Bulk Metal® Foil Technology Low Profile Conformally Coated
High Precision Voltage Divider Resistor with TCR Tracking
to 0.5 ppm/°C and Tolerance Match to 0.01 % (100 ppm)

FEATURES

- Temperature coefficient of resistance (TCR) absolute: ± 2 ppm/°C typical
  (-55 °C to +125 °C, +25 °C ref.) tracking: 0.5 ppm/°C
- Tolerance: absolute and matching to 0.01 %
  (100 ppm)
- Power rating: 0.2 W at 70 °C, for the entire resistive element R1 and R2, divided proportionally between the two values
- Load life ratio stability: < 0.01 % (100 ppm) 0.2 W at 70 °C for 2000 h
- Maximum working voltage: 200 V
- Resistance range: 100Ω 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
- Thermal stabilization time < 1 s (nominal value achieved within 10 ppm of steady state value)
- Current noise: 0.010 µVRMS/V of applied voltage (< -40 dB)
- Thermal EMF: 0.05 µV/°C typical
- Voltage coefficient: < 0.1 ppm/V
- Non inductive: < 0.08 µH
- Non hot spot design
- 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
- For better performances see VSH144Z (Z-Foil) datasheet

APPLICATIONS

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

TABLE 1A - MODEL VSH144 SPECIFICATIONS

<table>
<thead>
<tr>
<th>RESISTANCE VALUES</th>
<th>ABSOLUTE TOLERANCE</th>
<th>ABSOLUTE TCR (-55 °C to +125 °C, +25 °C ref.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 500 Ω to 20 kΩ</td>
<td>± 0.01 %</td>
<td>± 2 ppm/°C ± 3 ppm/°C</td>
</tr>
<tr>
<td>100 Ω to &lt; 500 Ω</td>
<td>± 0.02 %</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 1B - MODEL VSH144 SPECIFICATIONS

<table>
<thead>
<tr>
<th>RESISTANCE RATIO</th>
<th>TOLERANCE MATCH</th>
<th>TCR TRACKING MAX.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>0.01 %</td>
<td>0.5 ppm/°C</td>
</tr>
<tr>
<td>&gt; 1:1 to 4:1</td>
<td>0.01 %</td>
<td>1.0 ppm/°C</td>
</tr>
<tr>
<td>&gt; 4:1 to 10:1</td>
<td>0.02 %</td>
<td>1.5 ppm/°C</td>
</tr>
<tr>
<td>&gt; 10:1</td>
<td>0.02 %</td>
<td>2.0 ppm/°C</td>
</tr>
</tbody>
</table>

Note

- See table 2 for additional established ratios

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

What is precision?

For resistors, precision is the term used to describe a combination of attributes starting with accuracy but including stability with time, temperature and load as well.

There are many causes for a resistor to depart from the fundamental precept of Ohm's Law and it is in the realm of precision that this is most demanding and most challenging. There are ideal solutions to these issues in the form of Foil-based resistors.

Generally, “precision” resistors are those devices that are understood to fall within a range of accuracy better than 1 % and hold their initial value throughout the assembly and life of the equipment to better than 0.5 %. Resistors that maintain these characteristics with “orders-of-magnitude better performance”, such as the foil resistor technology, can be reasonably termed “ultra-precision”. Of course there are other considerations such as frequency response that may govern the selection but starting with these parameters we can pretty much rule out every technology except Foil, wire, and deposited metal film in that order of precision.

What is matching?

This term defines to what extent one or more resistors are referenced to one another as opposed to each resistor having its own independent specifications, unrelated to other resistors in the circuit. Usually, one resistor is defined as the reference resistor and all others are defined relative to the reference resistor. For example, the reference resistor may have an absolute (or independent) tolerance of ± 0.1 %, and other resistors can be specified as “matched” to within 0.01 % of the reference resistor. For a tighter grouping of three or more resistors, all resistors may be specified as having a defined match among all the resistors, thereby keeping the entire grouping of resistors within a tighter grouping than if they were all referred to just one reference resistor. The initial “match” refers to the initial supplied tolerance of each resistor and its relationship to other defined resistors in the group. However, the initial match is degraded in application as each resistor in the set responds differently to board-assembly stresses, temperature excursions, self-heating from power dissipation, thermal shock, load-life, etc. So the term “match” may be extended to indicate the limit of change in the set of resistors as they experience any number of defined exposures. That is, for example, the set may be defined as being matched to within 0.01 % initially, and within 0.05 % after exposure to thermal shock, load-life, etc. These exposure cause permanent changes in resistance. Temporary changes are classified in other terms such as TCR (Temperature Coefficient of Resistance) and TCR tracking, PCR (Power Coefficient of Resistance), etc but can be as important or more important than matching in that they change the relationships among the resistors immediately while in actual operation.

