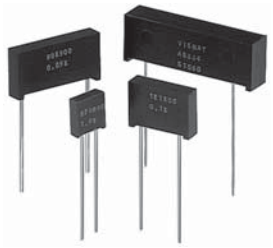
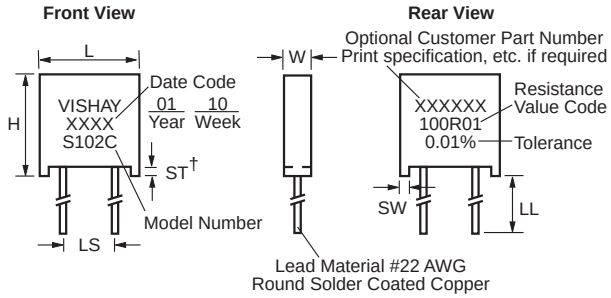
Bulk Metal® Foil Technology
High-Performance Aerospace and Instrumentation Resistors



Product may not be to scale

The "S" series of resistors and in particular the S102C is the starting point in the selection of foil resistors. Vishay has the longest history and most supporting data on this product. All other foil resistors are offshoots of this initial endeavor and provide unique features beyond the range of the "S" series.

FIGURE 1 - STANDARD IMPRINTING AND DIMENSIONS



†The standoffs shall be so located as to give a lead clearance of 0.010" minimum between the resistor body and the printed circuit board when the standoffs are seated on the printed circuit board. This is to allow for proper cleaning of flux and other contaminants from the unit after all soldering processes.

FEATURES

- S102K Series Nominal Temperature Coefficient of Resistance:
  – 0.3ppm/°C (0°C to + 25°C); + 0.3ppm/°C (+ 25°C to + 60°C);
  – 1.0ppm/°C (– 55°C to + 25°C); +1.0ppm/°C (+ 25°C to + 125°C)
- S102C Series Nominal Temperature Coefficient of Resistance:
  + 0.6ppm/°C (0°C to + 25°C); – 0.6ppm/°C (+ 25°C to + 60°C);
  + 2.2ppm/°C (– 55°C to + 25°C); –1.8ppm/°C (+ 25°C to + 125°C)
- Selected TCR Tracking: to 0.5 ppm/°C (matched sets)
- Shelf Life Stability: ± 25ppm maximum for 1 year
- Power Rating: 0.6 to 2.0 Watts at + 70°C; 0.3 to 1.0 Watts at + 125°C (depending on model)
- Load Life Stability: ± 150ppm Maximum deltaR (2000 hours at rated power)
- Resistance Tolerance (Initial Resistance Accuracy): ± 0.005% tightest to ± 1.0% loosest (depends on resistor value)
- Resistance Range: 0.5Ω to 1MΩ
- Current Noise: 0.010µV (RMS)/Volt of Applied Voltage
- Thermal EMF: 0.1µV/°C Maximum; 0.05µV/°C Typical; 1µV/watt (Model S102C, S102K)
- Rise/Decay Time: 1.0 nanosecond @ 1KΩ

