How to Find Burnt Resistor Value Even Without a Schematic Diagram

By Jestine Yong

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What Is A Resistor?

A resistor is a passive electronic component that opposes the flow of electrical current through it. The word resistance means opposition to some action. In electricity, resistance means the opposition to the flow of current. Resistance is measured in ohms using the Greek symbol omega (Ω). Resistance is also expressed in kilo-ohms, milli-ohms etc. With 1000Ω = 1 kilo ohms, 1,000,000Ω = 1 mega ohms.

The two main characteristics of resistor are its resistance R in ohms and its power rating in watts, W. Resistors are available in a very wide range of R value from a fraction of an ohm to many mega ohms. The value of the resistance can be measured by an ohmmeter or multimeter.
Types Of Resistors

There are two main classifications of resistors: fixed and variable. Fixed resistors have only one ohmic value, and unless the resistor is defective, it always has the same ohmic value. However, the ohmic value of a variable resistor can change, or vary.

Fixed Resistors

a) Carbon Composition Resistors

The resistance element in a carbon composition resistor is a compress slug of a finely ground mixture of carbon and silica. It is much harder for electrons to press through carbon than copper, so the flow of current is limited. The significant advantages of composition resistor include:

- Extremely small inductance and capacitance
- Do not fail catastrophically
- Can withstand higher voltages than the film resistors of standard configuration.

Carbon composition resistors are rarely used in modern electronics because they are large, less stable, comparatively noisier and they lack the precision needed to support contemporary circuits. The carbon composition resistor has been replaced by the film type resistors.

b) Film Type Resistors

There are two kinds: the carbon-film and metal-film resistors.

i. Carbon Film Resistors

In carbon film resistors, the resistive element is a thin layer of carbon on the surface of a ceramic or glass rod or tube. Carbon-film resistors have largely replaced carbon-composition resistors in most circuits requiring through-hole resistors.

The advantages of the carbon film resistors are:

- They are more accurate than carbon-composition devices because films are applied with more precision and control.
- They have better tolerances specification ($\pm 5\%$ to $\pm 0.5\%$)
- They have a wide resistance range (0.1\(\Omega\) to 100M\(\Omega\))
The disadvantages of carbon film resistors are:
- They are prone to catastrophic failure. The thin fragile film has no ability to withstand electrical overloads.
- They have comparatively higher inductances.

ii. Metal film Resistors
These are similar to carbon-film resistors in construction except that the film is of a metal alloy or a metal-oxide. These have the advantage of both carbon film and precision wire-wound resistors without having the disadvantages of either.

c) Wire-Wound Resistors
Sometimes it is necessary for a fixed resistor to dissipate more power in a circuit than a carbon resistor is able to handle. In these cases, wire-wound resistor is called for. A wire-wound resistor, which can run much hotter than a carbon resistor is fabricated by winding one or more than one layers of a high resistance wire. The fragile windings are protected against mechanical and environment hazards by dipped, sprayed, molded or rigid covers of high temperature silicone, inorganic cement, vitreous enamel, aluminum housed, plastic or ceramic materials. Wire-wound resistors are preferred over carbon composition resistors in low resistance, low noise applications. Since they are generally for high-current applications with low resistance and appreciable power, wire-wound resistors are available in wattage ratings from 5W up to 100W or more. The resistance can be less than 1Ω up to several thousand ohms. Wire-wound resistors do not have a color code, the value in ohms is printed on its body.
d) **Fusible Resistors**

Flame proof or fusible resistors are designed to meet the safety requirements of power supply, measurement, control and audio/video equipment where protection against overload is required. It serves the dual functions of a fuse and resistor to limit the current. The resistors became open circuit within a certain range if it overloads without the risk of fire. They are often designated ‘FR’. They look like power resistor but coated with blue or gray flame retardant lacquer that resist to all cleaning solvents. They also can come in the form of rectangular ceramic blocks. If the fusible resistor developed an open circuit or blown, you probably have shorted semiconductors that will need to be replaced as well. A shorted Horizontal Output Transistor (HOT) or diode may cause the resistor to go open-circuit especially in the Monitor or TV circuit. The value of a fusible resistor may be a fraction of an ohm but can be larger. For testing only, a normal resistor may be substituted but the proper replacement (identical rating) must be installed before returning the equipment to customer. A wrong replacement may increase the risk of fire.

![Fig 6: Fusible Flame Proof Resistors](image)

e) **Resistor Networks**

This is a special type of resistor where the resistors are manufactured together in a single package called single inline package (SIP), or in a package with two rows of inline pins called a DIP, for dual inline package. Packages contain three, four or five individual resistors, or common configurations of four, five, seven, eight or nine resistors of identical value. Their use greatly simplifies printed circuit layout, especially in logic circuits where many pull up or pull down resistors are required. Other advantages include considerable savings in space and assembly time.

![Fig 7: Resistor Networks](image)

a) Single Inline Package (SIP) b) Dual Inline Package (DIP)
Variable Resistors

Variable resistors can be wire-wound or the carbon type. The resistance value of variable resistors, as the name suggests, can be varied over the specified resistance range. The variable resistor has a movable contact arm called a wiper that can travel along the resistive material from one end of the resistor to the other. The wiper can therefore contact, or tap, any value of resistance from zero ohms up to the maximum value of the variable resistors. The ohmic value of a variable resistor is the maximum resistance from end to end. Thus, a 10k variable resistor measures 10,000 ohms from one end to the other. The wiper can tap any value between 0 and 10,000Ω. Variable resistors can be classified as:

a) **Potentiometers or Pots**

Potentiometers are the most common form of variable resistor in electronic circuits. A potentiometer or called pot in short, is made of either carbon composition material or resistive wire with a connection at each end. Specifically a potentiometer is designed for frequent and sometimes continuous movement of the adjustable terminal. There are two typical types of potentiometer: single turn potentiometer, where wiper is turned clockwise or counterclockwise using a rotating metal shaft, and slider potentiometer, where the wiper is moved back and forth in a straight line.