The differential self heating effect on “matching” is often overlooked. Even though the initial match is tight and good TCR “tracking” is exhibited, the same current flow through the resistors of different values will produce power dissipation differences (I^2R self heating) and induce ratio changes proportional to the absolute TCR. Therefore the lower the absolute TCR, the less the match will be affected over temperature changes, including differential power-induced temperatures.

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 VSH144 keeps both resistors at the same temperature regardless of resistance value or differential power.

Since for precision applications the TCR tracking is often selected to be less than the absolute TCR (e.g.: 15 ppm/°C absolute selected for 5 ppm/°C track) the absolute TCR is much more important any time the resistors are at different temperatures, regardless of the cause. The error in the match becomes critical when long term ratio stability is required under small variations of ambient temperature and self heating, even if selected for excellent initial matching and tracking.

Bulk Metal Foil resistor dividers have the lowest absolute TCR and TCR tracking of any technology and therefore have the best operational and end of life matching for applications where stability is important.

Why ratio stability is important?

Resistors in divider or network form, are called upon to track at more than ambient temperature. Throughout the service life of the equipment, the resistors around the operational amplifier, for example, are required to hold a defined ratio even though the dissipation in the feedback resistor is different from that in the input resistor, causing one to be at the higher temperature than the other. This is called tracking under power. If environment stresses cause one resistor to drift (permanent \( \Delta R \)'s) more than its counterpart, the ratio changes over a period of time and can be significant. This is called tracking with time. Foil resistors used in dividers form share the same substrate for thermal equality and possess a TCR track of less than 0.1 ppm/°C, they offer the best combination of temperature-load-time tracking.

The factors that contribute to this are:

1. Fundamentally low absolute TCR
2. Extremely low TCR tracking
3. Very small drift with load over time
4. Common behavior - all parts move the same direction with temperature, load and time

Our application engineering department is available to advise and make recommendations. For non-standard technical requirements and special applications. Please contact foil@vishaypg.com.
**FIGURE 2 - STANDARD PRINTING AND DIMENSIONS** in inches (millimeters)

Model VSH144 and Schematic (2)

![Diagram of VSH144 and Schematic](image)

Dimensional Tolerance: ± 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 144 and “-” after (D.C.)

**FIGURE 3 - POWER DERATING CURVE**

![Power Derating Curve](image)

**FIGURE 4 - TYPICAL RESISTANCE/TEMPERATURE CURVE**

![Resistance/Temperature Curve](image)

**Note**
- Power is divided proportionally between the 2 values
### TABLE 2 - EXAMPLES OF VCODES FOR POPULAR VALUES

(Other values available on request)

<table>
<thead>
<tr>
<th>VSH144 RATIOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCODES</td>
</tr>
<tr>
<td>V0009</td>
</tr>
<tr>
<td>V0010</td>
</tr>
<tr>
<td>V0100</td>
</tr>
<tr>
<td>V0055</td>
</tr>
<tr>
<td>V0223</td>
</tr>
<tr>
<td>V0097</td>
</tr>
<tr>
<td>V0001</td>
</tr>
<tr>
<td>V0042</td>
</tr>
<tr>
<td>V0006</td>
</tr>
<tr>
<td>V0166</td>
</tr>
<tr>
<td>V0226</td>
</tr>
<tr>
<td>V0003</td>
</tr>
<tr>
<td>V0013</td>
</tr>
<tr>
<td>V0107</td>
</tr>
<tr>
<td>V0014</td>
</tr>
<tr>
<td>V0160</td>
</tr>
<tr>
<td>V0159</td>
</tr>
<tr>
<td>V0005</td>
</tr>
<tr>
<td>V0002</td>
</tr>
<tr>
<td>V0373</td>
</tr>
<tr>
<td>V0026</td>
</tr>
<tr>
<td>V0156</td>
</tr>
<tr>
<td>V0158</td>
</tr>
</tbody>
</table>

**Note**
- A combination of these values are available in reverse order and in values up to 5 digits.
## TABLE 3 - GLOBAL PART NUMBER INFORMATION (1)

