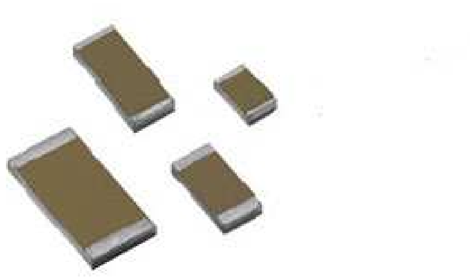
Ultra High Precision Foil Wraparound Surface Mount Chip Resistor for High Temperature Applications up to +200°C, Humidity proof (85°C/85% RH) to 0.015%, Stability under load of 0.02%



Top View

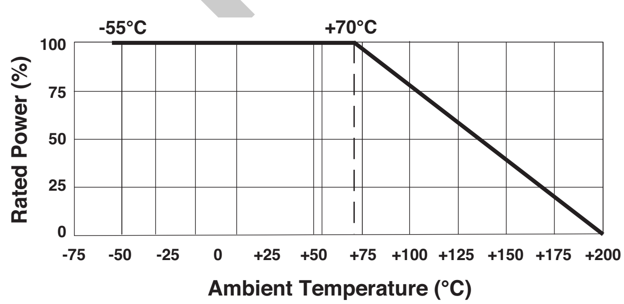
INTRODUCTION

The FRST is based on the new generation Z1- technology of the Bulk Metal® Precision Foil resistor elements by Vishay Precision Group (VPG), which makes these resistors virtually insensitive to destabilizing factors. Their element, based on the new Z1-Foil technology is a solid alloy that displays the desirable bulk properties of its parent material; thus, it is inherently stable (less than 0.02% ΔR after 2,000 hrs, derated power at +175 °C), noise-free and withstands ESD to 25KV 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 more than 175C°. Resistance patterns are photo-etched to permit trimming of resistance values to very tight tolerances.

The FRST series has a full wraparound termination, and was especially designed for applications up to +200°C.

The FRST is available in any value within the specified resistance range. VFR's application engineering department is available to advise and make recommendations. For non-standard technical requirements and special applications, please contact us using the e-mail address in the footer below.

FIGURE 1 - POWER DERATING CURVE



FEATURES

- **Humidity test : 85°C/85% RH, 1000 hrs to ΔR 0.015%, typical**
- Temperature coefficient of resistance (TCR): 2.5 ppm/°C typical (- 55 °C to + 175 °C, + 25 °C ref.)
- Resistance Range: 5 Ω to 125 kΩ (for higher and lower values, please contact us)
- Resistance tolerance: to ± 0.01 %
- Power coefficient "ΔR due to self heating": 5 ppm at rated power
- Power rating: to 750 mW at + 70 °C
  to 150 mW at +175°C
- **Load life stability:**
  ± 0.0025 % at 70 °C, 2000 h at rated power.
- **Stability under load: 0.02% at +175 °C, 2000 h at derated power**
- Vishay Foil resistors are not restricted to standard values; we can supply specific "as required" values at no extra cost or delivery (e.g. 1K2345 vs. 1K)
- Thermal stabilization time < 1 s (nominal value achieved within 10 ppm of steady state value)
- **Electrostatic discharge (ESD) at least to 25kV**
- Short time overload: 0.005 %
- Rise time: 1 ns effectively no ringing
- Current noise: 0.010 μV_{RMS}/V of applied voltage (< - 40 dB)
- Voltage coefficient: 0.1 ppm/V
- Non inductive: 0.08 µH
- Non hot spot design
- Terminal finish available: lead (Pb)-free only
- Matched sets are available on request
- For higher temperature application up to +240 °C and for better performances, please contact: foil@vishaypg.com

Pb-free Available

RoHS* COMPLIANT

TABLE 1 - TOLERANCE AND TCR VS. RESISTANCE VALUE (1)
(- 55 °C to + 175 °C, + 25 °C Ref.)

