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written by mahdi miled | 23 November 2017

Practical Electronics for Inventors, Fourth Edition

by: Paul Scherz, Dr. Simon Monk

Abstract: A fully updated, no-nonsense guide to electronics. Advance your electronics knowledge and gain the skills necessary to develop and construct your own functioning gadgets. Written by a pair of experienced engineers and dedicated hobbyists, Practical Electronics for Inventors, Fourth Edition, lays out the essentials and provides step-by-step instructions, schematics, and illustrations. Discover how to select the right components, design and build circuits, use microcontrollers and ICs, work with the latest software tools, and test and tweak your creations. This easy-to-follow book features new instruction on programmable logic, semiconductors, operational amplifiers, voltage regulators, power supplies, digital electronics, and more. Coverage includes:

- Resistors, capacitors, inductors, and transformers
- Diodes, transistors, and integrated circuits
- Optoelectronics, solar cells, and phototransistors
- Sensors, GPS modules, and touch screens
- Op amps, regulators, and power supplies
- Digital electronics, LCDs, and logic gates
- Microcontrollers and prototyping platforms
- Combinational and sequential programmable logic
- DC motors, RC servos, and stepper motors
- Microphones, audio amps, and speakers
- Modular electronics and prototypes

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Description: A fully updated, no-nonsense guide to electronics. Advance your electronics knowledge and gain the skills necessary to develop and construct your own functioning gadgets. Written by a pair of experienced engineers and dedicated hobbyists, Practical Electronics for Inventors, Fourth Edition, lays out the essentials and provides step-by-step instructions, schematics, and illustrations. Discover how to select the right components, design and build circuits, use microcontrollers and ICs, work with the latest software tools, and test and tweak your creations. This easy-to-follow book

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1. <https://www.amazon.com/Practical-Electronics-Inventors-Fourth-Scherz/dp/1259587541> [back]