![Single Turn Potentiometer](image1.jpg) ![Slider Potentiometer](image2.jpg)

Fig 8: Typical Potentiometers

b) **Trimmers or Presets**

They are designed for infrequent adjustment or calibration of electronic circuits. These are normally varied and then set for best performance. Use an insulated screwdriver or TV alignment tool to adjust these.

![Trimmers or Presets](image3.jpg)

Fig 9: Trimmers or Presets
c) **Rheostats**
Rheostat is a variable resistance of higher wattage and often used to control relatively large values of current in low resistance circuits for ac power applications. Rheostat has two terminals and connected in series with a load. Rheostats may be either wire-wound or carbon.

![Fig 10: Wire-wound Rheostat]
Power Rating of Resistors

A resistor should have a wattage rating high enough to dissipate the power produced by the current flowing through the resistance, without becoming too hot. However, if a resistor is forced to exceed its power rating, it cannot shed heat fast enough to maintain a stable temperature. Ultimately, the resistor will overheat and burn out.

The power rating is a physical property that depends on the resistor’s construction, especially its physical size. For a given type of resistor:

a) The larger it is the more power it can handle.

b) Higher-wattage resistors can operate at higher temperatures.

c) Wire-wound resistors are physically larger with higher wattage ratings than carbon resistors.

The majority of resistors in consumer electronics are 1/8W, 1/4W, 1/2W, 1W and 2W. As long as the power being dissipated by a resistor is less than it’s rating, the resistor should perform as expected and last indefinitely.

Voltage Rating of Resistors

I believe many technicians know that capacitors have voltage ratings and resistors have power ratings. But do you know that a resistor also has a voltage rating? This rating gives the highest voltage that may be applied across the resistor without arcing between the end caps or internal leads. A resistor with a higher power rating allows a higher voltage rating. In the cases of general-purpose carbon composition resistors, the maximum voltage rating is 150V (for 1/8W), 250V (for 1/4W), 350V (for 1/2W), 500V (for 1W) and 750V (for 2W). For general-purpose carbon film resistors, the values are more or less identical.
Resistor Color Code

Fixed resistors are marked in several ways. These are:
  i. Color coding
  ii. Straight numerical value
  iii. Certain numerical codes that can be easily translated.

Because carbon resistors are small physically, they are color coded to mark their R-value in ohms. In memorizing the colors, note that the darkest colors, black and brown, are for the lowest numbers, zero and one, through lighter colors to white for nine. Reading from left to right, the first band close to the edge gives the first digit in the numerical value of R. The next band marks the second digit. The third band is the decimal multiplier, which gives the number of zeros after the two digits. As for the five color bands resistors, the fourth band is the decimal multiplier. Technicians must know this code.

Table 1 and 2 shows the color code and their meanings.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Digit</th>
<th>Multiplier</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Brown</td>
<td>1</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Red</td>
<td>2</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Orange</td>
<td>3</td>
<td>1000</td>
<td>-</td>
</tr>
<tr>
<td>Yellow</td>
<td>4</td>
<td>10000</td>
<td>-</td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td>100000</td>
<td>-</td>
</tr>
<tr>
<td>Blue</td>
<td>6</td>
<td>1000000</td>
<td>-</td>
</tr>
<tr>
<td>Violet</td>
<td>7</td>
<td>10000000</td>
<td>-</td>
</tr>
<tr>
<td>Grey</td>
<td>8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>White</td>
<td>9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gold</td>
<td></td>
<td>0.1</td>
<td>±5%</td>
</tr>
<tr>
<td>Silver</td>
<td></td>
<td>0.01</td>
<td>±10%</td>
</tr>
<tr>
<td>No colour</td>
<td></td>
<td>-</td>
<td>±20%</td>
</tr>
</tbody>
</table>

TABLE 1- The four colors band of resistor and their meanings.
TABLE 2 - The five colors band of resistor and their meanings.

<table>
<thead>
<tr>
<th>Tolerance Code</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>-</td>
</tr>
<tr>
<td>Brown</td>
<td>±1%</td>
</tr>
<tr>
<td>Red</td>
<td>±2%</td>
</tr>
<tr>
<td>Orange</td>
<td>-</td>
</tr>
<tr>
<td>Yellow</td>
<td>-</td>
</tr>
<tr>
<td>Green</td>
<td>±0.5%</td>
</tr>
<tr>
<td>Blue</td>
<td>±0.25%</td>
</tr>
<tr>
<td>Violet</td>
<td>±0.1%</td>
</tr>
<tr>
<td>Grey</td>
<td>±0.05%</td>
</tr>
<tr>
<td>White</td>
<td>-</td>
</tr>
<tr>
<td>Gold</td>
<td>±5%</td>
</tr>
<tr>
<td>Silver</td>
<td>±10%</td>
</tr>
</tbody>
</table>
**Typical Example On How To Calculate The Resistor Color Codes And Tolerances**

Example 1:

```
  red      violet      red     gold
    |       |       |       |
   2      7       x   100 = 2700
```

The first band is red for 2 and the next band is violet for 7. The red multiplier in the third band means an additional two zeroes to 27. The result can be illustrated as follows:

Therefore, this R-value is 2700$\Omega$ with tolerance $\pm$ 5% (gold).

The value of a resistance has a tolerance (given in percentage) within which the value may vary due to imperfections in manufacturing process. It may be anything from 1% or even less (for critical applications) to 10 or 20% (for normal electronic circuits). Tolerance is marked in the color code by the last band of color (as given in the example).

For instance, the 2700$\Omega$ resistor with $\pm$ 5 percent tolerance can have a resistance of 5 percent above or below the coded value.

