Introduction to Electronics

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Today we will be covering:

- Voltage (V)
- Current (I)
- Fundamental Electronic Components

Batteries	Resistors	Diodes	LEDs
Buttons	Potentiometers	Capacitors	

- Circuit Diagrams
- Simple Circuit Designs

- ELECTRICITY => presence and flow of electric charge
- Electric current (I) is measured in Amperes
- Electric potential (V) is measured in Volts
- These are analogous to flow and pressure in plumbing

Current (I)

- Rate of flow of electric charge
- 1 Ampere = 1 Coulomb per second
- Quantity of electric charge (coulombs) passing a given point in the circuit per unit time.

Voltage (V)

- Energy per unit charge
- 1 Volt = 1 Joule per Coulomb
- Difference is electric potential between two different points in a circuit.
- Analogous to pressure

Power (W)

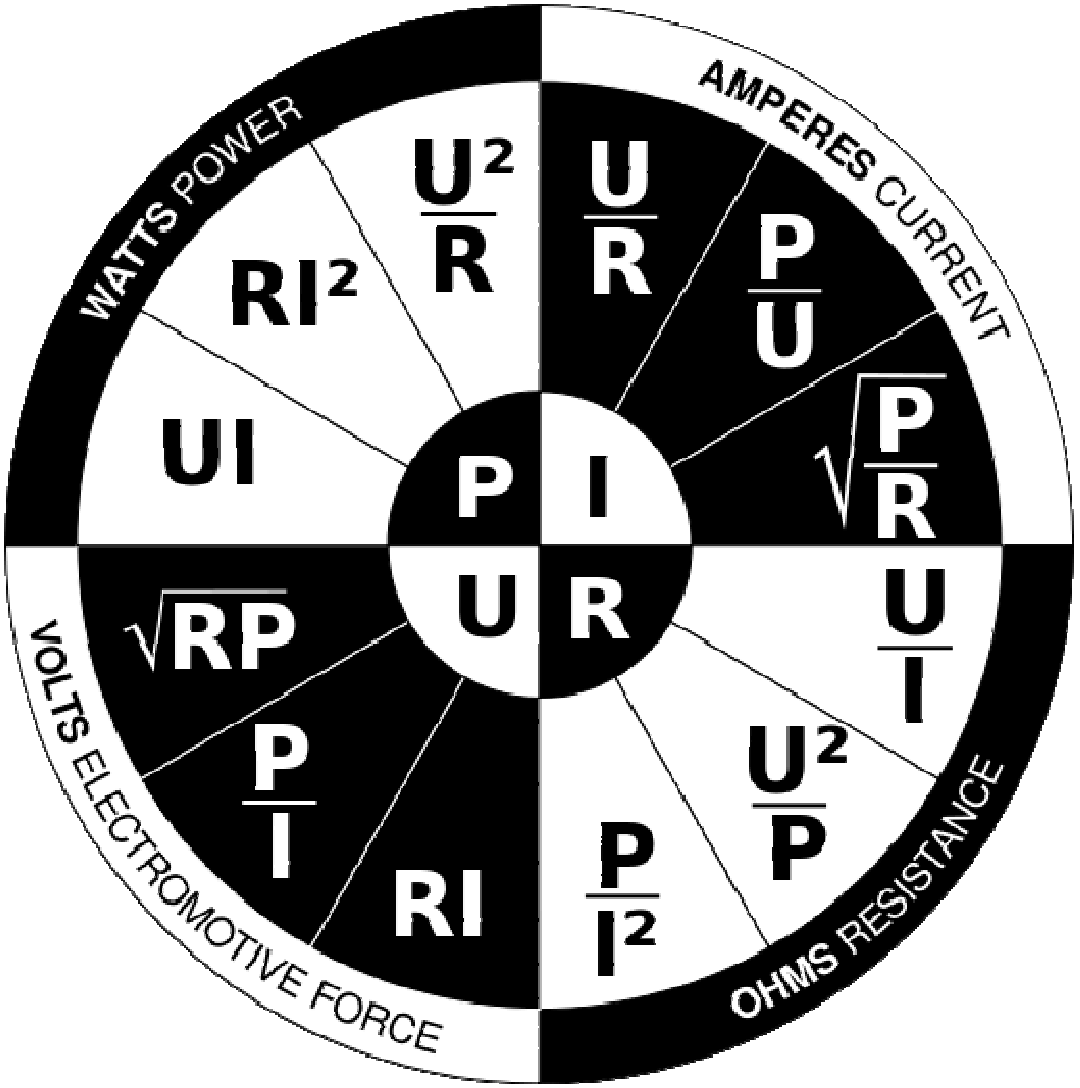
- 1 Watt = 1 Volt x 1 Ampere
- 1 Watt = 1 Joule per second
- $1W = \frac{Joule}{Coulomb} \times \frac{Coulomb}{second}$
- Situation is more complex for AC or mains power

Resistance (Ω)

- Measurement of the resistance to current flow in an electric circuit
- Measured in Ohms
- 1 Ohm (1 Ω) = 1 Volt per Amp

Ohm's Law

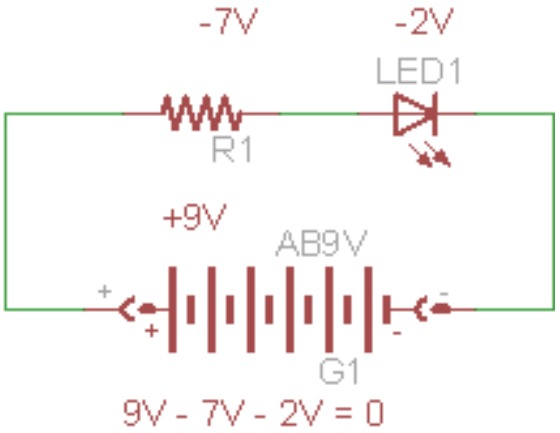
- $V = I \times R$
- $R = \frac{V}{I}$
- $I = \frac{V}{R}$



Kirchoff's Laws

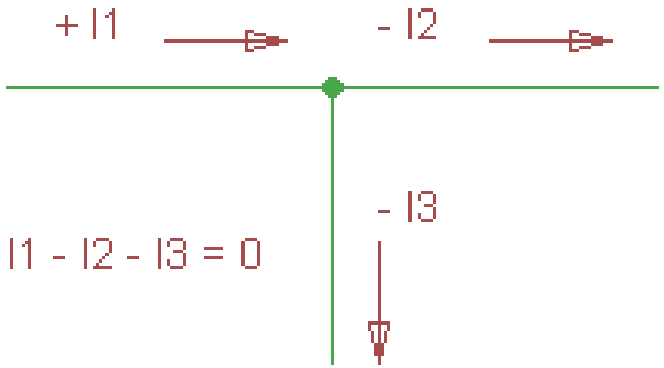
Voltage Law

The sum of the voltages around a closed loop is equal to zero



Current Law

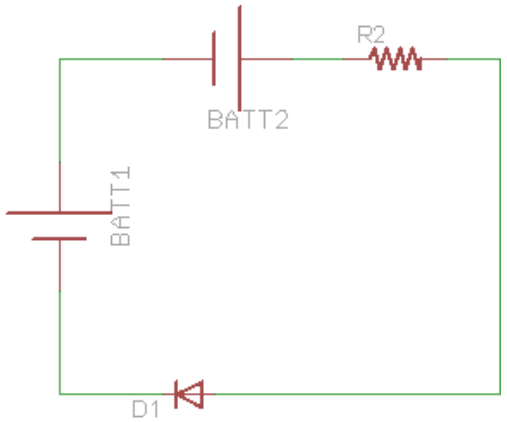
The sum of all currents into and out of a circuit node is equal to zero



Series and Parallel Circuit Construction

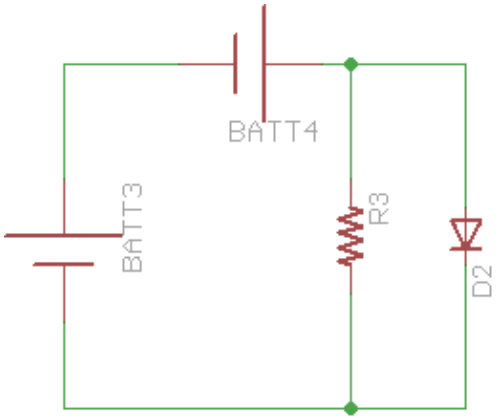
Series

- Voltage divides across components
- Current remains the same around the whole loop



Parallel

- Voltage stays the same
- Current divides across the loops



Voltage Sources

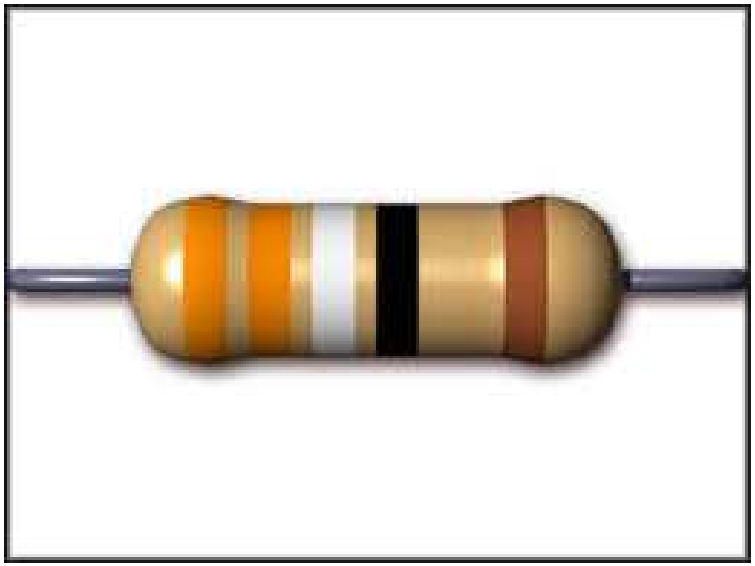
Battery: Direct Current

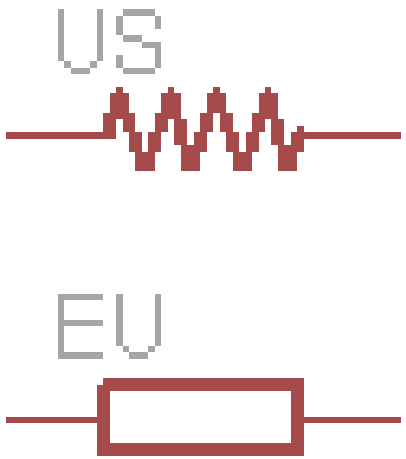
Supplies constant voltage

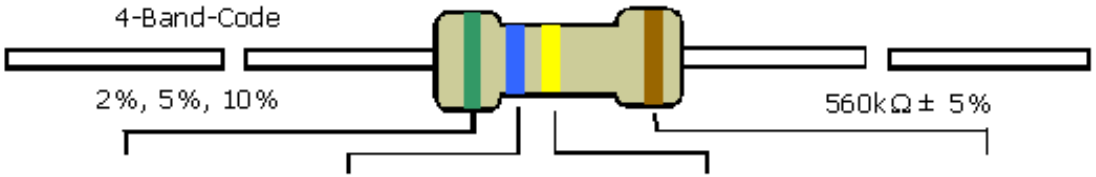
Current can vary

Resistors

- Used to control the current in a circuit
- Non-directional







COLOR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	±0.5% (D)
Blue	6	6	6	1MΩ	±0.25% (C)
Violet	7	7	7	10MΩ	±0.10% (B)
Grey	8	8	8		±0.05%
White	9	9	9		
Gold				0.1	± 5% (J)
Silver				0.01	± 10% (K)