THROUGH HOLE

TABLE 1 - MODEL SELECTION

MODEL NUMBER	RESISTANCE RANGE (Ω)	MAXIMUM WORKING VOLTAGE[2]	AMBIENT POWER RATING[3] @+70°C	AMBIENT POWER RATING[3] @+125°C	AVERAGE WEIGHT IN GRAMS	DIMENSIONS INCHES	DIMENSIONS mm	DIMENSIONS *F (INCHES)	TIGHTEST TOLERANCE% VS. LOWEST RESISTANCE VALUE Ω
S102C	1 to 150K	300	0.6 W	0.3 W up to 100K	0.6	W: 0.105 ± 0.010 L: 0.300 ± 0.010 H: 0.326 ± 0.010 ST: 0.010 Minimum SW: 0.040 ± 0.005 LL: 1.000 ± 0.125 LS: 0.150 ± 0.005[4]	2.67 ± 0.25 7.62 ± 0.25 8.28 ± 0.25 0.254 Minimum 1.02 ± 0.13 25.4 ± 3.18 3.81 ± 0.13		
S102K	1 to 100K		0.4 W	0.2 W over 100K					± 0.005 / 50
S104D (S104F*)	1 to 500K	350	1.0 W	0.5 W up to 200K	1.4	W: 0.160 Maximum L: 0.575 Maximum H: 0.413 Maximum ST: 0.035 ± 0.005 SW: 0.050 ± 0.005 LL: 1.000 ± 0.125 LS: 0.400 ± 0.020	4.06 Maximum 14.61 Maximum 10.49 Ma ximum 0.889 ± 0.13 1.27 ± 0.13 25.4 ± 3.18 10.16 ± 0.51	(0.138) (0.565) (0.413)	± 0.01 / 25
S104K	1 to 300K		0.6 W	0.3 W over 200K					± 0.02 / 12
S105D (S105F*)	1 to 750K	350	1.5 W	0.75 W up to 300K	1.9	W: 0.160 Maximum L: 0.820 Maximum H: 0.413 Maximum ST: 0.035 ± 0.005 SW: 0.050 ± 0.005 LL: 1.000 ± 0.125 LS: 0.650 ± 0.020	4.06 Maximum 20.83 Maximum 10.49 Maximum 0.889 ± 0.13 1.27 ± 0.13 25.4 ± 3.18 16.51 ± 0.51	(0.138) (0.890) (0.413) (0.7 ± 0.02)	± 0.05 / 5
S 105K	1 to 500K		0.8 W	0.4 W over 300K					± 0.1 / 2 ± 0.5 / 1
S106D	0.5 to 1M	500	2.0 W	1.0 W up to 400K	4.0	W: 0.260 Maximum L: 1.200 Maximum H: 0.413 Maximum ST: 0.035 ± 0.005 SW: 0.050 ± 0.005 LL: 1.000 ± 0.125 LS: 0.900 ± 0.020	6.60 Maximum 30.48 Maximum 10.49 Maximum 0.889 ± 0.13 1.27 ± 0.13 25.4 ± 3.18 22.86 ± 0.51		
S106K	0.5 to 600K		1.0 W	0.5 W over 400K					

*S104F and S105F have different package dimensions (see last column). All other specifications are the same.

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TABLE 2 - "S" SERIES SPECIFICATIONS[5]

Temperature Coefficient of Resistance	
S102K	
Nominal TCR[6] (See Fig. 7 and 8 in data sheet "7 Technical Reasons to Specify Bulk Metal® Foil Resistive Components.")	– 0.3ppm/°C (0°C to + 25°C) + 0.3ppm/°C (+ 25° to + 60°C) – 1.0ppm/°C (– 55°C to + 25°C) + 1.0ppm/°C (+ 25°C to + 125°C)
Maximum TCR (See Fig. 7 and 8 in data sheet "7 Technical Reasons to Specify Bulk Metal® Foil Resistive Components.")	± 2.5ppm/°C (0°C to + 25°C and + 25°C to + 60°C) ± 2.5ppm/°C (– 55°C to + 25°C and + 25°C to + 125°C)
Selected[9] TCR Tracking[10] (Closest Spread)	0.5ppm/°C
S102C	
Nominal TCR[6] (See Fig. 1 and 2 in data sheet "7 Technical Reasons to Specify Bulk Metal® Foil Resistive Components.")	+ 0.6ppm/°C (0°C to + 25°C) – 0.6ppm/°C (+ 25°C to + 60°C) + 2.2ppm/°C (– 55°C to + 25°C) – 1.8ppm/°C (+ 25°C to + 125°C)
Standard TCR Spread from Nominal[7] (See Fig. 5 and 6 in data sheet "7 Technical Reasons to Specify Bulk Metal® Foil Resistive Components.")	± 1.5ppm/°C (0°C to + 25°C and + 25°C to + 60°C) ± 2.0ppm/°C (– 55°C to + 25°C and + 25°C to + 125°C)
Maximum TCR Spread from Nominal[14] (See Fig. 5 and 6 in data sheet "7 Technical Reasons to Specify Bulk Metal® Foil Resistive Components.")	± 2.5ppm/°C (0°C to + 25°C and + 25°C to + 60°C) ± 2.3ppm/°C (– 55°C to + 25°C and + 25°C to + 125°C)
Selected[9] TCR Tracking[10]	0.5ppm/°C
Stability[15] Load Life at 2,000 hours.	± 0.015% Maximum ΔR @ 0.3W/+ 125°C ± 0.005% Maximum ΔR @ 0.1W/+ 70°C
Load Life at 10,000 hours.	± 0.05% Maximum ΔR @ 0.3W/+ 125°C ± 0.01% Maximum ΔR @ 0.05W/+ 125°C
Shelf Life Stability	± 0.0025% Maximum ΔR after 1 year ± 0.005% Maximum ΔR after 3 years
Current Noise	0.010μV (RMS)/Volt of applied voltage (–40dB)
High Frequency Operation Rise/Decay Time Inductance (L)[11] Capacitance (C)	 1.0ns at 1KΩ 0.1μH maximum; 0.08μH typical 1.0pF maximum; 0.5pF typical
Voltage Coefficient	< 0.1ppm/V[12]
Thermal EMF[13]	0.1μV/°C Maximum; 0.05μV/°C typical 1μV/watt (Model S102C)

