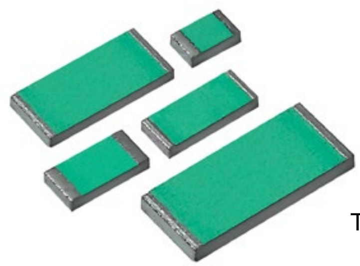
Ultra High-Precision Wrap-Around Chip Resistors, FRSM Z1 Foil Technology Configuration

Screen/Test Flow in Compliance with EEE-INST-002 (Tables 2A and 3A, Film/Foil, Level 1) and MIL-PRF-55342

FEATURES

- Temperature coefficient of resistance (TCR) (see table 1 and fig. 3):
  ±0.2 ppm/°C typical (–55°C to +125°C, +25°C ref.)
- Resistance tolerance: to ±0.01%
- Power coefficient "ΔR due to self heating": 5 ppm at rated power
- Power rating: to 400 mW at +70°C (see table 2)
- **Load life stability: ±0.02% after 2,000 hrs at 70°C at rated power.**
- Resistance range: 10 Ω to 75 kΩ (for higher and lower values, please contact us)
- Bulk Metal® Foil resistors are not restricted to standard values; specific "as required" values can be supplied at no extra cost or delivery (e.g., 1K2345 vs. 1K)
- Thermal stabilization time: <1 s (within 10 ppm of steady state value)
- **Electrostatic discharge (ESD): at least to 25 kV**
- Short time overload: ≤0.005% typical
- Rise time: 1 ns, effectively no ringing
- Current noise: <0.010 μV_{RMS}/V of applied voltage (<–40 dB)
- Non-inductive: <0.08 μH
- Non-hot spot design
- Terminal finishes available: tin/lead alloy
- Matched sets are available on request
- Fast prototype quantities are available. For more information, please contact us.
- For higher temperature application up to +240°C and for better performances, please contact us.
- Adding "U" to the model number (example: 303261U). These units have all of the Table 2A (page 5) 100% tests performed, with no destructive qualification testing required (Table 3A, page 6). For more information, please contact foil@vpgsensors.com.



Top View

INTRODUCTION

The 303261 through 303266 series, tested per EEE-INST-002 and MIL-PRF-55342, is based on the new generation Z1 Foil Technology of the Bulk Metal® precision foil resistor elements by Vishay Foil Resistors (VFR), which makes these resistors virtually insensitive to destabilizing factors. Their element, based on the Z1 Foil Technology, is a solid alloy that displays the desirable bulk properties of its parent material; thus, it is inherently stable (remarkably improved load life stability of 25 ppm), noise-free and withstands ESD to 25 kV or more. The alloy is matched to the substrate and forms a single entity with balanced temperature characteristics for an unusually low and predictable TCR over a wide range from –55°C to +150°C. Resistance patterns are photo-etched to permit trimming of resistance values to very tight tolerances.

The 303261 through 303266 series has a full wraparound termination which ensures reliable handling during the manufacturing process, as well as providing stability during multiple thermal cycles.

Our application engineering department is available to advise and make recommendations. For non-standard technical requirements and special applications, please contact us at foil@vpgsensors.com.

RELATED DOCUMENT

From our Technical Library, please see Reading Between the Lines in Resistor Datasheets.

RELATED VIDEO

From our Video Library, refer to Z-Foil vs Thin Film Resistors with Intersil Instrumentation Amplifier (Demo Video).

FIGURE 1—POWER DERATING CURVE

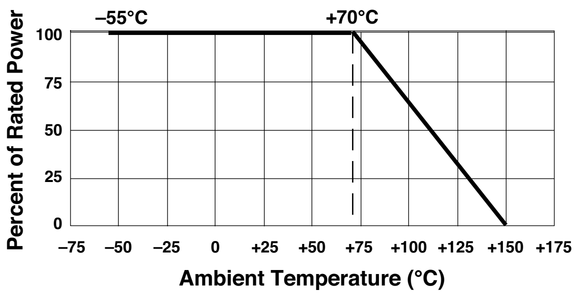
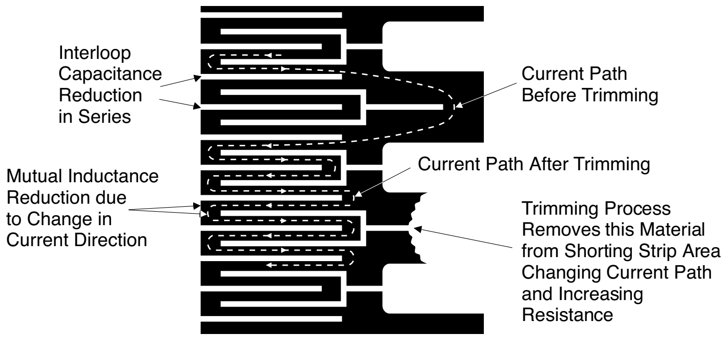


TABLE 1—BEST TOLERANCE AND TCR VS. RESISTANCE VALUE

(–55°C to +125°C, +25°C Ref.)