This R, therefore, is between 2565$\Omega$ and 2835$\Omega$. The calculations are as follows:

5 percent of 2700 is $0.05 \times 2700 = 135$

For $+5$ percent, the value is

$2700 + 135 = 2835 \Omega$

For $-5$ percent, the value is

$2700 - 135 = 2565 \Omega$

A 10$\Omega$ resistor with $\pm$ 5 percent tolerance will have the value range between 9.5$\Omega$ to 10.5$\Omega$. Say if you measure this resistor with a digital multimeter and it showed 10.3$\Omega$ or 9.8$\Omega$, the resistor is still within the tolerance range and said to be good. However if this resistor measure showed 10.9$\Omega$ or 8.9$\Omega$ it is considered out of the tolerance range and it should be replaced. It’s a good idea to check the actual resistance with your multimeter before you install the part.
How To Find Burnt Resistor Value Even Without A Schematic Diagram

Example 2:

![Resistor Diagram]

green    blue   orange   silver

\[
\text{green} \quad \text{blue} \quad \text{orange} \quad \text{silver} \\
\]

\[
5 \quad 6 \quad \times \quad 1000 = 56000\Omega
\]

Therefore, the R-value is 56000\(\Omega\) or 56k\(\Omega\) with tolerance \(\pm 10\%\) (silver).

Example 3:

![Resistor Diagram]

orange   orange   black     gold

Example 3 illustrates that black (third band) just mean that “do not add zeroes to the first two digit”. Since this resistor has orange, orange, and black band, the R-value is 33\(\Omega\) with tolerance \(\pm 5\%\) (gold).

Example 4:

![Resistor Diagram]

brown    grey    black    silver

\[
18 \quad \times \quad 1 = 18\Omega
\]

The R-value is 18\(\Omega\) with tolerance \(\pm 10\%\) (silver).

Example 5:

![Resistor Diagram]

brown   green   gold     gold

For these values, the third band is gold, indicating a fractional decimal multiplier. When the third band is gold, multiply the first two digits by 0.1. The R-value is

\[
\frac{\text{brown} \quad \text{green} \quad \text{gold} \quad \text{gold}}{1 \quad 5 \quad \times \quad 0.1 \quad = \quad 1.5\Omega \quad \pm 5\%}
\]

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Example 6:

![Resistor Diagram](image)

47 x 0.1 = 4.7Ω ±10%

Example 7:

![Resistor Diagram](image)

For these values, the third band is silver. When the third band is silver, multiply the first two digits by 0.01. The R-value is

red red silver gold

2 2 x 0.01 = 0.22Ω ± 5%

Example 8:

![Resistor Diagram](image)

68 x 0.01 = 0.68Ω ±10%

Example 9:

![Resistor Diagram](image)

The first band is green for 5, the next band is brown for 1 and the black for 0. The red multiplier in the fourth band means add two zeroes to 510. The result can be illustrated as follows:

510 x 100 = 51000

Therefore, this R-value is 51000Ω or 51kΩ with tolerance ± 1% (brown)

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Example 10:

```
4    3    6  x  1000 = 436000
```

Therefore, this R-value is 436000Ω or 436kΩ with tolerance ± 2%.
**Codes Indicating Values And Tolerances**

For some resistors like the wire-wound type, the value of resistance is indicated on the body of the resistor in digit-letter code. The letter placed after the digit indicates the multiplier and position of the decimal. R indicates $10^0$ multiplier, K indicates $10^3$ and M indicates $10^6$. Table 3 illustrates the digit-letter code system.

<table>
<thead>
<tr>
<th>Code</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R82</td>
<td>0.82Ω</td>
</tr>
<tr>
<td>15R2</td>
<td>15.2Ω</td>
</tr>
<tr>
<td>100R</td>
<td>100Ω</td>
</tr>
<tr>
<td>10K</td>
<td>10KΩ</td>
</tr>
<tr>
<td>2K7</td>
<td>2.7KΩ</td>
</tr>
<tr>
<td>2M2</td>
<td>2.2MΩ</td>
</tr>
</tbody>
</table>

Tolerance indicating letter is the last letter in digit-letter code. Letter F indicates 1% tolerance; G, 2%; H, 3%; I, 4%; J, 5%; K, 10% and M, 20%.

For example, a resistance of 1.2kΩ 20% tolerance would be indicated as 1K2M, and 100Ω 5% tolerance as 100RJ.
Surface Mount Resistor Coding

Color-coded resistors are rapidly being replaced by surface mount resistors (SMD chip resistor). As with carbon-film resistor, surface mount resistors are formed by depositing a layer of carbon film into a thin ceramic substrate. Metal tabs are attached at both ends of the wafer. Surface mount resistors are soldered directly on the top or bottom sides of a printed circuit board instead of using leads to penetrate the PC board. Surface mount resistors are used extensively in computers and printers. Surface mount resistors are far too small for clear color-coding (only a few square millimeters in area), yet they offer very tight tolerances. The identification value of the surface mount resistor is found on top, and is indicated with three numbers. The first number is the single digit, number two is the second digit, and the third number, the multiplier (Fig 11). Notice a solid SMD has “000” marked on top of part. Do not mistake this for a shorted component. It is actually a jumper.

Fig 11: The standard chips code with numbers on top of SMD resistor and example

| 102 | = 10 \times 100 \ (2 \text{ zeroes}) = 1000\Omega = 1\kOmega |
| 470 | = 47 \times 1 = 47\Omega |
| 000 | = \text{ chip jumper} = 0\Omega |

Standard Chip Resistor Code

Example
Resistors in Series and in Parallel

Resistors in Series
If R1, R2, R3, etc, are the resistors connected in series as shown in Fig 12, the total resistance R is equal to the sum of the individual resistances, as given by

\[ R = R_1 + R_2 + R_3 + \ldots \]

![Fig 12: Resistors in Series](image)

Example 1: What is the total resistance of the series circuit illustrated below?

\[ \begin{align*}
R_1 &= 5\Omega \\
R_2 &= 10\Omega \\
R_3 &= 15\Omega \\
\end{align*} \]

\[ R = R_1 + R_2 + R_3 \]
\[ R = 5\Omega + 10\Omega + 15\Omega \]
\[ R = 30\Omega \]

Example 2: What is the total resistance of the series circuit illustrated below?

\[ \begin{align*}
R_1 &= 10\Omega \\
R_2 &= 22\Omega \\
\end{align*} \]

\[ R = R_1 + R_2 \]
\[ R = 10\Omega + 22\Omega \]
\[ R = 32\Omega \]
Resistors in Parallel
When two or more resistors are connected in parallel as shown in Fig 13, the total resistance R is given
\[ R = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots \]

Fig 13: Resistor in Parallel

When two different value resistances say 20 Ω and 10 Ω are connected in parallel, the net resistance is equal to the product of two resistances divided by their sum.

\[ \text{Total resistance } R_T = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{20 \times 10}{20 + 10} = \frac{200}{30} = 6.67 \text{ ohms} \]

When equal value resistances are connected in parallel, the total resistance is equal to the value of any one of the resistances divided by the number of resistance in parallel.

