

## High Precision Bulk Metal® Foil Power Current Sensing Resistors with 3 A and 15 A Maximum Current, TCR to $\pm 15$ ppm/°C from 0.005 $\Omega$



### INTRODUCTION

Model VCS101, VCS103 and VCS401 resistors are available in 2 configurations. This Bulk Metal® resistor can serve as a low ohm, high power resistive shunt or as a medium power current sensing resistor. Resistors are non-insulated.

The art of current sensing calls for a variety of solutions based on application requirements. Current sensing is best achieved with a Kelvin connection, which removes the unwanted influences of lead resistance and lead sensitivity to temperature. Other requirements such as high stability and short thermal stabilization time when the power changes may dictate a special resistor design. High-precision resistors used for current sensing are usually low ohmic value devices suitable for four terminal connections. Two terminals, called “current terminals”, are connected to conduct electrical current through the resistor, while voltage drop VS is measured on the other two terminals, called “sense” or “voltage drop” terminals. According to Ohm’s law, the sensed voltage drop VS divided by the known resistance RS gives the sensed current IS. The accuracy of measurement depends on the stability of ohmic resistance RS between the nodes, i.e. the points of connection of the sense leads. Since the voltage leads feed into an “infinite” resistance circuit, there is no current flowing through the voltage terminals and, therefore, no IR drop in the voltage sense leads. Thus, the four-terminal system eliminates the voltage drop errors originated in the leads when the voltage terminations are connected close to the resistance element (excluding significant portions of the leads that carry the current).

This arrangement, called a “Kelvin connection”, reduces, especially for low ohmic resistance values, a measurement error due to the resistance of the lead wires and the solder joints as the sensing is performed inside the resistor, in or close to the active resistive bulk metal foil element. Of the commonly used methods of measuring the magnitude of electrical current, this current sensing resistor method provides the most precise measurement. According to Ohm’s law,  $V = IR$ , the voltage drop measured across a resistor is proportional to the current flowing through the resistor. With the known and stable value of the resistance R, the voltage drop sensed on the resistor indicates the intensity of the current flowing through it.

Assuming an ideal current sense resistor that doesn’t change its resistance value when there is a change in the magnitude of the current or a change in environmental conditions, like the ambient temperature or self heating, the measured voltage drop will yield a precise value of the current:  $I = V/R$ . But with a real-life resistor, such as a metal film resistor or a manganin bar, a change in current intensity (and in the dissipated power) will cause a change in the resistor’s value which will involve a thermal transient period taking a few seconds or longer to stabilize. Therefore, the key to a fast and precise measurement of current is the use of a real life current sensing resistor which approaches, as closely as possible, an ideal resistor. That is, a resistor that is not influenced by changes in the magnitude of the current flowing through it nor by changes in ambient temperature or any other environmental condition.

\* Pb containing terminations are not RoHS compliant, exemptions may apply

### FEATURES

- Temperature coefficient of resistance (TCR):  $\pm 20$  ppm/°C (available to  $\pm 15$  ppm/°C)
- Resistance tolerance: to  $\pm 0.1$  %
- Resistance range: 0.005  $\Omega$  to 0.25  $\Omega$  (for higher or lower values please contact us)
- Power rating: to 1.5 W at + 25 °C (free air)
- Maximum current: to 15 A
- Maximum operating temperature: + 175 °C
- Load life stability:  $\pm 0.5$  % at 25 °C, 2000 h at rated power
- Vishay Foil Resistors are not restricted to standard values; specific “as required” values can be supplied at no extra cost or delivery (e.g. 0R123 vs. 0R1)
- Non-inductive, non-capacitive design
- 4 leads for Kelvin connection
- Rise time: 1.0 ns effectively no ringing
- Thermal EMF: 0.05  $\mu$ V/°C typical
- Voltage coefficient: < 0.1 ppm/V
- Non-inductive: 0.08  $\mu$ H
- Terminal finish: lead (Pb)-free or tin/lead alloy\*
- Prototype quantities available in just 5 working days or sooner. For more information, please contact [foil@vpgsensors.com](mailto:foil@vpgsensors.com)
- For better performances, see VCS201, VCS202 and VCS301, VCS302 datasheets or contact application engineering



