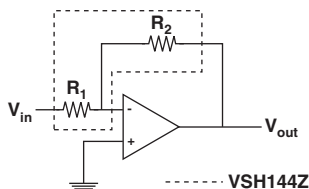


**Ultra High Precision Z-Bulk Metal® Foil Technology Low Profile Conformally Coated Voltage Divider Resistor with TCR Tracking to 0.1 ppm/°C, Power Coefficient Tracking of 5 ppm at Rated Power, and Tolerance Match to 0.01 % (100 ppm)**



**APPLICATIONS**

- Instrumentation amplifiers
- Bridge networks
- Differential amplifiers
- Military
- Space
- Medical
- Automatic test equipment
- Down-hole (high temperature)



**FEATURES**

- Temperature coefficient of resistance (TCR):  
absolute:  $\pm 0.05 \text{ ppm/}^\circ\text{C}$  typical ( $0^\circ\text{C}$  to  $+60^\circ\text{C}$ )  
 $\pm 0.2 \text{ ppm/}^\circ\text{C}$  typical ( $-55^\circ\text{C}$  to  $+125^\circ\text{C}$ ,  $+25^\circ\text{C}$  ref.)  
tracking:  $0.1 \text{ ppm/}^\circ\text{C}$  typical
- Tolerance: absolute and matching to  $0.01\%$  (100 ppm)
- Power coefficient tracking " $\Delta R$  due to self heating": 5 ppm at rated power
- Power rating: 0.2 W at  $70^\circ\text{C}$ , for the entire resistive element  $R_1$  and  $R_2$ , divided proportionally between the two values
- Load life ratio stability:  $< 0.01\%$  (100 ppm) 0.2 W at  $70^\circ\text{C}$  for 2000 h
- Maximum working voltage: 200 V
- Resistance range: 100R to 20K per resistive element
- Vishay Foil resistors are not restricted to standard values/ratios; specific "as requested" values/ratios can be supplied at no extra cost or delivery (e.g. 1K2345 vs. 1K)
- Electrostatic discharge (ESD) up to 25 000 V
- Non-inductive, non-capacitive design
- Rise time: 1 ns effectively no ringing
- Current noise:  $0.010 \mu\text{V}_{\text{RMS}}/\text{V}$  of applied voltage ( $< -40 \text{ dB}$ )
- Thermal EMF:  $0.05 \mu\text{V/}^\circ\text{C}$  typical
- Voltage coefficient:  $< 0.1 \text{ ppm/V}$
- Non-inductive:  $< 0.08 \mu\text{H}$
- Non hot spot design
- Thermal stabilization time  $< 1 \text{ s}$  (nominal value achieved within 10 ppm of steady state value)
- Terminal finish: lead (Pb)-free or tin/lead alloy
- Compliant to RoHS directive 2002/95/EC
- Prototype quantities available in just 5 working days or sooner. For more information, please contact [foil@vishaypg.com](mailto:foil@vishaypg.com)
- For better performances please contact us



**TABLE 1A - MODEL VSH144Z SPECIFICATIONS**

| RESISTANCE VALUES                         | ABSOLUTE TOLERANCE | ABSOLUTE TCR<br>( $-55^\circ\text{C}$ to $+125^\circ\text{C}$ , $+25^\circ\text{C}$ ref.)<br>TYPICAL AND MAX. SPREAD |
|-------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------|
| $\geq 500 \Omega$ to $20 \text{ k}\Omega$ | $\pm 0.01\%$       | $\pm 0.2 \text{ ppm/}^\circ\text{C} \pm 2.5 \text{ ppm/}^\circ\text{C}$                                              |
| $100 \Omega$ to $< 500 \Omega$            | $\pm 0.02\%$       |                                                                                                                      |

**TABLE 1B - MODEL VSH144Z SPECIFICATIONS**

| RESISTANCE RATIO  | TOLERANCE MATCH | TCR TRACKING MAX.                 |
|-------------------|-----------------|-----------------------------------|
| 1:1               | 0.01 %          | $0.5 \text{ ppm/}^\circ\text{C}$  |
| $> 1:1$ to $4:1$  |                 | $0.75 \text{ ppm/}^\circ\text{C}$ |
| $> 4:1$ to $10:1$ | 0.02 %          | $1.5 \text{ ppm/}^\circ\text{C}$  |
| $> 10:1$          |                 | $2.0 \text{ ppm/}^\circ\text{C}$  |

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

### INTRODUCTION

The VSH144Z voltage divider is based on the latest generation of Bulk Metal® Z-Foil technology which is the most recommended solution for ultra high precision, stability and reliable voltage division or anywhere else that requires two resistors to maintain a stable ratio under power and throughout all application variables.

