



# Basic Electronics Series

## Resistor Color Codes

Reading and Understanding the Codes



# Resistor Color Codes

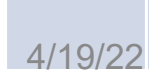
Most standard resistors today use a color-band code to identify the resistor values.

- Resistor Value
- Resistor Tolerance
- Resistor Temperature Coefficient\*
- Resistor Failure Rate\*

\*The temperature coefficient is provided on 6-band resistors, which are not often seen in everyday use. The failure rate is a Mil-Spec requirement.

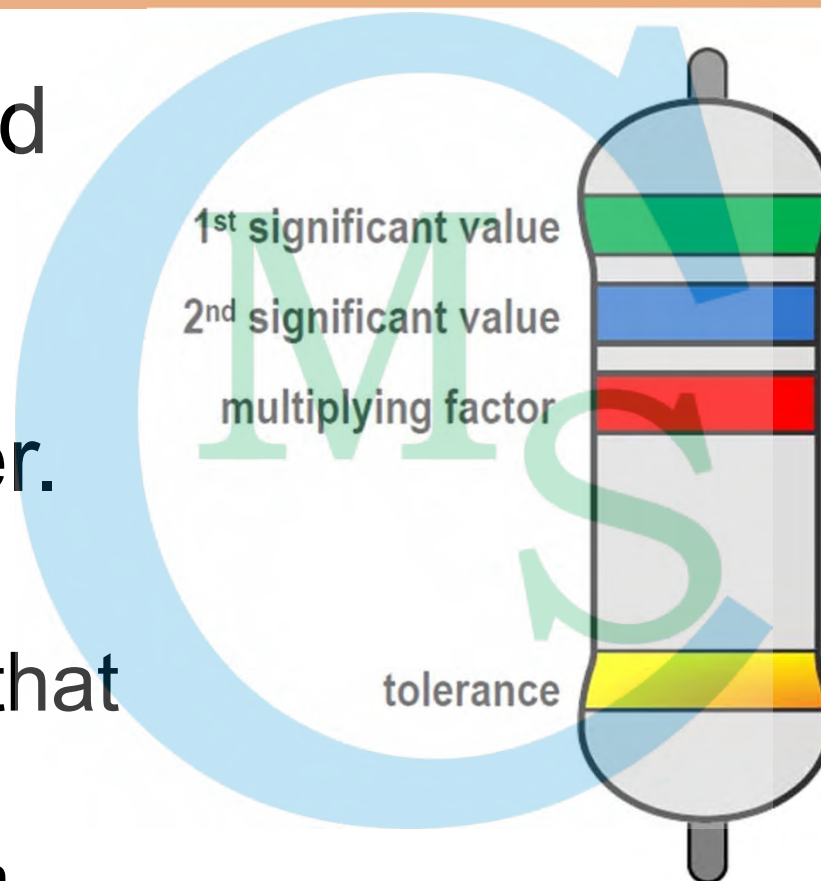


# The Color Code

| Color                                                                                      | 1 <sup>st</sup><br>Digit | 2 <sup>nd</sup><br>Digit | 3 <sup>rd</sup><br>Digit                              | Multiplier | Tolerance<br>% | Temp. Coeff.<br>ppm/K |
|--------------------------------------------------------------------------------------------|--------------------------|--------------------------|-------------------------------------------------------|------------|----------------|-----------------------|
|  Black    | 0                        | 0                        | 0                                                     | X1         |                | 250 (U)               |
|  Brown    | 1                        | 1                        | 1                                                     | X10        | 1 (F)          | 100 (S)               |
|  Red      | 2                        | 2                        | 2                                                     | X100       | 2 (G)          | 50 (R)                |
|  Orange   | 3                        | 3                        | 3                                                     | X1K        |                | 15 (P)                |
|  Yellow   | 4                        | 4                        | 4                                                     | X10K       |                | 25(Q)                 |
|  Green    | 5                        | 5                        | 5                                                     | X100K      | 0.5 (D)        | 20 (Z)                |
|  Blue    | 6                        | 6                        | 6                                                     | X1M        | 0.25 (C)       | 10 (Z)                |
|  Violet | 7                        | 7                        | 7                                                     | X10M       | 0.1 (B)        | 5 (M)                 |
|  Grey   | 8                        | 8                        | 8                                                     | X100M      | 0.05 (A)       | 1 (K)                 |
|  White  | 9                        | 9                        | 9                                                     | X1G        |                |                       |
|  Gold   |                          |                          | 3 <sup>rd</sup> digit<br>only for<br>5 and 6<br>bands | X0.1       | 5 (J)          |                       |
|  Silver |                          |                          |                                                       | X0.01      | 10 (K)         |                       |
|  Blank  |                          |                          |                                                       |            | 20 (M)         |                       |