Resistance Value Ω	Tolerance (%)	Maximum TCR (ppm/°C)
250 to 75k	±0.01%	±3
100 to <250	±0.05%	±3
50 to <100	±0.1%	±4
25 to <50	±0.25%	±5
10 to <25	±0.5%	±5

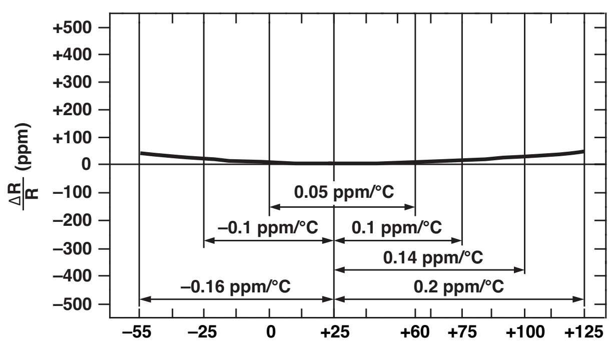
FIGURE 2—TRIMMING TO VALUES (conceptual illustration)



Foil shown in black, etched spaces in white

Note
To acquire a precision resistance value, the Bulk Metal® Foil chip is trimmed by selectively removing built-in “shorting bars.” To increase the resistance in known increments, marked areas are cut, producing progressively smaller increases in resistance. This method reduces the effect of “hot spots” and improves the long-term stability of VFR resistors.

FIGURE 3—NOMINAL RESISTANCE/TEMPERATURE CURVE



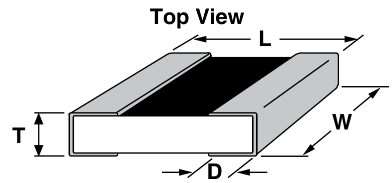
Ambient Temperature (°C) and TCR Chord Slopes for Different Temperature Ranges

TABLE 2—SPECIFICATIONS(1)

Model (Chip Size)	Rated Power at +70°C (mW)	Max. Working Voltage $(\leq\sqrt{P \times R})$	Resistance Range (Ω)	Max. Weight (mg)
303261 (0603)	50	14 V	100 to 2k	4
303262 (0805)	100	22 V	10 to 5k	6
303263 (1206)	150	46 V	10 to 14k	11
303264 (1506)	200	57 V	10 to 16k	12
303265 (2010)	300	102 V	10 to 35k	27
303266 (2512)	400	173 V	10 to 75k	40

Notes
(1) For tighter performances and non-standard values up to 125k, please contact VPG application engineering at foil@vishaypg.com.

TABLE 3—DIMENSIONS in Inches (Millimeters)



Chip Size	L ±0.005 (0.13)	W ±0.005 (0.13)	Thickness Maximum	D ±0.005 (0.13)
0603	0.063 (1.60)	0.032 (0.81)	0.025 (0.64)	0.011 (0.28)
0805	0.080 (2.03)	0.050 (1.27)		0.015 (0.38)
1206	0.126 (3.20)	0.062 (1.57)		0.020 (0.51)
1506	0.150 (3.81)	0.062 (1.57)		0.020 (0.51)
2010	0.198 (5.03)	0.097 (2.46)		0.025 (0.64)
2512	0.249 (6.32)	0.127 (3.23)		0.032 (0.81)

TABLE 4—PERFORMANCES

Test or Conditions	ΔR Limits of FRSM Series	
	Typical	Maximum[3]
Thermal Shock, 100 x (–65°C to +150°C), see Figure 6	±0.005% (50 ppm)	±0.01% (100 ppm)
Low Temperature Operation, –65°C, 45 min at P_{nom}	±0.005% (50 ppm)	±0.015% (150 ppm)
Short Time Overload, 6.25 x Rated Power, 5 s	±0.005% (50 ppm)	±0.02% (200 ppm)
High Temperature Exposure, +150°C, 100 h	±0.005% (50 ppm)	±0.015% (150 ppm)
Resistance to Soldering Heat, +245°C for 5 s, +235°C for 30 s	±0.005% (50 ppm)	±0.02% (200 ppm)
Moisture Resistance	±0.003% (30 ppm)	±0.025% (250 ppm)
Load Life Stability, +70°C for 2000 h at Rated Power, see Figure 7	0.0025% (25 ppm)	±0.02% (200 ppm)

Note

[3] As shown +0.01 Ω to allow for measurement errors at low values.