RESISTANCE VALUE (Ω)	TOLERANCE (%)	TYPICAL TCR (ppm/°C)
250 to 125K	± 0.01	± 2.5
100 to < 250	± 0.02	
50 to < 100	± 0.05	
25 to < 50	± 0.1	
10 to < 25	± 0.25	
5 to < 10(2)	± 0.5	

(1) For tighter performances and non-standard values lower than 5Ω and above 125kΩ, please contact VFR's application engineering using the e-mail addresses in the footer below.
(2) TCR of these low value range : ± 10ppm/°C max

HIGH TEMPERATURE PRODUCTS

Resistors are the passive building blocks of an electrical circuit. They may be used for dropping the voltage, buffering the surge when the circuit is turned on, providing feedback in a monitoring loop, sensing current flow, etc. When the application requires stability over time and load, initial accuracy, minimal change with temperature for more than 200 °C, resistance to moisture and a number of other characteristics that will be described below, only the new generation of Vishay Foil Resistors have the attributes needed for such application. Over the past few months, there has been considerable growth in the demand for precise, stable and reliable resistors that can operate in harsh environments such as 85°C /85% RH and especially at high temperatures to 200 °C. Many analog circuits for industrial, military, aerospace, medical, down-hole, oil well and automotive applications require passive components such as resistors to have a minimal drift from their initial values when operating above + 175 °C and in humid environments. In these applications, the most important factor is the temperature dependence and the end of life tolerance (which is part of the stability) and to a lesser extent, the initial tolerance.

The new Vishay Foil resistors provide stabilities well under the maximum allowable drift required by customers' specifications through thousands of hours of operation under harsh conditions, such as the extreme temperatures and radiation-rich environments of down-hole oil-well logging applications, in the frigid arctic, under the sea or in deep space. All Bulk Metal® Foil resistors receive stabilization processing, such as repetitive short term power overloads, to assure reliable service through the unpredictable stresses of extreme operation. Compared to Bulk Metal® Foil, thick and thin film resistor elements are produced with a non-controllable material. Heat or mechanical stresses on the resistive elements cause the particles forming the film to expand. However, after these stresses are alleviated, the particles in the film matrix do not return to the exact original position. That degenerates their overall stability.

Vishay Foil Resistors' Ultra High Precision Bulk Metal® Foil technology includes many types of resistors with a variety of standard configurations that can withstand unconventional environmental conditions above and below the earth's surface using special post manufacturing operations specially developed for this purpose. The stability of a resistor depends primarily on its history of exposures to high temperature. Stability is affected by:

1. Changes in the ambient temperature and heat from adjacent components (defined by the Temperature Coefficient of Resistance, or TCR)
2. Destabilizing thermal shock of suddenly-applied power (defined by the Power Coefficient of Resistance, or PCR)
3. Long-term exposure to applied power (load-life stability)
4. Repetitive stresses from being switched on and off

In very high-precision resistors that need to operate in an environment with temperatures above + 175 °C, these effects must be taken into account to achieve high stability with changes in load (Joule Effect) and ambient temperature.

The Bulk Metal® Foil Resistors' new Z1-Foil technology provides an order of magnitude reduction in the Bulk Metal® Foil element's sensitivity to temperature changes — both external and internal – with emphasis on long term stability in high temperature environments.

In order to take full advantage of the low TCR and long term stability improvement, it is necessary to take into account the differences in the resistor's response to each of the above-mentioned effects. As described below, new products have been developed to successfully deal with these factors. For high temperature applications where stability and total error budget is the main concern, the new generation of Vishay Foil resistors offers the best resilience against time at elevated temperature.

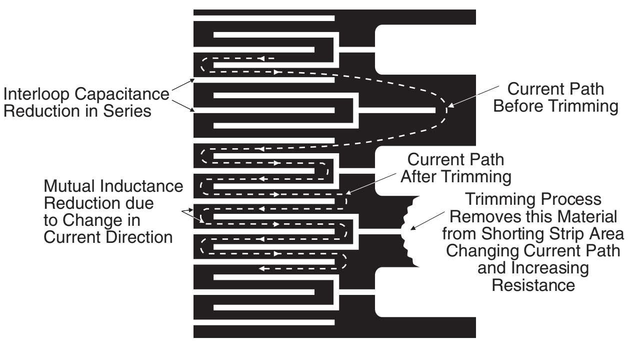
The new Vishay Foil technology allows us to produce customer-oriented products designed to satisfy unique and specific technical requirements. In addition to the special chip stabilization under extreme environment conditions in the production line, we offer additional specially oriented post manufacturing operations (PMO) for high temperature applications that require an even higher degree of reliability and stability.

