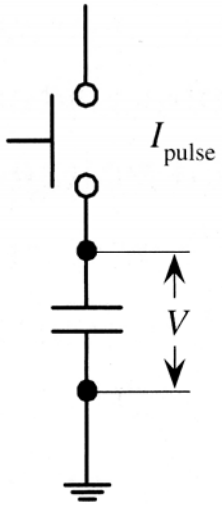
Questions?

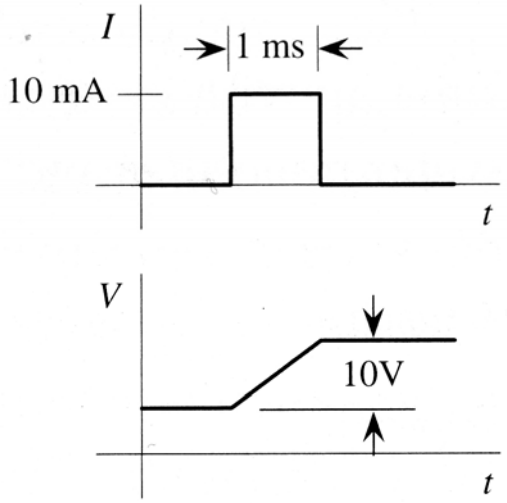
- Show and tell?
- Project?

Capacitor: key facts

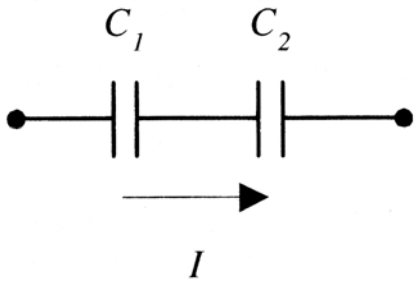
$$I = C\frac{\partial V}{\partial t}$$

$$\partial V = \frac{I}{C}\partial t$$

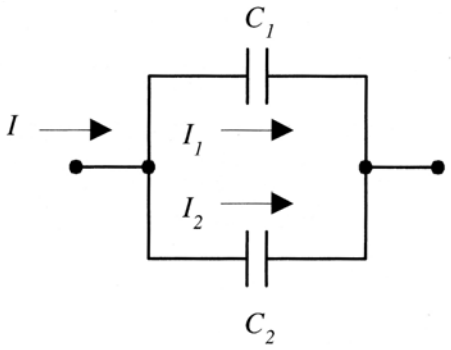




C = 1 μF



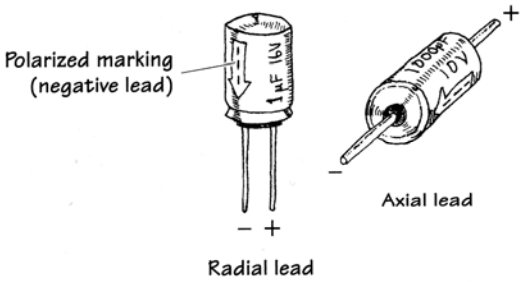
$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

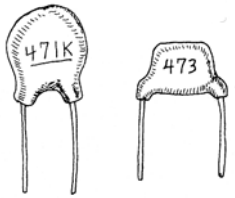


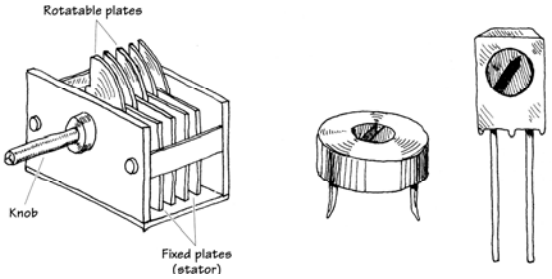
$$C_{eq} = C_1 + C_2$$

Illustrations from “Practical Electronics for Inventors” by P. Scherz

Capacitor: Examples







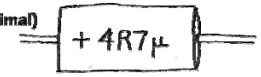
Electrolytic

(note, M here isn't a tolerance)

Label says: 100 MF
Actual value: 100 µF
(M means micro(µ))

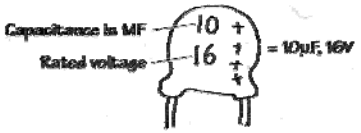
Tantalum

Label says: 4R7µ
Actual value: 4.7µF
(R represents a decimal)



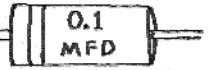
Label says: 475K
Actual value: 47 x 10^5pF
with 10% tolerance
(K = 10% tolerance)

Dipped Tantalum

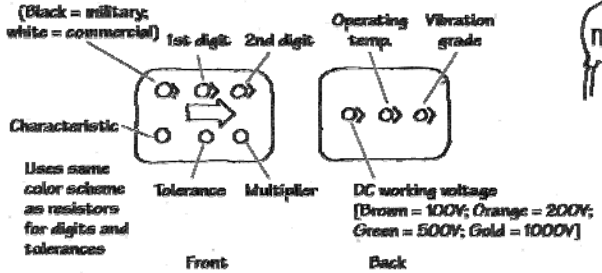


Mylar

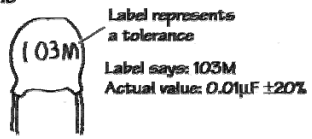
Label says: 0.1M
Actual value: 0.1µF
(M means micro)



