

FOURTH EDITION

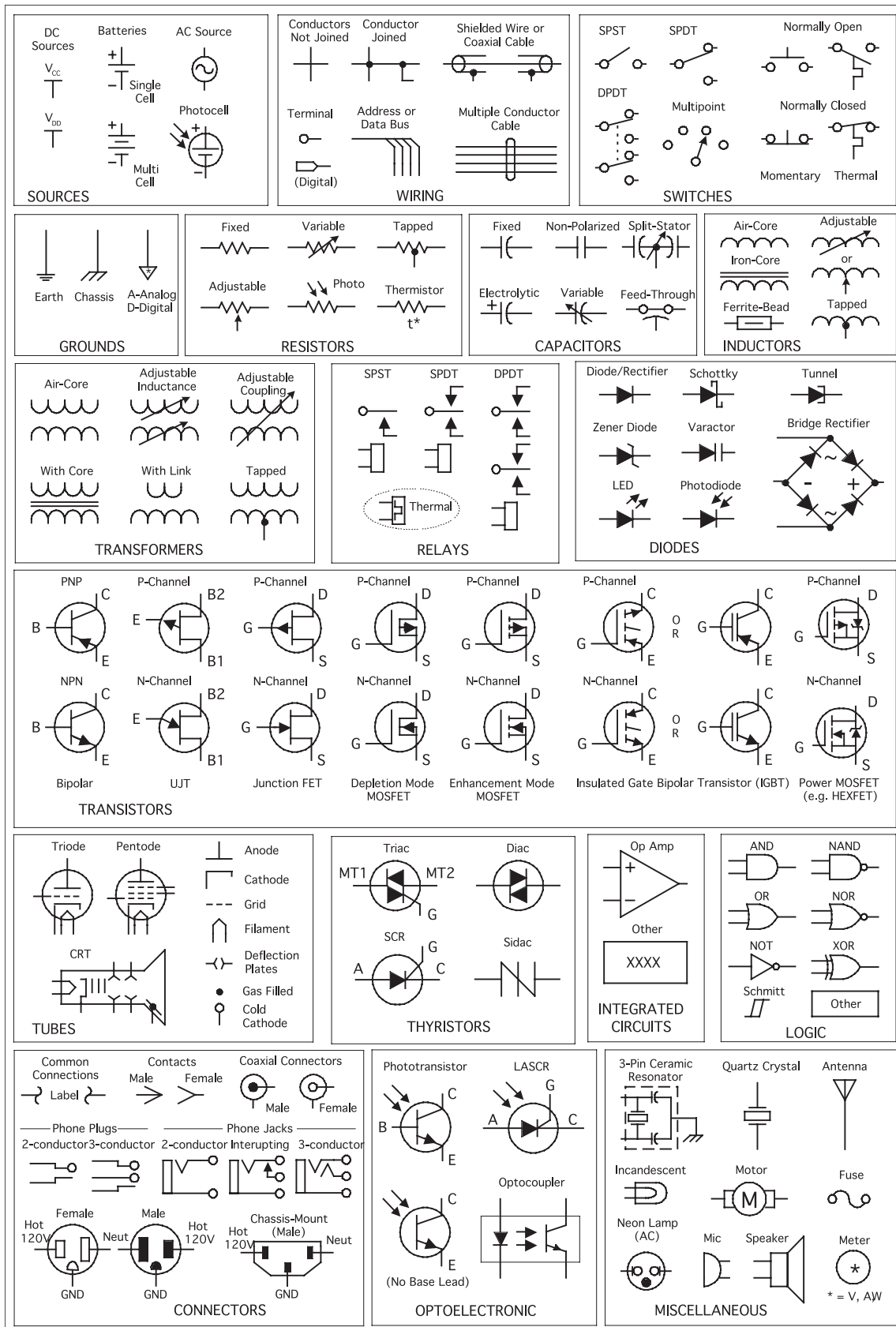
# PRACTICAL ELECTRONICS FOR INVENTORS



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Paul Scherz and Simon Monk





## 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  $\Omega$  =  $1.68 \times 10^6 \Omega$

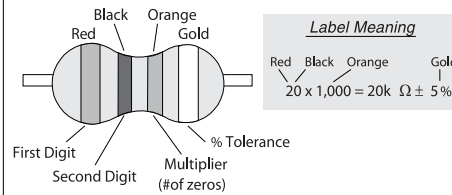
## Resistor Color Code

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

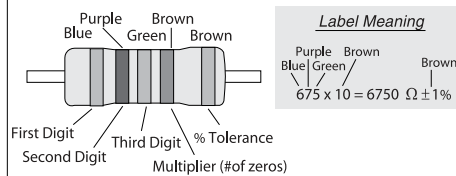
## Body Color

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 substitute ordinary resistors in their place.