Electrostatic Discharge (ESD) is another potential problem that can cause unpredictable failure in high temperature applications that increase the sensitivity of the resistors to ESD.

ESD damage to electronic devices can occur at any point in the device's life cycle, from manufacturing to field service. A resistor that is exposed to an ESD event may fail immediately or may experience a latent defect. With latent defects, premature failure can occur after the resistor is already functioning in the finished product after an unpredictable length of service. Bulk Metal® Foil resistors are capable of withstanding electrostatic discharges at least to 25 kV without degradation.

VFR's Application Engineering department is always available to assist with any special requirements you might have. If you are not sure which resistor best suits your needs, please do not hesitate to contact them for more information: Foil@vishaypg.com

FIGURE 2 - TRIMMING TO VALUES*
(Conceptual Illustration)



Note: Foil shown in black, etched spaces in white

* 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 eliminates "hot spot" and improves the long term stability of the resistor.

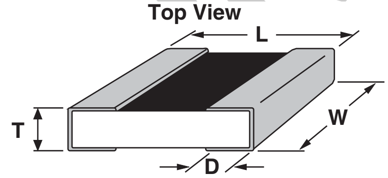
TABLE 3 - SPECIFICATIONS

CHIP SIZE	RATED POWER (mW) at + 70 °C	DERATED POWER (mW) at + 175 °C	MAX. WORKING VOLTAGE $(\leq \sqrt{P \times R})$	RESISTANCE RANGE (Ω)	MAXIMUM WEIGHT (mg)
0603*	100	20	22 V	100 to 4K*	4
0805	200	40	40 V	5 to 8K	6
1206	300	60	87 V	5 to 25K	11
1506	300	60	95 V	5 to 30K	12
2010	500	100	187 V	5 to 70K	27
2512	750	150	220 V	5 to 125K	40

* For 0603 values between 4K and 5K, please contact us

TABLE 2 - DIMENSIONS in Inches (Millimeters)

Top View



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)	0.025 (0.64)	0.015 (0.38)
1206	0.126 (3.20)	0.062 (1.57)	0.025 (0.64)	0.020 (0.51)
1506	0.150 (3.81)	0.062 (1.57)	0.025 (0.64)	0.020 (0.51)
2010	0.198 (5.03)	0.097 (2.46)	0.025 (0.64)	0.025 (0.64)
2512	0.249 (6.32)	0.127 (3.23)	0.025 (0.64)	0.032 (0.81)

TABLE 4 - PERFORMANCES

TEST OR CONDITIONS (Based on MIL PRF 55342)	TYPICAL ΔR LIMITS OF FRST SERIES	MAXIMUM ΔR LIMITS OF FRST SERIES(1)
Thermal Shock, 100 x (- 65 °C to + 175 °C) (see Figure 5)	± 0.005% (50 ppm)	± 0.01% (100 ppm)
Low Temperature Operation, - 65 °C, 45 min at P_{nom}	± 0.0025% (25 ppm)	± 0.005% (50 ppm)
Short Time Overload, 6.25 x Rated Power, 5 s	± 0.005% (50 ppm)	± 0.01% (100 ppm)
High Temperature Exposure, + 200 °C, 1000 h	± 0.03% (300 ppm)	± 0.05% (500 ppm)
Humidity test, 85°C/85% RH, 1000 hrs	0.015% (150 ppm)	0.03% (300 ppm)
Resistance to Soldering Heat, +245°C for 5 sec,+235°C for 30 sec	± 0.005 % (50 ppm)	± 0.01% (100 ppm)
Moisture Resistance	± 0.003% (30 ppm)	± 0.01% (100 ppm)
Load Life Stability + 70 °C for 2000 h at Rated Power	0.0025% (25 ppm)	± 0.005% (50ppm)
Stability under load +175°C for 2000h at derated power(2)	0.02% (200 ppm)	0.03% (300 ppm)

Note

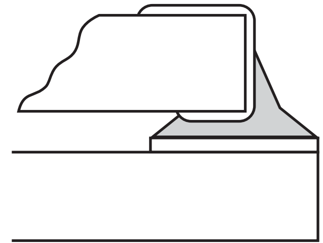
(1) As shown + 0.01 Ω to allow for measurement errors at low values.

(2) See table 3.

