**Electronic Color Code**

From Wikipedia, the free encyclopedia

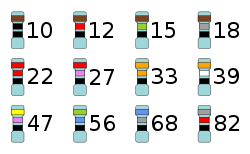
The **electronic color code** discussed here is used to indicate the values or ratings of electronic components, very commonly for resistors, but also for capacitors, inductors, and others. A separate code, the 25-pair color code, is used to identify wires in some telecommunications cables.

The electronic color code was developed in the early 1920s by the Radio Manufacturer's Association, (now part of Electronic Industries Alliance), and was published as EIA-RS-279. The current international standard is IEC 60062.

Color bands were commonly used (especially on resistors) because they were easily printed on tiny components, decreasing construction costs. However, there were drawbacks, especially for color blind people. Overheating of a component, or dirt accumulation, may make it impossible to distinguish brown from red from orange. Advances in printing technology have made printed numbers practical for small components, which are often found in modern electronics.

**Resistor, capacitor and inductor**

It is sometimes not obvious whether a color coded component is a resistor, capacitor, or inductor, and this may be deduced by knowledge of its circuit function, physical shape or by measurement.



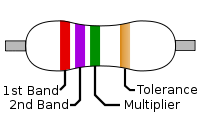
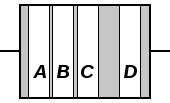
One decade of the preferred E12 values (there are twelve preferred values per decade of values) shown with their electronic color codes on resistors.



A 100 kΩ, 5% through-hole resistor.



A 0Ω resistor, marked with a single black band.



Resistor values are always coded in ohms ( symbol Ω), capacitors in picofarads (pF), and inductors in microhenries (µH).

* band **A** is first significant figure of component value
* band **B** is the second significant figure
* band **C** is the decimal multiplier
* band **D** if present, indicates tolerance of value in percent (no color means 20%)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Color** | **Significant figures** | **Multiplier** | **Tolerance** | | **Temp. Coefficient (ppm/K)** | |
| Black | 0 | ×100 | – | | 250 | U |
| Brown | 1 | ×101 | ±1% | F | 100 | S |
| Red | 2 | ×102 | ±2% | G | 50 | R |
| Orange | 3 | ×103 | – | | 15 | P |
| Yellow | 4 | ×104 | – | | 25 | Q |
| Green | 5 | ×105 | ±0.5% | D | 20 | Z |
| Blue | 6 | ×106 | ±0.25% | C | 10 | Z |
| Violet | 7 | ×107 | ±0.1% | B | 5 | M |
| Gray | 8 | ×108 | ±0.05% | A | 1 | K |
| White | 9 | ×109 | – | | – | |
| Gold | – | ×10-1 | ±5% | J | – | |
| Silver | – | ×10-2 | ±10% | K | – | |
| None | – | – | ±20% | M | – | |
|  | | | | | | |
| 1. Any temperature coefficient not assigned its own letter shall be marked "Z", and the coefficient found in other documentation. 2. For more information, see EN 60062. | | | | | | |

For example, a resistor with bands of *yellow, violet, red, and gold* will have first digit 4 (yellow in table below), second digit 7 (violet), followed by 2 (red) zeros: 4,700 ohms. Gold signifies that the tolerance is ±5%, so the real resistance could lie anywhere between 4,465 and 4,935 ohms.

Resistors manufactured for military use may also include a fifth band which indicates component failure rate (reliability); refer to MIL-HDBK-199 for further details.

Tight tolerance resistors may have three bands for significant figures rather than two, and/or an additional band indicating temperature coefficient, in units of ppm/K.

All coded components will have at least two value bands and a multiplier; other bands are optional (italicized below).

The standard color code per EN 60062:2005 is as follows:

As an example, let us take a resistor which (read left to right) displays the colors *yellow, violet, yellow, brown*. We take the first two bands as the value, giving us *4, 7*. Then the third band, another *yellow*, gives us the multiplier 104. Our total value is then *47 x 104 Ω*, totaling *470,000 Ω* or *470 kΩ*. Our brown is then a tolerance of ±1%.