RoHS\*  
COMPLIANT

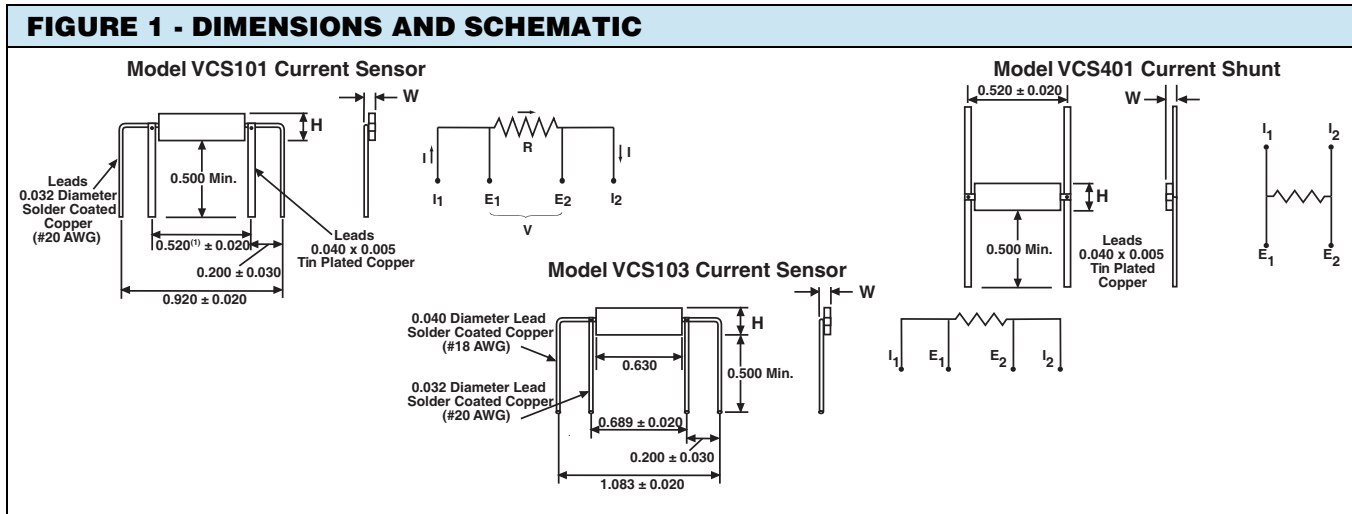
Real life resistors exhibit two types of reversible changes:

1. When they are cooled or heated by a changing ambient temperature, and
2. By self-heating due to the power they have to dissipate (Joule effect).

When a high precision is required, these two effects induce a change in the resistive element’s temperature,  $\Delta T_a$  due to ambient and  $\Delta T_{sh}$  due to self heating, both of which must be considered.

The ambient temperature changes slowly, and all parts of a resistor follow uniformly the change of the ambient temperature, but the effect of the dissipated power is different. The temperature of the resistive element - the active part of the resistor - will change rapidly with the change of the intensity of current. The power it has to dissipate will change proportionally to the square of the current and a rapid increase in current will cause a sudden increase in the temperature of the resistive element and in the heat that must be dissipated to the ambient air. These two effects of resistance changes are quantified by TCR - Temperature Coefficient of Resistance and by PCR - Power Coefficient of Resistance (called also “Power TCR”).

Our applications engineering department is prepared to advise and to make recommendations. For non-standard technical requirements and special applications, please contact us.



**TABLE 1 - CHARACTERISTICS AND DIMENSIONS (1)**

MODEL NUMBER	RESISTANCE RANGE ( $\Omega$ )	TIGHTEST RESISTANCE TOLERANCE (%)	POWER RATING at + 25 °C	MAXIMUM CURRENT	DIMENSIONS		
					INCHES	(mm)	
VCS101	0.005 to 0.01 $\Omega$ 0.01 to 0.05 $\Omega$ 0.05 to 0.2 $\Omega$	$\pm 1$ $\pm 0.5$ $\pm 0.1$	1 W	15 A	H W	0.130 0.080	(3.30) (2.03)
VCS401	0.005 to 0.01 $\Omega$ 0.01 to 0.05 $\Omega$ 0.05 to 0.2 $\Omega$	$\pm 1$ $\pm 0.5$ $\pm 0.1$	1 W	3 A	H W	0.130 0.080	(3.30) (2.03)
VCS103	0.005 to 0.01 $\Omega$ 0.01 to 0.05 $\Omega$ 0.05 to 0.25 $\Omega$	$\pm 1$ $\pm 0.5$ $\pm 0.1$	1.5 W	15 A	H W	0.190 0.080	(4.83) (2.03)

**Note**  
 (1) Tighter performances are available, please contact our application engineering department

**TABLE 2 - VCS101, VCS103 AND VCS401 PERFORMANCE - MIL-PRF-49465 (1)(2)**

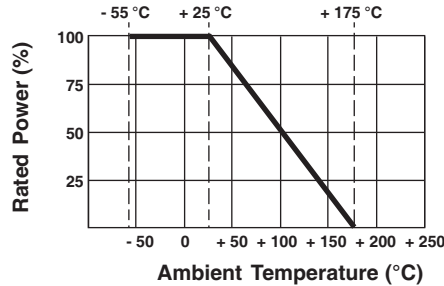
TEST OR CONDITION	VCS101, VCS103 AND VCS401	
	TYPICAL $\Delta$ LIMITS	MAXIMUM $\Delta$ LIMITS
Maximum Ambient Temperature at Rated Power	+ 25 °C	
Maximum Ambient Temperature at Zero Power	+ 175 °C	
Temperature Coefficient	See table 3	
Thermal Shock, 5 x (- 65 °C to + 125 °C)	$\pm 0.02$ %	$\pm 0.05$ %
Short Time Overload, 5 x P <sub>nom</sub> ; 5 s	$\pm 0.05$ %	$\pm 0.5$ %
Terminal Strength	$\pm 0.05$ %	$\pm 0.1$ %
High Temperature Exposure, 2000 h at + 175 °C	$\pm 0.05$ %	$\pm 1.0$ %
Moisture Resistance	$\pm 0.05$ %	$\pm 0.1$ %
Low Temperature Storage, 24 h at - 65 °C	$\pm 0.02$ %	$\pm 0.05$ %
Shock (Specified Pulse)	$\pm 0.05$ %	$\pm 0.1$ %
Vibration (High Frequency)	$\pm 0.05$ %	$\pm 0.1$ %
Life (Rated Power, + 25 °C, 2000 h)	$\pm 0.5$ %	$\pm 3.0$ %
Resistance Tolerance	$\pm 0.1$ %, $\pm 0.5$ %, $\pm 1$ %, $\pm 3$ %, $\pm 5$ %, $\pm 10$ %	

**Note**  
 (2)  $\Delta R$ 's plus additional 0.0005  $\Omega$  for measurement error

**TABLE 3 - TCR SPECIFICATION** (- 55 °C to + 125 °C, + 25 °C Ref.)

VALUE	TC (ppm/°C) <sup>(1)</sup>
0.005 Ω to 0.01 Ω	± 90
> 0.01 Ω to 0.05 Ω	± 30
> 0.05 Ω to 0.25 Ω	± 20

**FIGURE 2 - POWER DERATING CURVE**

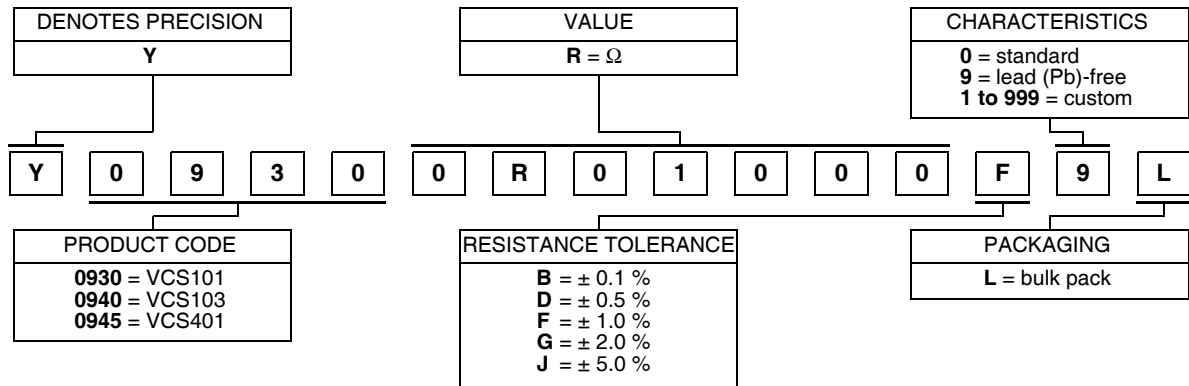


**Note**

- Further derating not necessary.

**TABLE 4 - GLOBAL PART NUMBER INFORMATION (1)**

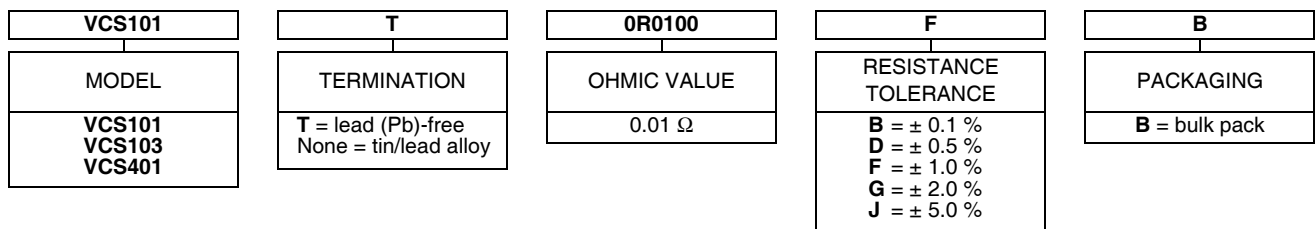
NEW GLOBAL PART NUMBER: Y09300R01000F9L (preferred part number format)



FOR EXAMPLE: ABOVE GLOBAL ORDER Y0930 0R01000 F 9 L:

TYPE: VCS101  
VALUE: 0.01 Ω  
ABSOLUTE TOLERANCE: ± 1.0 %  
TERMINATION: lead (Pb)-free  
PACKAGING: bulk pack

HISTORICAL PART NUMBER: VCS101T 0R0100 F B (will continue to be used)



**Note**

- (1) For non-standard requests, please contact application engineering.

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