The total resistance is: \[ \frac{20}{2} = 10 \text{ ohms} \]

Voltage across each parallel resistance remains the same, but current in each resistance would be different depending upon the value of the resistance.
Why Connecting Resistor In Series Or Parallel Is Important?

Imagine this scenario, if you came across an open circuit 36 ohm resistor and you could not find this value in the market or your customer need the equipment by tomorrow morning and the resistor is temporary out of stock from your spare part department, what would you do? The answer is to use the series or parallel resistance formula to solve your problem. In your case, you can always use two 18Ω resistor connected in series.

\[ RT = R_1 + R_2 \]
\[ RT = 18\Omega + 18\Omega \]
\[ RT = 36\Omega \]

Or you can use a 24Ω and a 12Ω resistor connected in series

\[ RT = R_1 + R_2 \]
\[ RT = 24\Omega + 12\Omega \]
\[ RT = 36\Omega \]

If you need a 50Ω resistor, you can connect two 100Ω resistor in parallel.

\[ RT = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{100 \times 100}{100 + 100} = \frac{10000}{200} = 50\Omega \]

In the field of servicing, time is money. The lesser amount of time you use on one job, the more number of jobs you can do and hence the more you can earn. For this you must understand the series and parallel connection of a resistor. It is not possible to run to the market every time to get a correct replacement of resistor, it is time-consuming, and it is also not economical. It kills the efficiency and presence of mind, and steals precious time.
Applications Of Resistors In Electronic Circuits

Resistors are used in electronic circuits for various functions. These are described below:

- **Voltage Drop** – When current I flows through a resistor, voltage drop, equaled to I X R, takes place across the resistor.

- **Current Limiter** – In zener diodes and diodes, a resistance is used in series to limit the current to a safe value in order to save the diodes from burning.

- **Bleeder Resistor In Power Supplies** – It is used in high-voltage power supplies. The capacitor of the power supply is charged to peak voltage and when the load is off, high voltage across the capacitor may dangerously leak through the body of service technician during servicing. To counter this problem, a resistance of high value is connected across the capacitor in power supplies.

- **Potential Divider** – When voltage is applied across two or more resistors in a series, voltage divides itself amongst the resistors so that voltage across each resistor = series current X value of resistor. Such voltage dividers are used for giving fixed bias in transistor circuits, giving desired voltage to the various electrodes of CRT, etc.

- **Resistive Matrix** – PA amplifier mixers use fader resistors to isolate different microphones. Resistive matrix is also used to obtain luminance signal in color TV transmitters.

- **Feedback Resistor** – Negative feedback is often given by a resistive network from output to input in amplifiers.

- **Q-reduction (Damping)** – Q of a resonant circuit is reduced by connecting a resistance in parallel with the circuit. This is sometimes required to flatten the resonance curve.

- **Receiver Controls** – Potentiometers are used in receivers for controlling various parameters, like gain, brightness, contrast, volume, etc.

In conjunction with capacitors, a resistor is used for many other functions some of which are mentioned below:

1. Decoupling circuits
2. Wave shaping circuits
3. Time base circuits
4. Ripple smoothing filter
5. Equalization circuits
6. Bass and treble controls
How Resistors Fail?

The most common trouble in resistor is either it increases in value, or it opens up altogether. Small resistors are physically fragile; mechanical abuse and corrosion in metal resistor can cause a lead to pull away from the carbon material in the center of the resistor body. Overheating can also make a resistor increase in value or open.

A faulty resistor may appear only slightly discolored, or it may look burnt and cracked, depending upon the severity and duration of its overheating. Severe overheating can also burn a printed circuit board. In nearly all cases of overheating, the resistor, itself is not at fault; rather, some other components, such as a transistor, diode or capacitor, have either shorted out or have become leaky due to higher supply voltage. This causes too much current to flow through the resistor, which then overheats. Generally, you will want to find and correct the cause of overheating first, and then replace the resistor.

Sometimes a resistor becomes electrically noisy and unstable. If you measured with an ohmmeter it will show a right value, but in an actual circuit with current flowing through it, the resistance fluctuates. If the resistance changes rapidly, the resistor is said to be noisy. In a monitor circuit, a noisy resistor can cause picture instability. However, noisy resistors are very rare.

Unstable and noisy resistors can be very hard to locate. It usually changes value slowly as it heats up. It causes the affected circuit to function intermittently. The affected circuit often works correctly for a while, but after the unit heats up, some problems appear. In order to solve this problem, a can of freeze spray is used. When a heat-sensitive component gets cooled off, normal operation is temporarily restored. Sometimes, several coats might be needed to get the suspected component to act up. Be very careful not to use just any spray coolant. Some types can generate static charges in the thousands of volts when they are used. Sensitive devices can be damaged by static discharges. Spraying a hot integrated circuit (IC) could cause it to crack under thermal stress.
Testing Of Resistors

Testing a Fixed Resistor
You can check the resistance of a resistor with a digital multimeter set to ohm’s range. Resistance is measured in parallel across components with all circuit power off as shown in Fig 14.

![Fig 14: Measuring Resistance](image)

It may be necessary to remove at least one component lead from its circuit to prevent interconnections with other components from causing false readings. In other words, you are measuring only the resistor, not other components in the circuit. Place your test lead across the component and read resistance directly from the display. An open resistor reads infinitely high ohms. It is important not to touch the meter’s lead. There is no danger of shock, but the body resistance acts as a parallel path that will lower the ohmmeter reading.

