

# Resistor & capacitor values & codes

Reading and choosing passives — the E-series preferred values, resistor colour and SMD codes, capacitor codes and dielectrics, and the derating that keeps them in spec.

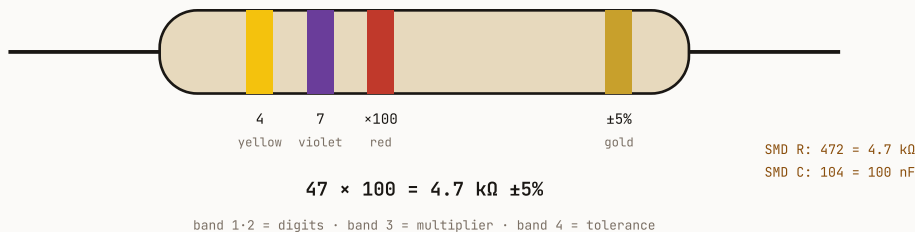
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## ABSTRACT

Passives only come in standard (E-series) values, and they're marked with compact codes. This reference decodes resistor colour bands and SMD codes, capacitor codes and dielectric types, and gives the derating rules that keep a chosen part actually meeting its number in circuit.

Section 1 is the E-series. Section 2 is resistor codes. Section 3 is capacitor codes and dielectrics. Section 4 is tolerance and selection. Section 5 is power and voltage derating. Section 6 is a quick reference.

### RESISTOR COLOR CODE - 4-BAND



A 4-BAND RESISTOR: TWO DIGIT BANDS, A MULTIPLIER, A TOLERANCE BAND — YELLOW-VIOLET-RED-GOLD = 4.7 kΩ ±5%. SMD PARTS USE A 3-DIGIT SHORTHAND (472 = 4.7 kΩ, 104 = 100 nF).

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## 1. The E-series (preferred values)

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Components are made only in **preferred values** spaced logarithmically so each value's tolerance band just meets the next. Pick the nearest E-series value to your calculated one:

SERIES	TOLERANCE	VALUES PER DECADE
E6	±20%	6
E12	±10%	12
E24	±5%	24
E48	±2%	48
E96	±1%	96

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**E12** (the everyday set): 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 (× any decade). For tight dividers/filters use E96 (1%).

Preferred value	A standard E-series value — design to these, not arbitrary numbers
Tolerance	± band on the value; tighter = more series values and more cost
Multiplier	Power-of-ten band (resistor) or implied pF exponent (cap code)
Dielectric	The capacitor's insulator — sets stability, temp range and DC-bias behaviour

## 2. Resistor codes

**4-band colour:** digit · digit · multiplier · tolerance. **5-band** adds a third digit (for 1%).

COLOUR	DIGIT	MULTIPLIER	TOLERANCE
Black		0	×1 —
Brown		1	×10 ±1%
Red		2	×100 ±2%
Orange		3 ×1k	—
Yellow		4 ×10k	—
Green		5 ×100k	±0.5%
Blue		6 ×1M	±0.25%
Violet		7 ×10M	—
Grey / White	8 / 9	—	—
Gold / Silver	—	×0.1 / ×0.01	±5% / ±10%

**SMD codes:** 3-digit 472 =  $47 \times 10^2 = 4.7 \text{ k}\Omega$ ; 4-digit 4702 =  $470 \times 10^2 = 47 \text{ k}\Omega$ ; R marks the decimal: 4R7 =  $4.7 \Omega$ . **EIA-96** uses 2 digits (a value lookup) + a letter (multiplier) for 1% parts.

### 3. Capacitor codes and dielectrics

**Code** is in **pF**: 3 digits = first two digits  $\times 10^{\text{(third)}}$ . **104** =  $10 \times 10^4$  pF = 100 000 pF = **100 nF**. **220** = 22 pF. An **R** marks a decimal ( **4R7** = 4.7 pF). A trailing letter is tolerance.

Always note the **voltage rating** and the **dielectric** — the dielectric dominates real-world behaviour:

DIELECTRIC	STABILITY	USE
<b>COG / NP0 (class 1)</b>	excellent, no DC-bias loss	timing, filters, RF; small values only
<b>X7R (class 2)</b>	$\pm 15\%$ over $-55\text{...}+125$ °C; loses C with DC bias	general decoupling, bulk
<b>X5R</b>	like X7R but to $+85$ °C	space-constrained decoupling
<b>Y5V / Z5U</b>	huge capacitance, terrible stability	last resort bulk only
<b>Film</b>	very stable, low loss	audio, snubbers, timing (bulky)
<b>Aluminium electrolytic</b>	high bulk C, polarised	power-rail bulk, low cost
<b>Tantalum / polymer</b>	high C small size, polarised	compact bulk — derate voltage hard

## 4. Tolerance and selection

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- Pick the nearest E-series value for the tolerance you need; don't specify a value that isn't made.
- **MLCC DC bias: class-2 ceramics (X7R/X5R) lose capacitance under applied voltage**  
sometimes 50–80% at rated volts. Choose a higher-voltage / larger case part and verify the effective capacitance at your operating voltage.
- **Temperature coefficient: use COG/NPO where the value must be stable (oscillators, filters).**

## 5. Power and voltage derating

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**Resistor power by SMD size** (rated; derate to ~50%):

SIZE	RATED POWER
0201	1/20 W
0402	1/16 W
0603	1/10 W
0805	1/8 W
1206	1/4 W
2010 / 2512	3/4 W / 1 W

**Capacitor voltage derating:** MLCC to ~50–70% of rated (and watch DC bias); aluminium electrolytic to ~80%; **tantalum to ~50%** (lower in high-inrush rails) — tantalum fails short and can ignite if not derated.

## 6. Quick reference

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- E12: 10 12 15 18 22 27 33 39 47 56 68 82.
- Resistor SMD: 472 =4.7 k · 4702 =47 k · 4R7 =4.7 Ω.
- Cap code (pF): 104 =100 nF · 103 =10 nF · 102 =1 nF · 220 =22 pF.
- Defaults: 0603/0402 for general SMD; 100 nF X7R decoupling per IC power pin; COG for timing.