#### Why are extremely low TCR resistors required?

This is a proper question when evaluating system cost. The answers are as numerous as the system in which they are installed but a few examples may provide insight:

- 1) Commercial broadcast equipment heats up through the day and requires constant manual adjustment through the day for proper signal adjustment.
- 2) Satellites in synchronous orbit rotate through temperature extremes.
- 3) A fighter jet resting on the 115° desert floor takes off and reaches altitude at - 60° in less than two minutes.
- 4) A system that requires fast response time in order to produce the required signal with minimum stabilization time.

Resistors may be selected for TCR tracking but that is only useful when the resistors are operating at the same temperature. If the resistors are operating at different temperatures because of differential self-heating, or due to locally-different thermal influence from different adjacent components, or because they are operating in different regions of the equipment, the ratios change proportional to the differences in operating temperature times and the absolute TCR in addition to differences in TCR tracking ratios. Additionally, when resistors within a set have different absolute TCR's (individual TCR's - not relative or tracking TCR), the ratios change even more due to the differential self-heating as well as to differential ambient temperatures:

$\Delta \text{ratio} = (\text{TCR track} \times \Delta \text{temp 1}) + (\text{absolute TCR} \times \Delta \text{temp 2})$   
where  $\Delta \text{temp 1}$  is the change of ambient temperature and  $\Delta \text{temp 2}$  is the temperature difference between two resistors due to differential self-heating.

Differential self-heating can occur, for example, when the same current flows through resistors of different resistance values. The construction of the VSH144Z keeps both resistors at the same temperature regardless of resistance value or differential power.

For best performance in such applications, low absolute TCRs are required.

#### What is TCR tracking and why it is important?

TCR tracking is a measure of the uniformity of the thermally-induced resistance changes in two or more resistors. Resistors "track" closely when their individual TCRs are close, and this is a measure of how closely these resistors will maintain their initial ratios over various temperature changes. Some resistors may increase in value with an increase in temperature (positive TCR) while others will decrease in value with an increase in temperature (negative TCR), or, they may not change in value at the same rate (differential TCR). Other temperature effects, such as self heating due to the application of power can add to the ambient temperature effects. An example of these effects can be seen where two resistors with different TCR characteristics are used around an operation amplifier. The amplification ratio will be affected by the differential TCR of the resistors and will be compounded by the differential self heating effects of the  $I^2R$  differences of the feedback VS the input resistor.

Good design practice requires fundamentally low TCR networks in this application since this would minimize both varying temperature and self heating effects.

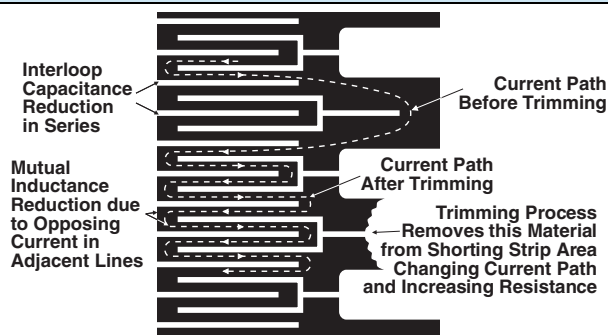
This could not be accomplished with high TCR resistors, even with good tracking.

#### What is the reason for such excellent stability?

The secret of Bulk Metal Z-Foil technology's benchmark stability lies in the fact that it retains the inherent metallurgical stability of the alloy from which it is made: the alloy is not melted and drawn as it is in the manufacture of wirewound resistors, nor is it evaporated and re-deposited or sputtered as it is in thin-film resistors. This underlying metallurgical stability is preserved throughout the manufacturing processes by preventing the introduction of additional stresses into the final component.

Our application engineering department is available to advise and make recommendations. For non-standard technical requirements and special applications. Please contact [foil@vishaypg.com](mailto:foil@vishaypg.com).