If you are experienced enough, you can check a resistor in circuit without soldering out the resistor lead from the circuit. Always be aware of possible back circuits when performing in-circuit resistance measurements. But if you connect your meter leads across a resistor in a circuit and it measures higher than it should, then you know the resistor is either opened or has gone up in value. Other circuit components cannot possibly increase the value of a resistor; and back circuit could only make the resistance reading lower.

If a component measures less resistance than its rated value when checked in the circuit but normal when measured out of the circuit, a parallel path is being measured. This parallel path could be a junction of a transistor or a diode, or it could be that a capacitor is conducting when capacitors usually do not conduct. This is one way to identify a leaky capacitor.
Testing Variable Resistor

Failure among variable resistors usually takes form of intermittent connections between the wiper blade and resistive film. Sometimes it also can be burned due to overload of currents and develop an open circuit. Remember that film slowly wears away as the wiper moves back and forth across it. After sometimes the overall film can wear away that which the wiper cannot make a good contact at certain points. The poor contact can cause all types of erratic or intermittent operation.

If the intermittent connections are due to dust and debris, using an electronic oil-based contact cleaner may help to solve the problem. But, if the problems are caused by the wearing away of the resistive film, the only option is to replace the variable resistors.

You can check the variable resistor resistance with a digital multimeter set to ohm’s range as shown in Fig 15.

![Fig 15: Testing a variable resistor with a digital multimeter](image)

Use either one probe to touch pin 1 and 2 (Fig 15a) of variable resistor while the other probe touching pin 3. Turn the knob clockwise and anti-clockwise to see the changing of resistance. The meter should show a smooth reading. If the reading is erratic, service or replace the variable resistor. Say if the variable resistor is 10kΩ the ohms value should vary from 0Ω to 10kΩ, or 10kΩ to 0Ω as you turn the knob clockwise and anti-clockwise.

Now, using the probe that touches pin 3 short to pin 2 (Fig 15b) while the other probe connects to pin 1, test for the result. The reading should be the same except that the ohms range instead of starting at 0Ω should now start at 10kΩ.
Resistor Replacement

Sometimes, it can be more trouble to find parts than it is to identify the problem in the first place. In some cases, you must locate an exact replacement for the bad parts; sometimes, you can get away with a “near match”.

A replacement resistor should have the same resistive value and tolerance (or better) as the original. It is acceptable to replace a resistor with one having a higher wattage rating. For example, suppose you measure a 1/8W resistor in a TV circuit and find it to be 870 ohms, when it should be 330 ohms. Go ahead and replace this with a 330Ω 1/4W or even 1/2W resistor. Resistors with a wattage rating of 1/8W can be hard to find or buy in small quantities, but are available from larger electronic suppliers and mail order companies. It’s a good idea to check the actual resistance with your multimeter before you install the part. Finally, consider the physical size of the resistor. Be sure the replacement will fit into your equipment.

Note: Always use a replacement resistor with a power rating that is equal to or greater than the original.
## Typical Resistors Value

<p>| | | | | | | | | | |</p>
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<td>135</td>
<td>3.9 MΩ</td>
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Let’s Get Started

**Construction Of A Film–Type Resistors**

In carbon-film resistors, the resistive element is a thin layer of carbon on the surface of a ceramic or glass rod or tube. Metal film resistors are similar to carbon-film resistors in construction except that the film is of a metal alloy or a metal-oxide. The thickness of these coating (carbon or metal film) affects the amount of resistance – thicker coatings yield lower levels of resistance, and vice versa. Metal caps on both ends provide the electrical connections as shown on Fig 16.

![Fig 16: Cross-sectional view of a film-type resistor](image)

A spiral groove is cut with a lathe or laser beam through the deposit to produce a spiral-wound resistor, which is then covered or encapsulated in a hard epoxy material as shown in Fig 17.

![Fig 17: Construction of film-type resistor](image)
Tips: View the resistor where the encapsulating material has been removed to see how many stripes the spiral groove produced. In Fig 17, the spiral groove produced three stripes. Some resistors have half, one, two, three and up to seven or more stripes. **Generally, the more stripes a resistor has, the higher resistance it will be. The fewer stripes it has, the lower resistance it will be** as shown in Fig 18.

![Resistor Images](image1.png)

a) ½ stripe (0.1Ω)  
b) 1 stripe (1Ω)  
c) 2 stripes (10 Ω)

d) 3 stripes (100Ω)  
e) 4 stripes (1KΩ)  
f) 5 stripes (10KΩ)

g) 6 stripes (100KΩ)

**Fig 18: Counting total number of stripes of a resistor**

**Note:** The construction of wire wound resistor is quite similar to film type resistor except that the protective layer is covered by ceramic or silicon.
Tools And Test Equipment Required To Determine The Value Of A Burnt Resistor

To successfully determine the value of a burnt resistor, you will need an assortment of tools, and simple test equipment. Once you have the tools and test equipment, you will be ready to check all burnt resistor problems that come your way. Gathering the proper tools from the beginning can save time and frustration.

a) **Digital Multimeter (DMM)** – A good quality and accurate digital multimeter determines the value of a burnt resistor more precisely than an analog multimeter. DMMs are easier to read than analogs. The liquid crystal display produces a direct readout in numbers, so you don’t have to interpret a meter scale. Some DMMs even have auto-ranging; they automatically select the correct resistance range depending on the resistor being read. If you don’t have one, you may want to consider purchasing a new DMM. The cost of DMM has come down to the point where they are very competitive with analog meters.

b) **Test Leads** – Your DMM should have a good quality test lead. A good quality and sharp test lead will make a good contact with the resistor you are measuring. Besides, you will get a stable reading instead of a fluctuating reading, which is very frustrating especially when you are checking a burnt resistor. If you already have a DMM, make sure the tip is clean and sharp because for some resistors, the gap of the stripe is very narrow and it can only be reached with a sharp test lead.

c) **Wise** - Get a small wise to clamp on the resistors. Without a wise, checking the burnt resistor value is quite difficult, as it will slip away when the meter test leads is placed on the resistor.
d) **Wire Cutter** – A wire cutter is useful to remove the protective layer of the resistor. With some resistors, their color code has lost its vibrancy due to heat. To determine the resistor value, we need to peel off the layer so that it can be check by a DMM. Gently remove the layer without destroying the thin coating of the resistive material. The resistive material is the only clue to determine the burnt resistor value.

Note: The ceramic or silicon coated body of wire-wound resistor also can be broken to gain access into the resistive material of the resistor.

e) **Magnifying Lamp** – A magnifying lamp provides not only light, but also makes the resistor markings easier to be read. When you check a burnt resistor, it is often necessary to check for cracks and the burnt spot (which will be discussed later). A magnifying lamp is perfect for this job.
Step By Step Guide

There are four steps that you must follow in order to successfully determine the value of a burnt resistor in a faster and easier way.

Step one:  **Identify the burnt resistor**
Most often when resistors fail, they either increase in value or open up all together. But in certain case, you can normally pick out an overheated carbon or metal-film resistor visually. The resistor will have a darkened or even burnt appearance, and the color bands will have lost their vibrancies. There may even be evidence of cracking or blistering. Once you have identified the burnt resistor, solder it out and measure the resistance. Not all burnt resistor will open up, with some burnt resistor the original value still remain intact. After you have confirmed that the burnt resistor value have opened up or gone up in resistance (many mega ohms), then only you start removing the protective layer of the resistor. Do it gently, for you may accidentally break the resistor into pieces. If this happens, it will be very difficult or impossible to determine the value of the burnt resistor.

In nearly all cases of overheating, the resistor itself is not at fault; rather, some other components, such as transistor, diode or capacitor, has either shorted out or has become leaky. This causes too much current to flow through the resistor, which then overheats. Generally, you will want to locate the cause of overheating first, and then replace the resistor.

Step two:  **Total stripe count of a burnt resistor**
It is important to find out how many stripes the burnt resistors have after you had removed the protective layer. A half or one stripe may indicate the burnt resistor is under 10Ω, two stripes may indicate the burnt resistor is under 100Ω, three stripes may indicate the burnt resistor is under 1kΩ and so on. However, different type of resistors may produce different results. With some hands-on practice on a certain type of resistors, you will quickly identify to which range a burnt resistor belong (under 10Ω, 100Ω, 1KΩ and etc).

**Note:** Even though a resistor is burnt, you will still be able to see or count the stripes of the resistor.

Step three:  **Using the right method**
Not all resistors are burnt at the same area; some at the side, some at the center. In some cases it might burn up 3/4 of the resistive material of a resistor. Even though it is badly burnt there is still a method used to successfully identify the value. In the coming topic, I will show you how to use the right method to tackle different kind of burnt resistor problems.
Step four: **Retest**

Once you have found the right value of the burnt resistor, retest the equipment thoroughly to make sure that you have solved the problem. Do not be discouraged if the equipment is still not working. Simply walk away, clear your mind, and start again by defining the symptoms. Never continue with a repair if you are tired or frustrated – tomorrow is another day. You should also realize that there might be more than one bad component to deal with. Normally when one parts fails, it may cause one or more interconnected parts to fail as well. Be prepared to make several repair attempts before the equipment is repaired completely.

**Note:** Always use a replacement resistor with a power rating that is equal to or greater than the original.
The Right Method To Check The Value Of A Resistor With Protective Layer Removed

As mentioned earlier, the more stripes a resistor has the higher resistance it will be, and the fewer stripes a resistor has the lower resistance it will have. Thus, just by basing on the number of stripes of a resistor you will be able to estimate the ohms range of the burnt resistor, whether it is under 1Ω, 10Ω, 100Ω, 1kΩ, 10kΩ, 100kΩ, 1MΩ or even 10MΩ. Once the protective layer of a resistor has been removed, you are able to see the total number of stripes (spiral grooves) on the surface of the resistive material (carbon film or metal type).

The method on how to check the value of a resistor with protective layer removed is the same regardless whether it is a one-stripe or eight-stripe resistor.

Let’s begin.

Note that every resistor has a spiral groove that is cut using a lathe or laser beam. There is a starting and ending point as shown in Fig 19. Usually the starting point is near to the metal cap of resistor.

![Fig 19: Showing a starting and ending point of spiral groove in a resistor](image-url)
Regardless of how many stripes a resistor has the measurement should be measured between the right lead and ending point or left lead and starting point of a resistor as shown in Fig 20. Either way will identify the exact value of the resistor.

Fig 20: The right method to check the value of a resistor with protective layer removed

Note: Do not let your test probe touch the spiral groove because it will show you an infinite reading. With your test probe, touch only the adjacent of the spiral groove.
The result that you achieved by measuring both points is not always exact, but at least you will know the range to which the resistance belongs. For example, measuring between the ending point and right lead of a resistor showed 11.3 to 12.5Ω (the resistance varies due to the movement of the test lead or putting the probe at different distance near to the ending point) then the only resistor that falls under this range is 12Ω. 12Ω is the original value of the resistor.

Although you now know how to determine the value of resistor with protective layer removed, there is certain way of measuring the resistor that you should not use. For example:

a) Please do not measure a resistor after the ending point area as shown in Fig 21 because it will produce a higher than normal resistance value reading.

![Fig 21: Measuring this point (darkened area) should be avoided](image)

b) Resistance should not be taken between the left lead can ending point as shown in Fig 22 as this will produced lower than normal resistance value reading.

![Fig 22: Avoiding measuring resistance between left lead and ending point](image)
c) Measuring between these points (darkened area) as shown in Fig 23 will also produce inaccurate reading.

```
Fig 23: Showing the wrong way to check a resistor
```

Experimenting with a few resistors using a digital multimeter as you go back through the material is an excellent way to gain greater understanding of how to check the value of resistors with its protective layer removed.