# 3 and 4 Bands

- 3- and 4-band resistors are read in the same manner.
  - » The only difference is that the 4-band resistor has a defined tolerance other than 20%.



**5.6K $\Omega$  5%**



# 5 Bands

- 5-band resistors are usually of a higher precision value than are the 3- or 4-band resistors.

» We now have three significant digits rather than two as in the 3-band and 4-band varieties.

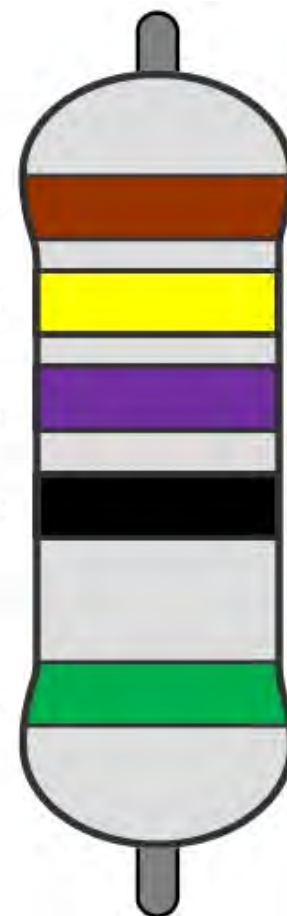
1<sup>st</sup> significant value

2<sup>nd</sup> significant value

3<sup>th</sup> significant value

multiplying factor

tolerance



**147Ω 0.5%**

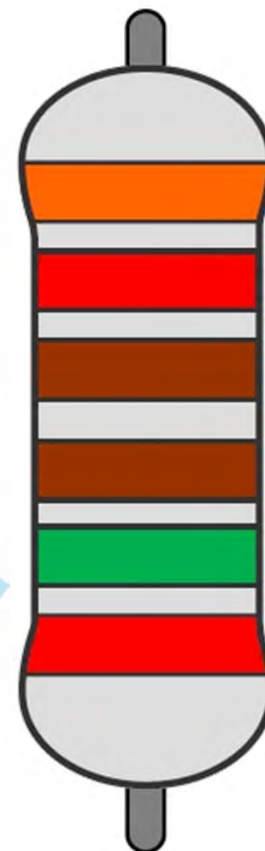


# 6 Bands

- 6-band resistors are usually precision resistors, but also carry some additional information regarding resistor temperature coefficient or typical failure rates (Mil-spec resistor types).

**3210Ω 0.5% 50ppm/K**

1<sup>st</sup> significant value  
2<sup>nd</sup> significant value  
3<sup>rd</sup> significant value  
multiplying factor  
tolerance  
TCR



**Band 6:**

For some military standards, the 6th band is failure rate.





# Tips for Reading Codes

- The reading direction might not always be clear.
  - » Sometimes the increased space between band 3 and 4 give away the reading direction.
  - » Also, the first band is usually the closest to a lead.
  - » A gold or silver band (the tolerance) is always the last band.



