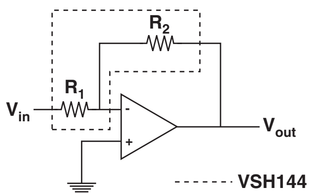
Bulk Metal® Foil Technology Low Profile Conformally Coated High Precision Voltage Divider Resistor with TCR Tracking to 0.5 ppm/°C and Tolerance Match to 0.01 % (100 ppm)

APPLICATIONS

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



FEATURES

Pb-free Available RoHS* COMPLIANT

- 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 R_1 and R_2, 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: 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
- Thermal stabilization time < 1 s (nominal value achieved within 10 ppm of steady state value)
- Current noise: 0.010 µV_{RMS}/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

TABLE 1A - MODEL VSH144 SPECIFICATIONS

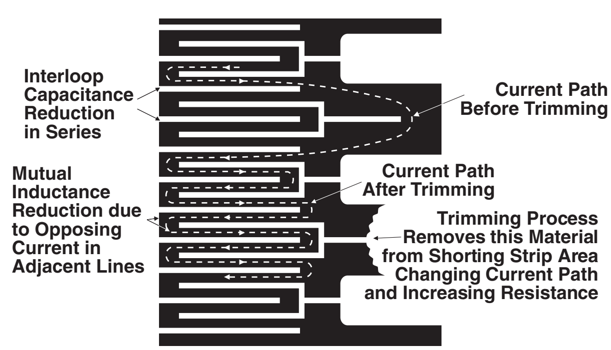
RESISTANCE VALUES	ABSOLUTE TOLERANCE	ABSOLUTE TCR (- 55 °C to + 125 °C, + 25 °C ref.) TYPICAL AND MAX. SPREAD
≥ 500 Ω to 20 kΩ	± 0.01 %	± 2 ppm/°C ± 3 ppm/°C
100 Ω to < 500 Ω	± 0.02 %	

TABLE 1B - MODEL VSH144 SPECIFICATIONS

RESISTANCE RATIO	TOLERANCE MATCH	TCR TRACKING MAX.
1:1	0.01 %	0.5 ppm/°C
> 1:1 to 4:1		1.0 ppm/°C
> 4:1 to 10:1	0.02 %	1.5 ppm/°C
>10:1		2.0 ppm/°C

Note
- See table 2 for additional established ratios

FIGURE 1 - TRIMMING TO VALUES



Note: Foil shown in black, etched spaces in white

* 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 refered 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:

Δ ratio = (TCR track x Δ temp 1) + (absolute TCR x Δ temp 2)

where Δ temp 1 is the change of ambient temperature and Δ 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 ΔR’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.

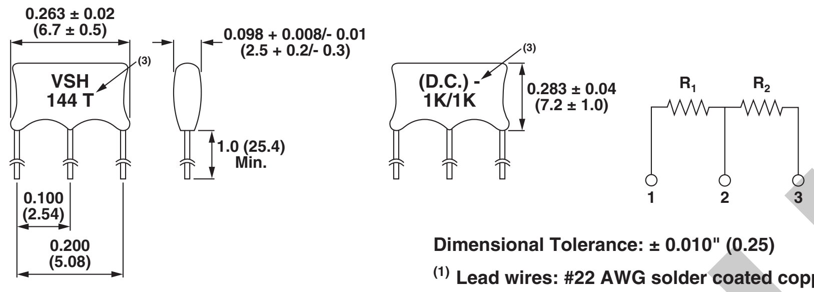
The factors that contribute to this are:

1. Fundamentally low absolute TCR
2. Extremely low TCR tracking
2. Very small drift with load over time
3. 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)



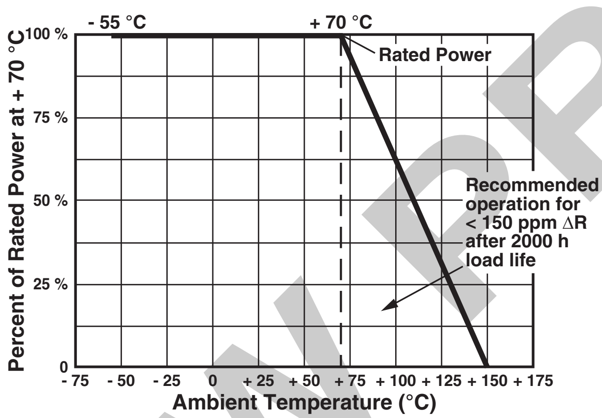
Dimensional Tolerance: ± 0.010" (0.25)

(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



Note

- Power is divided proportionally between the 2 values

FIGURE 4 - TYPICAL RESISTANCE/ TEMPERATURE CURVE

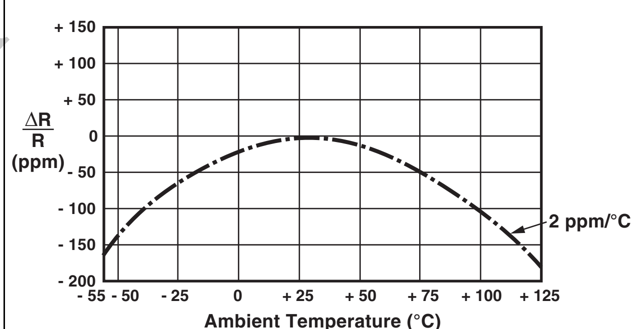


TABLE 2 - EXAMPLES OF VCODES FOR POPULAR VALUES (other values available on request)

VSH144 RATIOS					
VCODES	R_1	R_2	VCODES	R_1	R_2
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 [1]

NEW GLOBAL PART NUMBER: Y1767V0058QT9L (preferred part number format)

DENOTES PRECISION	VCODE	TOLERANCE MATCH	PACKAGING
Y	RESISTANCE VALUE CODE	**V** = 0.005 % **T** = 0.01 % **Q** = 0.02 % **A** = 0.05 % **B** = 0.1 % **D** = 0.5 % **F** = 1.0 %	**L** = bulk pack

Y	1	7	6	7	V	0	0	5	8	Q	T	9	L

PRODUCT CODE	RESISTANCE TOLERANCE	CHARACTERISTICS
1767 = VSH144	**V** = ± 0.005 % **T** = ± 0.01 % **Q** = ± 0.02 % **A** = ± 0.05 % **B** = ± 0.1 % **D** = ± 0.5 % **F** = ± 1.0 %	**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	**T**	**2K/20K**	**TCR2**	**Q**	**T**	**B**
MODEL	TERMINATION	OHMIC VALUE	TCR CHARACTERISTIC	ABSOLUTE TOLERANCE	TOLERANCE MATCH	PACKAGING
VSH144	**T** = lead (Pb)-free **None** = tin/lead alloy	R_1 = 2 kΩ R_2 = 20 kΩ		**V** = ± 0.005 % **T** = ± 0.01 % **Q** = ± 0.02 % **A** = ± 0.05 % **B** = ± 0.1 % **D** = ± 0.5 % **F** = ± 1.0 %	**V** = 0.005 % **T** = 0.01 % **Q** = 0.02 % **A** = 0.05 % **B** = 0.1 % **D** = 0.5 % **F** = 1.0 %	**B** = bulk pack

Note

[1] For non-standard requests, please contact application engineering

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