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FOURTH EDITION

PRACTICAL ELECTRONICS FOR INVENTORS

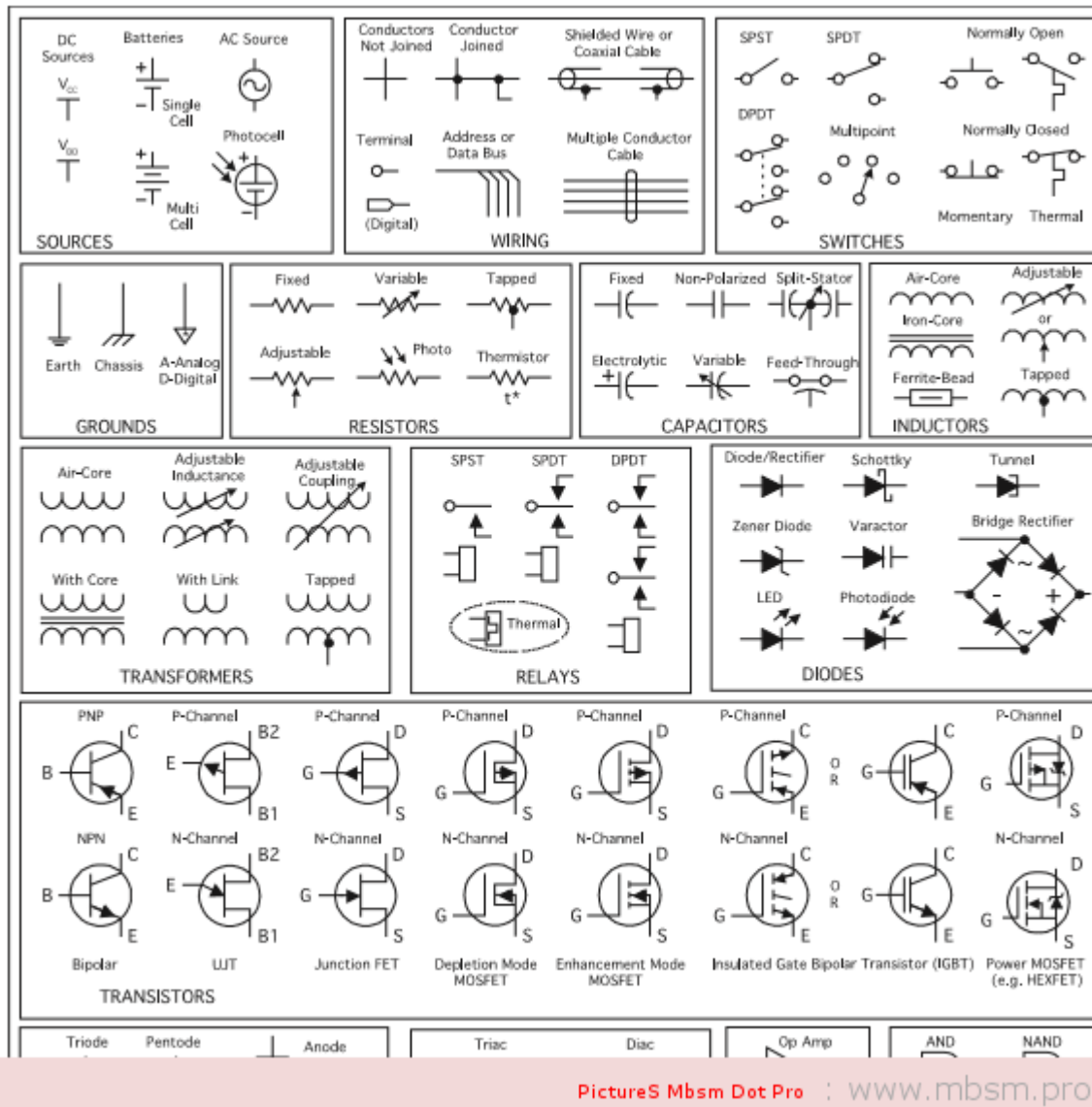


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Resistor Labels

Conversion Calculator

k = 1,000 ; M = 1,000,000

1MΩ = 1,000,000 Ω = 1 x 10⁶Ω

1kΩ = 1,000 Ω = 1 x 10³Ω

Examples:

3.3 kΩ = 3,300 Ω = 3.3 x 10³Ω

22 kΩ = 22,000 Ω = 22 x 10³Ω

2 MΩ = 2,000,000 Ω = 2 x 10⁶Ω

1.68 MΩ = 1,680,000 Ω = 1.68 x 10⁶Ω

Resistor Color Code

| Color | Sig. Fig. | Decimal Multiplier | Tolerance (%) |
|----------|-----------|--------------------|---------------|
| Black | 0 | 1 | - |
| Brown | 1 | 10 | 1 |
| Red | 2 | 100 | 2 |
| Orange | 3 | 1,000 | - |
| Yellow | 4 | 10,000 | - |
| Green | 5 | 100,000 | 0.5 |
| Blue | 6 | 1,000,000 | 0.25 |
| Purple | 7 | 10,000,000 | 0.1 |
| Gray | 8 | 100,000,000 | - |
| White | 9 | 1,000,000,000 | - |
| Gold | - | 0.1 | 5 |
| Silver | - | 0.01 | 10 |
| No Color | - | - | 20 |

Body Color

The body color of a resistor typically doesn't carry meaning, except in some instances where it may specify temperature coefficient. However, if you find resistors within a circuit that are white/gray or blue in color, they may be non-flammable or fusible resistors. Care must be taken when entering such resistors. don't

4-Band Resistor Code (Most Common)

Label Meaning

Red Black Orange Gold
20 x 1,000 = 20k Ω ± 5%

First Digit Second Digit Multiplier (#of zeros) % Tolerance

5-Band Resistor Code (3-digit)

Label Meaning

Purple Blue Green Brown Brown
675 x 10 = 6750 Ω ± 1%

First Digit Second Digit Third Digit Multiplier (#of zeros) % Tolerance

5-Band Resistor Code (Reliability)

Label Meaning

Yellow Purple Green Silver Brown
47 x 100,000 = 4.7 MΩ ± 10%

1% Reliability/1000 Hr — Brown

| Color | Reliability (%/1000 Hr) |
|--------|-------------------------|
| Brown | 1 |
| Red | 0.1 |
| Orange | 0.01 |
| Yellow | 0.001 |

First Digit Second Digit Multiplier (#of zeros) Reliability % Tolerance

6-Band Resistor Code

Label Meaning

Purple Red Black Blue Brown Red
276 x 1 = 276Ω ± 1%

TC of 50 ppm — Red

| Color | Temp. Coeff |
|-------|-------------|
| Brown | 100 ppm |
| Red | 50 ppm |

First Digit Second Digit Third Digit Multiplier (#of zeros) Temp. Coeff. % Tolerance

Surface Mount Resistor Code

3-digit Label

Label Meaning

101 10 and 1 zero = 100 Ω

105 10 and 5 zero = 1,000,000 Ω

224 22 and 4 zeros = 220,000 Ω

1R0 1.0 and no zeros = 1 Ω

22R 22.0 and no zeros = 22 Ω

R10 0.1 and no zeros = 0.1 Ω

The first two digits represent significant figures; the last digit specifies the multiplier. For values under 100 Ω, the letter R is substituted for one of the significant digits and represents a decimal point.

