



VISHAY INTERTECHNOLOGY, INC.

ULTRA-HIGH-PRECISION BULK METAL® FOIL RESISTORS

Advanced Medical Applications, Treatment Solutions, and Biotechnology



RESISTIVE PRODUCTS

CAPABILITIES



Ultra-High-Precision Bulk Metal[®] Foil Resistors

For Advanced Medical Applications, Treatment Solutions, and Biotechnology

Bulk Metal[®] foil resistors were invented some 40 years ago by Dr. Felix Zandman. Until today, they remain the performance leader among all resistor types, categories, and brands. Their unique construction, featuring a special resistive alloy, results in a resistor element with characteristics that no other technology can match. These include the industry's lowest temperature coefficient of resistance (TCR), and power coefficient (PCR).

All of these performance characteristics are particularly desirable in medical instrumentation and equipment, where Bulk Metal foil resistors deliver proven reliability and stable performance, even when exposed to unstable levels of temperature and humidity or other harsh environmental conditions. Their long track record of success in medical applications and Vishay's long-term commitment to the medical market have made Bulk Metal Foil the preferred resistor for medical applications including non-invasive equipment, imaging equipment and systems, and biological implants.

As a leading supplier to the worldwide medical market, Vishay has produced a steady stream of breakthroughs in component technology, including new Z-Foil resistors that provide a temperature coefficient of ± 0.2 ppm/ $^{\circ}$ C and a power coefficient of 5 ppm at rated power: a ten-fold improvement over standard foil resistors.

Many medical applications require custom or semi-custom component solutions. Vishay's Application Engineering department is available to advise customers and to make recommendations regarding non-standard technical requirements and special applications.

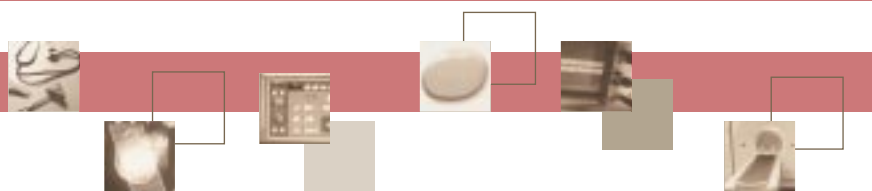
Please contact us at Foil@vishay.com.

Key features of Vishay Bulk Metal foil resistors:

- "Zero TCR": ± 0.2 ppm/ $^{\circ}$ C (MIL range) with Z-Foil technology
- TCR tracking: to 0.1 ppm/ $^{\circ}$ C
- PCR (power coefficient): 5 ppm typical at rated power for Z-Foil resistors
- Load-life stability under applied power:
 - 0.005% (50 ppm) over 2,000 hours at 70 $^{\circ}$ C
- Resistance range: any value from 2 m Ω to 3.3 M Ω (for higher and lower values, please contact us)
- Tolerance: absolute and match for voltage dividers and networks: to ± 0.001 %
- 4-terminal connections for low values
- Low current noise: - 40 dB
- Thermal EMF: 0.05 μ V/ $^{\circ}$ C
- Voltage coefficient: <0.1 ppm/V
- Non-inductive: <0.08 μ H
- Rise time: 1 ns without ringing
- Lead (Pb)-free and RoHS-compliant available upon request

















The following device types are available as part of Vishay foil resistor product portfolio:

- Surface-mount chips, molded resistors, and networks
- Through-hole (leaded) resistors and networks
- Hermetically sealed and molded networks
- Power current-sensing resistors
- Hybrid chips
- Voltage dividers
- Military-established-reliability resistors
- Trimming potentiometers



Applications:

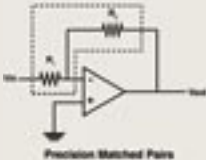
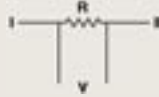



- Medicine and health care
- Medical R&D projects
- Non-invasive equipment
- Disease detection
- Automated imaging and scanning systems for analysis
- Biological implants
- Biotechnology
- Body navigation solutions (real-time)
- 3D cardiac mapping and navigation
- Electrophysiology

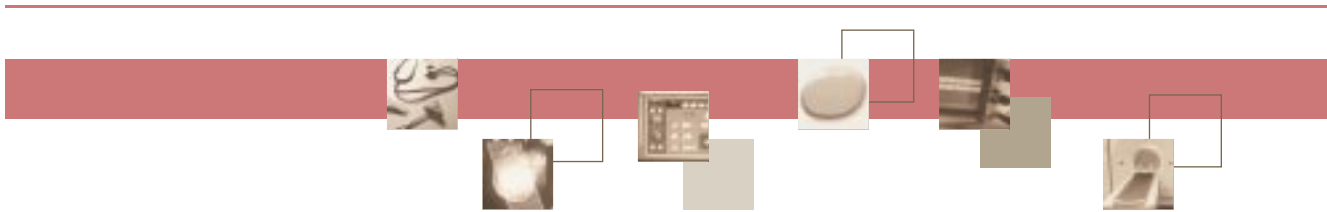
<p>VSMP Series</p> 	<p>SMRxD Series</p> 
<p>VFCP Series</p> 	<p>VH Series</p> 
<p>Z201</p> 	<p>VHP Series</p> 
<p>VCS2516Z</p> 	<p>VPR Series</p> 
<p>CSM Series</p> 	<p>PRND</p> 
<p>DSM / SMN</p> 	<p>VHA Series</p> 
<p>VCS Series</p> 	<p>VFP Series</p> 
<p>S Series</p> 	<p>300144</p> 