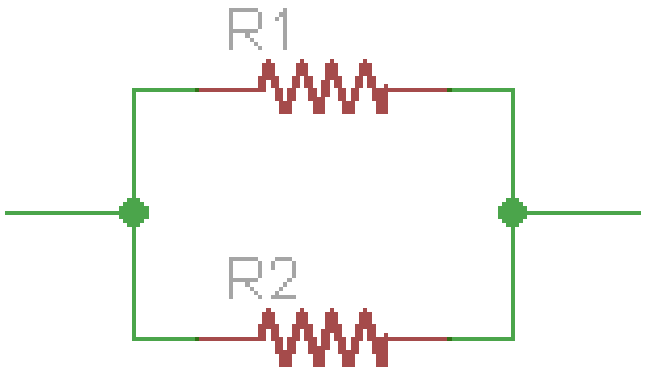
Serial and Parallel Behaviors (Resistors)

Series

- $Rt = R1 + R2$

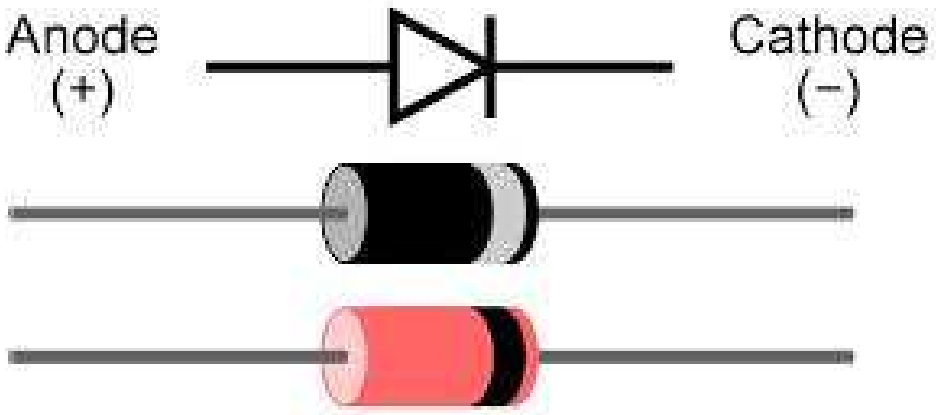
Parallel

- $Rt = \frac{1}{\frac{1}{R1}+\frac{1}{R2}}$



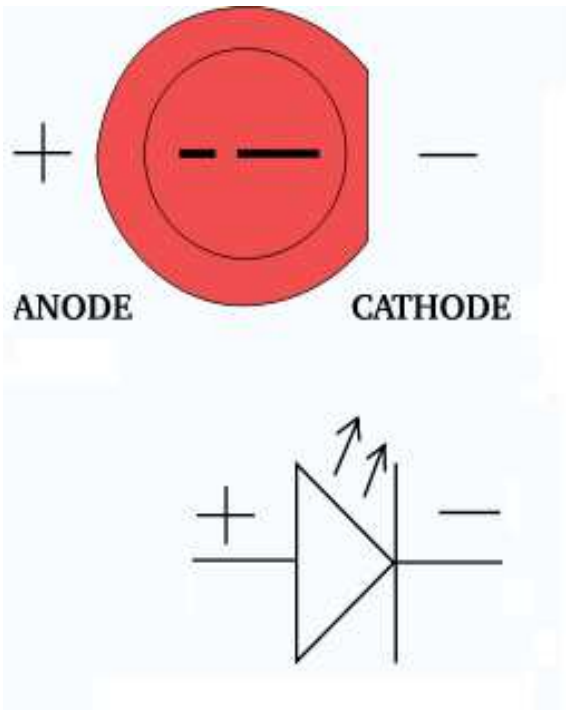
Diodes

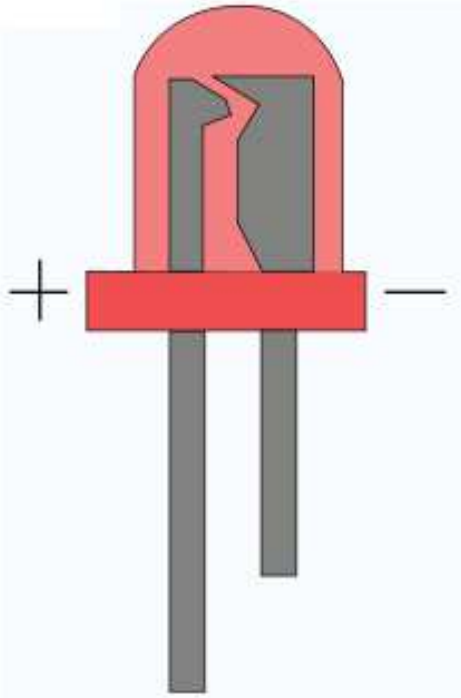
- Used to maintain current direction
- Voltage drop across a diode is (roughly) constant
- Directional: current flows in one direction, not in the other



Light Emitting Diodes (LEDs)

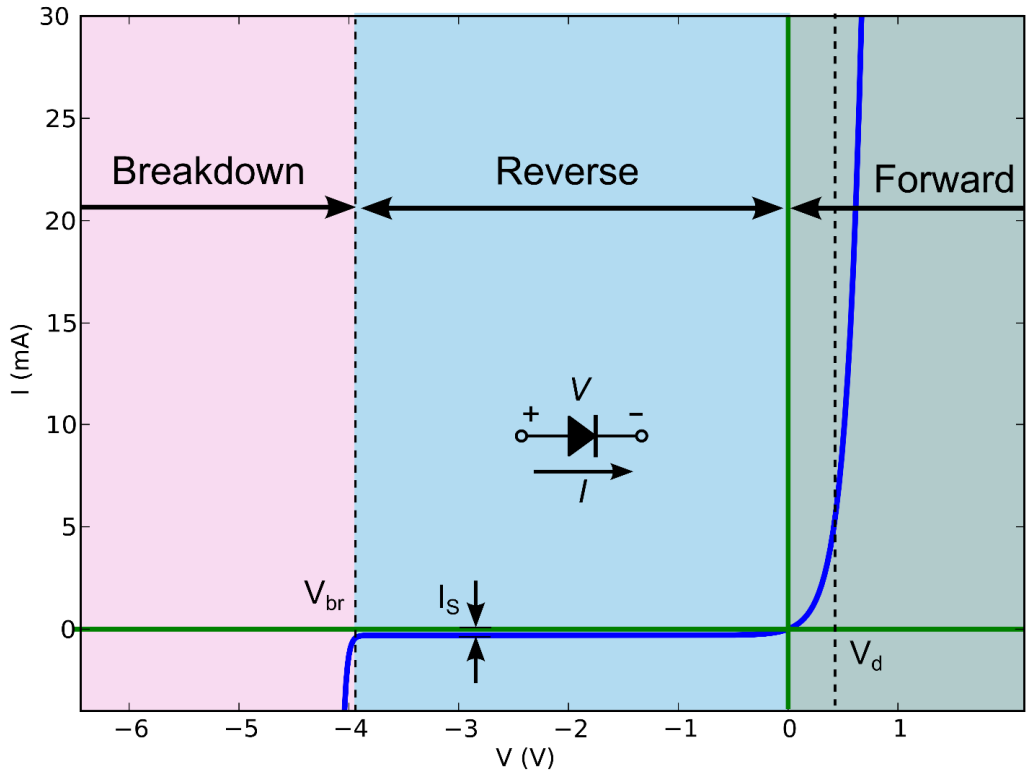
- Special type of diode that emits light. Amount of light is proportional to current.
- Current must be limited with external resistor