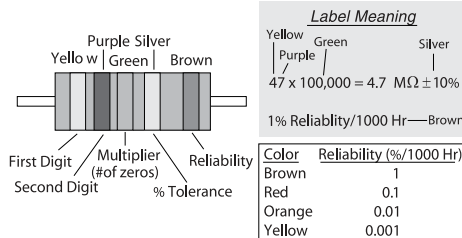
## 4-Band Resistor Code (Most Common)



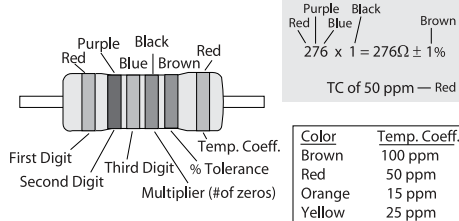
## 5-Band Resistor Code (3-digit)



## 5-Band Resistor Code (Reliability)



## 6-Band Resistor Code



## Surface Mount Resistor Code

### 3-digit Label

**Label Meaning**

101	10 and 1 zero = 100 $\Omega$
105	10 and 5 zero = 1,000,000 $\Omega$
224	22 and 4 zeros = 220,000 $\Omega$
1R0	1.0 and no zeros = 1 $\Omega$
22R	22.0 and no zeros = 22 $\Omega$
R10	0.1 and no zeros = 0.1 $\Omega$

The first two digits represent significant figures; the last digit specifies the multiplier. For values under 100  $\Omega$ , 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 $\Omega$
22R0	22.0 and no zeros = 22 $\Omega$

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

### Tolerance Label

**Label Meaning**

101F	100 $\Omega \pm 1\%$
1R0D	1.0 $\Omega \pm 0.5\%$

Letter	Tolerance
D	$\pm 0.5\%$
F	$\pm 1.0\%$
G	$\pm 2.0\%$
J	$\pm 5.0\%$

## Standard Resistor Values (1%, 5% and 10% Tolerance)

1%								5%		10%
1.00	1.02	1.05	1.07	1.10	1.13	1.15	1.18	10	11	10
1.21	1.24	1.27	1.30	1.33	1.37	1.40	1.43	12	13	12
1.47	1.50	1.54	1.58	1.62	1.65	1.69	1.74	15	16	15
1.78	1.82	1.87	1.91	1.96	2.00	2.05	2.10	18	20	18
2.15	2.21	2.26	2.32	2.37	2.43	2.49	2.55	22	24	22
2.61	2.67	2.74	2.80	2.87	2.94	3.01	3.09	27	30	27
3.16	3.24	3.32	3.40	3.48	3.57	3.65	3.74	33	36	33
3.83	3.92	4.02	4.12	4.22	4.32	4.42	4.53	39	43	39
4.64	4.75	4.87	4.99	5.11	5.23	5.36	5.49	47	51	47
5.62	5.76	5.90	6.04	6.19	6.34	6.49	6.65	56	62	56
6.81	6.98	7.15	7.32	7.50	7.68	7.87	8.06	68	75	68
8.25	8.45	8.66	8.87	9.09	9.31	9.53	9.76	82	91	82

Standard resistance value is obtained from the above chart by multiply by powers of 10.

5% example resistors: 51 $\Omega$ , 510 $\Omega$ , 5.1k $\Omega$ , 51k $\Omega$ , 510k $\Omega$ , 5.1M $\Omega$ .

1% example resistors: 1.21 $\Omega$ , 12.1 $\Omega$ , 121 $\Omega$ , 1.21k $\Omega$ , 12.1k $\Omega$ , 121k $\Omega$ , 1.21M $\Omega$



# Capacitor Markings

## Capacitance Conversion Calculator

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

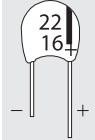
$1000 \mu\text{F} = 1,000,000 \text{ nF} = 10 \times 10^8 \text{ pF}$   
 $100 \mu\text{F} = 100,000 \text{ nF} = 10 \times 10^7 \text{ pF}$   
 $10 \mu\text{F} = 10,000 \text{ nF} = 10 \times 10^6 \text{ pF}$   
 $1 \mu\text{F} = 1,000 \text{ nF} = 10 \times 10^5 \text{ pF}$   
 $0.1 \mu\text{F} = 100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

## Tantalum

### Label meaning 1

1st significant figure in  $\mu\text{F}$   
 2nd significant figure in  $\mu\text{F}$   
 Multiplier (See table)  
 Voltage

Color	S.F.	Multipl	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 $\mu\text{F}$ , 16 V

## Mylar (Polyester Film)

## Polypropylene

## Dipped Mica

### Label meaning

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

### Labels:

1st digit, 2nd digit, multiplier in pF (or  $\mu\text{F}$  if decimal before digits), and tolerance.

