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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

features new instruction on programmable logic, semiconductors, operational amplifiers, voltage regulators, power supplies, digital electronics, and more. Coverage includes:

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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

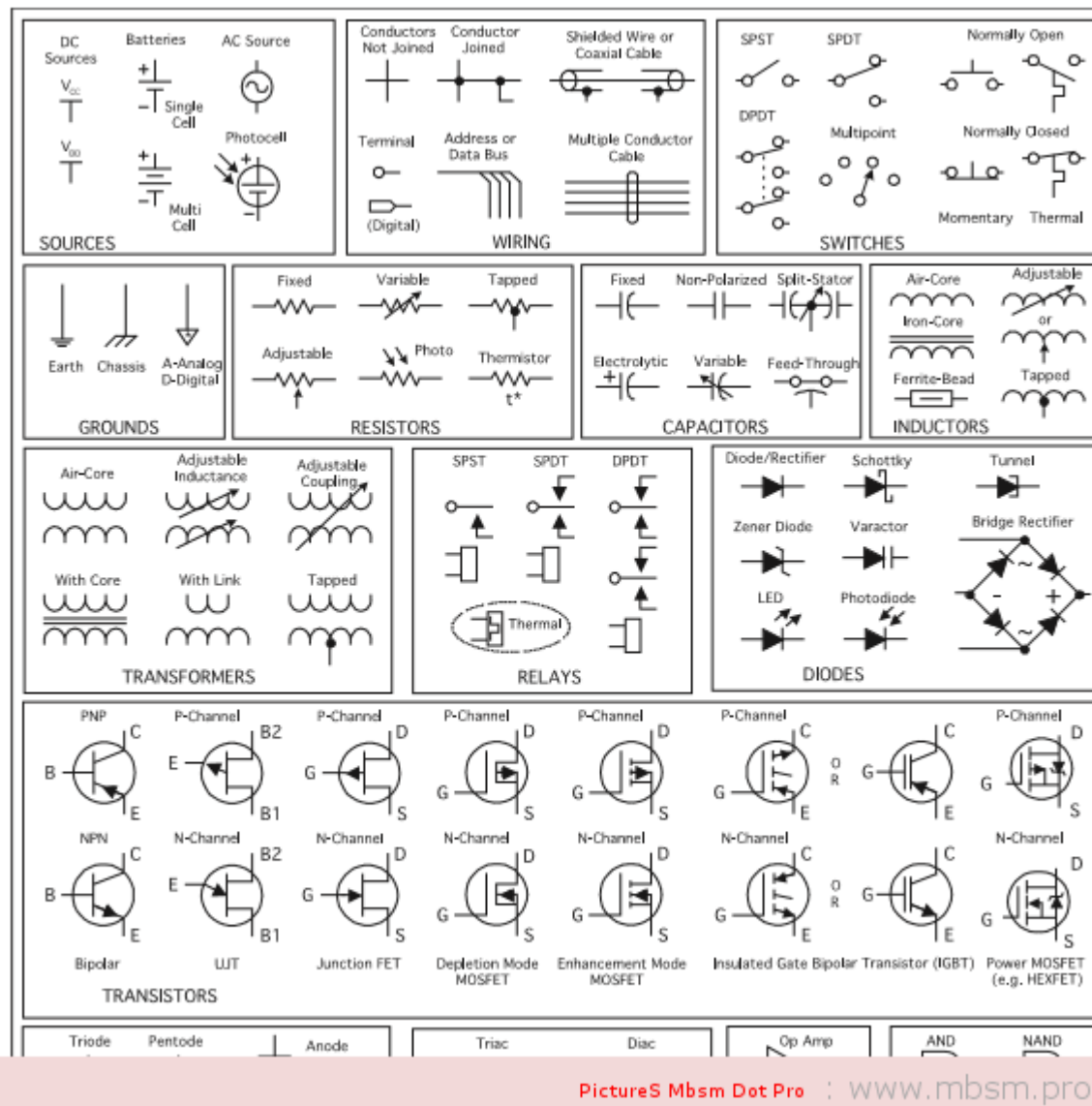


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Resistor Labels

Conversion Calculator

$k = 1,000$; $M = 1,000,000$
 $1M\Omega = 1,000,000\ \Omega = 1 \times 10^6\ \Omega$
 $1k\Omega = 1,000\ \Omega = 1 \times 10^3\ \Omega$

Examples:

$3.3\ k\Omega = 3,300\ \Omega = 3.3 \times 10^3\ \Omega$
 $22\ k\Omega = 22,000\ \Omega = 22 \times 10^3\ \Omega$
 $2\ M\Omega = 2,000,000\ \Omega = 2 \times 10^6\ \Omega$
 $1.68\ M\Omega = 1,680,000\ \Omega = 1.68 \times 10^6\ \Omega$

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 replacing such resistors; don't

4-Band Resistor Code (Most Common)

Label Meaning

Red Black Orange Gold
 $20 \times 1,000 = 20k\ \Omega \pm 5\%$

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

5-Band Resistor Code (3-digit)

Label Meaning

Purple Blue Green Brown Brown
 $675 \times 10 = 6750\ \Omega \pm 1\%$

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

5-Band Resistor Code (Reliability)

Label Meaning

Yellow Purple Silver Green Brown
 $47 \times 100,000 = 4.7\ M\Omega \pm 10\%$

First Digit Second Digit Third Digit Multiplier (# of zeros) Reliability

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

6-Band Resistor Code

Label Meaning

Purple Red Black Blue Brown Red
 $276 \times 1 = 276\ \Omega \pm 1\%$

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

Color	Temp. Coeff.
Brown	100 ppm
Red	50 ppm

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 $\Omega \pm 1\%$

Letter	Tolerance
D	$\pm 0.5\%$
F	$\pm 1.0\%$

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<p>an Labels</p> <p>International 100 ohms $10^2 \Omega$ 10 ohms $10^1 \Omega$ 1 ohm $10^0 \Omega$ 0.1 ohm $10^{-1} \Omega$ 0.01 ohm $10^{-2} \Omega$ 0.001 ohm $10^{-3} \Omega$</p> <p>an Color Code</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p> <p>an Color</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p>	<p>4-Band Resistor Code (Most Common)</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p> <p>5-Band Resistor Code (3-digits)</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p> <p>3-Band Resistor Code (Potentiometer)</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p> <p>6-Band Resistor Code</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p>	<p>Surface Mount Resistor</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p>
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<p>an Labels</p> <p>International 100 ohms $10^2 \Omega$ 10 ohms $10^1 \Omega$ 1 ohm $10^0 \Omega$ 0.1 ohm $10^{-1} \Omega$ 0.01 ohm $10^{-2} \Omega$ 0.001 ohm $10^{-3} \Omega$</p> <p>an Color Code</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p> <p>an Color</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p>	<p>4-Band Resistor Code (Most Common)</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p> <p>5-Band Resistor Code (3-digits)</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p> <p>3-Band Resistor Code (Potentiometer)</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p> <p>6-Band Resistor Code</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p>	<p>Surface Mount Resistor</p> <p>100 ohms 10 ohms 1 ohm 0.1 ohm 0.01 ohm 0.001 ohm</p>
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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
Voltage (See table)

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 , $\pm 1\%$

Voltage Rating

Ceramic Disc Capacitors

Temperature Coefficient
Color Code
Tolerance
1st Digit
2nd Digit
Decimal Point
Multiplier

22 pF $\pm 20\%$
1000V
Temp. Char.
Z5U
.0033 $\pm 20\%$
-56% to +22% variation from +10°C to +85°C
0.033 μF $\pm 20\%$
1Z
100V
0.1 μF -20% +80% 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% to +80°C
12V DC

N2200
47 pF
47 pF $\pm 20\%$
Neg. Temp. Coeff. of 2200 ppm/°C

Label:
Varies widely according to manufacturer. Usually given in pF (see multiplier code table) but may be given in μF when there is a decimal before digits. See other tables for temperature and tolerance markings.

Ceramic Disc (European Markings)

Label Meaning

Marking	Actual	Marking	Actual
47p			
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

1st Digit 2nd Digit Multiplier

Color	S.F.	Tolerance	Temp. Coeff. ppm/°C
Black	0	$\pm 20\%$	-50
Brown	1	$\pm 1\%$	-30
Red	2	$\pm 2\%$	-40
Orange	3	$\pm 3\%$	-50
Yellow	4	$\pm 4\%$	-60
Green	5	$\pm 5\%$	-70
Blue	6	$\pm 6\%$	-80
Violet	7	$\pm 7\%$	-90
Gray	8	$\pm 8\%$	-100
White	9	$\pm 9\%$	-110

Temp. Coeff. Tolerance

Surface Mount Capacitors

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%

EIA Temperature Coefficient

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