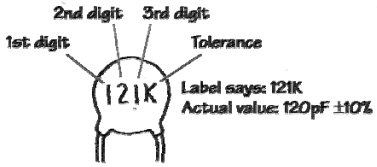
Standard



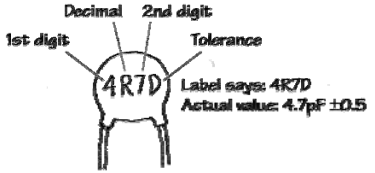
Ceramic



Label says: 103M
Actual value: 0.01µF ±20%



Label says: 121K
Actual value: 120pF ±10%



Label says: 4R7D
Actual value: 4.7pF ±0.5

European Marking

Label says: 68p
Actual value: 68pF

Label says: p68
Actual value: 0.68pF

Label says: n68
Actual value: 0.68µF

Multipliers

0 = none
1 = x 10
2 = x 100
3 = x 1000
4 = x 10,000

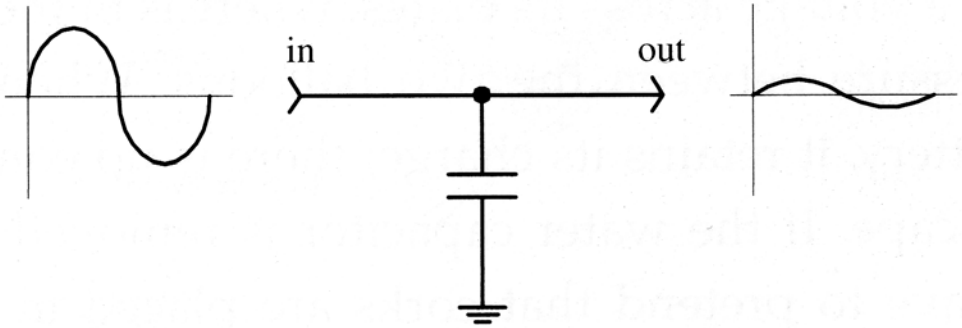
Tolerance

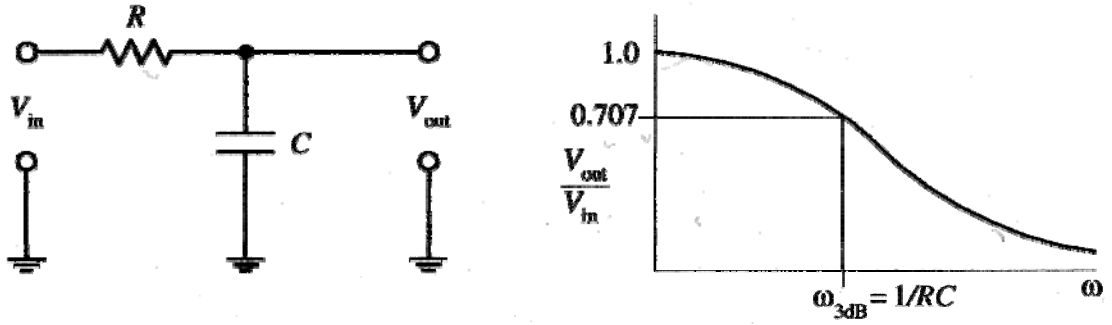
Z = +80%, −20% (asymmetric capacitor construction)
M = ±20%
K = ±10% B = ±0.1%
J = ±5% A = ±0.05%
G = ±2%
F = ±1%
D = ±0.5%
C = ±0.25%
B = ±0.1%
A = ±0.05%

1pF = 1 x 10^{-12}F
1nF = 1 x 10^{-9}F
1µF = 1 x 10^{-6}F

Illustrations from "Practical Electronics for Inventors" by P. Scherz

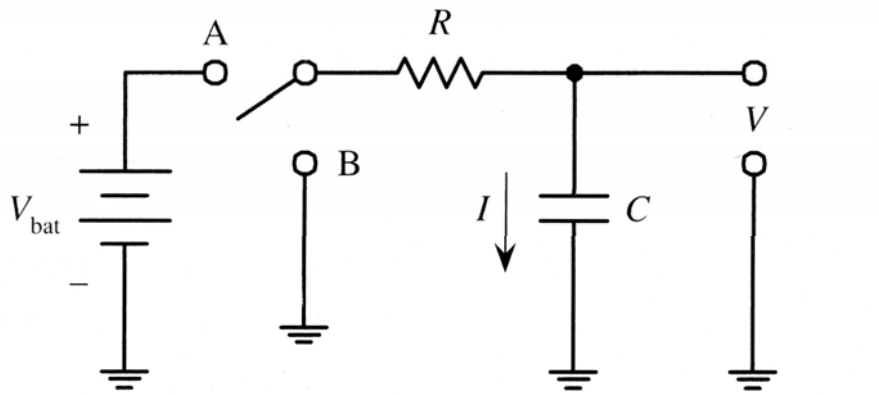
Capacitor: low pass filter (I)