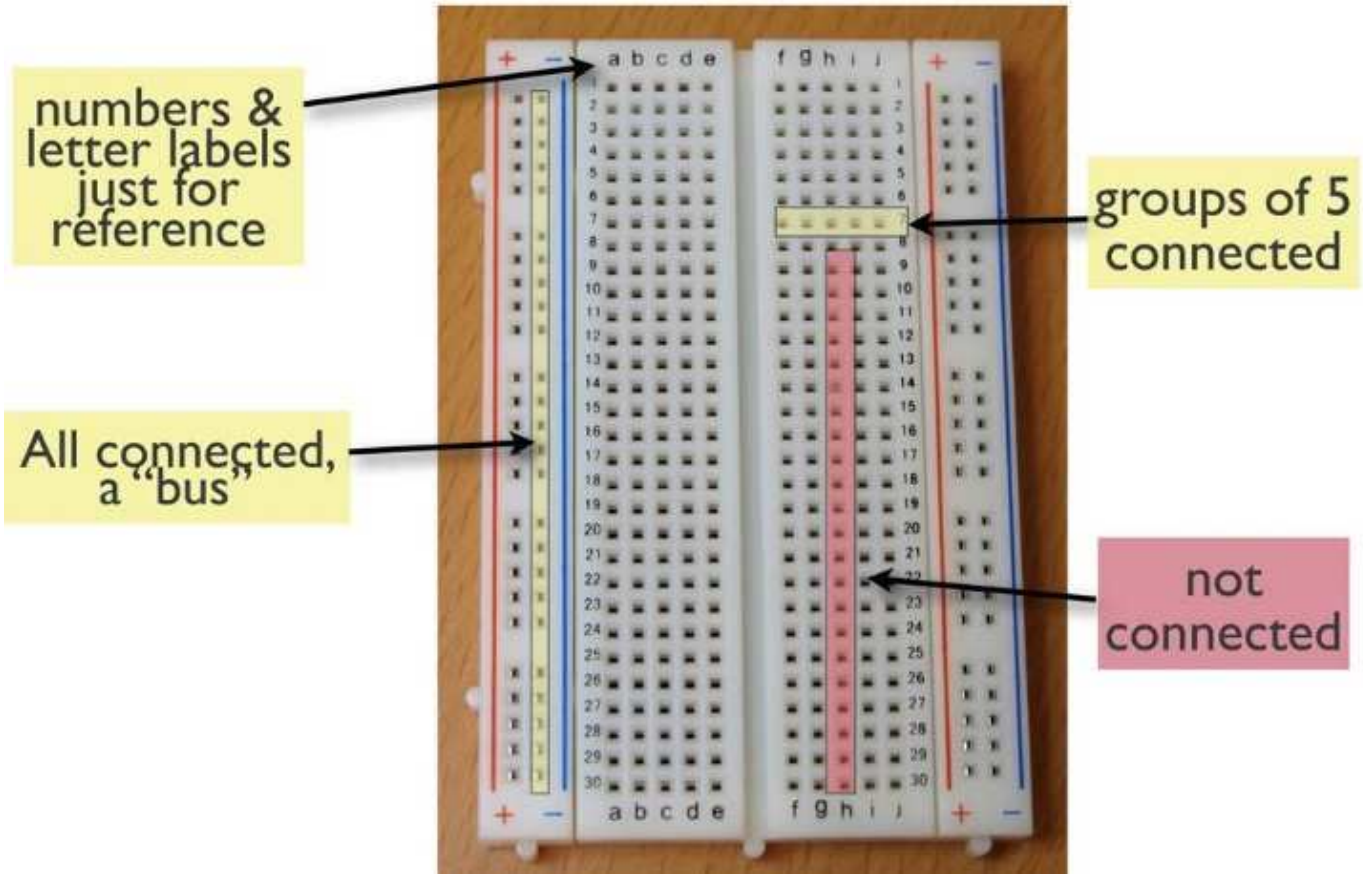


Diode Voltage-Current Relationship

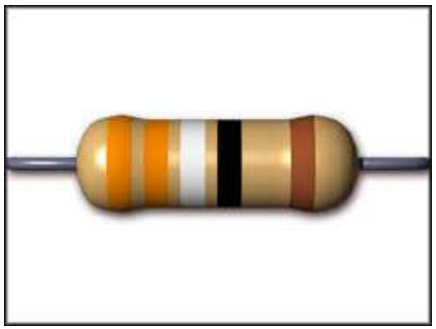
- $I = I_s\left(e^{\frac{qV}{kT}} - 1\right)$
- I_s = reverse leakage current
- V = forward voltage across diode
- e = Euler's number = 2.71828…
- q = electron charge = $1.60217657 \times 10^{-19}$ C
- k = Boltzmann's constant = $1.3806488 \times 10^{-23} \frac{kg*m^2}{K*s^2}$
- T = temperature in Kelvin (room temperature ~300K)

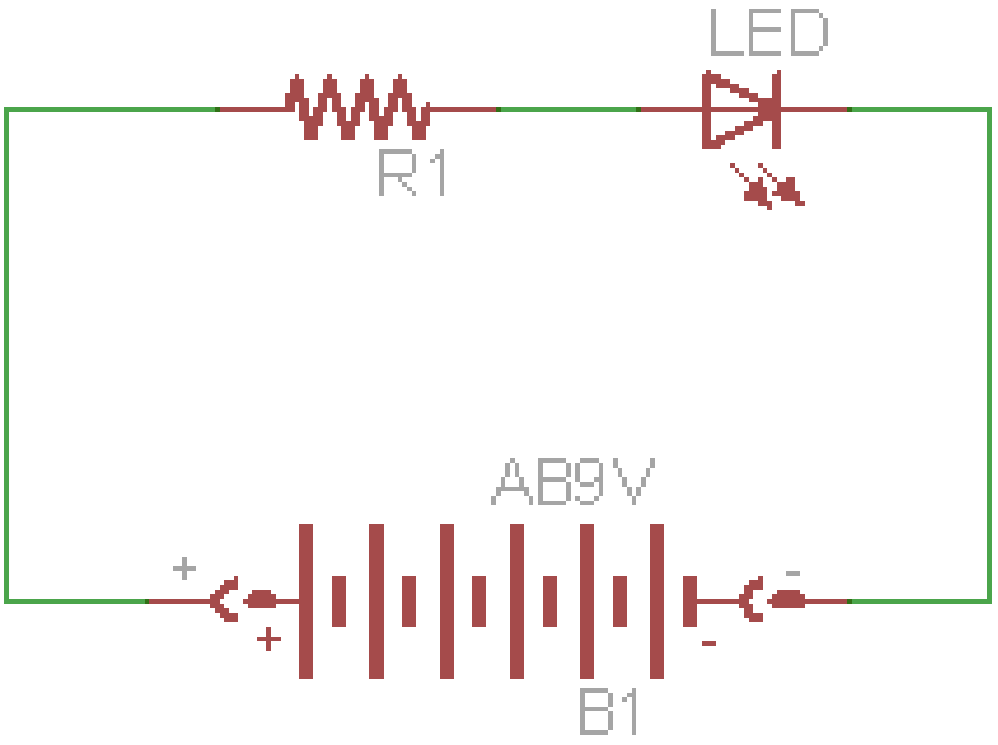


Solderless Breadboards



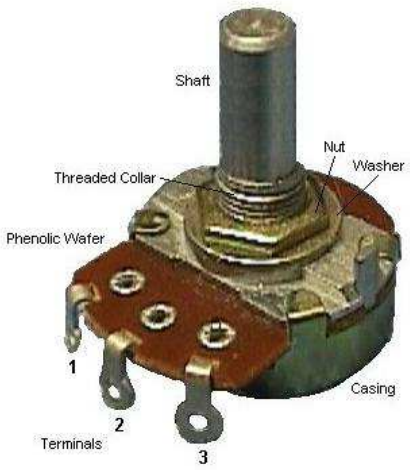
Let There Be Light!

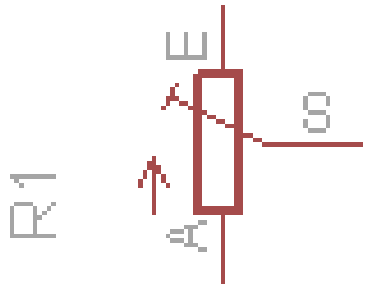


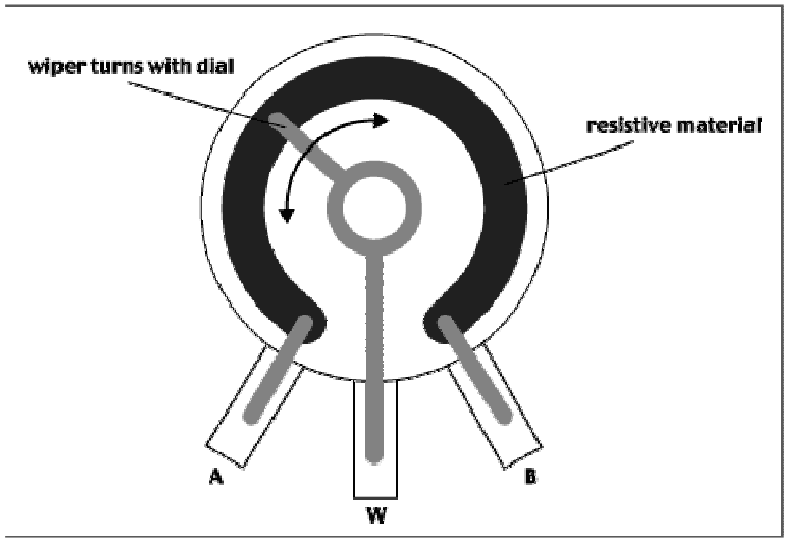


Potentiometers

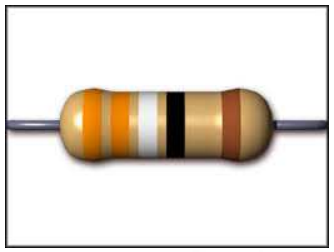
- Variable resistor
- Constant resistance between A & B
- Variable resistance on W (middle leg aka wiper)