Resistors use specific values, which are determined by their tolerance. These values repeat for every order of magnitude; 6.8, 68, 680, and so forth. This is useful because the digits, and hence the first two or three stripes, will always be similar patterns of colors, which make them easier to understand.

Zero ohm resistors *are* manufactured; these are lengths of wire wrapped in a resistor-shaped body which can be substituted for another resistor value in automatic insertion equipment. They are marked with a single black band.

The 'body-end-dot' or 'body-tip-spot' system was used for radial-lead composition resistors sometimes found in vacuum-tube equipment; the first band was given by the body color, the second band by the color of the end of the resistor, and the multiplier by a dot or band around the middle of the resistor. The other end of the resistor was colored gold or silver to give the tolerance, otherwise it was 20%.

Extra bands on ceramic capacitors will identify the voltage rating class and temperature coefficient characteristics. A broad black band was applied to some tubular paper capacitors to indicate the end that had the outer electrode; this allowed this end to be connected to chassis ground to provide some shielding against hum and noise pickup.

Polyester film and "gum drop" tantalum electrolytic capacitors are also color coded to give the value, working voltage and tolerance.

**Diode part number**

The part number for diodes was sometimes also encoded as colored rings around the diode, using the same numerals as for other parts. The JEDEC "1N" prefix was assumed, and the balance of the part number was given by three or four rings.

**Postage stamp capacitors and war standard coding**

Capacitors of the rectangular 'postage stamp" form made for military use during World War II used *American War Standard* (AWS) or *Joint Army Navy* (JAN) coding in six dots stamped on the capacitor. An arrow on the top row of dots pointed to the right, indicating the reading order. From left to right the top dots were: black, indicating JAN mica or silver indicating AWS paper. first and second significant figures. The bottom three dots indicated temperature characteristic, tolerance, and decimal multiplier. The characteristic was black for +/- 1000 ppm/ degree c, brown for 500, red for 200, orange for 100, yellow for -20 to +1—ppm/ degree c, and green for 0 to +70 ppm/degree C. A similar six-dot code by EIA had the top row as first, second and third significant digits and the bottom row as voltage rating (in hundreds of volts - no color indicated 500 volts), tolerance, and multiplier. A three-dot EIA code was used for 500 volt 20% tolerance capacitors, and the dots signified first and second significant digits and the multiplier. Such capacitors were common in vacuum tube equipment and in surplus for a generation after the war but are unavailable now.

**Mnemonics**

*Further information: List of electronic color code mnemonics*

A useful mnemonic matches the first letter of the color code, by order of increasing magnitude. There are many variations:

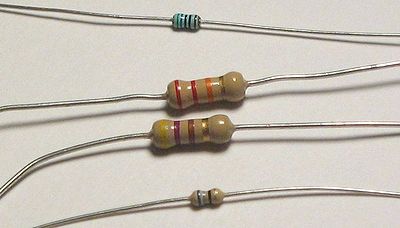
* **B**ad **b**oys **r**ape **o**ur **y**oung **g**irls **b**ut **V**iolet **g**ives **w**illingly.

The tolerance codes, gold, silver, and none, are not usually included in the mnemonics; one extension that includes them is:

* **B**ad **b**eer **r**ots **o**ur **y**oung **g**uts **b**ut **v**odka **g**oes **w**ell – **g**et **s**ome **n**ow.

The colors are sorted in the order of the visible light spectrum: red (2), orange (3), yellow (4), green (5), blue (6), violet (7). Black (0) has no energy, brown (1) has a little more, white (9) has everything and grey (8) is like white, but less intense.