FIGURE 3 - RECOMMENDED MOUNTING

Notes

(1) IR and vapor phase reflow are recommended.
(2) Vacuum pick up is recommended for handling
(3) If using a soldering iron, precautions should be taken to avoid damaging the resistor



PULSE TEST

TEST DESCRIPTION

All parts baked at +125°C for 1 hr and allowed to cool at room temperature for 1 hr, prior to testing. By using an electrolytic 0.01μF capacitor charged to 1000 VDC, a single pulse was performed on 20 units of 1206, for each value: 100Ω, 1KΩ and 10KΩ of Surface Mount Vishay Foil resistors and Thin Film resistors. The units were allowed time to cool down, after which the resistance measurement was taken and displayed in ppm deviation from the initial reading.

TEST RESULTS

FIGURE 4 - PULSE TEST DESCRIPTION

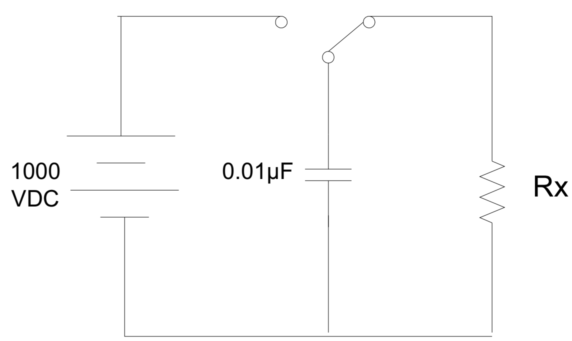
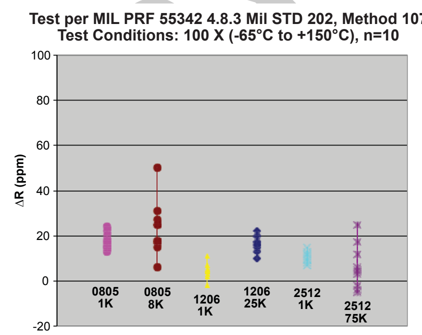


TABLE 5 - PULSE TEST RESULTS

VALUE	VOLTAGE	T= RC	AVERAGE DEVIATION (%)	
			VISHAY FOIL RESISTOR	THIN FILM
100R	1000VDC	1μsec	<0.001	Open
1K		10 μsec		>35
10K		100 μsec		>0.008

FIGURE 5 - THERMAL SHOCK TEST



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, since it is very difficult to detect by re-measurement or by visual inspection, since damage may have occurred under the external coating.

TEST DESCRIPTION

By using a electrolytic 500 pF capacitor charged up to 4500 V, pulses were performed on 10 units of 1206, 10KΩ of three different Surface Mount Chip Resistors technologies, with an initial voltage spike of 2500 V (Figure 6). 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 500 V increments up to 4500 V.

TEST RESULTS

FIGURE 6 - ESD TEST DESCRIPTION

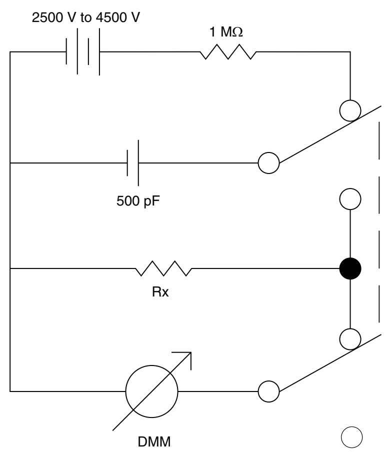


TABLE 6 - ESD TEST RESULTS

VOLTS	ΔR (%)		
	THICK FILM	THIN FILM	FOIL
2500	-2.7	97	<0.005
3000	-4.2	366	<0.005
3500	-6.2	>5000	<0.005
4000	-7.4	>5000	<0.005
4500	-8.6	OPEN	<0.005