You can purchase several types of resistors for less than $0.30 each from many electronic suppliers. Get a few films, metal or wire wound types of resistor, break the protective layer, grab your digital multimeter, and see for yourself. With some hands-on activity, it won’t take you long to become confident in performing a resistor test (with protective layer removed) and successfully be able to identify the value of a burnt resistor.
Typical Examples Of Burnt Area In A Resistor And How To Determine The Value

A burnt resistor does not always cause the ohms value to increase or become open. In some cases, the ohms value still remain the same even though the resistor already burnt into crisp or the color bands have lost its vibrancy due to overheat. In other cases, the value might increase a little bit than the original value and a near replacement value might put the equipment back to work again. For example, a burnt resistor measured 113Ω, and the nearest replacement value would be 100Ω. Note that a spoilt resistor can either become open circuit or increase in resistance. Since there is no 110Ω resistor in the market, the only nearest value available is 100Ω.

Always check a burnt resistor value first before starting to ‘peel off’ the protective layer, because a burnt resistor can be very fragile especially when applying force on it with wire cutter. Who knows, the measurement you get from the burnt resistor is the resistor original value. If you accidentally break the burnt resistor into pieces then you might not be able to find the value of the resistor.

Problem 1:  *Color band fade out or missing due to the use of cleaning solvent*

Solution 1:  Color band fade out or missing due to the use of cleaning solvent such as thinner will not cause the value of the resistance to vary. Usually the measurement you get is the resistor’s original value. You can always check if the resistor is in good condition by removing the protective layer of the resistor. If you can see a smooth resistive material on the surface without any defect then most probably the resistor is good.

Another way to confirm is to examine the value you get from the measurement. Say, if you measured the resistor and showed 46.5 or 46.8Ω then you knows that it is a 47Ω resistor. But, if the reading showed 41.3Ω then most probably there is a problem with the resistor because the value you measured (41.3Ω) is out of the typical resistor value list. Although the value (41.3Ω) might be found in certain precision design of circuit but it is extremely rare. If you suspected that the value you measured is not the resistor original value then you may use the method described at previous topic to confirm it.

Problem 2:  *Color band fade out or missing due to overheat with protective layer still intact*

Solution 2:  In this case, the resistor will usually have a darkened or even burnt appearance, and the color bands will have lost their vibrancy. There may even be evidence of cracking or blistering. There is a 50 percent chance that the value you measured is the resistor original value. As mentioned earlier, an overheat resistor does not necessarily always cause the ohms value to vary or become open. Follow the explanation on solution 1 to find the original value of the suspected resistor.
Problem 3: *Resistor leads became rusted due to water entering into PCB board or electrolyte from electrolytic capacitor*

Solution 3: If the resistor leads have become rusted even though the color band is not affected, it is always recommended to replace the resistor with a new one. A rusted resistor leads can cause intermittent problem, noise, resistance value run and etc. Do not take the risk of not replacing the rusted resistor. A new resistor cost less than 30 cents as compared to the time you wasted checking an intermittent problem caused by only a rusted resistor leads. To find out the value, simply calculate the resistor value based on the color band of the rusted resistor.

Problem 4: *Burnt areas at the side of a resistor as shown in Fig 24*

Solution 4: In this case, you have to put your probe at right lead and the other probe to the ending point of the resistor as shown in Fig 25.

The resistance read-out is the value of the resistor original value. Do not measure the resistor between left lead and ending point, as this will only showed high resistance or infinity reading.

Note: If the burnt area at the right side of a resistor as shown in Fig 26, then you must measure it between left lead and the starting point as shown in Fig 27.
Fig 26: Burnt area of a resistor

Fig 27: Checking the resistor original value between left lead and starting point
Problem 5:  *Nearly half of the resistor is burnt as shown in Fig 28*

![Resistor Diagram](image)

Fig 28: A resistor burnt nearly half of the part

Solution 5: First determine how many stripes the burnt resistor has. Assuming it has 3 stripes then most probably the resistor’s value is under the range of 100Ω. To find out the value of the burnt resistor, simply connect the meter’s probe to the right lead and center of the resistor as shown in Fig 29.

![Measurement Diagram](image)

Fig 29: Measurement taken between center of resistor and right lead

Say if the measurement showed somewhere between 45 to 52Ω then use these value to multiply by 2 (because you are measuring half of the resistor), which gives the range of 90 to 104Ω. There are two values that you can choose from i.e. 91Ω or 100Ω. To know which the correct value to replace is, simply look at the first stripe of the color band of the resistor. If it is white color band then choose 91Ω, and if it is brown color band then you choose 100Ω. If you only can see a gold color band, then you have to try out either 91Ω or 100Ω to see which one makes your equipment perform normally.
Problem 6:  *Burnt at the center of resistor as shown in Fig 30*

![Fig 30: Burnt area at the center of resistor](image)

Solution 6:  As usual, see how many stripes this resistor has. In the above case it has only two stripes, which indicate the value is under the range of $10\Omega$. Measurement should be made between right lead to the side of the spiral groove as shown in Fig 31.

![Fig 31: Measurement taken at the side of spiral groove and right lead](image)

If the measurement showed 4.7 to 5.1\(\Omega\) then use these value to multiply by 2 (because it has only two stripes) resulting in a range between 9.4\(\Omega\) and 10.2\(\Omega\). Since this resistor has only 2 stripes, the best value to choose is 10\(\Omega\).

Say if the burnt resistor has 3 stripes and the measurement you get is between 29\(\Omega\) to 34\(\Omega\) then using this value to multiply by 3, which gives 87\(\Omega\) to 102\(\Omega\). Since this resistor has 3 stripes, the best value would be 100\(\Omega\). Again it depends on the first color band of the resistor as explained in solution 5.
Using Comparison Method

If you want to make sure that the burnt resistor value you have determined is the right value before you replace and switch on the equipment, you can always use the comparison method to find out.

For example, if you have determined a burnt resistor value, which is 47Ω and you are unsure if this is the correct value, in order to find out you have to use a similar type of resistor (film or wire-wound) with same wattage rating (1/2W, 1W, 2W or 5W). Get a new 47Ω resistor and remove the protective layer with wire cutter. Now compare the reading as shown below.

