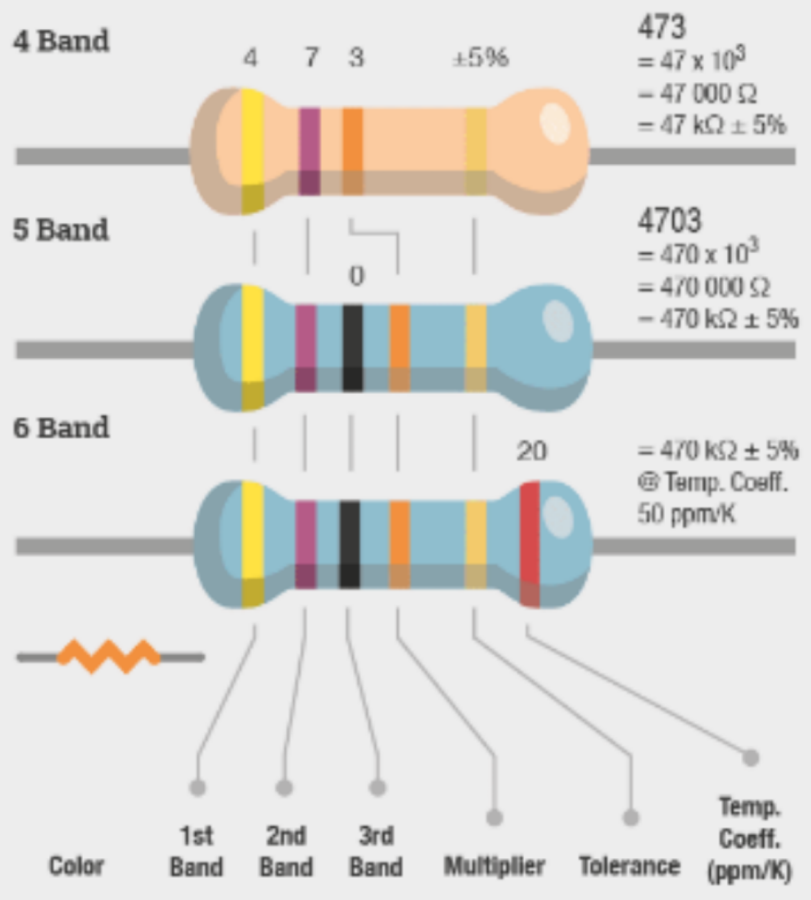
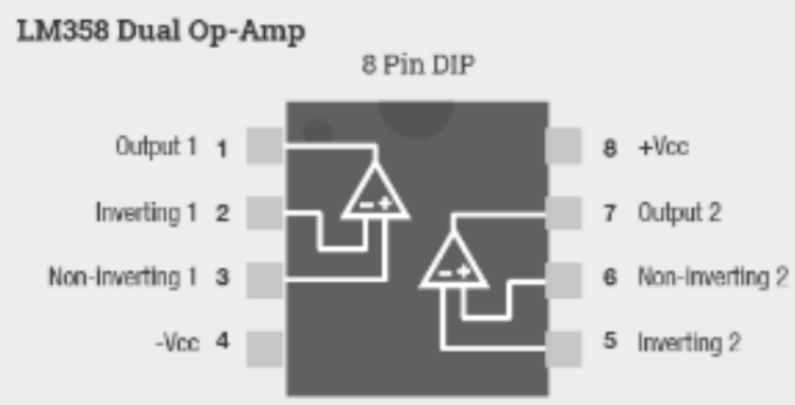
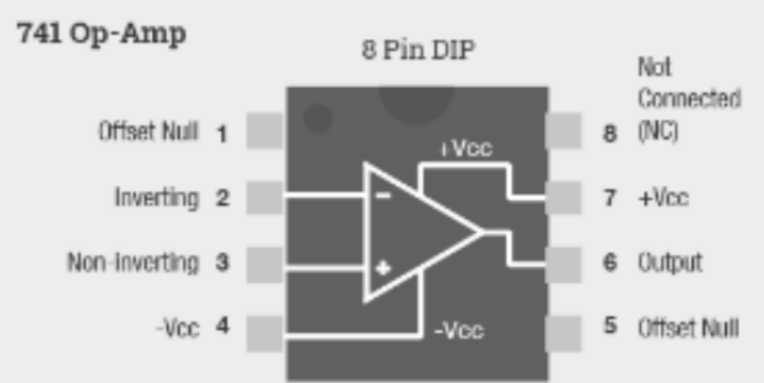


Resistor Color Coding

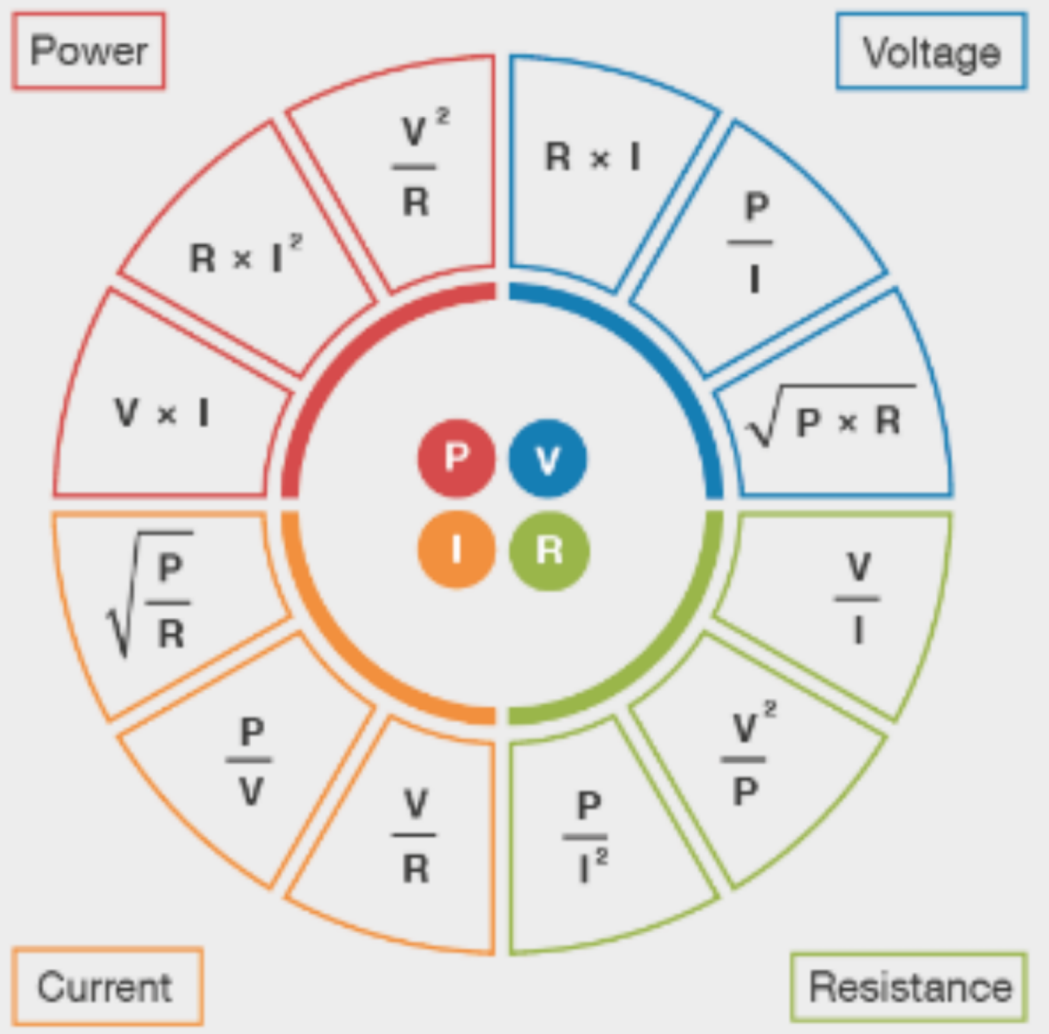


| | | | | | | |
|--------|---|---|------------------|----|-------|-----|
| Black | 0 | 0 | $\times 10^0$ | 0 | | 250 |
| Brown | 1 | 1 | $\times 10^1$ | 1 | ±1% | 100 |
| Red | 2 | 2 | $\times 10^2$ | 2 | ±2% | 50 |
| Orange | 3 | 3 | $\times 10^3$ | 3 | | 15 |
| Yellow | 4 | 4 | $\times 10^4$ | 4 | | 25 |
| Green | 5 | 5 | $\times 10^5$ | 5 | ±.50% | 20 |
| Blue | 6 | 6 | $\times 10^6$ | 6 | ±.25% | 10 |
| Violet | 7 | 7 | $\times 10^7$ | 7 | ±.10% | 5 |
| Grey | 8 | 8 | | | ±.05% | 1 |
| White | 9 | 9 | | | | |
| Gold | | | $\times 10^{-1}$ | -1 | ±5% | |
| Silver | | | $\times 10^{-2}$ | -2 | ±10% | |

Op-Amp



Ohm's Law

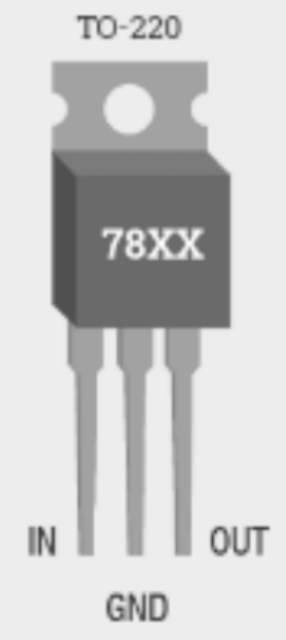


M Metric Prefixes

| | | | |
|--------|----|-------------------|-------------------|
| Tera- | T | $\times 10^{12}$ | 1 000 000 000 000 |
| Giga- | G | $\times 10^9$ | 1 000 000 000 |
| Mega- | M | $\times 10^6$ | 1 000 000 |
| Kilo- | K | $\times 10^3$ | 1 000 |
| Hecto- | H | $\times 10^2$ | 100 |
| Deka- | Da | $\times 10^1$ | 10 |
| (base) | - | $\times 10^0$ | 1 |
| Deci- | d | $\times 10^{-1}$ | 0.1 |
| Centi- | c | $\times 10^{-2}$ | 0.01 |
| Milli- | m | $\times 10^{-3}$ | 0.001 |
| Micro- | μ | $\times 10^{-6}$ | 0.000 001 |
| Nano- | n | $\times 10^{-9}$ | 0.000 000 001 |
| Pico- | p | $\times 10^{-12}$ | 0.000 000 000 001 |

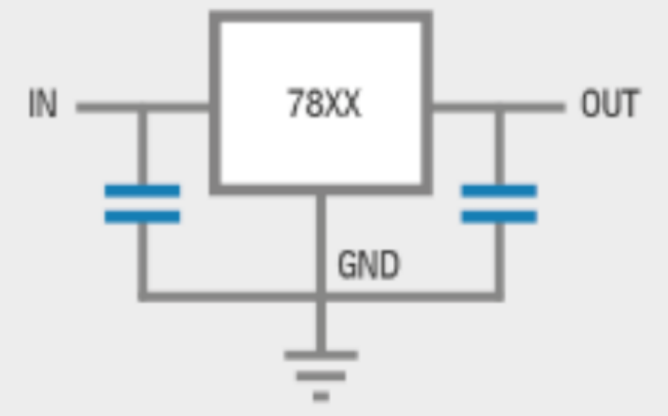
R Regulator

LM78XX Regulator



- Common Outputs**
- 7805, 5V Regulator
 - 7812, 12V Regulator
 - 7905, -5V Regulator
 - 7912, -12V Regulator

Basic Configuration



Light Emitting Diode (LED)

Typical LED Characteristics

| Color | Wavelength (nm) | Typical Forward Voltage (V) @ 20 mA |
|-------------|-----------------|-------------------------------------|
| Red | 630 - 660 | 1.8 |
| Orange | 605 - 620 | 2.0 |
| Yellow | 585 - 595 | 2.2 |
| Green | 550 - 570 | 3.5 |
| Blue | 430 - 505 | 3.6 |
| White | 450 | 4.0 |
| Ultraviolet | 850 - 940 | 1.2 |

Surface Mount Devices (SMDs)

SMD Resistor Markings

| 3 Digit | 4 Digit |
|--|---|
| 473 = 47×10^3 = 47 000 Ω = 47 k Ω | 4702 = $470 \times 10^2 \Omega$ = 47 000 Ω = 47 k Ω |
| 4R7 = 4.7 Ω | OR47 = 0.47 Ω |

SMD Capacitor Markings

Tantalum

| | |
|--|--|
| 473 = 47×10^3 pF = 47 nF @ 16V | 473 = 47×10^3 pF = 47 nF @ 16V |
|--|--|

Electrolytic Capacitor

Capacitor Coding

Common Capacitors

Ceramic
2D
103
J
Max. Voltage
Capacitance
Tolerance

103
= 10×10^3
= 1000 pF
= 1 nF

Electrolytic
1uF 25 V

Capacitance Conversion Table

| Microfarads (uF) | Nanofarads (nF) | Picofarads (pF) |
|------------------|-----------------|-----------------|
| 0.000001 uF | = 0.001 nF | = 1 pF |
| 0.00001 uF | = 0.01 nF | = 10 pF |
| 0.0001 uF | = 0.1 nF | = 100 pF |
| 0.001 uF | = 1 nF | = 1 000 pF |
| 0.01 uF | = 10 nF | = 10 000 pF |
| 0.1 uF | = 100 nF | = 100 000 pF |
| 1 uF | = 1 000 nF | = 1 000 000 pF |

Max. Operating Voltage

| | | | |
|----|-------|----|-------|
| 1H | 50 V | 2E | 250 V |
| 2A | 100 V | 2G | 400 V |
| 2T | 150 V | 2J | 630 V |
| 2D | 200 V | | |

Tolerance

| | | | |
|---|---------------|---|--------------|
| B | ± 0.1 pF | H | $\pm 3\%$ |
| C | ± 0.25 pF | J | $\pm 5\%$ |
| D | ± 0.50 pF | K | $\pm 10\%$ |
| F | $\pm 1\%$ | M | $\pm 20\%$ |
| G | $\pm 2\%$ | Z | +80% -20% |

Diodes and Transistors

Diode

A K
Schematic Symbol

1N4001
Anode (A) Cathode (K)

Bipolar Junction Transistor (BJT)

TO-92

C B E
NPN
2N3903
2N2222

E B C
NPN
BC546

B C
PNP
BC556

E
NPN

B C E
PNP

BJT Schematic Symbols

MOS Field Effect Transistor (MOSFET)

TO-92

D G S
N-channel
2N7000

S G D
P-channel
BS250

D S
N-channel

S D
P-channel

SOT-23
G S D
N-channel
2N7002

Enhancement Mode MOSFET Schematic Symbols

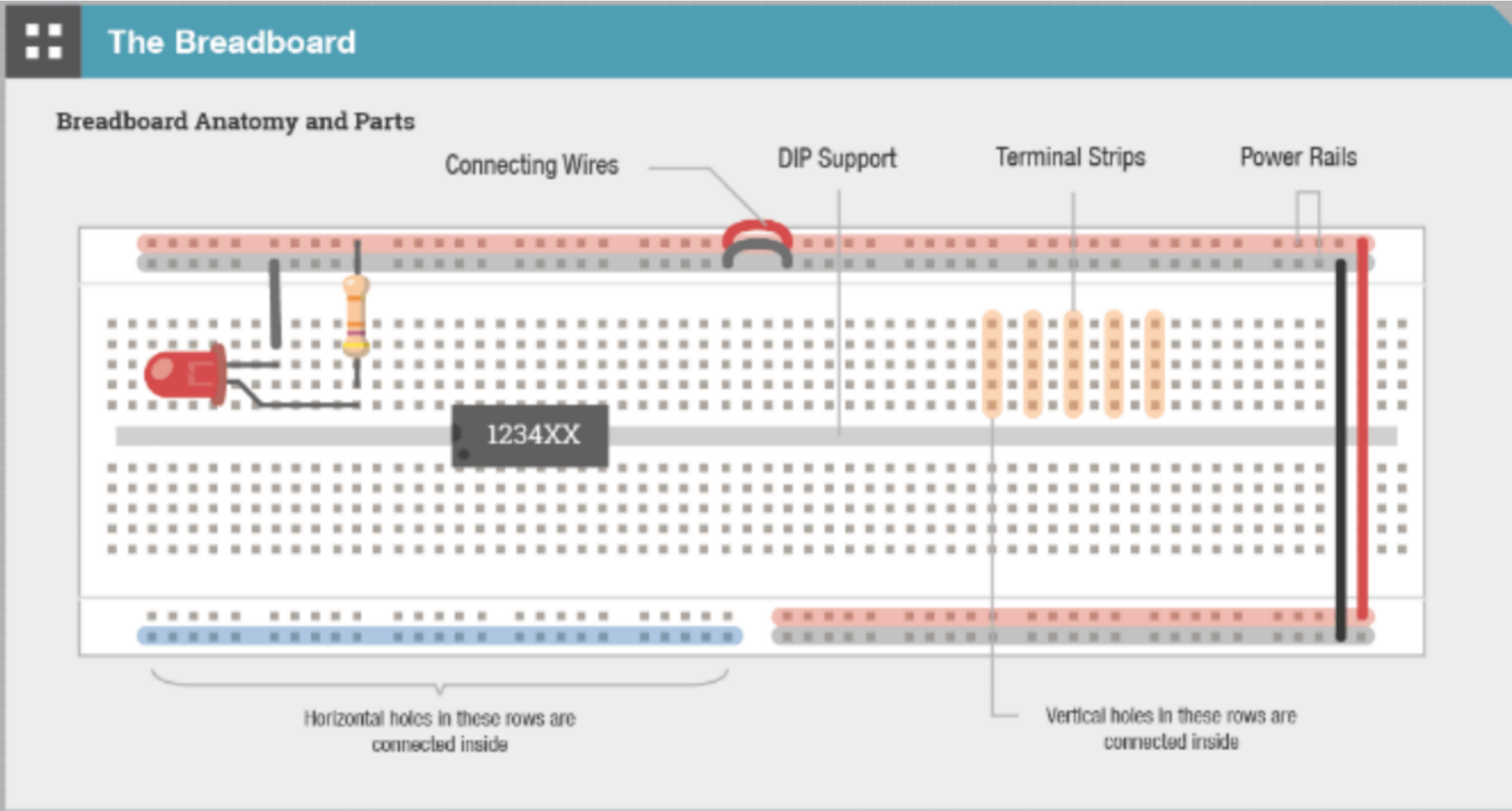
Component pinouts shown are the most common and may still vary per device manufacturer. Refer to the specific device datasheet to be sure.



Electrical Units

Basic Electrical Units

| Quantity | Abbrev. / Unit | Quantity | Abbrev. / Unit |
|-------------|------------------|---------------|-----------------|
| Capacitance | F Farad | Inductance | H Henry |
| Charge | C Coulomb | Magnetic Flux | Wb Weber |
| Current | A Ampere | Potential | V Volt |
| Energy | J Joule | Power | W Watt |
| Force | N Newton | Resistance | Ω Ohm |
| Frequency | Hz Hertz | | |



American Wire Gauge

Copper Wire

Diameter

Cross Sectional Area

Actual Cross Sect. Size

| AWG No. | Diameter (in) | Diameter (mm) | CS Area (mm ²) | Resistance (Ω/km) |
|---------|---------------|---------------|----------------------------|-------------------|
| 4/0 | .4600 | 11.68 | 107.2 | .1608 |
| 3/0 | .4096 | 10.40 | 85.03 | .2028 |
| 2/0 | .3649 | 9.296 | 67.43 | .2557 |
| 1/0 | .3249 | 8.252 | 53.48 | .3224 |
| 1 | .2893 | 7.348 | 42.41 | .4066 |
| 2 | .2576 | 6.544 | 33.63 | .5127 |
| 3 | .2294 | 5.827 | 26.67 | .6465 |
| 4 | .2043 | 5.189 | 21.15 | .8152 |
| 5 | .1819 | 4.621 | 16.77 | 1.028 |
| 6 | .1620 | 4.115 | 13.30 | 1.296 |
| 7 | .1443 | 3.665 | 10.55 | 1.634 |
| 8 | .1285 | 3.264 | 8.366 | 2.061 |
| 9 | .1144 | 2.906 | 6.634 | 2.589 |
| 10 | .1019 | 2.588 | 5.261 | 3.277 |
| 11 | .0907 | 2.305 | 4.172 | 4.132 |
| 12 | .0808 | 2.053 | 3.309 | 5.211 |
| 13 | .0720 | 1.828 | 2.624 | 6.571 |
| 14 | .0641 | 1.628 | 2.081 | 8.286 |
| 15 | .0571 | 1.450 | 1.650 | 10.45 |
| 16 | .0508 | 1.291 | 1.309 | 13.17 |
| 18 | .0403 | 1.024 | .8231 | 20.95 |
| 20 | .0320 | .8118 | .5176 | 33.31 |
| 22 | .0253 | .6438 | .3255 | 52.96 |
| 24 | .0201 | .5106 | .2047 | 84.22 |
| 26 | .0159 | .4049 | .1288 | 133.9 |
| 28 | .0126 | .3211 | .08098 | 212.9 |
| 30 | .0100 | .2546 | .05093 | 338.6 |
| 32 | .00795 | .2019 | .03203 | 538.3 |
| 34 | .00630 | .1601 | .02014 | 856.0 |
| 36 | .00500 | .1270 | .01267 | 1361 |
| 38 | .00397 | .1007 | .00797 | 2164 |
| 40 | .00314 | .0799 | .00501 | 3441 |