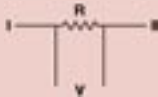



Ultra-High-Precision Bulk Metal[®] Foil Resistors

For Advanced Medical Applications, Treatment Solutions, and Biotechnology

	Series/Part Number	Features	Benefits
Surface Mount			
Wraparound	VSMP Series (Z-Foil) VSM Series (Sizes: 0805, 1206, 1506, 2010, 2512)	<ul style="list-style-type: none"> Nearly zero TCR: "Z-Foil" ± 0.2 ppm/$^{\circ}$C (MIL range) typical Long-term stability under applied power ± 0.01 % or ± 0.005 % (reduced power) over 2,000 hours at $+70$ $^{\circ}$C Low PCR (power coefficient) 5 ppm typical at rated power for Z-Foil resistors Resistance range: 10 Ω to 150 kΩ Tolerance: ± 0.01 % Low current noise: -40 dB 	 <ul style="list-style-type: none"> Precision-matched pairs of Z-Foil VSMP series with absolute TCR of ± 0.2 ppm/$^{\circ}$C typical and TCR tracking of 0.4 ppm/$^{\circ}$C typical Protective top coat Excellent stability under different environmental conditions Small size saves circuit board area
Flip Chip	VFCP Series (Z-Foil) (Sizes: 0805, 1206, 1506, 2010, 2512)		
Molded	SMR1D SMR3D	<ul style="list-style-type: none"> Resistance range: 5 Ω to 80 kΩ Long-term stability under 0.1 Watt: ± 0.005 % over 2,000 hours at $+70$ $^{\circ}$C Thermal shock: 0.005% typical Shelf life stability: 25 ppm Moisture resistance: 0.01 % Resistance to soldering heat ± 0.01 % typical 	<ul style="list-style-type: none"> Shielded construction Proven reliability and advanced level of stability Small size Excellent stability under different environmental conditions
Power Current Sensing	CSM2512 CSM3637	 <ul style="list-style-type: none"> Resistance range: 2 mΩ to 200 mΩ TCR: 0\pm15 ppm/$^{\circ}$C Tolerance: ± 0.1 % Rated power: to 3 Watt 4-terminal (Kelvin) connections 	<ul style="list-style-type: none"> 4-terminal connections reduce terminal resistance effect Small size Tight tolerance
	VCS2516Z (Z-Foil) VCS2516	 <ul style="list-style-type: none"> Low TCR of ± 0.2 ppm/$^{\circ}$C (MIL range) typical PCR (power coefficient): 5 ppm/$^{\circ}$C typical at rated power for Z-Foil resistors Load-life stability under 1 Watt: 0.05 % over 2,000 hours at $+70$ $^{\circ}$C Resistance range: 0.01 Ω to 2 Ω Tolerance: to ± 0.1 % 	<ul style="list-style-type: none"> High-precision, low-ohmic-value resistors with 4-terminal connections Z-Foil provides a very low TCR and PCR over wide temperature range 4-terminal connections reduce terminal resistance effect
Voltage Dividers & Networks	VFCD1505 (Z-Foil) DSM SMN	<ul style="list-style-type: none"> Any ratio of values between 100 Ω to 20 kΩ TCR of ± 0.2 ppm/$^{\circ}$C (MIL range) typical for Z-Foil resistors TCR tracking: 0.1 ppm/$^{\circ}$C typical Ratio tolerance: 0.01 % Integrated construction – real estate saving 	<ul style="list-style-type: none"> Small size Nearly zero TCR tracking <p>DSM / VFCD: </p> <p>SMN: </p>
Hermetic Networks (PRND)	VSM40, 42, 45, 46 VSM85-89	<ul style="list-style-type: none"> TCR tracking: 0.5 ppm/$^{\circ}$C Shelf life stability: 2 ppm typical Load-life stability over 1,000 hours: $\Delta R=0.01$ % $\Delta R_{Ratio}=0.005$ % Ratio tolerance: 0.005 % Moisture resistance: $\Delta R=0.003$ % $\Delta R_{Ratio}=0.003$ % typical No set-up charges 	<ul style="list-style-type: none"> Proven reliability and advanced level of long-term stability Small package for multiple resistors Provides superior environmental protection and moisture resistance



	Series/Part Number	Features	Benefits	
Through-Hole				
	Molded	Z201 (Z-Foil) S Series S102 IPT (Improved Performance Testing)	<ul style="list-style-type: none"> Nearly zero TCR of ± 0.2 ppm/$^{\circ}\text{C}$ (MIL range) typical PCR (power coefficient): 5 ppm typical at rated power Load-life stability under power: 0.005 % after 2,000 hours at $+125$ $^{\circ}\text{C}$ 0.015 % after 10,000 hours at $+125$ $^{\circ}\text{C}$ 	<ul style="list-style-type: none"> Excellent stability and reliability under broad range of environmental conditions Tight tolerance to ± 0.005 %
Power Current Sensing	Molded	VFP4Z, VCS332Z, VPR221Z, VPR220Z, VCS232Z* (Z-Foil)	<ul style="list-style-type: none"> Resistance range: 0.25 Ω to 10 kