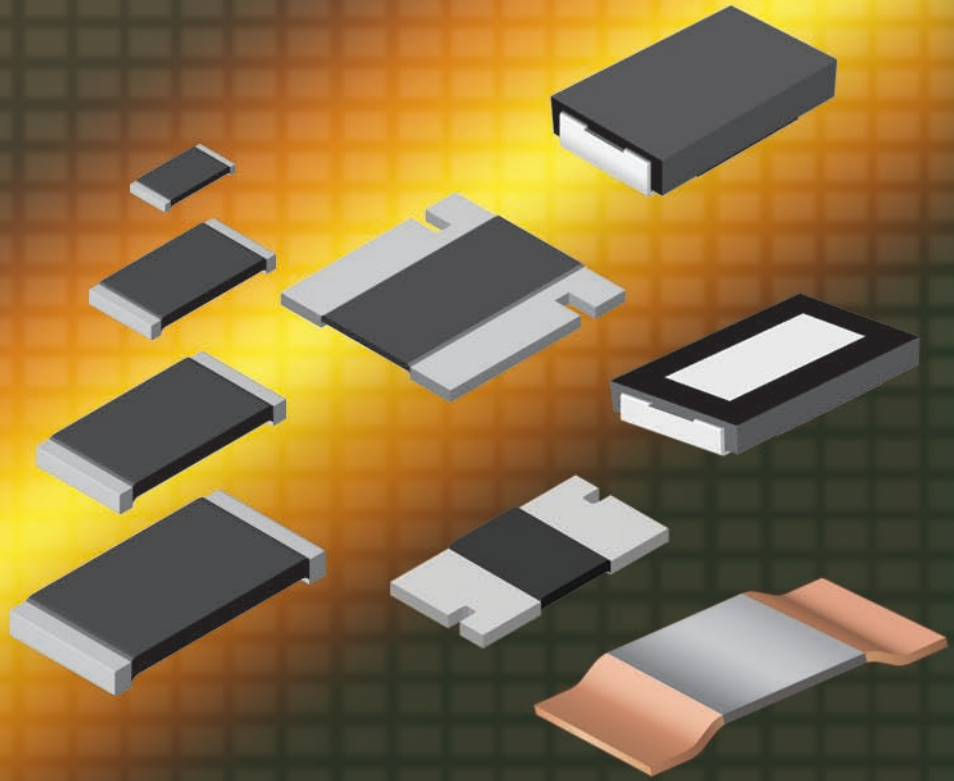





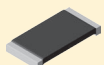
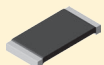
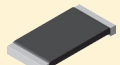






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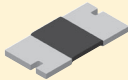
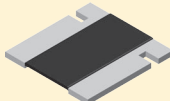
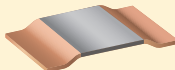
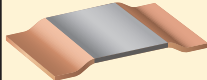
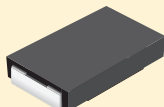
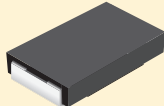
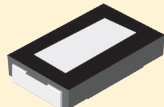
# POWER METAL STRIP®



# POWER METAL STRIP® SURFACE MOUNT RESISTORS

GLOBAL MODEL	Power Rating	Resistance Range	RTC (ppm/°C)	Tolerance	Dimensions	Applications
 WSL0603	0.1 W	0.015 Ω - 0.10 Ω	± 75	0.5%, 1%	L = 0.060 in. [1.52 mm] W = 0.030 in. [0.76 mm] H = 0.013 in. [0.33 mm]	<ul style="list-style-type: none"> <li>Cell phone battery fuel gauging</li> <li>Disc drive motor controls</li> <li>DC/DC Converter in cell phones/pagers</li> </ul>
 WSL0805	0.125 W	0.01 Ω - 0.2 Ω	± 75	0.5%, 1%	L = 0.080 in. [2.03 mm] W = 0.050 in. [1.27 mm] H = 0.013 in. [0.33 mm]	<ul style="list-style-type: none"> <li>Cell phone battery fuel gauging</li> <li>Disc drive motor controls</li> <li>DC/DC Converter in cell phones/pagers</li> </ul>
 WSL0805-18	0.25 W	0.01 Ω - 0.2 Ω	± 75	0.5%, 1%	L = 0.080 in. [2.03 mm] W = 0.050 in. [1.27 mm] H = 0.013 in. [0.33 mm]	<ul style="list-style-type: none"> <li>Cell phone battery fuel gauging</li> <li>Disc drive motor controls</li> <li>DC/DC Converter in cell phones/pagers</li> </ul>
 WSL1206	0.25 W	0.002 Ω - 0.0029 Ω 0.003 Ω - 0.0049 Ω 0.005 Ω - 0.0069 Ω 0.007 Ω - 0.2 Ω	± 275 ± 150 ± 110 ± 75	1% 1% 1% 0.5%, 1%	L = 0.126 in. [3.20 mm] W = 0.063 in. [1.60 mm] H = 0.025 in. [0.64 mm]	<ul style="list-style-type: none"> <li>Li-Ion battery management</li> <li>Disc drive motor controls</li> <li>DC/DC Converter in cell phones/pagers</li> </ul>
 WSL1206-18	0.5 W	0.002 Ω - 0.0029 Ω 0.003 Ω - 0.0049 Ω 0.005 Ω - 0.0069 Ω 0.007 Ω - 0.2 Ω	± 275 ± 150 ± 110 ± 75	1% 1% 1% 0.5%, 1%	L = 0.126 in. [3.20 mm] W = 0.063 in. [1.60 mm] H = 0.025 in. [0.64 mm]	<ul style="list-style-type: none"> <li>Li-Ion battery management</li> <li>Disc drive motor controls</li> <li>DC/DC Converter in cell phones/pagers</li> </ul>
 WSL2010	0.5 W	0.001 Ω - 0.0029 Ω 0.003 Ω - 0.0049 Ω 0.005 Ω - 0.0069 Ω 0.007 Ω - 0.5 Ω	± 275 ± 150 ± 110 ± 75	1% 1% 1% 0.5%, 1%	L = 0.200 in. [5.08 mm] W = 0.100 in. [2.54 mm] H = 0.025 in. [0.64 mm]	<ul style="list-style-type: none"> <li>Li-Ion battery management</li> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook PCs</li> <li>Disc drive motor controls</li> </ul>
 WSL2010-18	1.0 W	0.001 Ω - 0.0029 Ω 0.003 Ω - 0.0049 Ω 0.005 Ω - 0.0069 Ω 0.007 Ω - 0.5 Ω	± 275 ± 150 ± 110 ± 75	1% 1% 1% 0.5%, 1%	L = 0.200 in. [5.08 mm] W = 0.100 in. [2.54 mm] H = 0.025 in. [0.64 mm]	<ul style="list-style-type: none"> <li>Li-Ion battery management</li> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook PCs</li> <li>Disc drive motor controls</li> </ul>
 WSL2512	1.0 W	0.001 Ω - 0.0029 Ω 0.003 Ω - 0.0049 Ω 0.005 Ω - 0.0069 Ω 0.007 Ω - 0.5 Ω	± 275 ± 150 ± 110 ± 75	1% 1% 1% 0.5%, 1%	L = 0.250 in. [6.35 mm] W = 0.125 in. [3.18 mm] H = 0.025 in. [0.64 mm]	<ul style="list-style-type: none"> <li>Li-Ion battery management</li> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook/desktop PCs</li> <li>Automotive controls for body controls and Powertrain</li> </ul>
 WSL2512-18	2.0 W	0.001 Ω - 0.0029 Ω 0.003 Ω - 0.0049 Ω 0.005 Ω - 0.0069 Ω 0.007 Ω - 0.01 Ω	± 275 ± 150 ± 110 ± 75	1% 1% 1% 0.5%, 1%	L = 0.250 in. [6.35 mm] W = 0.125 in. [3.18 mm] H = 0.025 in. [0.64 mm]	<ul style="list-style-type: none"> <li>Li-Ion battery management</li> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook/desktop PCs</li> <li>Automotive controls for body controls and Powertrain</li> </ul>
 WSL2816	2.0 W	0.01 Ω - 0.1 Ω	± 75	0.5%, 1%	L = 0.280 in. [7.10 mm] W = 0.165 in. [4.20 mm] H = 0.025 in. [0.64 mm]	<ul style="list-style-type: none"> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook/desktop PCs</li> <li>Automotive controls for EPS</li> </ul>

# POWER METAL STRIP® SURFACE MOUNT RESISTORS

GLOBAL MODEL	Power Rating	Resistance Range	RTC (ppm/°C)	Tolerance	Dimensions	Applications
<b>WSK2512</b> 	1.0 W	0.003 Ω - 0.01 Ω	± 50	0.5%, 1%	L = 0.250 in. [6.35 mm] W = 0.125 in. [3.18 mm] H = 0.025 in. [0.64 mm]	<ul style="list-style-type: none"> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook/desktop PCs</li> <li>Instrumentation</li> </ul>
<b>WSL3637</b> 	3.0 W	0.001 Ω - 0.0029 Ω 0.003 Ω - 0.0049 Ω 0.005 Ω - 0.010 Ω	± 75 ± 50 ± 50	1% 0.5%, 1% 0.5%, 1%	L = 0.370 in. [9.40 mm] W = 0.360 in. [9.14 mm] H = 0.025 in. [0.64 mm]	<ul style="list-style-type: none"> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook/desktop PCs</li> <li>Automotive controls for EPS</li> </ul>
<b>WSL3921</b> 	3.0 W	0.0003 Ω 0.0005 Ω 0.001 Ω 0.002 Ω 0.003 Ω 0.004 Ω	± 50 ± 50 ± 50 ± 50 ± 50 ± 50	1% 1% 1% 1% 1% 1%	L = 0.394 in. [10.0 mm] W = 0.205 in. [5.20 mm] H = 0.037 in. [0.93 mm]	<ul style="list-style-type: none"> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook/desktop PCs</li> <li>Automotive controls for EPS</li> </ul>
<b>WSL5931</b> 	5.0 W	0.0003 Ω 0.0005 Ω 0.001 Ω 0.002 Ω 0.003 Ω	± 50 ± 50 ± 50 ± 50 ± 50	1% 1% 1% 1% 1%	L = 0.591 in. [15.0 mm] W = 0.305 in. [7.75 mm] H = 0.083 in. [2.10 mm]	<ul style="list-style-type: none"> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook/desktop PCs</li> <li>Automotive controls for EPS</li> </ul>
<b>WSR2</b> 	2.0 W	0.001 Ω - 0.0019 Ω 0.002 Ω - 0.0029 Ω 0.003 Ω - 0.0039 Ω 0.004 Ω - 0.0049 Ω 0.005 Ω - 0.0099 Ω 0.01 Ω - 1.0 Ω	± 750 ± 600 ± 450 ± 300 ± 110 ± 75	1% 1% 1% 1% 0.5%, 1% 0.5%, 1%	L = 0.455 in. [11.56 mm] W = 0.275 in. [6.98 mm] H = 0.095 in. [2.41 mm]	<ul style="list-style-type: none"> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook/desktop PCs</li> <li>Instrumentation</li> <li>Automotive controls for body controls and Powertrain</li> </ul>
<b>WSR3</b> 	3.0 W	0.001 Ω - 0.0019 Ω 0.002 Ω - 0.0029 Ω 0.003 Ω - 0.0039 Ω 0.004 Ω - 0.0049 Ω 0.005 Ω - 0.0099 Ω 0.01 Ω - 0.2 Ω	± 750 ± 600 ± 450 ± 300 ± 110 ± 75	1% 1% 1% 1% 0.5%, 1% 0.5%, 1%	L = 0.455 in. [11.56 mm] W = 0.275 in. [6.98 mm] H = 0.095 in. [2.41 mm]	<ul style="list-style-type: none"> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook/desktop PCs</li> <li>Automotive controls for body controls and Powertrain</li> </ul>
<b>WSR5</b> 	5.0 W	0.0075 Ω - 0.0099 Ω 0.01 Ω - 0.3 Ω	± 110 ± 75	0.5%, 1% 0.5%, 1%	L = 0.455 in. [11.56 mm] W = 0.275 in. [6.98 mm] H = 0.095 in. [2.41 mm]	<ul style="list-style-type: none"> <li>DC/DC Converter in switching power supplies</li> <li>VRMs in notebook/desktop PCs</li> <li>Automotive controls for body controls and Powertrain</li> </ul>



## INTRODUCTION

Vishay's Power Metal Strip® current sensing resistors combine superior performance in high temperature applications with a wide range of package sizes and a choice of resistance values from 0.0002  $\Omega$  to 1  $\Omega$ . These patented, state-of-the-art products deliver overload capabilities equivalent to wirewound devices and temperature coefficients as low as 30 ppm/°C.

Current sensing Power Metal Strip® resistors allow control circuitry to monitor the level of current in a circuit by translating current into a voltage that can be monitored easily. The devices work by resisting the current flow in a circuit to a calibrated level, thus allowing a voltage drop to be detected and monitored by control circuitry. The low resistance values of Power Metal Strip® resistors allow this function to be carried out with exceptional efficiency.

## APPLICATIONS

### Industrial

- Power supplies
- Power tools
- Bar code scanners
- HVAC
- Other current detection

### Consumer Goods

- Home electronics
- White goods
- Gaming systems
- Lighting controls
- Video cameras
- Television

### Automotive

- Engine controls
- Anti-lock brakes
- Air bag
- Traction controls
- Multimedia
- Climate controls
- Electronic power steering
- Electric / hybrid vehicle

### Medical and Instrumentation

- Monitoring systems
- Defibrulators
- Implantables
- Electronic scales
- Diagnostic equipment

### Telecom

- Cell phones
- Modems
- Pagers
- Base stations
- Bluetooth
- Switching circuits

### Military and Aerospace

- Guidance systems
- Satellites
- Missiles
- Surveillance equipment

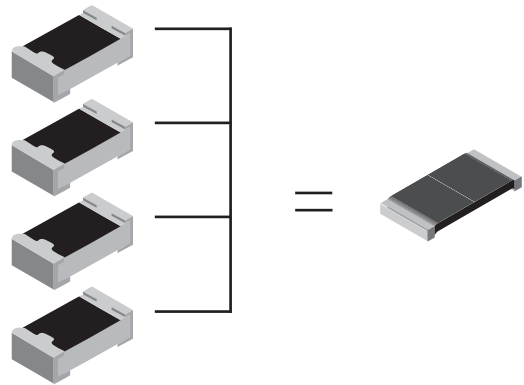
### Computer

- DC/DC converter
- Disk drives
- Power supplies
- Graphic cards
- PCMCIA
- Li-Ion battery management

## TECHNICAL INFORMATION

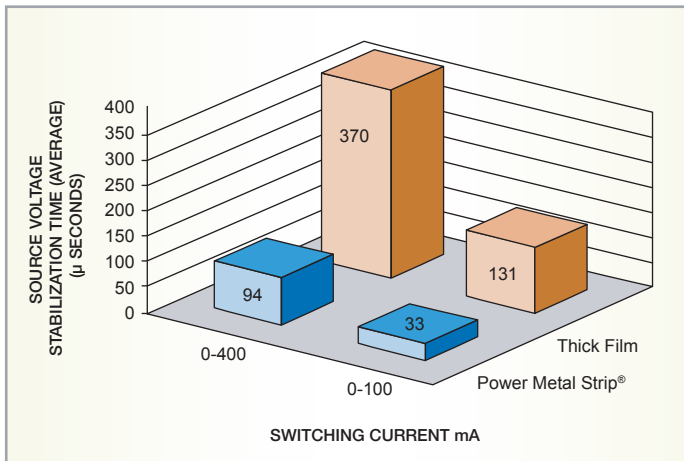
### Very Low Ohmic Value (0.2 mΩ to 1 Ω)

To maximize energy conversion efficiency and minimize power consumption, current sense resistors should be of the lowest resistance value possible (typically below 25 mΩ). The single Power Metal Strip® resistor can achieve the same low ohmic values for which four to six conventional cermet chips or two or more conventional thin film chips are required.



Multiple Chip

Single Power Metal Strip®

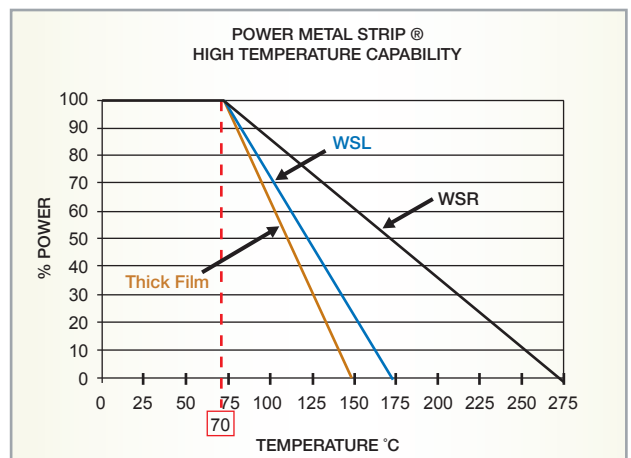


### Tight Tolerance (1% Standard, 0.5% Available)

For maximizing the sensing performance and saving energy, the tolerance of the sense resistor must be  $\pm 1\%$  or tighter. 1% tolerance allows designers to use a narrow resistance window when specifying sensing voltages. Another advantage of 1% or better tolerance is reduced response time to switching currents. The chart to the left shows that it takes a comparable thick film resistor almost three times longer than the Power Metal Strip® to stabilize its sensing voltage.

### High Temperature Capability (Up to +275 °C)

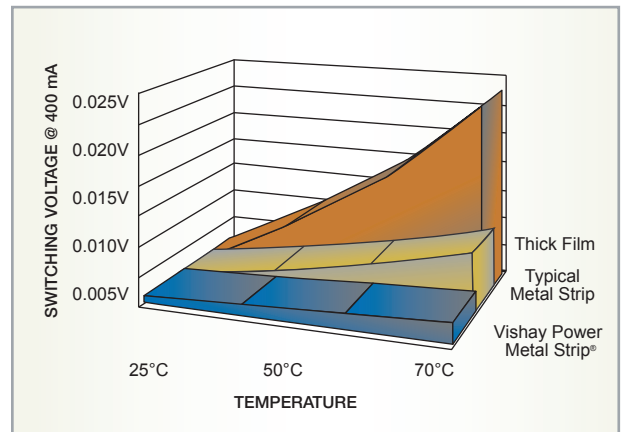
When used in industrial and automotive applications, components may be exposed to high temperatures. The current sensing resistor must be capable of operating in high temperature conditions with a minimal reduction (derating) of rated power. The Vishay Dale WSL (maximum temperature of 170 °C) and WSR (maximum temperature of 275 °C) type resistors will withstand high temperatures much better than cermet chips. The chart to the right provides a high temperature comparison for these device types.



### Low Temperature Coefficient of Resistance (TCR) (Down to 30 ppm/°C)

The low TCR of Vishay Power Metal Strip® resistors minimizes the resistance change caused by self heating and high temperature environments.

This chart illustrates voltage of a 30 ppm/°C Vishay Power Metal Strip® resistor compared to a typical 100 ppm/°C metal strip and 700 ppm/°C thick film chip.



Metal Alloy	Thermal EMF vs. Copper $\mu\text{V}/^\circ\text{C}$
Evanohm	+2
Cupron	-45
Manganin	-3
Zeranin	-1.3
Nickel	-22
Gold	+0.2
Silver	-0.2
Aluminum	-4

### Low Thermal EMF (Below $1\mu\text{V}/^\circ\text{C}$ )

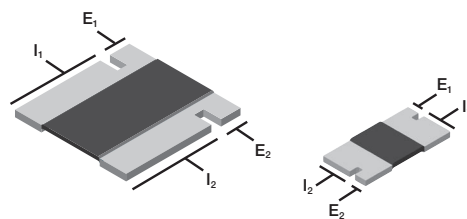
Dissimilar metals, in contact with each other, produce a small voltage. This voltage varies with temperature and is therefore called a “Thermal EMF”, or “thermocouple effect.” The rate of change of voltage with temperature from an intermetallic junction is a function of the metallic combination and the polarity of the voltage produced. Virtually all resistors have intermetallic combinations and it is presumed will eventually be connected to copper as a final intermetallic junction (circuit trace). Hence, copper is the typical reference metal.

Thermal EMF is an important consideration in low value resistors used in DC circuits. Thermal EMF can be large enough, when compared to the expected signal, that it can result in large sensing error. Vishay’s Power Metal Strip® current sensing resistors utilize resistance materials that have low Thermal EMF characteristics (Below  $1\mu\text{V}/^\circ\text{C}$ ).



### Terminal Construction

At resistance levels down to 1 mΩ and tolerance of 1% or larger, a two-terminal construction is typically acceptable. Where better accuracy is required, Vishay recommends the use of the four-terminal WSK2512 or WSL3637. The four-terminal construction reduces terminal resistance, copper terminal TCR, and solder joint TCR.