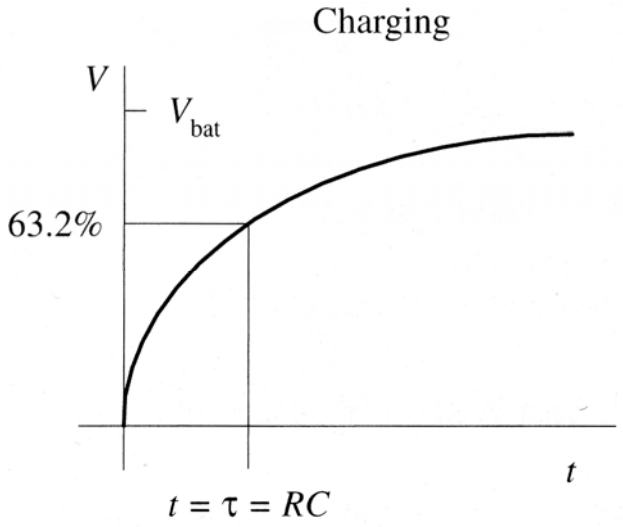


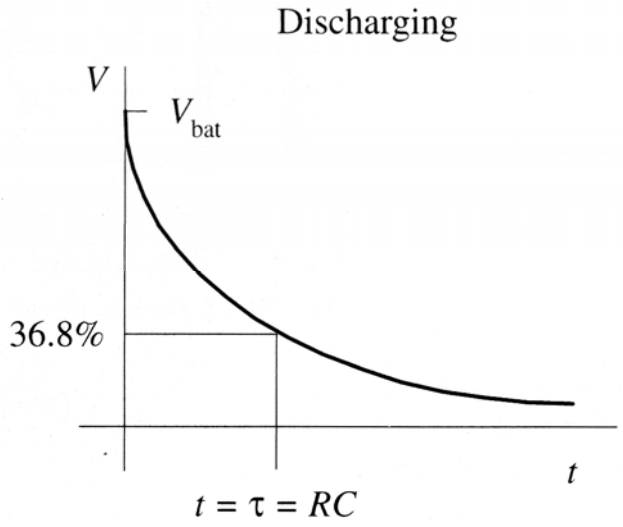


Illustrations from “Practical Electronics for Inventors” by P. Scherz

Capacitor: low pass filter (II)

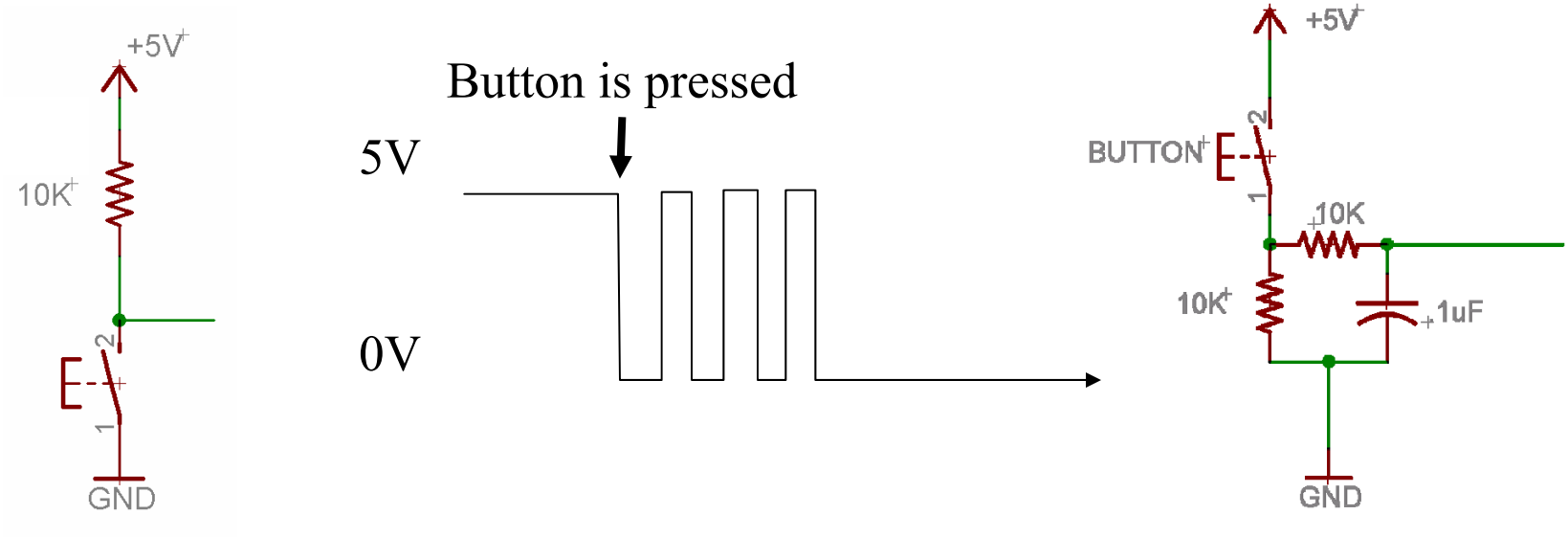






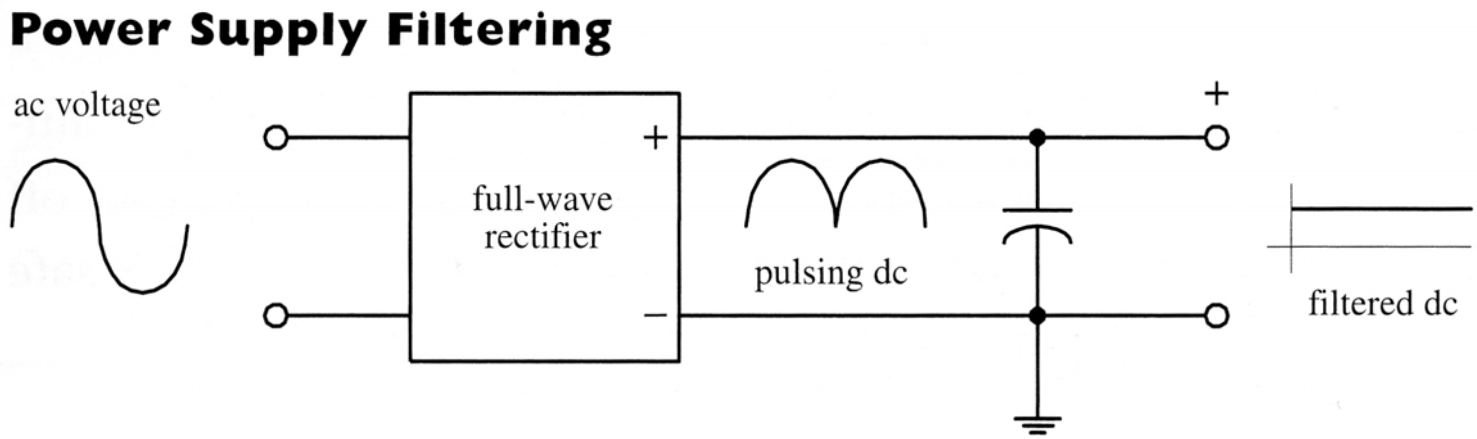
Illustrations from “Practical Electronics for Inventors” by P. Scherz

Capacitor: low pass filer (de-bouncing)

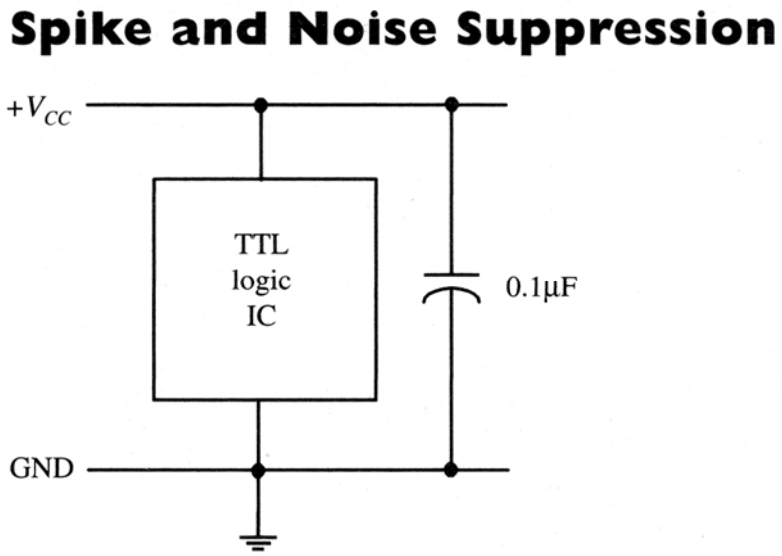


- Work in conjunction with Schmitt Trigger input (such as port RE1)
- Software solution: wait until the end of the bouncing.

Capacitor: low pass filter (power)