## Metallized Polyester Film

### Label meaning

Marking	Actual
2 $\mu$ 2	2.2 $\mu\text{F}$
100V	0.22 $\mu\text{F}$
68n	68 nF
4n7	4.7 nF

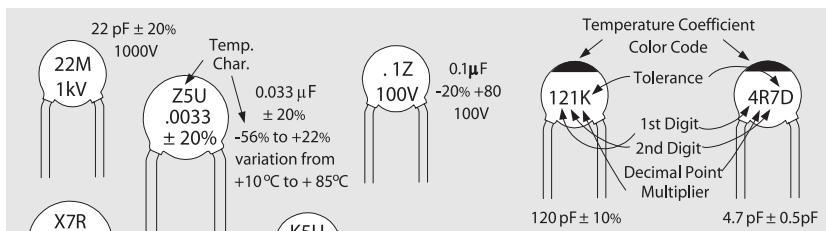
### Label:

" $\mu$ " place of decimal in microfarads  
 "n" place of decimal in nanofarads

## Polyester Color Coded

1st digit (pF)	2nd digit (pF)	Multiplier	Tolerance	Voltage
Black			$\pm 20\%$	
White			$\pm 10\%$	
Green			$\pm 5\%$	
Brown			100	
Red			250	
Yellow			400	

## Ceramic Disc 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%

### Label:

Varies widely according to manufacturer. Usually given in pF (see multiplier code table) but may be given in  $\mu\text{F}$  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	0.47 pF	22p	22 pF
p68	0.68 pF	n10	0.1 nF
1p0	1.0 pF	n27	0.27 nF
4p7	4.7 pF		

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

## Fixed Ceramic Color Code

1st Digit	2nd Digit	Multiplier	Temp. Coeff.	Tolerance
Black	0	1	$\pm 20\%$	2.0 pF
Brown	1	10	$\pm 1\%$	-30
Red	2	100	$\pm 2\%$	-60
Orange	3	1000		-150
Yellow	4		$\pm 5\%$	-220
Green	5			-330
Blue	6			-470
Violet	7			-750
Gray	8	0.01		0.25 pF
White	9	0.1	$\pm 10\%$	1.0 pF

## Surface Mount Capacitors

### SMD Ceramic

### Label meaning

Marking	Actual
N1	33 pF
A4	0.01 $\mu\text{F}$
S6	4.7 $\mu\text{F}$

### SMD Electrolytic

### Label meaning 1

Marking	Actual
10 6V	10 $\mu\text{F}$ , 6V
A475	4.7 $\mu\text{F}$ , 10V

## Significant Figure Code

Char.	S. F.	Char.	S. F.
A	1.0	T	5.1
B	1.1	U	5.6
C	1.2	V	6.2
D	1.3	W	6.8
E	1.5	X	7.5
F	1.6	Y	8.2
G	1.8	Z	9.1
H	2.0	a	2.5
J	2.2	b	3.5
K	2.4	d	4.0
L	2.7	e	4.5
M	3.0	f	5.0
N	3.3	m	6.0
P	3.6	n	7.0
Q	3.9	t	8.0
R	4.3	y	9.0
S	4.7		

## Multiplier Code

Numeric Character	Decimal Multiplier (pF)
0	1
1	10
2	100
3	1,000
4	10,000
5	100,000
6	1,000,000
7	10,000,000
8	100,000,000
9	0.1

## Label 2:

Voltage (see table below), 1st digit, 2nd digit, multiplier (pF).

Char.	Voltage
e	2.5
G	4
J	6.3
A	10
C	16
D	20
E	25
V	35
H	50

## 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 Color Codes

Color	Temp. Coeff.	Industry	EIA
Black	NP0		C0G
Brown	N030/N033		S1G
Red	N075/N080		U1G
Orange	N 150		P2G
Yellow	N 220		R2G
Green	N 330		S2H
Blue	N 470		U2J
Violet	N 750		
Gray			
White	P 100		
Red/Violet	P 100		

## Electrolytic Capacitors



Label: Usually self-explanatory



# **Practical Electronics for Inventors**

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# Practical Electronics for Inventors

Fourth Edition

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