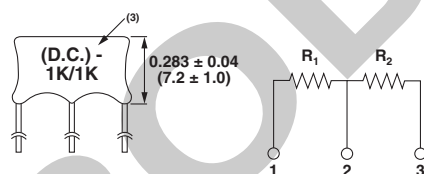
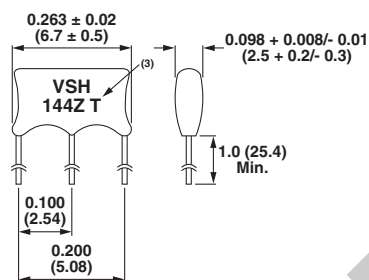
**FIGURE 1 - TRIMMING TO VALUES** (conceptual illustration)



Note: Foil shown in black, etched spaces in white

**FIGURE 2 - STANDARD PRINTING AND DIMENSIONS** in inches (millimeters)

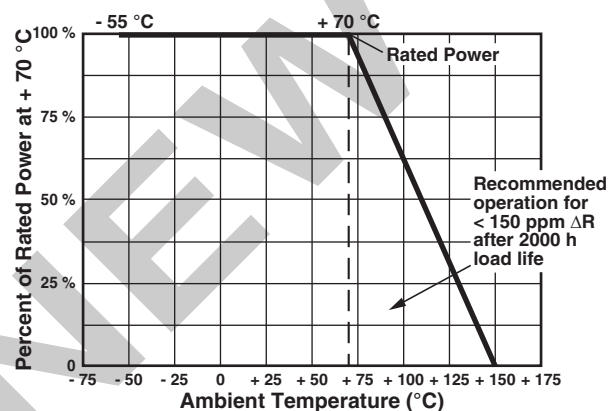
**Model VSH144Z and Schematic (2)**



Dimensional Tolerance:  $\pm 0.010$  (0.25)

- (1) Lead wires: #22 AWG solder coated copper, 0.75" minimum length
- (2) Each divider pair consists of two resistors on one single chip
- (3) For lead (Pb)-free: print "T" after 144Z and "-" after (D.C.)

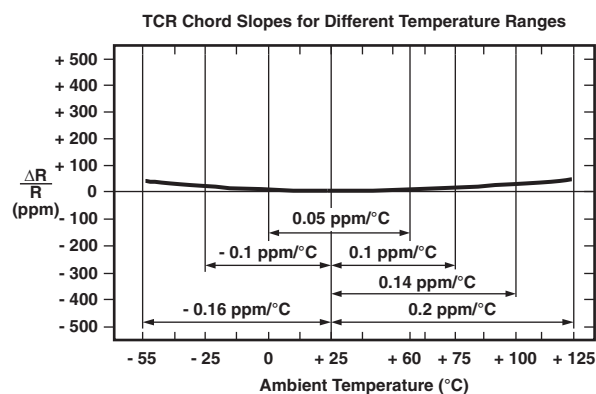
**FIGURE 3 - POWER DERATING CURVE**



**Note:**

- Power is divided proportionally between the 2 values

**FIGURE 4 - TYPICAL RESISTANCE/TEMPERATURE CURVE**  
(for more details see table 1A)



**TABLE 2 - EXAMPLES OF VCODES FOR POPULAR VALUES** (other values available on request)

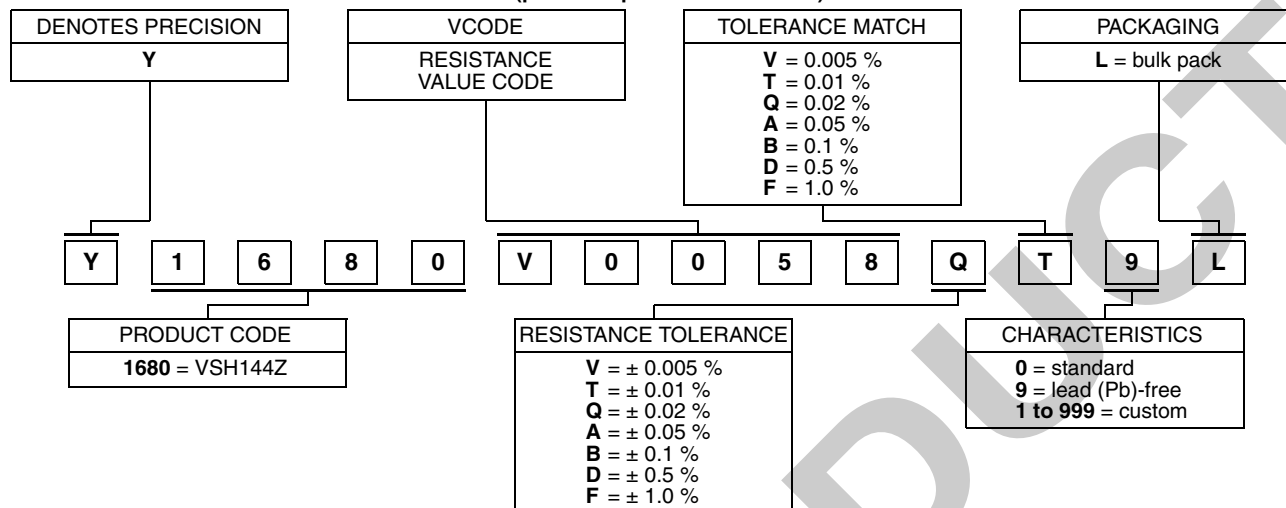
| VSH144Z RATIOS |                |                |        |                |                |
|----------------|----------------|----------------|--------|----------------|----------------|
| VCODES         | R <sub>1</sub> | R <sub>2</sub> | VCODES | R <sub>1</sub> | R <sub>2</sub> |
| V0009          | 20K            | 20K            | V0058  | 2K             | 20K            |
| V0010          | 20K            | 10K            | V0030  | 2K             | 18K            |
| V0100          | 20K            | 2K             | V0029  | 2K             | 4K             |
| V0055          | 19K4           | 9K7            | V0059  | 2K             | 2K             |
| V0223          | 17K5           | 20K            | V0103  | 2K             | 3K             |
| V0097          | 15K            | 15K            | V0154  | 1K5            | 3K             |
| V0001          | 10K            | 10K            | V0032  | 1K             | 16K            |
| V0042          | 10K            | 8K323          | V0121  | 1K             | 2K             |
| V0006          | 10K            | 2K             | V0004  | 1K             | 1K             |
| V0166          | 10K            | 15K            | V0379  | 1K             | 7K             |
| V0226          | 9K             | 10K            | V0374  | 800R           | 800R           |
| V0003          | 9K             | 1K             | V0022  | 511R           | 16K2           |
| V0013          | 8K             | 16K            | V0091  | 500R           | 500R           |
| V0107          | 6K             | 20K            | V0162  | 500R           | 15K            |
| V0014          | 6K             | 7K             | V0378  | 500R           | 4K5            |
| V0160          | 6K             | 6K             | V0061  | 300R           | 300R           |
| V0159          | 5K5            | 7K7            | V0088  | 100R           | 100R           |
| V0005          | 5K             | 10K            | V0380  | 100R           | 15K            |
| V0002          | 5K             | 5K             | V0375  | 100R           | 12K3           |
| V0373          | 4K             | 12K            | V0381  | 100R           | 50R            |
| V0026          | 3K             | 19K2           | V0377  | 50R            | 28K            |
| V0156          | 3K             | 6K             | V0376  | 35R            | 20K            |
| V0158          | 2K7            | 10K            | -      | -              | -              |

**Note**

- A combination of these values are available in reverse order and in values up to 5 digits

**TABLE 3 - GLOBAL PART NUMBER INFORMATION <sup>(1)</sup>**

**NEW GLOBAL PART NUMBER: Y1680V0058QT9L (preferred part number format)**



FOR EXAMPLE: ABOVE GLOBAL ORDER Y1680 V0058 Q T 9 L:

TYPE: VSH144Z

VALUES: 2K/20K

ABSOLUTE TOLERANCE: ± 0.02 %

TOLERANCE MATCH: 0.01 %

TERMINATION: lead (Pb)-free

PACKAGING: bulk pack

**HISTORICAL PART NUMBER: VSH144ZT 2K/20K TCR0.2 Q T B (will continue to be used)**

| VSH144Z | T                                           | 2K/20K                                          | TCR0.2             | Q                                                                                                          | T                                                                                            | B             |
|---------|---------------------------------------------|-------------------------------------------------|--------------------|------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|---------------|
| MODEL   | TERMINATION                                 | OHMIC VALUE                                     | TCR CHARACTERISTIC | ABSOLUTE TOLERANCE                                                                                         | TOLERANCE MATCH                                                                              | PACKAGING     |
| VSH144Z | T = lead (Pb)-free<br>None = tin/lead alloy | R <sub>1</sub> = 2 kΩ<br>R <sub>2</sub> = 20 kΩ |                    | V = ± 0.005 %<br>T = ± 0.01 %<br>Q = ± 0.02 %<br>A = ± 0.05 %<br>B = ± 0.1 %<br>D = ± 0.5 %<br>F = ± 1.0 % | V = 0.005 %<br>T = 0.01 %<br>Q = 0.02 %<br>A = 0.05 %<br>B = 0.1 %<br>D = 0.5 %<br>F = 1.0 % | B = bulk pack |

**Note**

<sup>(1)</sup> For non-standard requests, please contact application engineering

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