**Examples**



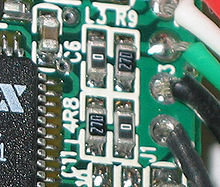
Color coded resistors

From top to bottom:

* Green-Blue-Black-Black-Brown
  + 560 ohms ± 1%
* Red-Red-Orange-Gold
  + 22,000 ohms ± 5%
* Yellow-Violet-Brown-Gold
  + 470 ohms ± 5%
* Blue-Gray-Black-Silver
  + 68 ohms ± 10%

Note: The physical size of a resistor is indicative of the power it can dissipate, not of its resistance.

**Printed numbers**



0Ω and 27Ω (27×100) surface-mount resistors.

Color-coding of this form is becoming rarer. In newer equipment, most passive components come in surface mount packages. Many of these packages are unlabeled and, those that are, normally use alphanumeric codes, not colors.

In one popular marking method, the manufacturer prints 3 digits on components: 2 value digits followed by the power of ten multiplier. Thus the value of a resistor marked **472** is 4,700 Ω, a capacitor marked **104** is 100 nF (10x104 pF), and an inductor marked **475** is 4.7 H (4,700,000 µH). This can be confusing; a resistor marked **270** might seem to be a 270 Ω unit, when the value is actually 27 Ω (27×100). A similar method is used to code precision surface mount resistors by using a 4-digit code which has 3 significant figures and a power of ten multiplier. Using the same example as above, **4701** would represent a 4.70 KΩ, 1% resistor. Another way is to use the "kilo-" or "mega-" prefixes in place of the decimal point:

1K2 = 1.2 kΩ = 1,200 Ω

M47 = 0.47 MΩ = 470,000 Ω

68R = 68 Ω

For some 1% resistors, a three-digit alphanumeric code is sometimes used, which is not obviously related to the value but can be derived from a table of 1% values. For instance, a resistor marked **68C** is 499(**68**) × 100(**C**) = 49,900 Ω. In this case the value 499 is the 68th entry of a table of 1% values between 100 and 999.

**Transformer wiring color codes**

Power transformers used in North American vacuum-tube equipment often were color-coded to identify the leads. Black was the primary connection, red secondary for the B+ (plate voltage), red with a yellow tracer was the center tap for the B+ full-wave rectifier winding, green or brown was the heater voltage for all tubes, yellow was the filament voltage for the rectifier tube (often a different voltage than other tube heaters). Two wires of each color were provided for each circuit, and phasing was not identified by the color code.

Audio transformers for vacuum tube equipment were coded blue for the finishing lead of the primary, red for the B+ lead of the primary, brown for a primary center tap, green for the finishing lead of the secondary, black for grid lead of the secondary, and yellow for a tapped secondary. Each lead had a different color since relative polarity or phase was more important for these transformers. Intermediate-frequency tuned transformers were coded blue and red for the primary and green and black for the secondary.[10]

**Other wiring codes**

Wires may be color-coded to identify their function, voltage class, polarity, phase or to identify the circuit in which they are used. The insulation of the wire may be solidly colored, or where more combinations are needed, one or two tracer stripes may be added. Some wiring color codes are set by national regulations, but often a color code is specific to a manufacturer or industry.

Building wiring under the US National Electrical Code and the Canadian Electrical Code is identified by colors to show energized and neutral conductors, grounding conductors and to identify phases. Other color codes are used in the UK and other areas to identify building wiring or flexible cable wiring.

Thermocouple wires and extension cables are identified by color code for the type of thermocouple; interchanging thermocouples with unsuitable extension wires destroys the accuracy of the measurement.

Automotive wiring is color-coded but standards vary by manufacturer; differing SAE and DIN standards exist.

Modern personal computer peripheral cables and connectors are color coded to simplify connection of speakers, microphones, mice, keyboards and other peripherals.

A common convention for wiring systems in industrial buildings is; black jacket - AC less than 1000 volts, blue jacket - DC or communications, orange jacket - medium voltage 230-0 or 4160 V, red jacket 13,800 volts or higher.

Local area network cables may also have jacket colors identifying, for example, process control network vs. office automation networks, or to identify redundant network connections, but these codes vary by organization and facility.

**See also**

* 25-pair color code for wiring
* Other color codes