![Comparison Method Diagram](image)

- a) Measuring a burnt resistor value
- b) Measuring a good 47Ω resistor

Fig 32: Using comparison method to check if the burnt resistor value is actually 47Ω

Since both resistors are from the same type and wattage rating, it should produce a close result when doing comparison. In Fig 32a, measuring point A gives the result of 23Ω while measuring point B shows 47Ω. If using the similar method in checking the resistor in Fig 32a check on a new resistor (Fig 32b) and if it shows almost the same result say 46.5Ω then most probably the burnt resistor is 47Ω. If point A in Fig 32b shows 23Ω and point B shows 68Ω then most probably the burnt resistor value is also 68Ω and not 47Ω.

Comparison method is used if you are uncertain of the value you have determined from a burnt resistor.
True Case Histories

Five actual burnt resistors case histories
The following are five actual problems and their solutions.

Case No 1:

This monitor came in with no power symptoms. But upon checking, found a ¼ watt resistor badly burnt at its power side. When the resistor measured showed infinite reading. By looking at the color band i.e. the blue and gold color, it could indicate the resistor to be somewhere in the range of 0.62Ω, 0.68Ω, 6.2Ω, 6.8Ω, 62Ω, 68Ω, 620Ω, 680Ω, 6.2k, 6.8k, 62k, 68k, 620k, 680k, 6.2MΩ or even 6.8MΩ. This is a very wide range. In order to narrow down the search, simply remove the protective layer and clean the resistor with a brush. Once the protective layer had been removed, only two stripes can be seen, which mean the resistor is under the range of 10Ω, eliminating the guessing game of other possible values.

By measuring between the metal film layer and the right lead as shown in Fig 33, it produced 1.7Ω.

This value indicated that the resistor was more than 1.7Ω but less than 10Ω. Since the first color band was blue, then most probably the value was either 6.2Ω or 6.8Ω. I chose 6.8Ω because it was more widely used. After substituting the resistor, the monitor worked perfectly.

Note: Besides the resistor that was problematic, the power FET and SMPS IC also shorted.
**Case No 2:**

![Resistor Diagram](image)

This 1/4w resistor was badly burnt and only the orange color band could be seen. Measuring the resistance showed 116Ω. With the measurement reading (116Ω), we knew that the original value was lower than 116Ω. So the value could be 0.33Ω, 0.39Ω, 3.3Ω, 3.9Ω, 33Ω or 39Ω.

To find the right value, we removed the protective layer. Once the protective layer had been removed, the three stripes meant that it was in the range of more than 10Ω and less than 100Ω. The only values falling on this range was either a 33Ω or 39Ω resistor. I tried the 39Ω resistor first and it cured the problem.

**Case No 3:**

![Resistor Diagram](image)

Fig 34: Checking the value of a burnt resistor

The monitor came in with no high voltage and I found a resistor with the color band, having lost its vibrancy due to overheat. Measuring the resistor produced very high ohm reading in mega ohms. Gently removing the protective layer I found a slight burnt at the side of the resistor. Measuring the resistor between the ending point and the right lead as shown in Fig 34 produced a 1.285kΩ reading. Replacing a new 1.2kΩ resistor solved the no high voltage problem.

**Note:** The overheating caused the resistance value to increase a little bit higher than the original value.
Case No 4:

![Resistor Diagram]

Fig 35: Usually 4 stripes resistor is in the kilo ohms range

Acer monitor model 7254e had no display. Upon checking the flyback, I found that the internal diode had shorted. Usually when the internal diode is shorted in the flyback, it will cause components along the Automatic Blanking Limiter (ABL) line to be burnt. The burnt resistor caused the controlling contrast not to function in the monitor. Tracking the ABL line I found the R355 1/4W resistor burnt. All the color couldn’t be seen. The burnt resistor measured 11.01kΩ. Removing the remaining protective layer, it showed it had 4 stripes, which meant it belonged to the kilo ohms range. Measuring between the right lead and ending point, it showed 9.95kΩ as shown in Fig 35. Replacing the burnt resistor with a 10kΩ resistor cured the fault.

Case No 5:

![Resistor Diagram]

Fig 36: More than 6 stripes resistors usually values more than the 10 kilo ohms range

No power was the complaint of this 17” supreme monitor model: BM17GLC. Upon checking the power section I found a 2-watt resistor, with its color band having lost its vibrancy except for the first blue color band. Measuring that resistor with a meter showed an open reading. Peeling off the protective layer of the resistor I found that it had a burnt mark near to the ending point. This resistor had 6 stripes, which meant it was above the 10 kilo ohms range. Placing the probe near to the burnt mark and right lead as shown in Fig 36 it measured 62 kilo ohms. Since this resistor first color band started with blue, then most probably it was in the range of 62kΩ or 68kΩ. I believed the burnt mark had eaten up the remaining 6kΩ value. Replacing the resistor with a 68kΩ 2W value solved the no power problem.
Conclusion

Wow! Now you’ve possessed a complete roadmap to determine the value of a burnt resistor.

Do not expect to be an expert in a few minutes as it takes patience and time. It is normal to have some trouble at the beginning. Try experimenting with a few resistors using a digital multimeter as you go back through the materials. Take your time, as I promised you, it will be worth spent! You will be able to determine the next burnt resistor value in no time …

Drop me a line and let me know how you’ve progressed!

Thanks again – Happy finding burnt resistor values!

To your success,

Jestine Yong

http://www.ElectronicRepairGuide.com
http://www.TestingElectronicComponents.com
http://www.JestineYong.com
How To Find Burnt Resistor Value Even Without A Schematic Diagram

About The Author

Jestine Yong

Jestine Yong graduated as an Electrical And Electronic Engineer in Robert Gordon University Aberdeen UK. He has been repairing computers since 1991. During his tenure as an engineer, he has worked on a wide range of electronics repair. When not repairing computers, he’s busy designing new methods to solve electronic repair problems. He owns and operates a successful computer repair business since 1996. His plan is to go into full-time writing.

Jestine lives in Kuala Lumpur, Malaysia with his wife, Michelle Tan, and is blessed with two lovely children – Noah and Hannah. He enjoys writing, internet marketing, reading, traveling and fishing!