FIGURE 7 - PULSE RESPONSE COMPARISON

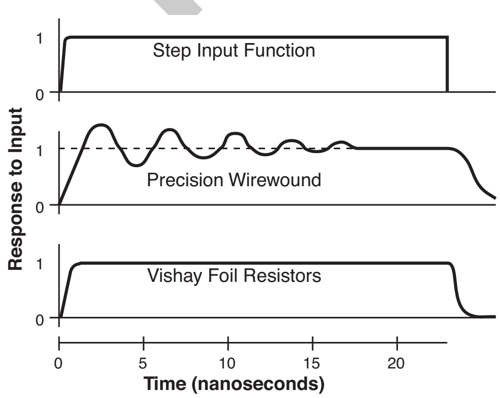


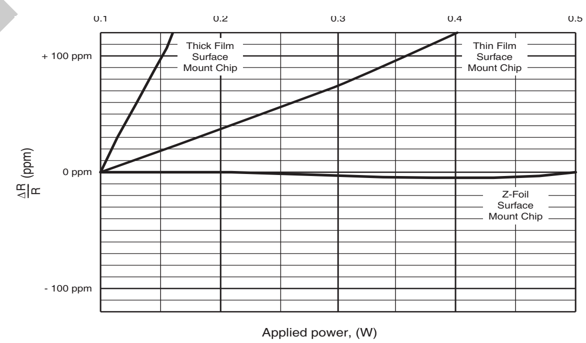
Figure 7 shows the current response to a voltage pulse comparing a fast Bulk Metal® Foil resistor to a slower wirewound resistor. Here a pulse width of one nanosecond would have been completely missed by the wirewound resistor while the Vishay Foil resistor achieves full replication in the time allotted.

POWER COEFFICIENT OF RESISTANCE (PCR)

In precision resistors with low TCR, the self heating (Joule effect) causes the resistor not to perform strictly to its TCR specifications. This inaccuracy will result in an error at the end in the resistance value under applied power. Vishay Foil Resistors introduced a new concept of Power Coefficient of Resistance (PCR) along with a new Z-Foil technology which leads to reduction of the sensitivity of precision resistor to ambient temperature variations and changes of applied power.

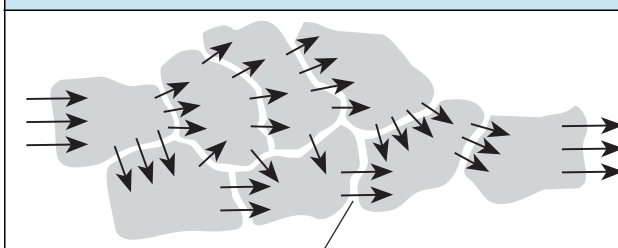
Figure 8 represents PCR behavior of three different resistor technologies under applied power.

FIGURE 8 - BEHAVIOR OF THREE DIFFERENT RESISTOR TECHNOLOGIES UNDER APPLIED POWER (POWER COEFFICIENT TEST)



Note: Size 1206, value: 1K

FIGURE 9 - CURRENT PATH IN A RESISTIVE ALLOY



Noise generation is minimal when current flow is through multiple paths as exists in Bulk Metal® Foil resistive alloy.

POST MANUFACTURE OPERATIONS (PMO)

The Post Manufacturing Operations (PMOs) enhance the already superior stability of the Foil resistors. These PMOs are uniquely applicable to resistors made of resistive Foil and constitute an exercising of the resin that bonds the Foil to the substrate. Among the operations that are employed: Temperature cycling, Short time overload and Accelerated load life.

Question: 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. Some applications require long-term stability without the possibility of re-calibration, such as in satellites, deep-space probes, underwater repeater cables, etc. FRST 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 the maintenance department 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 - GLOBAL PART NUMBER INFORMATION [(1)]

NEW GLOBAL PART NUMBER: Y401612K7560T9R (preferred part number format)

Y	4	0	1	6	1	2	K	7	5	6	0	T	9	R

DENOTES PRECISION
Y

PRODUCT CODE
4013 = FRST0603
4014 = FRST0805
4015 = FRST1206
4016 = FRST1506
4017 = FRST2010
4018 = FRST2512

VALUE
R = Ω
K = kΩ

RESISTANCE TOLERANCE
T = ± 0.01 %
Q = ± 0.02 %
A = ± 0.05 %
B = ± 0.10 %
C = ± 0.25 %
D = ± 0.5 %
F = ± 1.0 %

CHARACTERISTICS
9 = lead (Pb)-free
1 to 999 = custom

PACKAGING
R = tape and reel
W = waffle pack

FOR EXAMPLE: ABOVE GLOBAL ORDER Y4016 12K7560 T 9 R:

TYPE: FRST1506
VALUES: 12.7560 kΩ
ABSOLUTE TOLERANCE: 0.01 %
TERMINATION: lead (Pb)-free
PACKAGING: tape and reel

Note

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

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