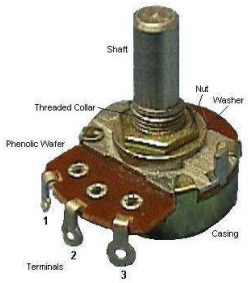


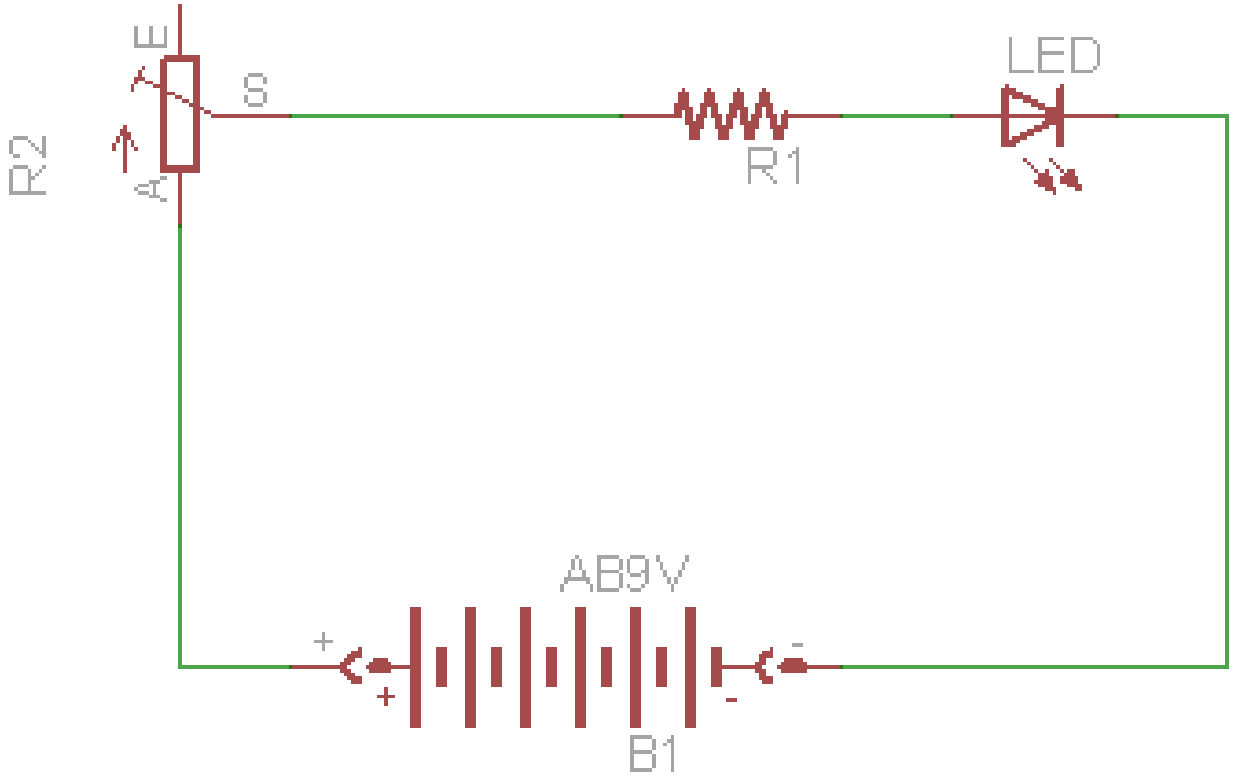




Mood Lighting

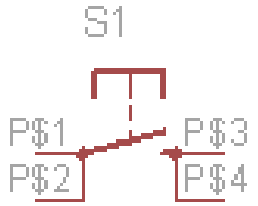




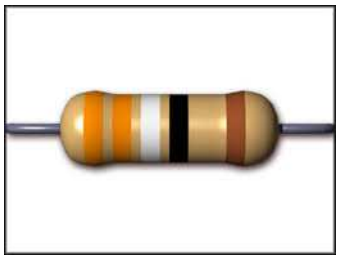


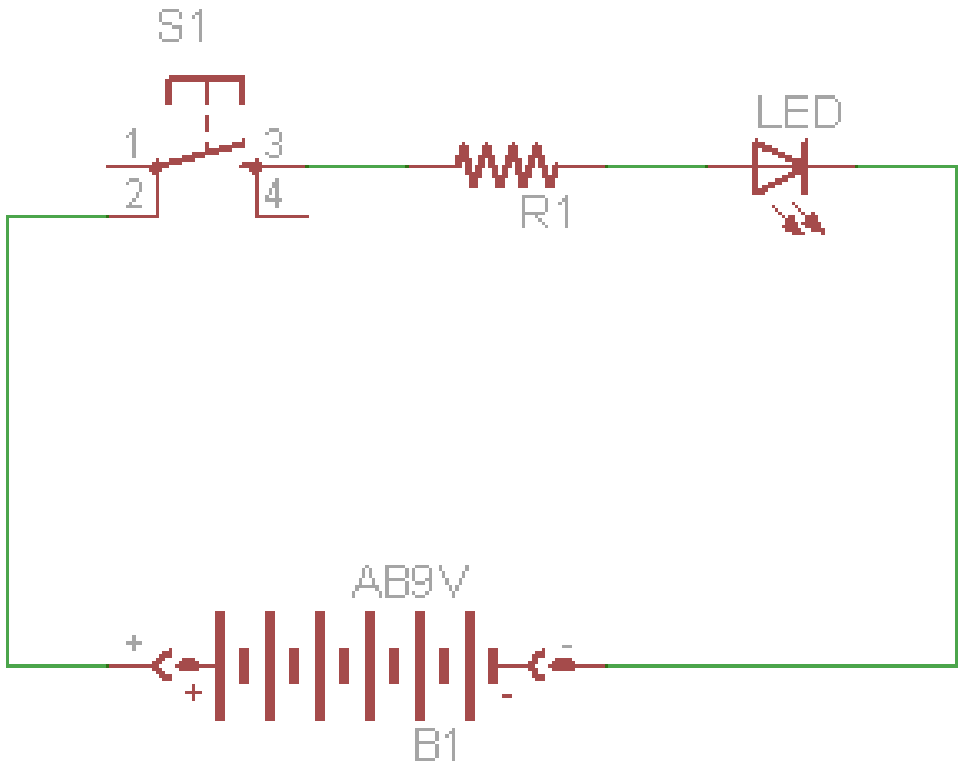
Buttons and Switches

- Provide a controlled break point in the circuit
- We have one button
  - Single Pole – controls just one circuit
  - Single Throw – just two positions, on or off
  - Momentary – on only when pressed



Now You See It, Now You Don’t



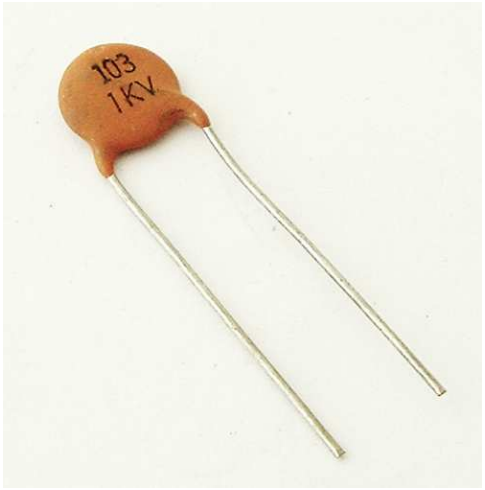


Capacitors

- Storage tanks for charge – they resist sudden changes in voltage
- Can be used to smooth out voltages
- Measured in Farads
- $F = \frac{A \times s}{V}$
- We have two types, electrolytic and ceramic

Electrolytic

- Directional
- Uses liquid dielectric

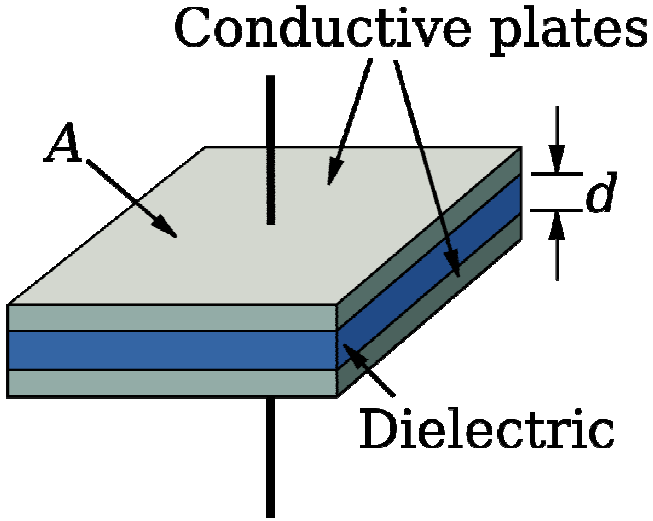


Ceramic

- Non-directional
- Uses solid ceramic dielectric

Capacitor Voltage-Current Relationship

- $I(t) = C\frac{dV}{dt}$
- Passes no current in response to a constant voltage
- Passes current only in response to a time-varying voltage
- Solution of Kirchoff's Laws requires differential equations
- Solutions tend to be exponentials



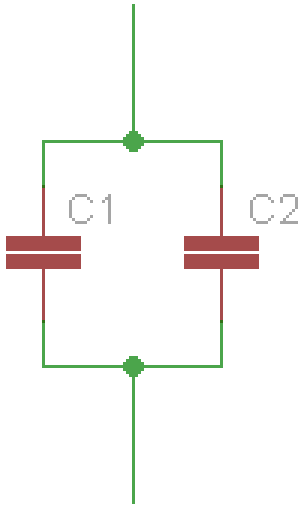
Series and Parallel Behavior (Capacitors)

Series

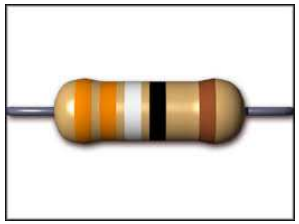
- $Ct = \frac{1}{\frac{1}{C1}+\frac{1}{C2}}$