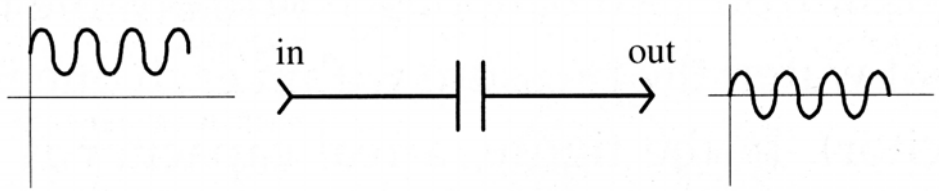


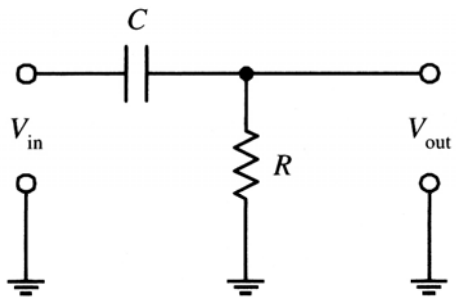
Be careful about discharge

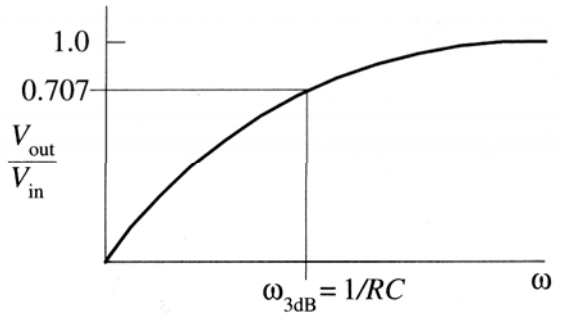


Illustrations from “Practical Electronics for Inventors” by P. Scherz

Capacitor: high pass filtering

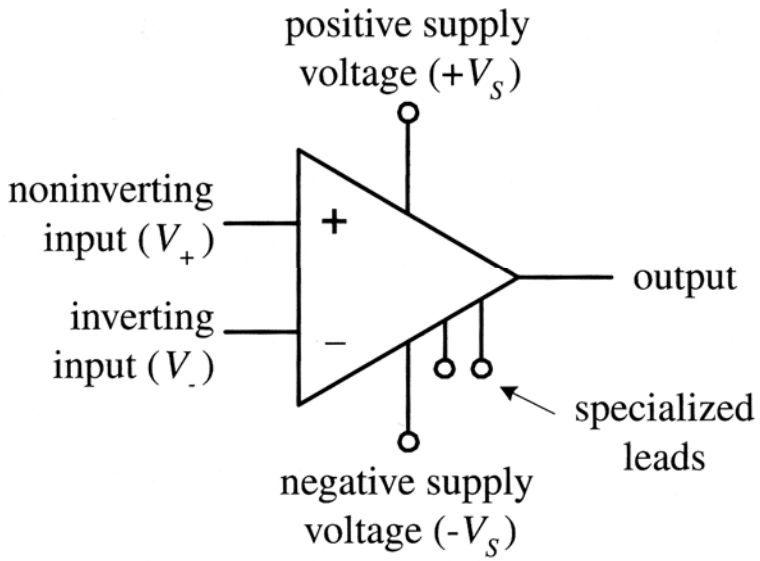




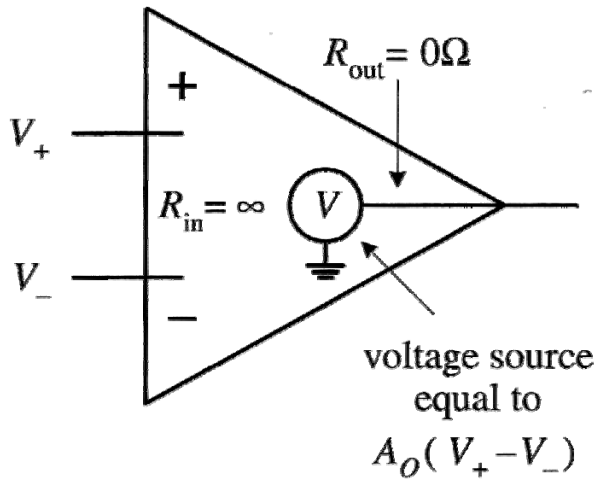


Illustrations from “Practical Electronics for Inventors” by P. Scherz