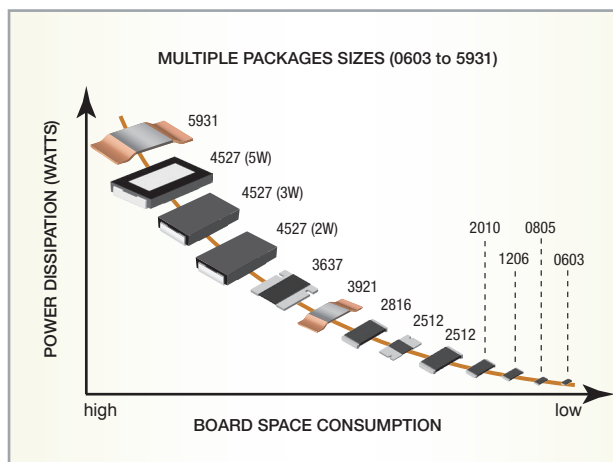
(E<sub>1</sub> & E<sub>2</sub> Voltage Connections, I<sub>1</sub> & I<sub>2</sub> Current Connections)

### High Current Capability (More than 125 A)

The maximum dc load current required by today's applications is in excess of 70 A. Vishay's Power Metal Strip® current sensing resistors utilize solid metal resistance elements which are capable of handling the highest load currents.

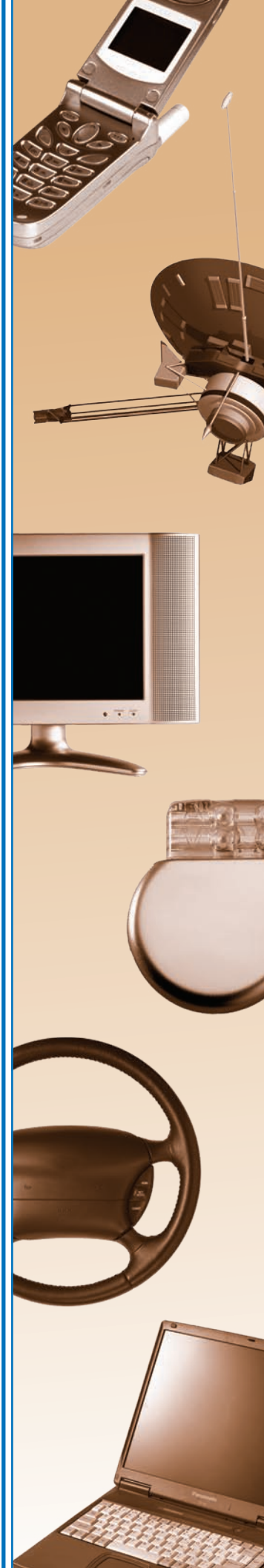
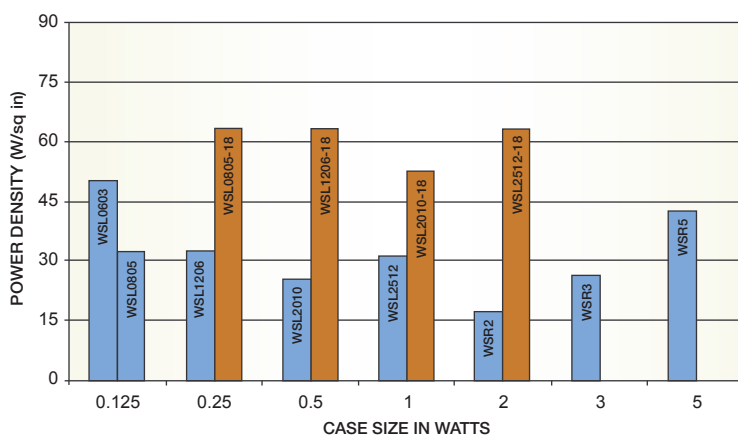
### Multiple Package Sizes (0603 to 5931)

Vishay's Power Metal Strip® resistors are available in more than 10 package sizes. Multiple package sizes give the customer the ability to minimize PCB space by utilizing a smaller component or lessen resistor temperature by utilizing a larger component for their current sense applications.



### High Power Density (Up to 64 W/sq in)

Vishay's Power Metal Strip® resistors have evolved to "High Power" WSL...-18, WSR3 & WSR5 type resistors. With the higher power capacity of standard WSL & WSR2 type resistor series, the WSL...-18, WSR3 & WSR5 series are intended for high power, current sensing applications. Specially selected materials permit these high power ratings of up to 5 watts. The WSL...-18, WSR3 & WSR5 resistors offer a high power-to-package size ratio while maintaining superior electrical characteristics. These high power ratings enable designers to use smaller PCBs, which in turn increases manufacturing speed and reduces raw material costs.



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