- It is a good practice to check the manufacturer's documentation to be sure about the coding system used.
  - » Even better is to measure the resistance with a multi-meter or ohmmeter.
  - » In some cases this might even be the only way to figure out the resistance; for example when the color bands are burnt off.
- The four band color code is the most common variation.
  - » These resistors have two bands for the resistance value, one multiplier and one tolerance band.





- If the tolerance band is left blank, the result is a 3 band resistor.
  - » This means that the resistance value remains the same as a 4 band resistor of the same colors, but the tolerance is 20%.
- Resistors with high precision have an extra band to indicate a third significant digit.
  - » Therefore, the first three bands indicate the significant digits, the fourth band is the multiply factor and the fifth band represents the tolerance.



- There are exceptions to this.
  - » For example, sometimes the extra band indicates failure rate (military specification) or temperature coefficient (older or specialized resistors).
- Resistors with 6 bands are usually for high precision resistors that have an additional band to specify the temperature coefficient (ppm/K).
  - » The most common color for the sixth band is brown (100 ppm/K).
    - This means that for a temperature change of 10 °C, the resistance value can change 0.1%. For special applications where temperature coefficient is critical other colors are sometimes assigned.



# Special Cases

- Reliability Band
  - » Resistors that are produced according to military specifications, sometimes include an extra band to indicate reliability.
    - This is specified in failure rate (%) per 1000 hours of service.
    - This is rarely used in commercial electronics.
    - Mostly the reliability band can be found on four band resistors.
    - More information about the reliability can be found in the US military handbook MIL-HDBK-199.



- **Single black band or zero-ohm resistor**

- » A resistor with a single black band is called a zero-ohm resistor.

- Principally it is a wire link with its only function that of connecting traces on a PCB.
- Using the resistor package has the advantage of being able to use the same automated machines to place components on a circuit board.

- **Deviating colors**

- » For high voltage resistors, often the colors gold and silver are replaced with yellow and gray.

- This is to prevent having metal particles in the coating.