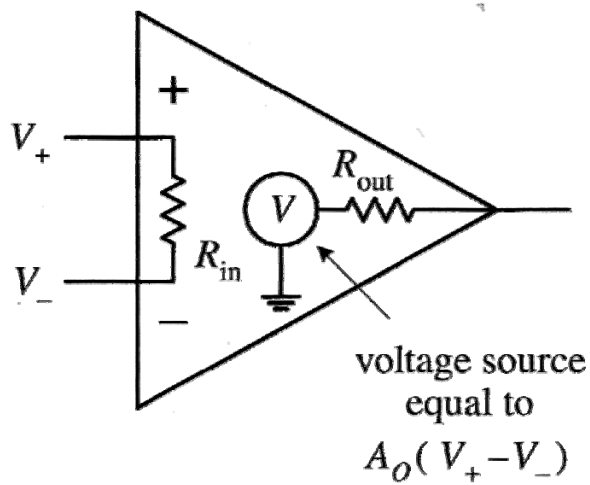
Operational Amplifier: key facts



Ideal op amp

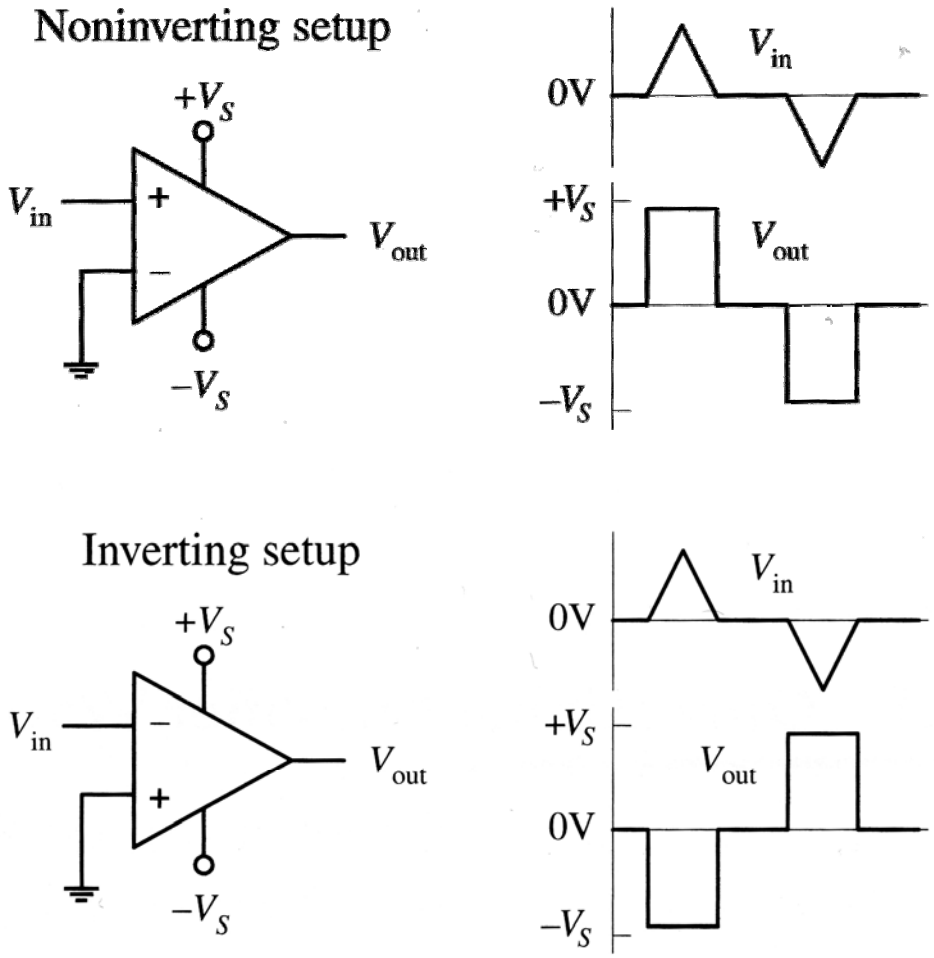


Real op amp



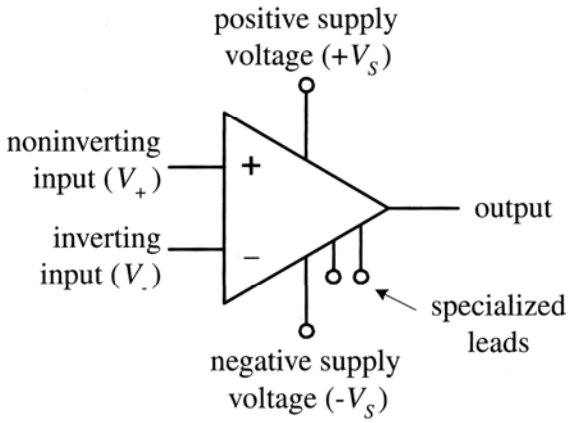
Illustrations from “Practical Electronics for Inventors” by P. Scherz

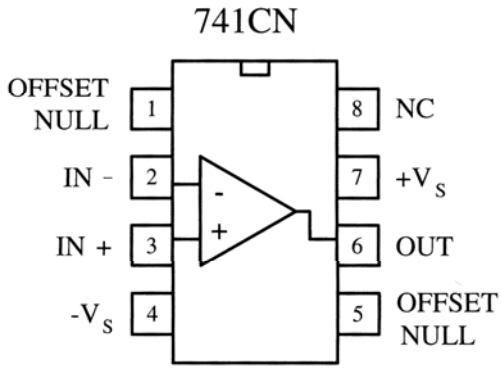
Operational Amplifier: key facts



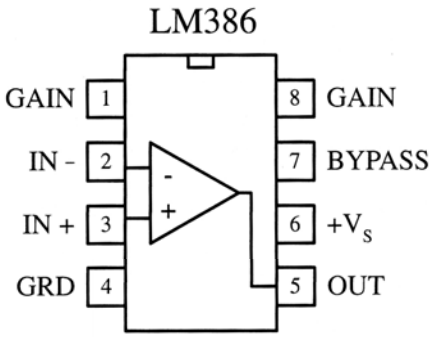
Illustrations from “Practical Electronics for Inventors” by P. Scherz

