. Discharge: Connected to external capacitor/circuit whose discharge controls timing. Output (pin 3) goes low when voltage on pin 7 goes above 2/3 VCC.
8. DC Power Supply: VCC

555 V_{OUT} vs V_{RB}

- Trigger pin is responsible for **setting** the output high
  - When the voltage on the trigger pin goes lower than ⅓ VCC
- Threshold is responsible for **resetting** output low
  - when its voltage exceeds ⅔ VCC
- Control width by external components

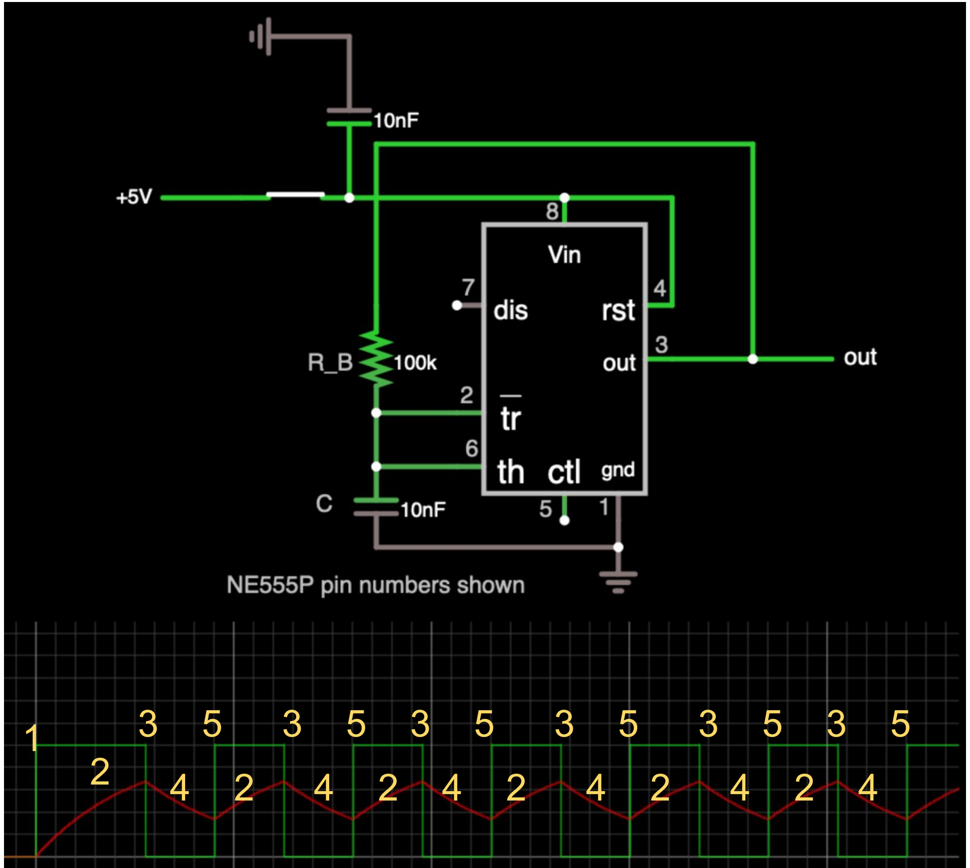
https://www.edn.com/inductor-based-astable-555-timer-circuit/





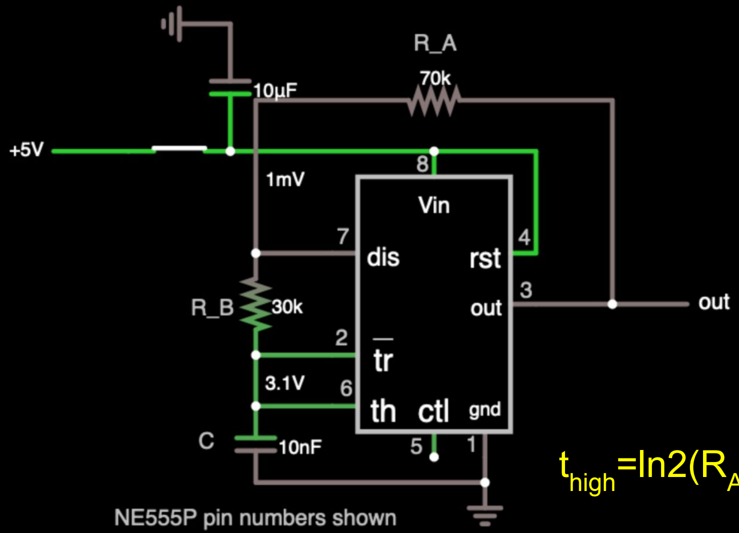
Simplest 555 Oscillator

1. When switch closed out pin 3 goes to +5 V
2. Capacitor starts to charge through R_B
3. Out goes to 0V when threshold pin 6 goes past ⅔ x 5V
4. Capacitor starts to discharge through R_B
5. Out goes high when trigger pin 2 goes below ⅓ x 5V