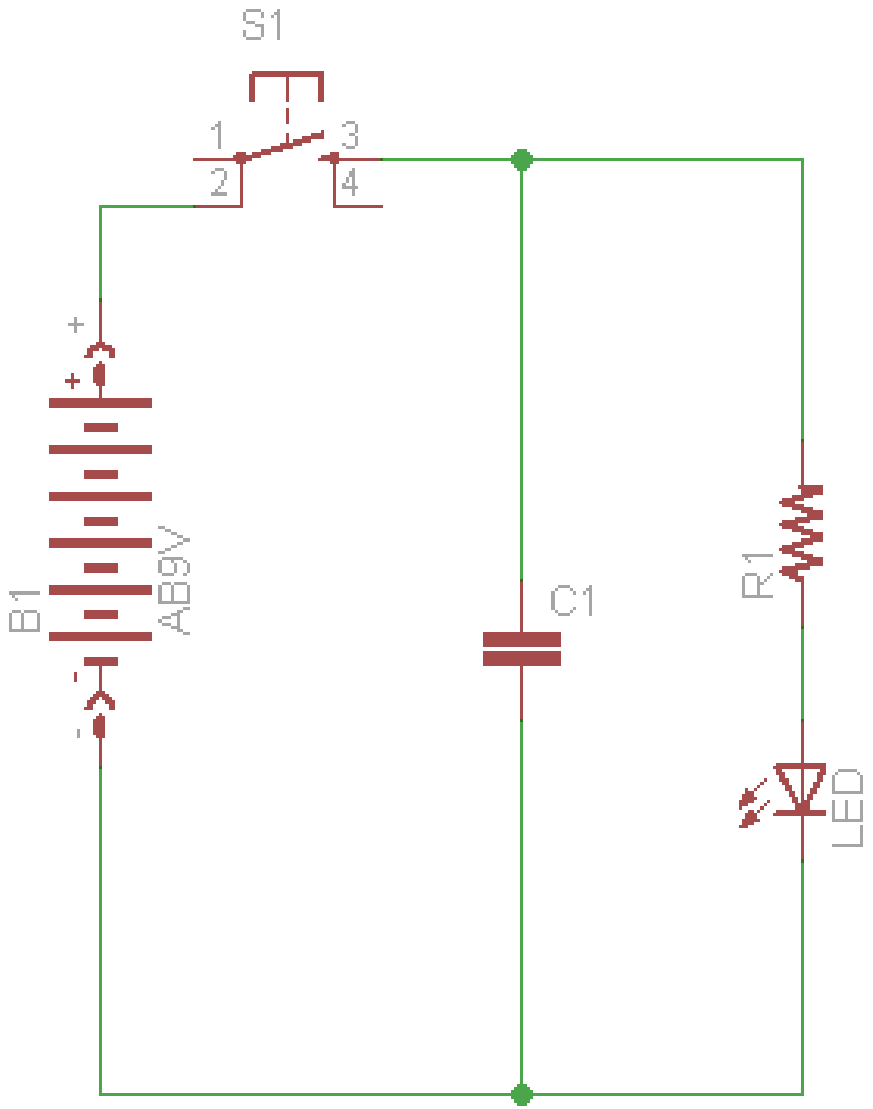
Parallel

- $Ct = C1 + C2$

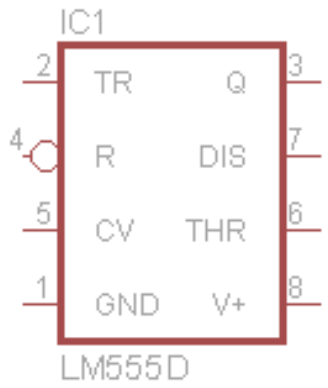


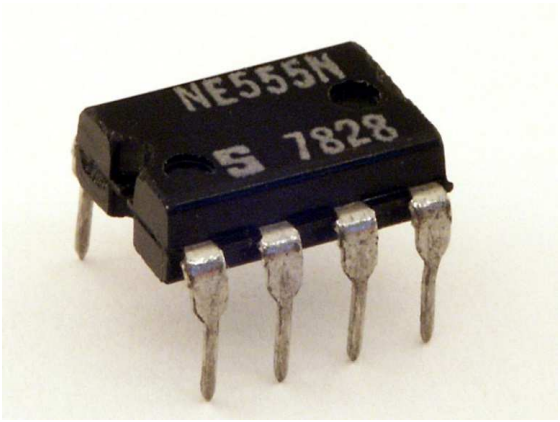
Backup Supply





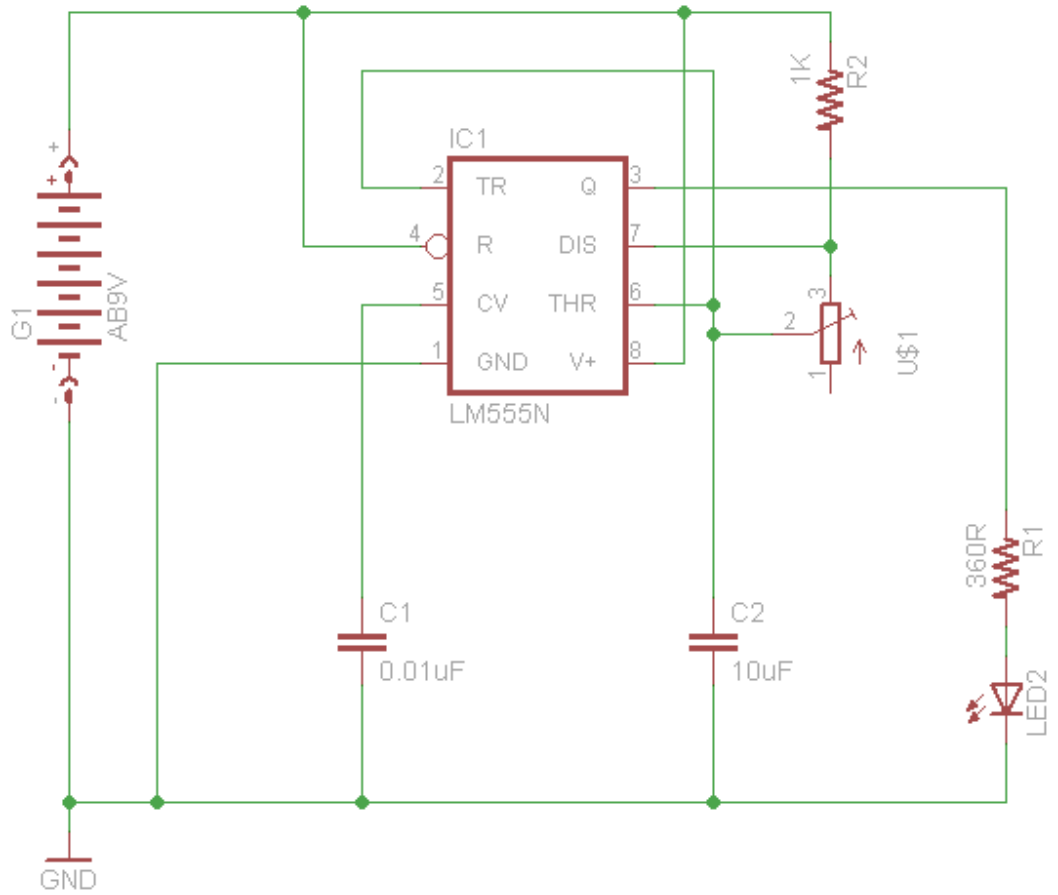
Integrated Circuits: 555 Timer

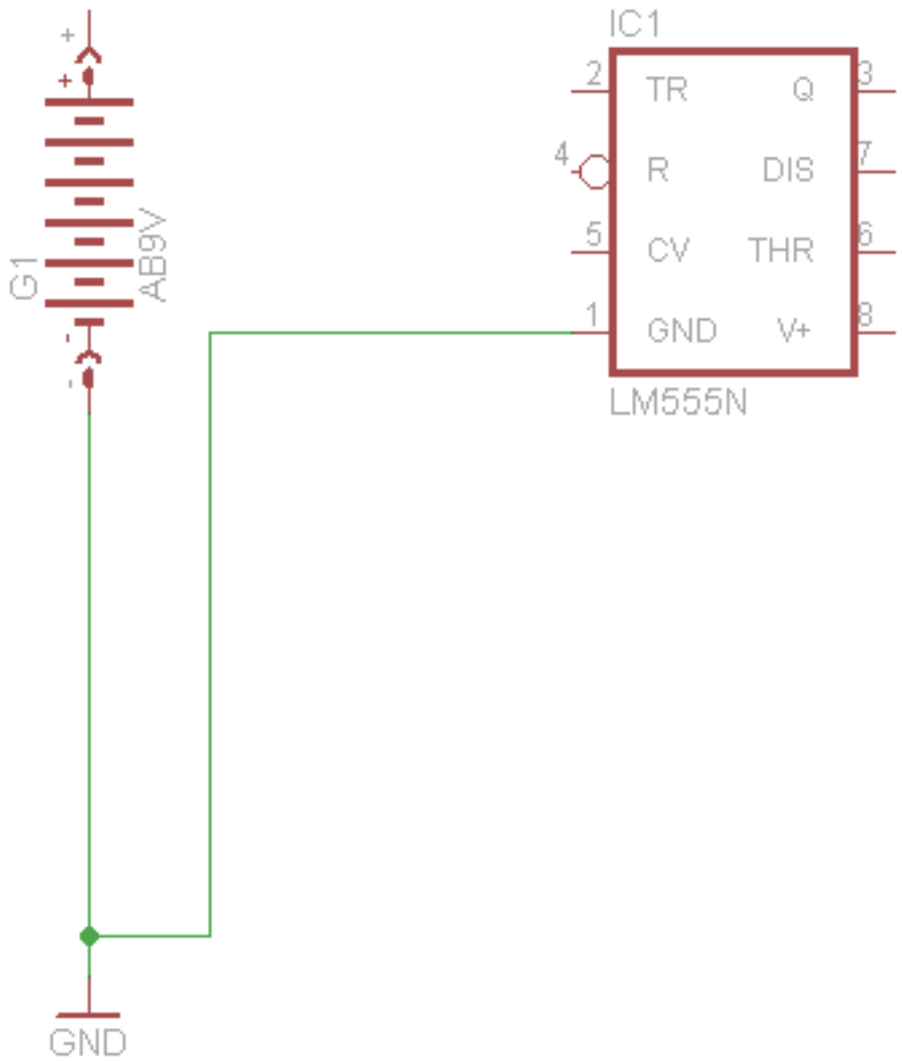




- Adjustable oscillator
- On the market since 1971
- Controlled by connecting resistors & capacitors to the pins
- Datasheet has:
  - Pin-outs
  - Min/max values
  - Theory of operation
  - Example circuits