4-digit Label

Label Meaning

1001 100 and 1 zero = 1000 Ω

22R0 22.0 and no zeros = 22 Ω

The first three digits represent significant figures; the last digit specifies the multiplier. R represents a decimal point

Tolerance Label

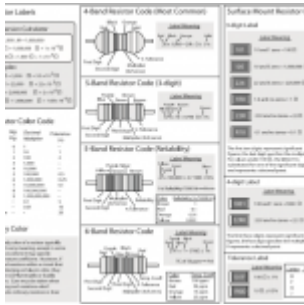
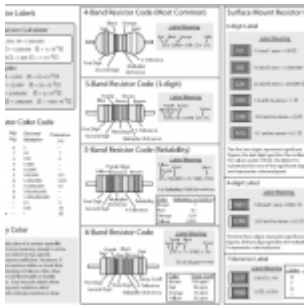
Label Meaning

101F 100 Ω ± 1%

| Letter | Tolerance |
|--------|-----------|
| D | ±0.5 % |
| F | ±1.0 % |
| G | ±2.0 % |
| J | ±5.0 % |
| K | ±10.0 % |
| M | ±20.0 % |
| P | ±1.0 % |
| R | ±0.5 % |
| S | ±0.25 % |
| T | ±0.1 % |
| Z | ±20.0 % |

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Capacitor Markings

Capacitance Conversion Calculator

$1\text{ F} = 1 \times 10^6 \mu\text{F} = 1 \times 10^9 \text{ nF} = 1 \times 10^{12} \text{ pF}$
 $1 \mu\text{F} = 1 \times 10^{-6} \text{ F} = 1 \times 10^3 \text{ nF} = 1 \times 10^6 \text{ pF}$
 $1 \text{ nF} = 1 \times 10^{-9} \text{ F} = 1 \times 10^{-3} \mu\text{F} = 1 \times 10^3 \text{ pF}$
 $1 \text{ pF} = 1 \times 10^{-12} \text{ F} = 1 \times 10^{-6} \mu\text{F} = 1 \times 10^{-3} \text{ nF}$
 $\text{F} = \text{Farad}, \mu = \text{micro}, \text{n} = \text{nano}, \text{p} = \text{pico}$

$1000 \mu\text{F} = 1,000,000 \text{ nF} = 10 \times 10^8 \text{ pF}$
 $100 \mu\text{F} = 100,000 \text{ nF} = 10 \times 10^7 \text{ pF}$
 $10 \mu\text{F} = 10,000 \text{ nF} = 10 \times 10^6 \text{ pF}$
 $1 \mu\text{F} = 1,000 \text{ nF} = 10 \times 10^5 \text{ pF}$
 $0.1 \mu\text{F} = 100 \text{ nF} = 10 \times 10^4 \text{ pF}$
 $0.01 \mu\text{F} = 10 \text{ nF} = 10 \times 10^3 \text{ pF}$
 $0.001 \mu\text{F} = 1 \text{ nF} = 10 \times 10^2 \text{ pF}$

Tantalum

Label meaning 1

1st significant figure in μF
 2nd significant figure in μF
 Multiplier (See table)
 Voltage

| Color | S.F. | Multiple | Voltage |
|--------|------|----------|---------|
| Black | 0 | 1 | 10V |
| Brown | 1 | 10 | |
| Red | 2 | 100 | |
| Orange | 3 | 1000 | |
| Yellow | 4 | | 6.3V |
| Green | 5 | | 16V |
| Blue | 6 | | 20V |
| Violet | 7 | | |
| Gray | 8 | 0.01 | 25V |
| White | 9 | 0.1 | 3V |
| Pink | | | 35V |

Label meaning 2

| Marking | Actual |
|---------|-------------------------|
| 22 | 22 μF , 16 V |

Mylar (Polyester Film)
Polypropylene
Dipped Mica

Label meaning

| Marking | Actual |
|---------|-----------------------------------|
| .001K* | 0.001 μF , $\pm 10\%$ |
| 104K | 0.1 μF , $\pm 10\%$ |
| .22J* | 0.22 μF , $\pm 5\%$ |
| 472K | 0.0047 μF , $\pm 10\%$ |
| 221J | 220 pF, $\pm 5\%$ |
| 470J | 47 pF, $\pm 5\%$ |
| 102J | 1000 pF, $\pm 5\%$ |
| 103F | 0.01 μF , $\pm 1\%$ |
| 223F | 0.022 μF , $\pm 1\%$ |

Ceramic Disc Capacitors

22M 1kV: 22 pF $\pm 20\%$, 1000V
Z5U .0033 $\pm 20\%$: 0.033 μF $\pm 20\%$, -56% to +22% variation from +10°C to +85°C
.1Z 100V: 0.1 μF $\pm 20\%$, 100V
X7R 10K 1 kV: 10 pF $\pm 10\%$, $\pm 15\%$ variation from -55°C to 125°C, 1000V
K5U 474M: 0.47 μF $\pm 20\%$, +22% to -70% variation from +25°C to 85°C
20 $\pm 20\%$ 50V AC 400V DC: 20 pF $\pm 20\%$, 50V AC, 400V DC
Z5P 2200 K: 2200 pF $\pm 10\%$, $\pm 10\%$ variation from +10°C to +85°C
200 nZ 12V: 200 nF -20°C to +80°C, 12V DC
N2200 47 pF $\pm 20\%$: 47 pF $\pm 20\%$, Neg. Temp. Coeff. of 2200 ppm/°C

Ceramic Disc (European Markings)

Label Meaning

| Marking | Actual | Marking | Actual |
|---------|---------|---------|---------|
| p68 | 0.68 pF | 22p | 22 pF |
| 1p0 | 1.0 pF | n10 | 0.1 nF |
| 4p7 | 4.7 pF | n27 | 0.27 nF |

Label: p = picofarads, n = nanofarads; location of p or n signifies decimal point.

Fixed Ceramic Color Code

| Color | S.F. | Tolerance | Temp. Coeff. ppm/°C |
|--------|------|------------|---------------------|
| Black | 0 | $\pm 20\%$ | 2.0 pF |
| Brown | 1 | $\pm 3\%$ | -30 |
| Red | 2 | $\pm 10\%$ | -40 |
| Orange | 3 | $\pm 20\%$ | -50 |
| Yellow | 4 | $\pm 20\%$ | -50 |
| Green | 5 | $\pm 5\%$ | 0.5 pF |
| Blue | 6 | | -75 |
| Violet | 7 | | -75 |
| Gray | 8 | 0.01 | 0.25 pF |
| White | 9 | 0.1 | 1.0 pF |

Surface Mount Capacitors

Temperature Coefficient

Color Code

Tolerance

1st Digit

2nd Digit

Decimal Point

Multiplier

121K: 120 pF $\pm 10\%$
4R7D: 4.7 pF $\pm 0.5\text{pF}$

Multiplier Code

| Numeric Character | Decimal Multiplier (pF) |
|-------------------|-------------------------|
| 0 | None |
| 1 | 10 |
| 2 | 100 |
| 3 | 1000 |
| 4 | 10,000 |

EIA Capacitor Tolerance Codes

| Letter | $\leq 10 \text{ pF}$ | $\geq 10 \text{ pF}$ |
|--------|-----------------------|----------------------|
| B | $\pm 0.1 \text{ pF}$ | - |
| C | $\pm 0.25 \text{ pF}$ | - |
| D | $\pm 0.5 \text{ pF}$ | - |
| E | - | $\pm 25\%$ |
| F | $\pm 1 \text{ pF}$ | $\pm 1\%$ |
| G | - | $\pm 2\%$ |
| H | - | $\pm 2.5\%$ |
| J | - | $\pm 5\%$ |
| K | - | $\pm 10\%$ |
| M | - | $\pm 20\%$ |
| P | - | -0 + 100% |
| S | - | -20 + 50% |
| W | - | -0 + 200% |
| X | - | -20 + 40% |
| Z | - | -20 + 80% |

EIA Temperature Characteristic Codes

| Minimum temperature | Maximum temperature | Max. cap. change over temp. range |
|---------------------|---------------------|-----------------------------------|
| X -55°C | 2 +45°C | A $\pm 1.0\%$ |
| Y -35°C | 4 +65°C | B $\pm 1.5\%$ |
| Z +10°C | 5 +85°C | C $\pm 2.2\%$ |
| | 6 +105°C | D $\pm 3.3\%$ |
| | 7 +125°C | E $\pm 4.7\%$ |
| | | F $\pm 7.5\%$ |
| | | P $\pm 10\%$ |
| | | R $\pm 15\%$ |
| | | S $\pm 22\%$ |
| | | T -33% + 22% |
| | | U -56% + 22% |
| | | V -82% + 22% |