FIGURE 4—RECOMMENDED MOUNTING

1. IR and vapor phase reflow are recommended.
2. Avoid the use of cleaning agents that attack epoxy resins, which form part of the resistor construction.
3. Vacuum pick up is recommended for handling.
4. If the use of a soldering iron becomes necessary, precautionary measures should be taken to avoid any possible damage/overheating of the resistor.

* Recommendation: The solder fillet profile should be such as to avoid running over the top metallization.

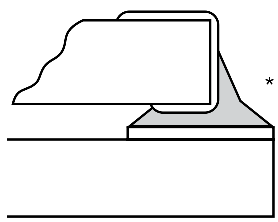


TABLE 5—EEE-INST-002 (TABLE 2A FILM/FOIL, LEVEL 1) 100% TESTS/INSPECTIONS	
Test or Inspection	**Result**
Pre-cap Visual Inspection	Performed in production flow prior overcoating
RC Record	In tolerance
Thermal Shock	25 x (–65°C to +150°C)
Power Conditioning	70°C, 100 h, 1.5 rated power—not to exceed max. voltage
RC Record	In tolerance ΔR = 0.05% for thermal shock and conditioning combined
Final Inspection	5% PDA on ΔR only, 10% PDA on “Out of Final Tolerance”
Visual Inspection	Materials, design, etc.
Mechanical Inspection	Physical dimensions, sample size: 3 units, zero failure

ELECTROSTATIC DISCHARGE (ESD)

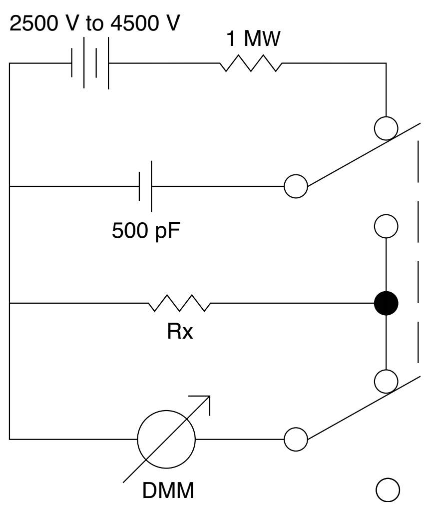
ESD can be categorized into three types of damages:

Parametric Failure occurs when the ESD event alters one or more device parameters (resistance in the case of resistors), causing it to shift from its required tolerance. This failure does not directly pertain to functionality; thus a parametric failure may be present while the device is still functional.

Catastrophic Damage occurs when the ESD event causes the device to immediately stop functioning. This may occur after one or a number of ESD events with diverse causes, such as human body discharge or the mere presence of an electrostatic field.

Latent Damage occurs when the ESD event causes moderate damage to the device, which is not noticeable, as the device appears to be functioning correctly. However, the load life of the device has been dramatically reduced, and further degradation caused by operating stresses may cause the device to fail during service. Latent damage is the source for greatest concern, because it is very difficult to detect by re-measurement or by visual inspection, since damage may have occurred under the external coating.

FIGURE 5—ESD TEST DESCRIPTION AND RESULTS



By using an electrolytic 500 pF capacitor charged up to 4500V, pulses were performed on 10 units of 1206, 10 kΩ of three different Surface Mount Chip Resistors technologies, with an initial voltage spike of 2500V. The unit was allowed time to cool down, after which the resistance measurement was taken and displayed in ppm deviation from the initial reading. Readings were then taken in 500V increments up to 4500V.

Volts	ΔR (%)		
	Thick Film	Thin Film	Foil
2500	–2.7	97	
3000	–4.2	366	
3500	–6.2	>5000	<0.005
4000	–7.4	>5000	
4500	–8.6	Open	