Blinking an LED

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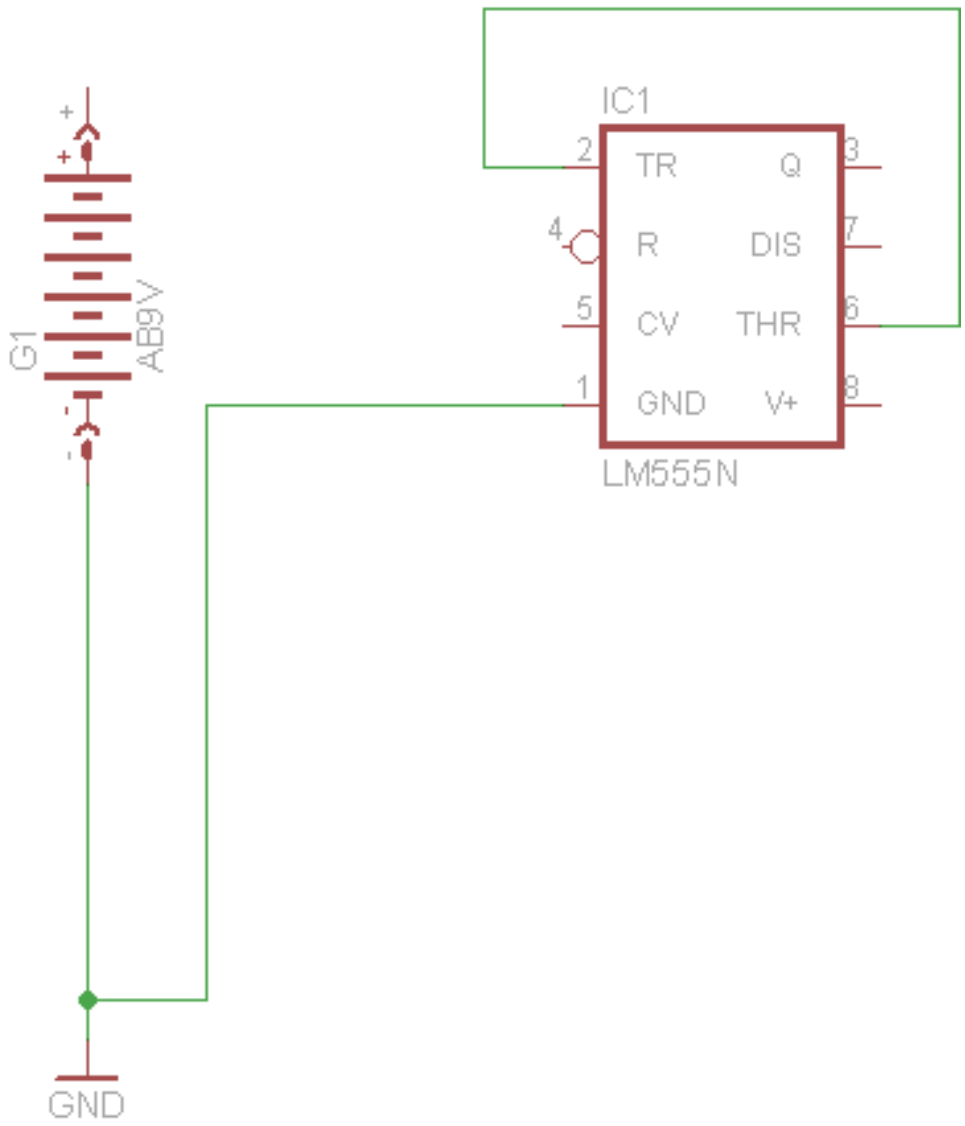
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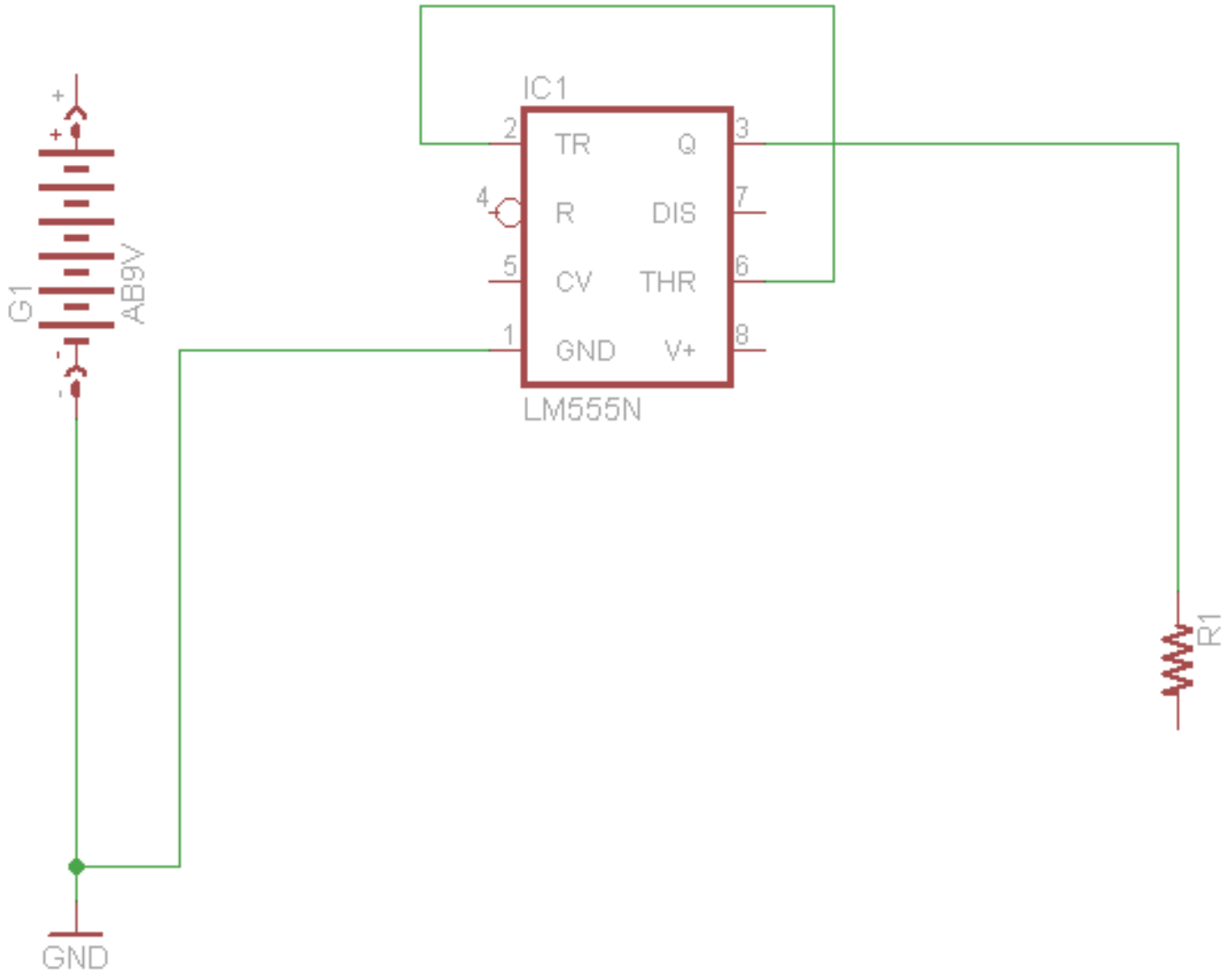
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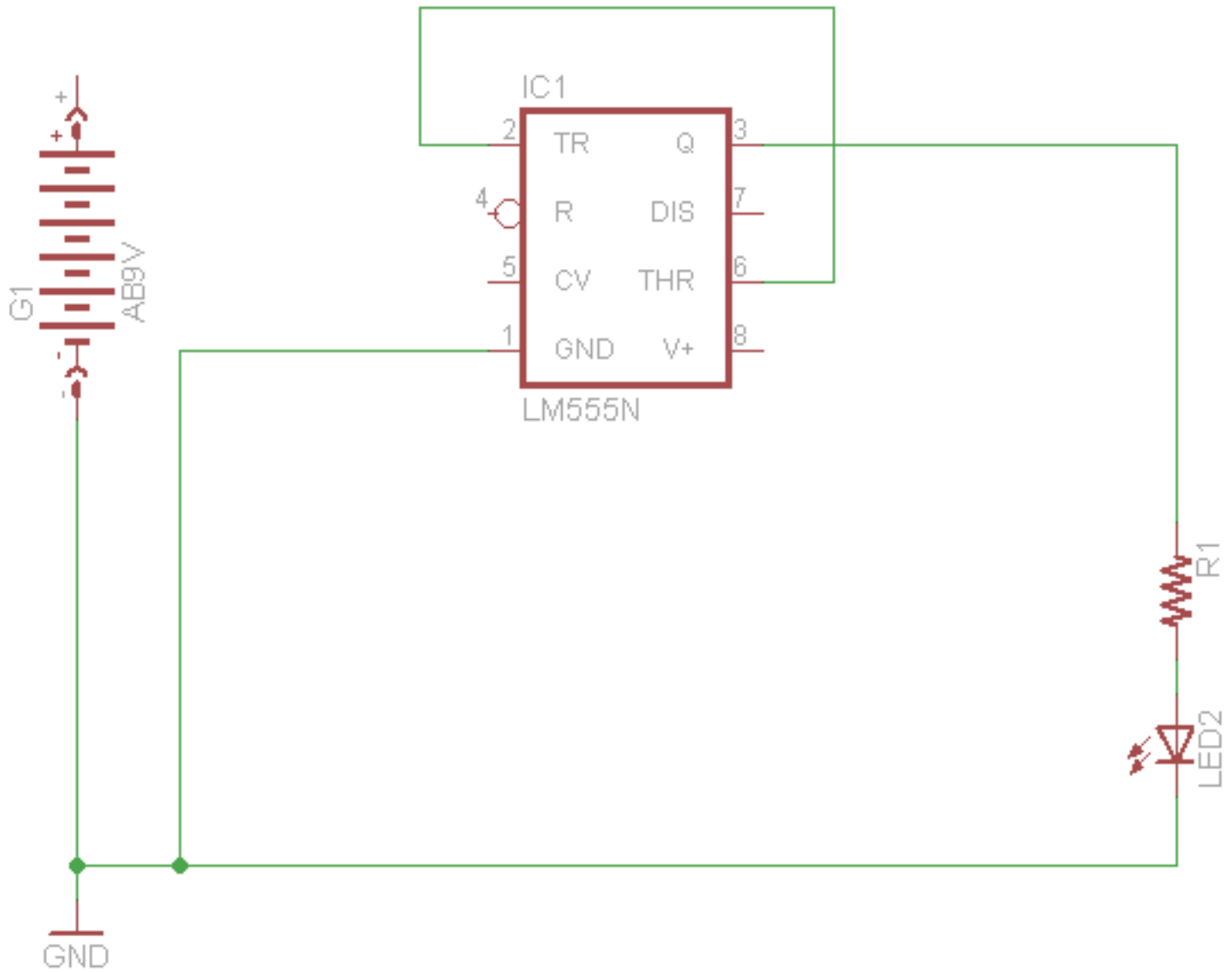
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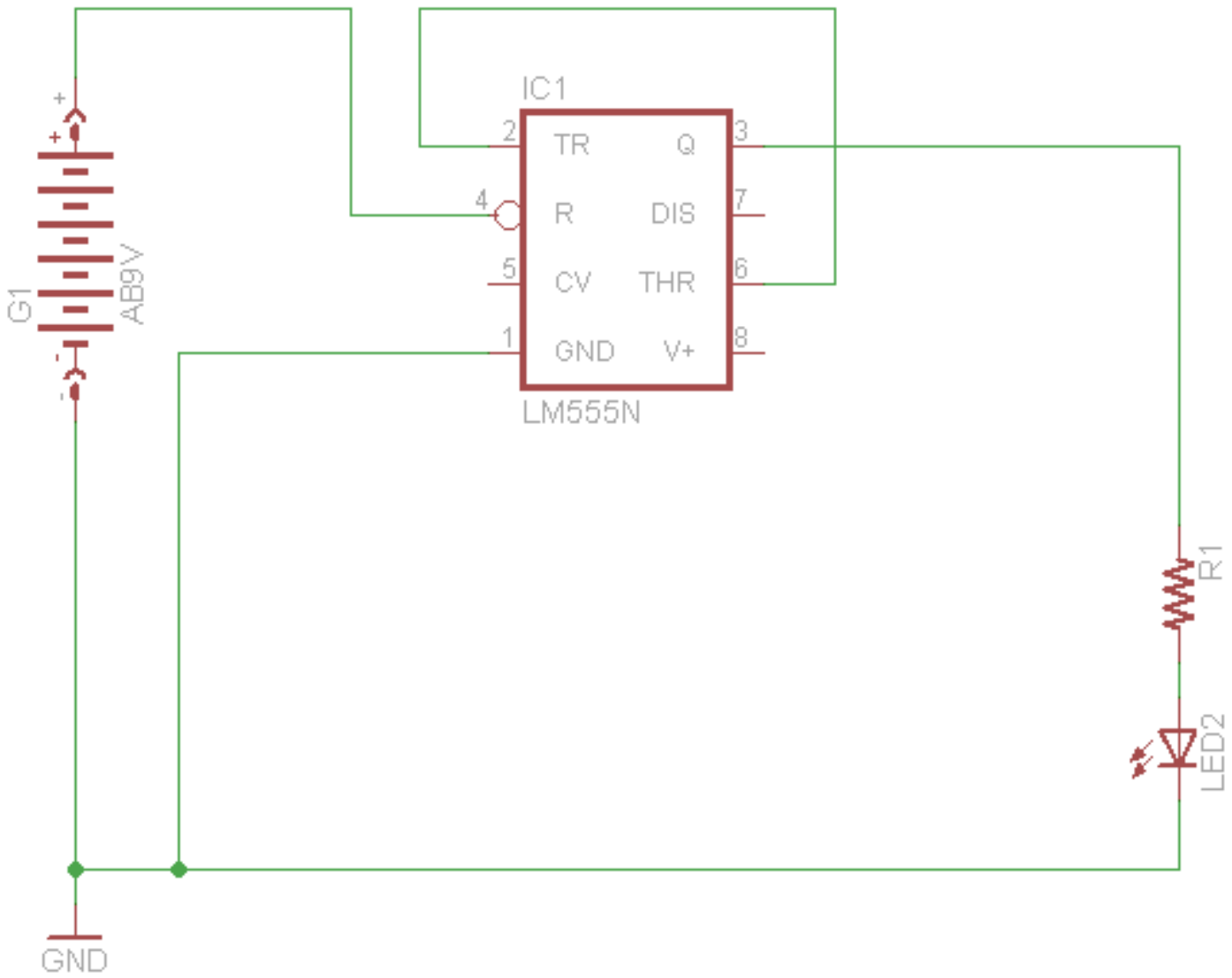
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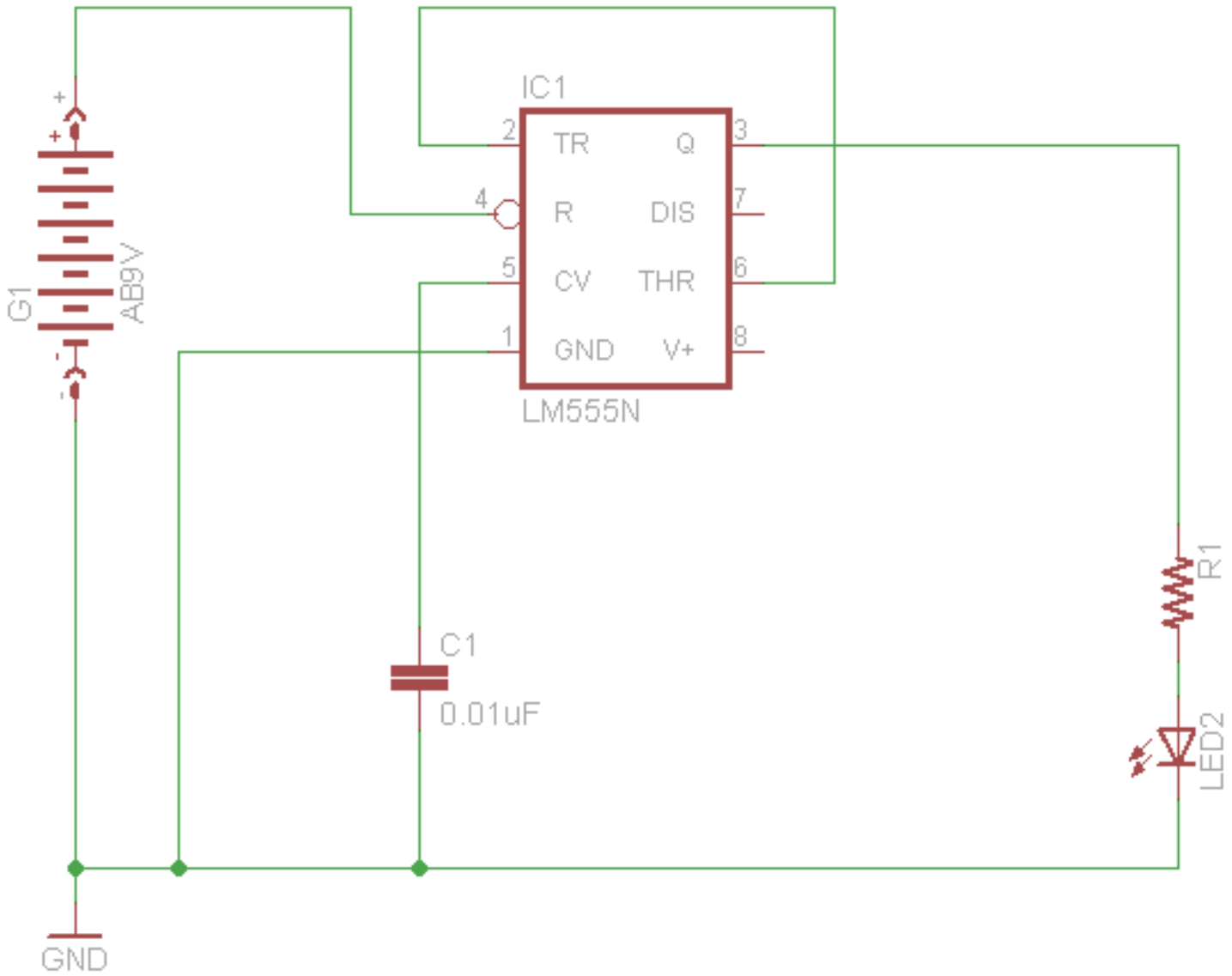
R1
LED2
GND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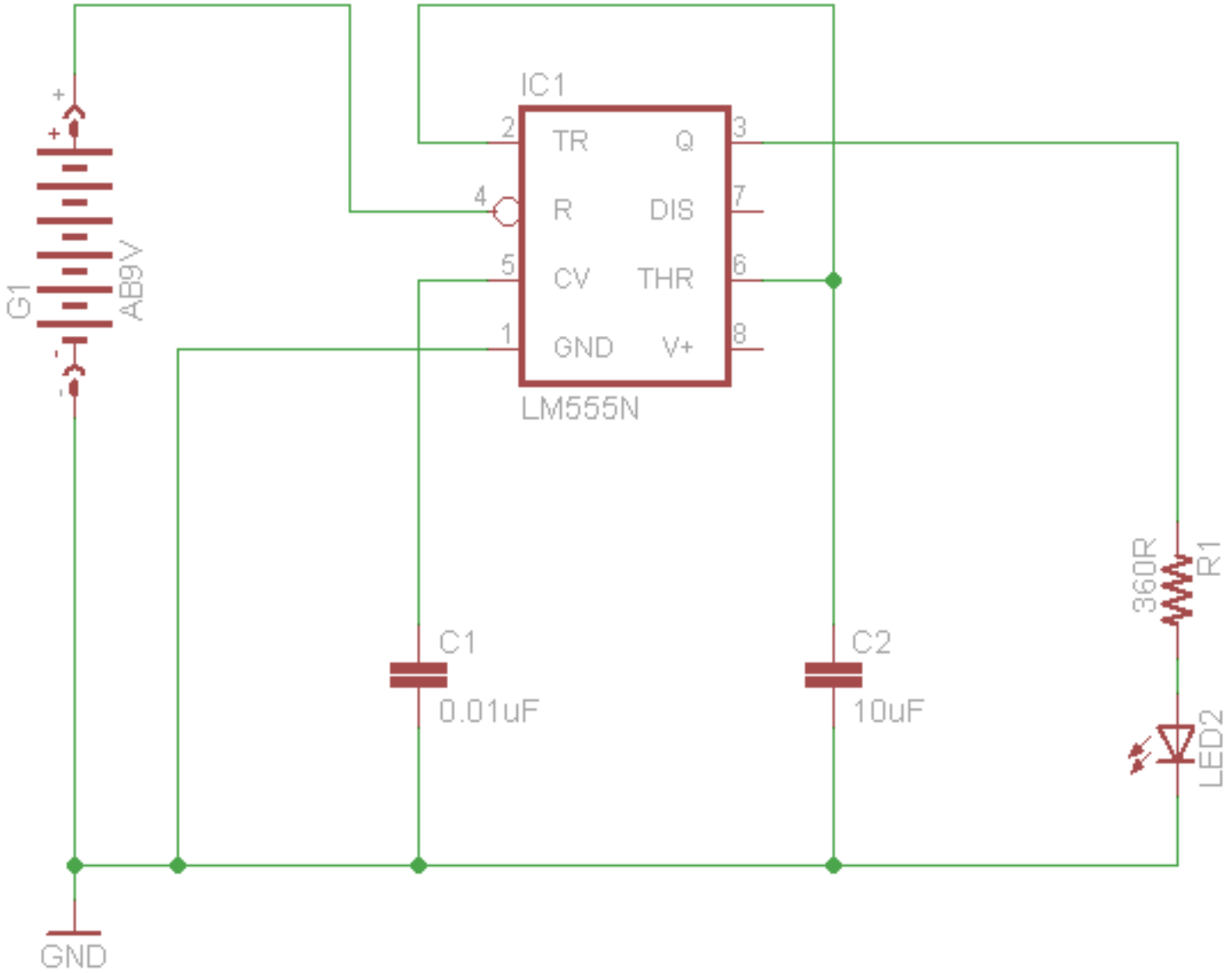