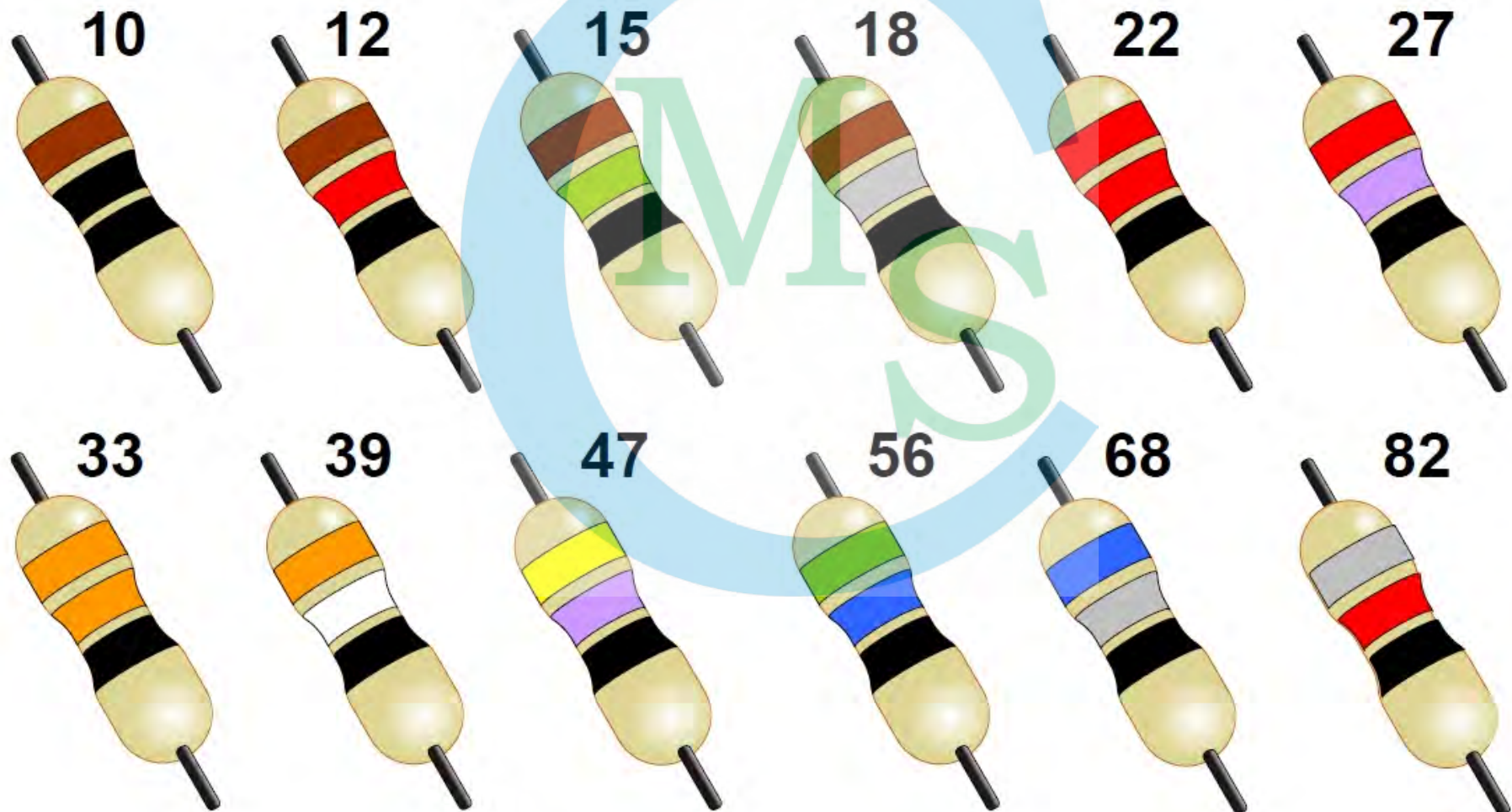


- **5 band resistor with a 4th band of gold or silver**
  - » Five band resistors with a fourth band of gold or silver form an exception, and are used on specialized and older resistors.
    - The first two bands represent the significant digits, the 3th the multiply factor, the 4th the tolerance and the 5th the temperature coefficient (ppm/K).
- The other major exception to the color code is when it is not used at all!
  - » Some precision resistors will be printed with the value and tolerance directly on the resistor body, as well as the TC and maker's name.





# Examples





# Example



**Resistance:  $1\text{K}\Omega$**

**Tolerance:  $\pm 5\%$**



# Example



**Resistance:  $6.8\text{M}\Omega$**

**Tolerance:  $\pm 10\%$**



# Example



**Resistance:  $390\Omega$**

**Tolerance:  $\pm 5\%$**



# Example



**Resistance:  $56\Omega$**

**Tolerance:  $\pm 5\%$**



# Example



**Resistance:  $471\Omega$**

**Tolerance:  $\pm 1\%$**



# Example



**Resistance:  $1\text{K}\Omega$**   
**Tolerance:  $\pm 0.5\%$**





# Example



**Resistance: 51K $\Omega$**

**Tolerance:  $\pm 1\%$**



# Example



**Resistance:  $270\text{K}\Omega$**

**Tolerance:  $\pm 0.1\%$**



# Example



**Resistance:  $4.7\text{K}\Omega$**

**Tolerance:  $\pm 1\%$**



# Example



**Resistance:  $1\text{M}\Omega$**

**Tolerance:  $\pm 1\%$**



# Things to Remember

- Sometimes, the color code is difficult or impossible to read properly
  - » In those cases, use an ohmmeter to ascertain the resistance of a resistor, but remember...
    - That you most likely cannot measure it accurately in-circuit due to parallel resistances, and...
    - That the resistor should fall within a plus-or-minus value (the tolerance) of its nominal value.
      - Thus, a  $4.7\text{K}\Omega$  1% resistor can be anywhere from  $4653\Omega$  to  $4747\Omega$  –  $4700\Omega \pm 47\Omega$ .



**QUESTIONS?**