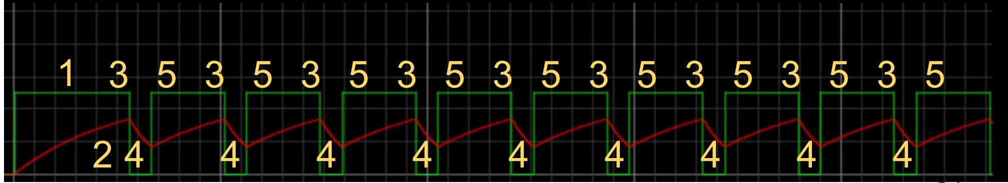
Control Duty Factor

1. When switch closed out pin 3 goes to +5 V
2. Capacitor starts to charge through R_A+R_B
3. Out goes to 0V when threshold pin 6 goes past ⅔ x 5V
4. Capacitor starts to discharge through R_B
5. Out goes high when trigger pin 2 goes below ⅓ x 5V

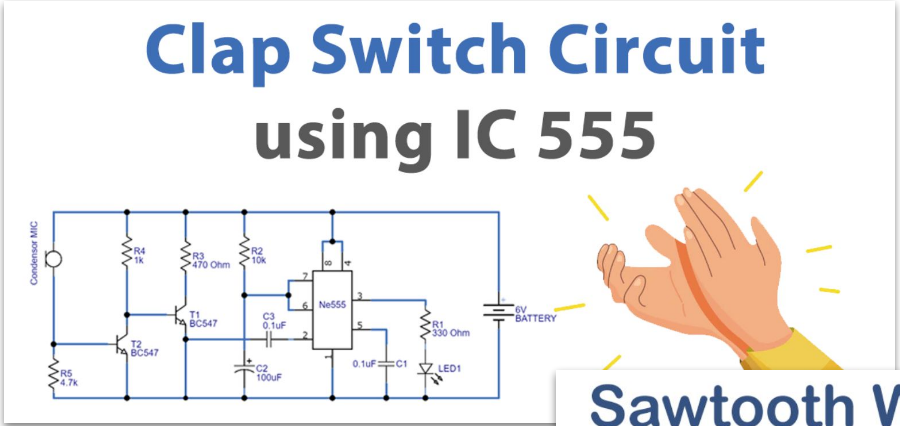


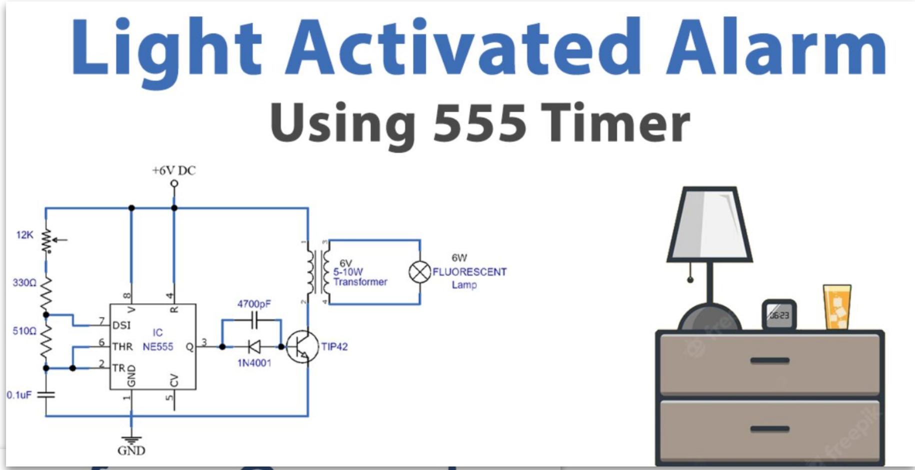
$t_{high} = \ln 2(R_A + R_B)C$

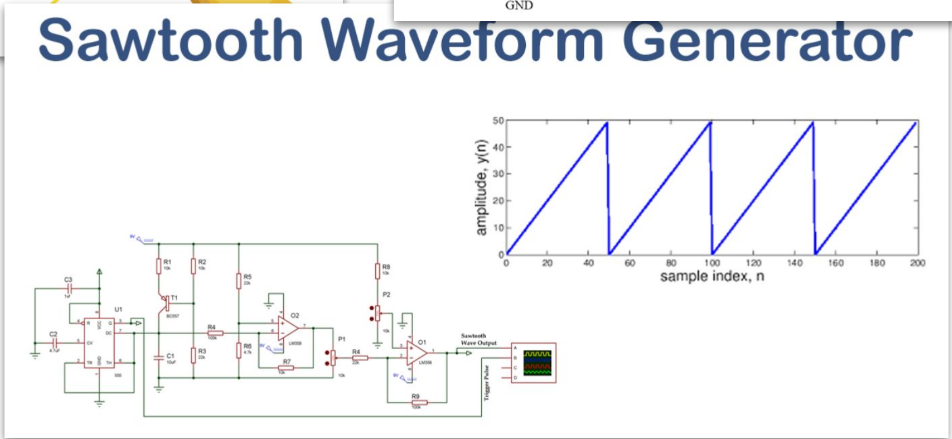
$t_{low} = \ln 2 R_B C$



Example 555 circuits