LED2
GND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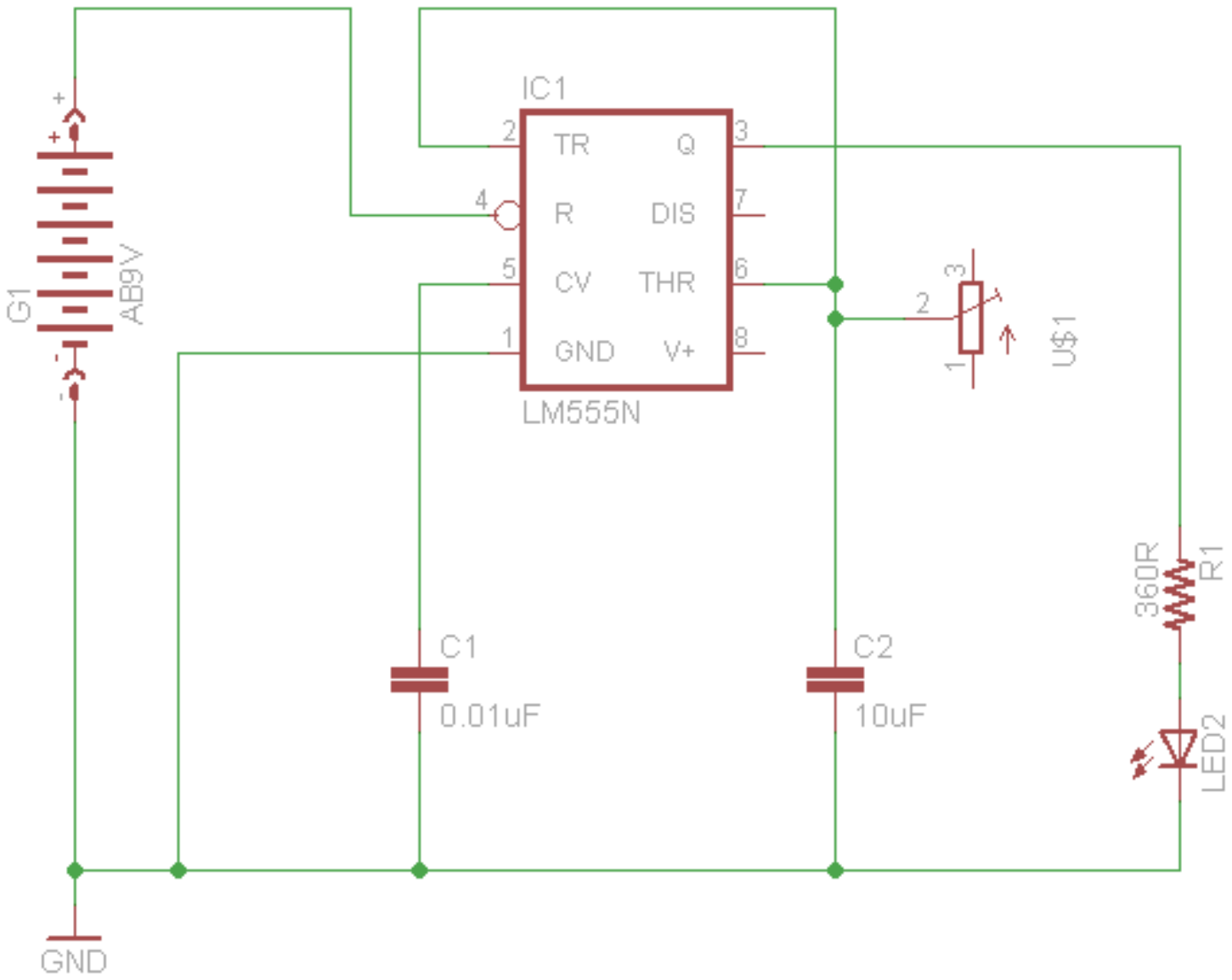
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LED2
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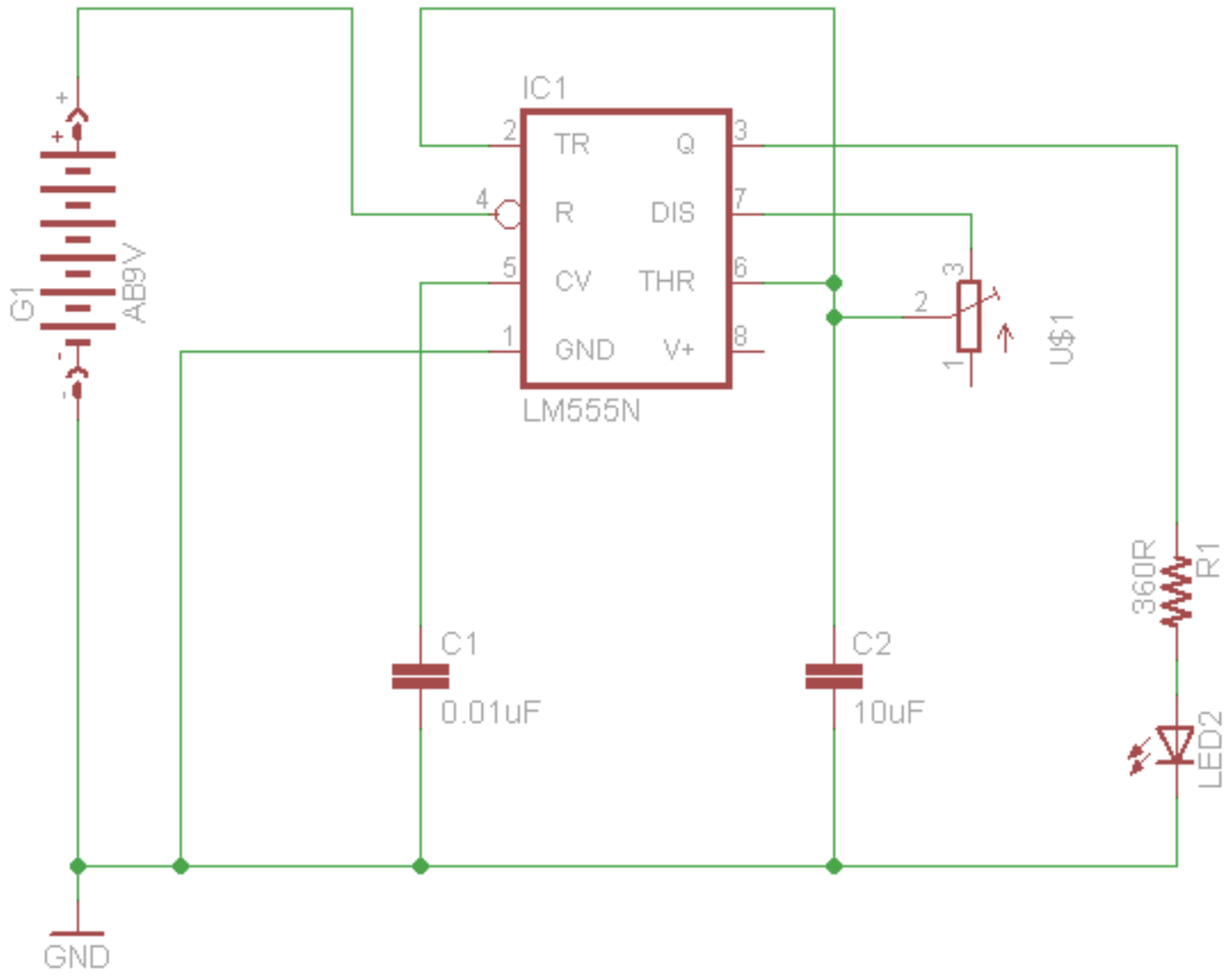
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C2
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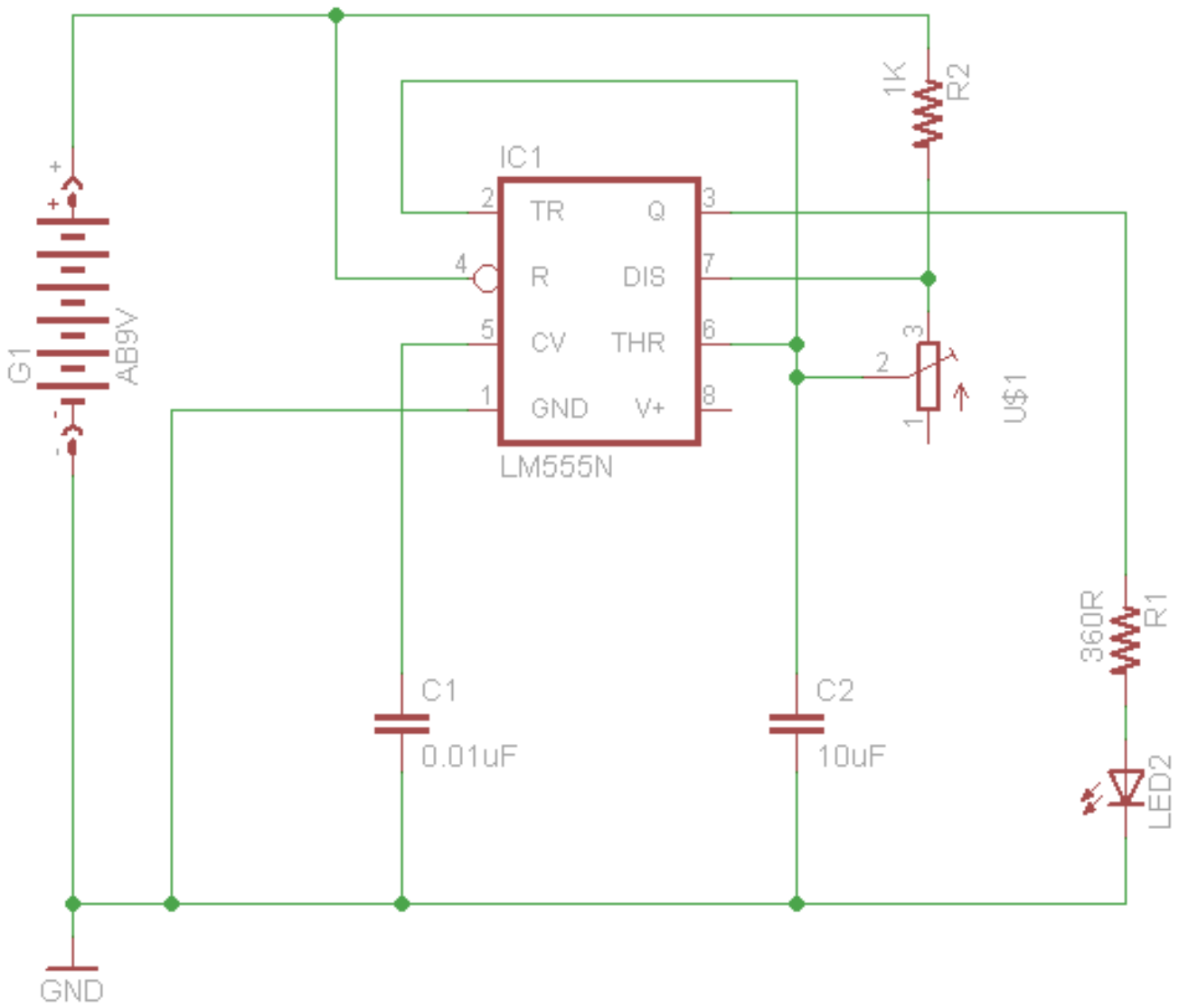
LED2
GND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C1
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C2