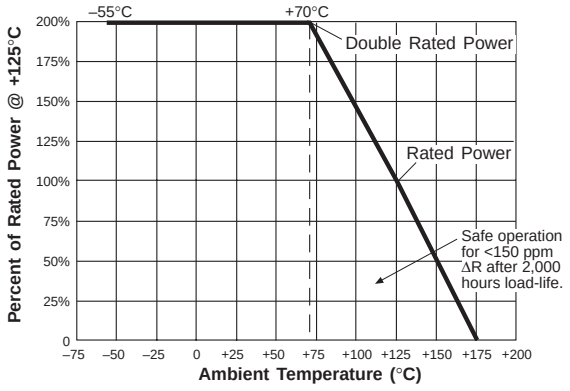
NOTES:

1. Standard Resistance Tolerance: ± 0.005%; ± 0.01%; ± 0.02%; ± 0.05%; ± 0.1%; ± 0.25%; ± 0.5%; ± 1.0%.
2. Not to exceed power rating of resistor.
3. See Figure 2.
4. 0.200" (5.08 mm) lead spacing available– specify S102J for S102C, and S102L for S102K.
   Note its Minor Outline Dimension Variations:

	INCHES	mm
W:	0.098 Maximum	2.49 Maximum
L:	0.295 Maximum	7.49 Maximum
H:	0.315 Maximum	8.00 Maximum
ST:	0.01 Minimum	0.254 Minimum
LL:	0.875 Minimum	22.23 Minimum
LS	0.200 ± 0.003	5.08 ± 0.076

5. Maximum is 1.0% A.Q.L. standard for all specifications except TCR. (For TCR information, see notes 6-10 and 14). Typical is a designers reference which represents that 85% of the units supplied, over a long period of time, will be at least the figure shown or better.
6. Vishay Nominal TCR is defined as the chord slopes of the relative change of resistance/temperature, expressed in ppm (parts per million), called (RT) curve from 0°C to + 25°C and + 25°C to + 60°C ("Instrument" Range); and from – 55°C to + 25°C and + 25°C to + 125°C ("Military" Range). These specifications and the definition of Nominal TCR apply to all resistance values including low-value resistors.
7. Vishay Standard TCR Spread is defined as a designers reference which represents that at least 92% of the units, and 82% of the lots, supplied by Vishay will be within the stated band centered on the nominal curve. This definition of the Vishay Standard TCR Spread from Nominal applies to all resistance values. However, as the resistance value decreases below 60 ohms, the Vishay Standard TCR Spread from Nominal specification starts to increase. (See Figure 3 in data sheet "7 Technical Reasons to Specify BMF Resistive Components.")
8. Vishay Maximum TCR Spread is defined as the 3σ (Sigma) limit of a normal Gaussian distribution (99.73% of a production lot) which is within a band, centered on the nominal curve. This Vishay Maximum TCR Spread is no greater than ± 2.5ppm/°C from nominal throughout the full temperature range. This definition of the Vishay Maximum TCR Spread from Nominal applies to all resistance values. However, as the resistance value decreases below 80 ohms, the Vishay maximum TCR Spread from Nominal specification starts to increase. (See Figure 3 in data sheet "7 Technical Reasons to Specify BMF Resistive Components.")
9. Selected TCR Tracking is available for specially ordered lots of resistors. The selected TCR tracking can be 3, 2, 1 and as close as 0.5 ppm/°C throughout the full temperature range.
10. TCR tracking is a measure of the similarity of resistance value change in two or more resistors which are undergoing the same temperature changes. Tracking could be expressed as the difference in the temperature coefficients of the resistors, expressed in ppm/°C as $(\Delta R_1/R_1 - \Delta R_2/R_2) \times 10^{-6}/\Delta T°C$. When a number of resistors are referenced to a nominal TCR, the spread or envelope around the nominal would be the difference. If the spread is ±1.5 ppm/°C about a nominal, the tracking, as defined above, will be 3ppm/°C. For sets comprising different values, tracking can be defined with reference to a given value.
11. Inductance (L) due mainly to the leads.
12. The resolution limit of existing test equipment (within the measurement capability of the equipment, or "essentially zero.")
13. μV/°C relates to EMF due to lead temperature difference and μV/watt due to power applied to the resistor.
14. + 4.5ppm/°C is the worst case (maximum) TCR for a Vishay resistor over the temperature range of – 55°C to + 125°C. + 4.5ppm/°C is derived from the S102C (– 55°C to +25°C) nominal TCR of + 2.2ppm/°C plus the maximum TCR spread figure of + 2.3 ppm/°C. Other temperature ranges and TCR data will yield a lower maximum characteristic. See Figures 5, 6, 7 and 8 in data sheet "7 Technical Reasons to Specify BMF Resistive Components" and see Table 2 above.
15. Load life ΔR Maximum can be reduced by 80% through a burn-in procedure.