Operational Amplifier: Examples

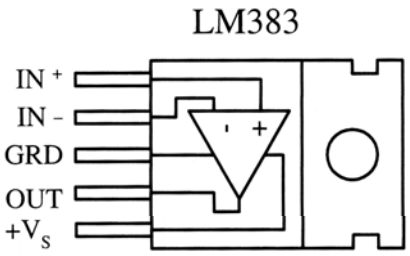




Audio Amplifiers



low-voltage power amplifier

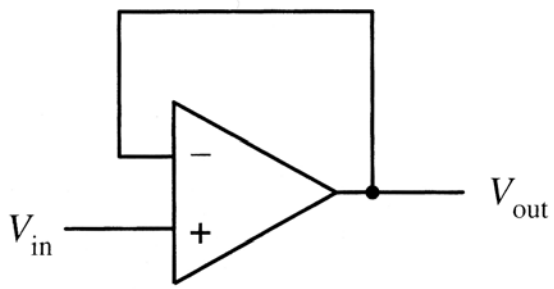


8-watt power amplifier

Illustrations from “Practical Electronics for Inventors” by P. Scherz

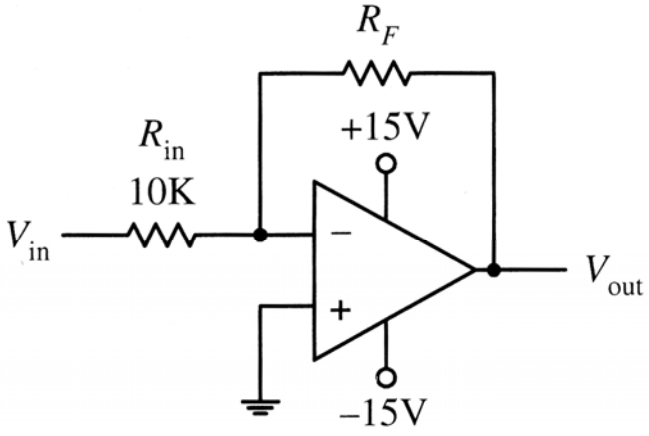
Operational Amplifier: Key circuits

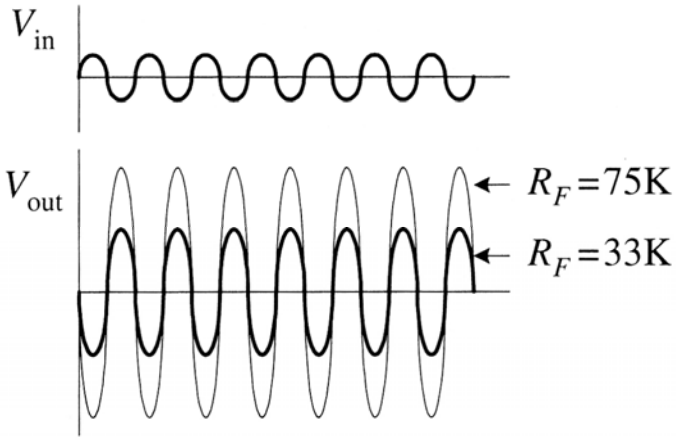
- Follower



$$V_{out} = V_{in}$$

- Inverting amplifier



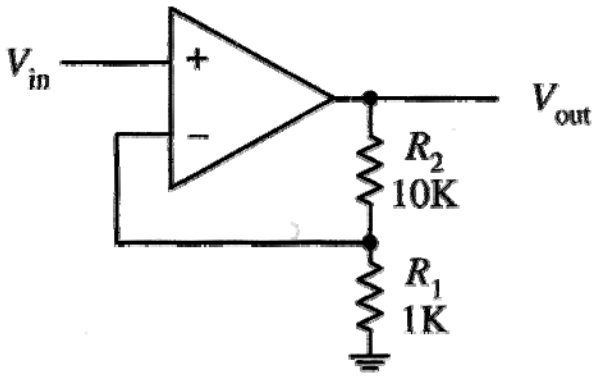


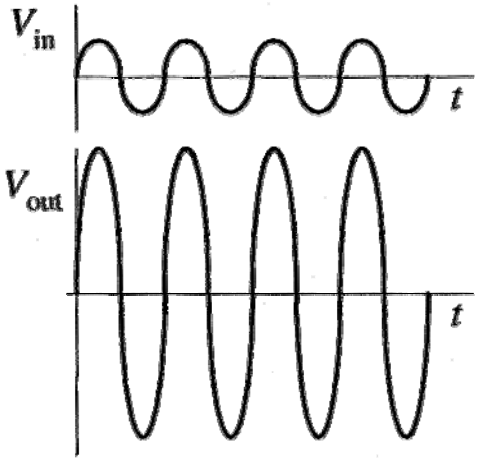
$$V_{out} = -\frac{R_F}{R_{in}} V_{in}$$

Illustrations from “Practical Electronics for Inventors” by P. Scherz

Operational Amplifier: Key circuits

- Amplifier



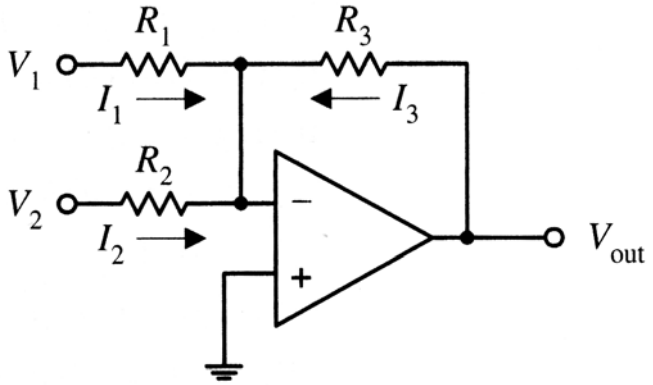


$$V_{out} = \frac{R_1 + R_2}{R_1} V_{in}$$

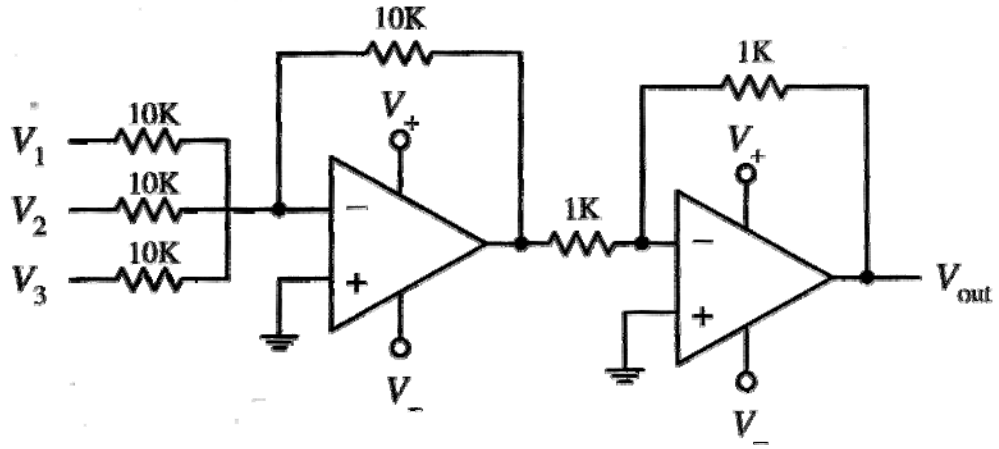
Illustrations from “Practical Electronics for Inventors” by P. Scherz

Operational Amplifier: Key circuits

- Adder



$$V_{out} = -R_3\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right)$$

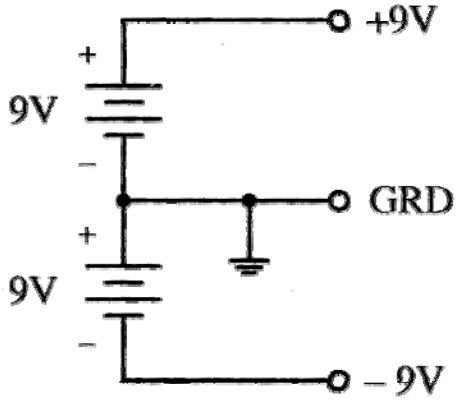


- Other operations are possible
  - Addition, derivation, integration

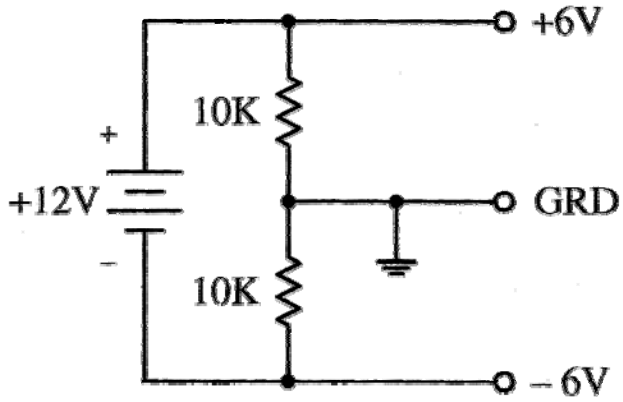
Illustrations from "Practical Electronics for Inventors" by P. Scherz