<table>
<thead>
<tr>
<th>NEW GLOBAL PART NUMBER:</th>
<th>Y1767V0058QT9L (preferred part number format)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DENOTES PRECISION</strong></td>
<td><strong>Y</strong></td>
</tr>
<tr>
<td><strong>VCODE</strong></td>
<td><strong>V</strong> = ± 0.005 %</td>
</tr>
<tr>
<td><strong>RESISTANCE VALUE CODE</strong></td>
<td><strong>T</strong> = ± 0.01 %</td>
</tr>
<tr>
<td></td>
<td><strong>Q</strong> = ± 0.02 %</td>
</tr>
<tr>
<td></td>
<td><strong>A</strong> = ± 0.05 %</td>
</tr>
<tr>
<td></td>
<td><strong>B</strong> = ± 0.1 %</td>
</tr>
<tr>
<td></td>
<td><strong>D</strong> = ± 0.5 %</td>
</tr>
<tr>
<td></td>
<td><strong>F</strong> = ± 1.0 %</td>
</tr>
<tr>
<td><strong>PACKAGING</strong></td>
<td><strong>L</strong> = bulk pack</td>
</tr>
</tbody>
</table>

### PRODUCT CODE

| **1767** = VSH144 |

### RESISTANCE TOLERANCE

- **V** = ± 0.005 %
- **T** = ± 0.01 %
- **Q** = ± 0.02 %
- **A** = ± 0.05 %
- **B** = ± 0.1 %
- **D** = ± 0.5 %
- **F** = ± 1.0 %

### CHARACTERISTICS

- **0** = standard
- **9** = lead (Pb)-free
- **1 to 999** = custom

For Example: Above global order Y1767 V0058 Q T 9 L:

- **TYPE**: VSH144
- **VALUES**: 2K/20K
- **ABSOLUTE TOLERANCE**: ± 0.02 %
- **TOLERANCE MATCH**: ± 0.01 %
- **TERMINATION**: lead (Pb)-free
- **PACKAGING**: bulk pack

**HISTORICAL PART NUMBER**: VSH144T 2K/20K TCR2 Q T B (will continue to be used)

### VSH144

<table>
<thead>
<tr>
<th>MODEL</th>
<th>TERMINATION</th>
<th>OHMIC VALUE</th>
<th>TCR CHARACTERISTIC</th>
<th>ABSOLUTE TOLERANCE</th>
<th>TOLERANCE MATCH</th>
<th>PACKAGING</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSH144</td>
<td>T = lead (Pb)-free</td>
<td>R1 = 2 kΩ</td>
<td></td>
<td><strong>V</strong> = ± 0.005 %</td>
<td><strong>V</strong> = ± 0.005 %</td>
<td><strong>B</strong> = ± 1.0 %</td>
</tr>
<tr>
<td></td>
<td>None = tin/lead alloy</td>
<td>R2 = 20 kΩ</td>
<td></td>
<td><strong>T</strong> = ± 0.01 %</td>
<td><strong>T</strong> = ± 0.01 %</td>
<td></td>
</tr>
</tbody>
</table>

**Note**

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

ALL PRODUCTS, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE.

Vishay Precision Group, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, “Vishay Precision Group”), disclaim any and all liability for any errors, inaccuracies or incompleteness contained herein or in any other disclosure relating to any product.

The product specifications do not expand or otherwise modify Vishay Precision Group’s terms and conditions of purchase, including but not limited to, the warranty expressed therein.

Vishay Precision Group makes no warranty, representation or guarantee other than as set forth in the terms and conditions of purchase. To the maximum extent permitted by applicable law, Vishay Precision Group disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Information provided in datasheets and/or specifications may vary from actual results in different applications and performance may vary over time. Statements regarding the suitability of products for certain types of applications are based on Vishay Precision Group’s knowledge of typical requirements that are often placed on Vishay Precision Group products. It is the customer’s responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application.

No license, express, implied, or otherwise, to any intellectual property rights is granted by this document, or by any conduct of Vishay Precision Group.

The products shown herein are not designed for use in life-saving or life-sustaining applications unless otherwise expressly indicated. Customers using or selling Vishay Precision Group products not expressly indicated for use in such applications do so entirely at their own risk and agree to fully indemnify Vishay Precision Group for any damages arising or resulting from such use or sale. Please contact authorized Vishay Precision Group personnel to obtain written terms and conditions regarding products designed for such applications.

Product names and markings noted herein may be trademarks of their respective owners.