FIGURE 2 - POWER DERATING CURVE "S" SERIES



ORDERING INFORMATION - "S" SERIES PARTS

Please specify Vishay "S" series resistors as follows: (See Imprinting Illustration and Table 1 for further details).

Example:

S102C	100R01	0.01%
MODEL NO.	RESISTANCE VALUE	TOLERANCE

Resistance Value, in ohms, is expressed by a series of 6 characters, 5 of which represent significant digits while the 6th is a dual purpose letter that designates both the multiplier and the location of the comma or decimal point.

RESISTANCE RANGE	LETTER DESIGNATOR	MULTIPLIER FACTOR	TOLERANCE
0.5Ω to < 1KΩ	R	x1	100R01 = 100.01Ω
1KΩ to < 1MΩ	K	$x10^3$	15K231 = 15,231Ω
1MΩ	M	$x10^6$	1M0000 = 1,000,000Ω

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TABLE 3 - ENVIRONMENTAL PERFORMANCE COMPARISON

	MIL-PRF-55182 CHAR J	S-SERIES MAXIMUM ΔR [5]	S-SERIES TYPICAL ΔR [5]
Test Group I			
Thermal Shock	± 0.2%	± 0.01%	± 0.002%
Overload	± 0.2%	± 0.01%	± 0.003%
Test Group II			
Resistance Temperature Characteristic	± 25ppm/°C	+ 4.5ppm/°C[14]	See Figs. 5, 6, 7, 8 in data sheet "7 Technical Reasons to specify BMF Resistive Components."
Low Temp Storage	± 0.15%	± 0.01%	± 0.005%
Low Temp Operation	± 0.15%	± 0.01%	± 0.005%
Terminal Strength	± 0.2%	± 0.01%	± 0.002%
Test Group III			
DWV	± 0.15%	± 0.01%	± 0.005%
Resistance to Solder Heat	± 0.1%	± 0.01%	± 0.002%
Moisture Resistance	± 0.4%	± 0.05%	± 0.02%
Test Group IV			
Shock	± 0.2%	± 0.01%	± 0.002%
Vibration	± 0.2%	± 0.01%	± 0.002%
Test Group V			
Life Test @ 0.3 W/+125°C			
2,000 Hours	± 0.5%	± 0.015%	± 0.01%
10,000 Hours	± 2.0%	± 0.05%	± 0.03%
Test Group Va			
+70°C Power Rating	± 0.5%	±0.1%	± 0.05%
Test Group VI			
High Temperature Exposure	± 2.0%	± 0.1%	± 0.05%
Test Group VII			
Voltage Coefficient	0.005%/V	< 0.00001%/V[12]	< 0.00001%/V[12]

See previous page for footnotes.

STANDARD OPERATIONS & TEST CONDITIONS

A. Standard Test Operations:

By 100% Inspection

- Short-time overload (6.25 x rated power for 5 seconds)
- Resistance – tolerance check
- Visual and mechanical

By Sample Inspection

- TCR
- Environmental tests per Table 3 on a quarterly basis to establish performance by similarity.

B. Standard Test Conditions:

- Lead test point: 0.5" (12.7 mm) from resistor body
- Temperature: + 22°C ± 2°C
- Relative humidity: per MIL-Std-202

IMPROVED PERFORMANCE TESTING

The preceding information is based on product directly off the production line. Improved performance (meaning increased time stability with load and other stresses) is available through factory conducted "Improved Performance Testing". The test routine is usually tailored to the users stabilty objectives and product that has been screened can be brought down to a potential load life of less than 50ppm. For example, Figure 12 in data sheet "7 Technical Reasons to Specify BMF Resistive Components" shows the drift characteristics of standard product.

Various screen test routines are available and all anticipated stresses must be taken into account before settling on one specific test routine. Our Applications Engineering Department (610) 644-1300 is prepared to discuss and recommend appropriate routines given the full spectrum of anticipated stresses and stability requirements.

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