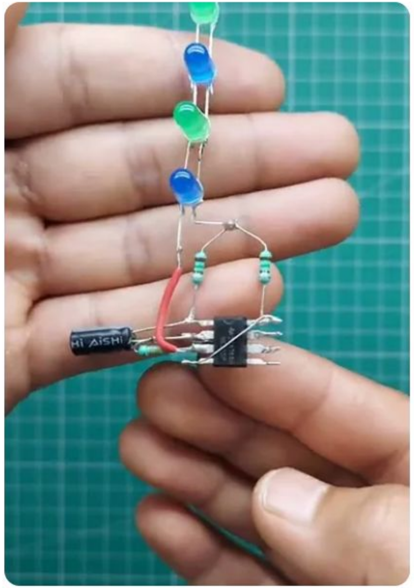




https://www.youtube.com/results?search_query=555+projects

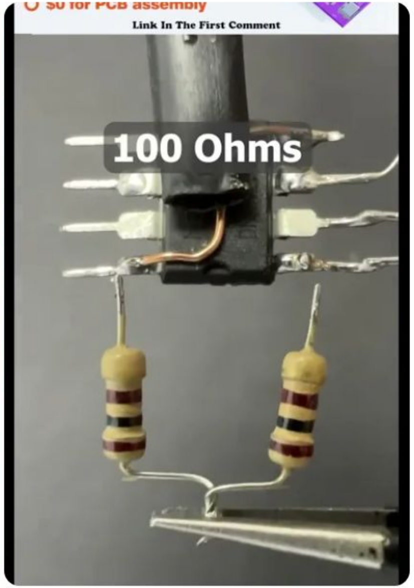
555 projects search on youtube…

Shorts



NE555 IC Projects | NE555 Projects | |NE555 LED Chas...

48K views

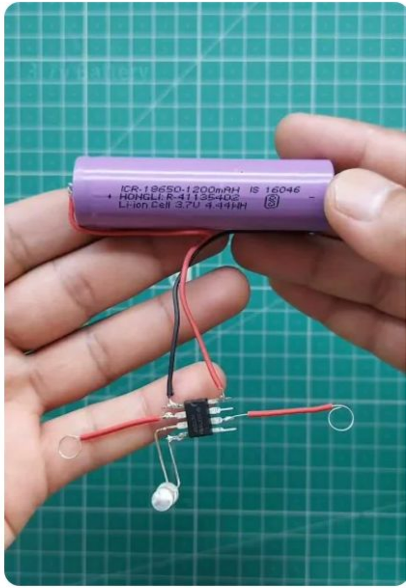


How to make a LED Chaser | NE555 IC Projects 🤩🤩

298K views

How to make a Running LED Circuit | NE555 IC Projects ...

7.6M views



NE555 Projects | Touch On Off Switch Circuit | Touch O...

8.1K views

Questions?