FIGURE 6—THERMAL SHOCK TEST

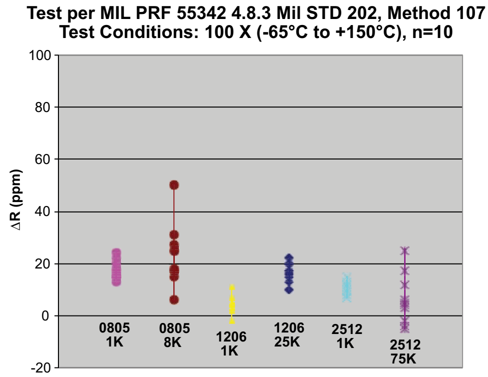


FIGURE 7—LOAD LIFE TEST FOR 2000 HRS @ +70°C AT RATED POWER

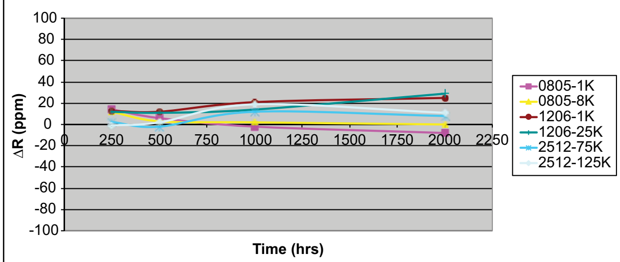


TABLE 6—EEE-INST-002 (TABLE 3A FILM/FOIL, LEVEL 1) DESTRUCTIVE TESTS

Group 2	Sample size: 3, zero failure	
	Solderability	
Group 3	Sample size: 10, zero failure—mounted on FR4	
	TCR (–55°C/+25°C/+125°C)	**Values** / **TCR Limits** ≥100 Ω / ±3 ppm/°C 50 Ω to <100 Ω / ±4 ppm/°C 10 Ω to <50 Ω / ±5 ppm/°C
	Low temperature storage	ΔR = 0.02%
		–65°C no load dwell for 24 h ±4 h
		+25°C ambient no load dwell for 2 h to 8 h
	Low temperature operation	ΔR = 0.015%
		–65°C no load dwell for 1 h
		rated power for 45 min
		+25°C ambient no load dwell for 2 h to 8 h
	Short time overload	ΔR = 0.02%
		6.25 x rated power, 5 s—no “I” limitation: not to exceed twice the max. voltage
Group 4	Sample size: 9, zero failure—mounted on FR4	
	Resistance to soldering heat	ΔR = 0.02%
		Performed per MIL-PRF-55342 para. 4.8.8.1
Group 6	Sample size: 12, zero failure—mounted on FR4	
	Life	ΔR = 0.02%
		2000 h, +70°C, rated power
Group 7B	Sample size: 10, zero failure—mounted on FR4	
	Solder mounting integrity	Performed per MIL-PRF-55342
		Force applied: for 0630—1 kg, 30 s / for 0805, 1206, and 1506—2 kg, 30 s
		For 2010, 2512: force applied: 3 kg, 30 s
Group 8	Sample size: 5, zero failure—chips not mounted	
	Voltage coefficient	ΔR = 3 ppm/V
		Applicable resistors ≥1k
		Performed per MIL-STD-202 method 309
Group 9	Sample size: 5, zero failure—mounted on FR4	
	High temperature exposure	ΔR = 0.015%
		Performed per MIL-PRF-55342
		100 h at +150°C ±5°C

What is the importance of resistor stability in an electronic circuit?

Answer—The circuit was probably not intended for just a onetime use. Also, the equipment may have to endure some environmental and operational stresses. So, the ongoing use of the equipment is expected and the more stable the resistors, the longer the time before recalibrations. FRSM offers the most stability in all categories but there is more than recalibration at stake here: extremes of surge voltage can cause thin film resistors to go open while the Foil resistor based on the Z-1 technology is not affected. An open means the equipment must be returned to have the resistor replaced or, worse yet, mission failure. The cost of a Foil resistor would have been insignificant compared to the cost of mission failure or the cost of returning an instrument for repair or replacement of a blown resistor. Add to this the down time of the equipment.

Designing for Extended Service—All electronic equipment is expected to do something useful for a specified period of time. At the end of that period, and in spite of permissible service conditions, the equipment is expected to still be functional in its intended service and within its accuracy limits. All the components contribute in some way to the stability of the equipment but the resistors are the devices relied upon most to retain the original accuracy of the equipment. Any departure from the end-of-life accuracy limits set for one resistor renders the entire equipment “out of service” and subject to repair or recalibration. The prospect of repair or recalibration is unthinkable in certain applications (space for example) and only devices that can be given an appropriate initial tolerance with the expectation of retaining proximity to the initial value throughout the service life are suitable. This is especially true of the resistors in a circuit which may have power applied causing self heating, load applied for extended periods or load life and load applied differentially from other resistors resulting in a ratio offset. The equipment itself may see elevated temperatures for extended periods of storage. Foil resistors are the best solution when these factors come into play.

TABLE 7—PART NUMBER IDENTIFICATION

Model #	303261	303262	303263	303264	303265	303266
Chip Size	0603	0805	1206	1506	2010	2512
Value Range (Space Application)	100 Ω to 2 kΩ	10 Ω to 5 kΩ	10 Ω to 14 kΩ	10 Ω to 16 kΩ	10 Ω to 35 kΩ	10 Ω to 75 kΩ

Part Number: **{Model} - {Value} - {Tolerance} {Termination} {Packaging}**

Resistance Value	Tolerance (Tightest)	Code
250R to 75k	0.01%	T
100R to <250R	0.05%	A
50R to <100R	0.1%	B
25R to <50R	0.25%	C
10R to <25R	0.5%	D

Termination	Code
Tin/lead	B

Packaging	Code
Waffle	W
Tape and reel	T

Example: 303263 - 10K025 - QBW

1206 chip size, 10.025 kΩ, 0.02%, tin/lead termination, waffle packaging

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