Operational Amplifier: Key circuits

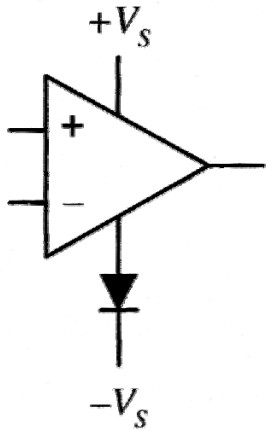
- Power supply

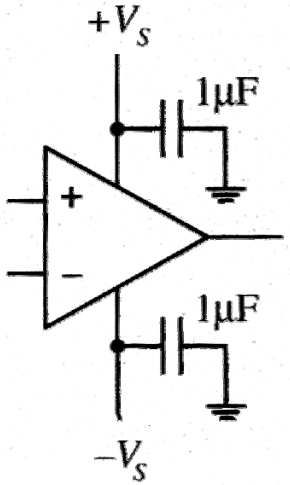


Reverse-polarity protection



Oscillation prevention

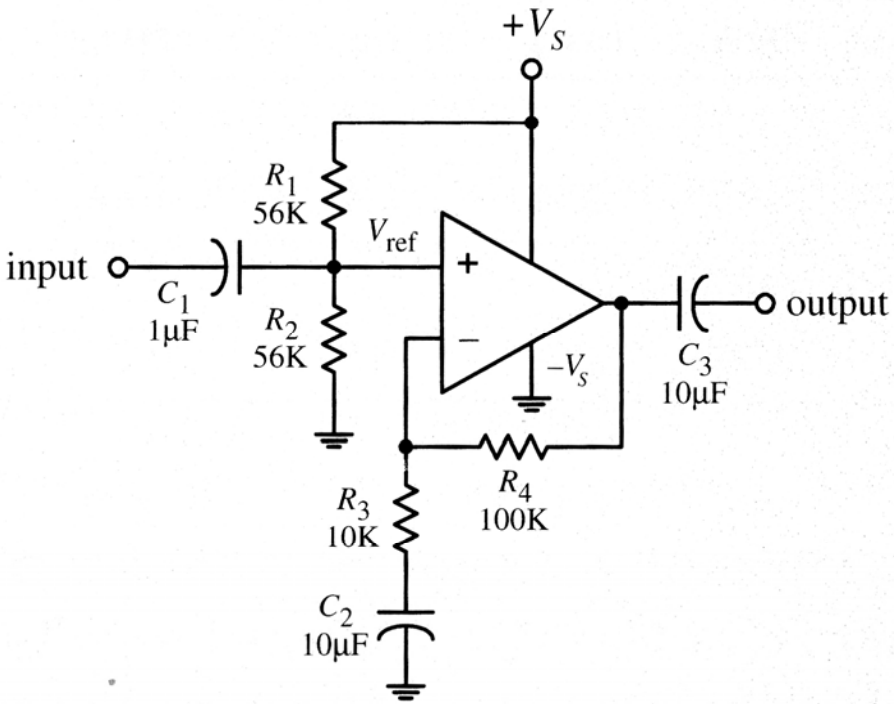




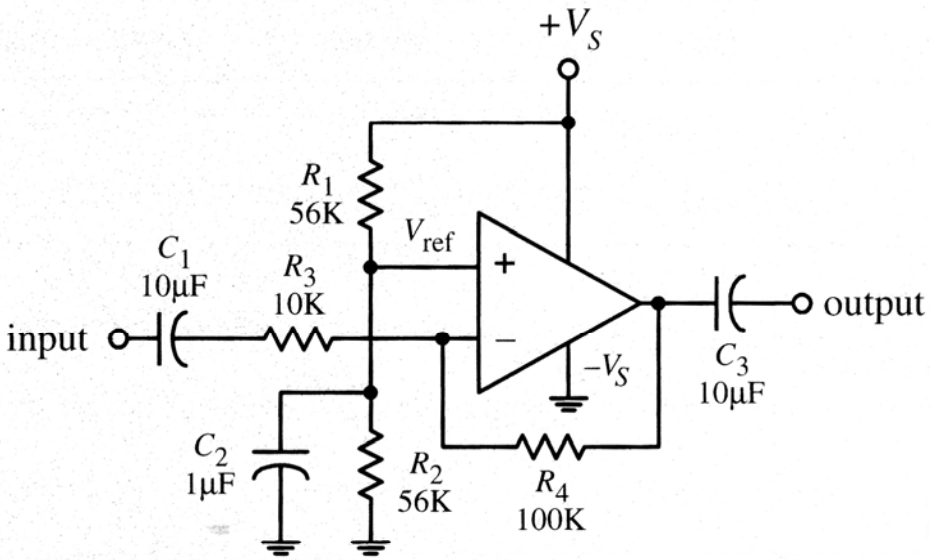
Illustrations from “Practical Electronics for Inventors” by P. Scherz

Operational Amplifier: Key circuits

Noninverting single-supply ac amplifer



Inverting single-supply ac amplifer



Illustrations from “Practical Electronics for Inventors” by P. Scherz