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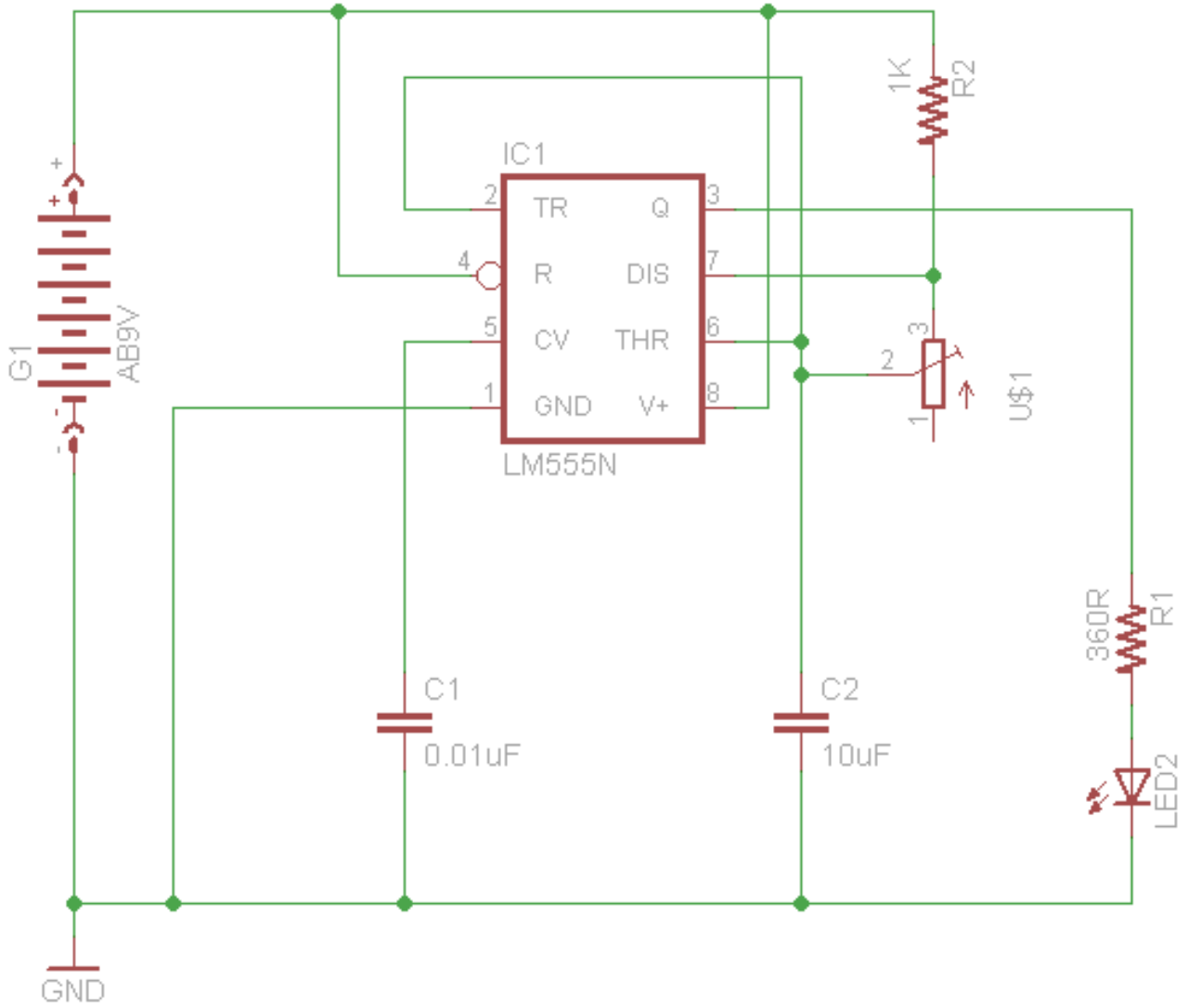
360R
R1
LED2
GND

It’s Alive!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C1
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R1
LED2
GND

Next Steps

I will be teaching a more advanced electronics class in April. What should I teach?

- Power
  - Power supplies, voltage regulators, power transistors, H-bridges
- Op-Amps
  - Amplifiers, voltage followers, current sources, oscillators
- Digital Logic
  - Buffers, comparators, level converters, logic gates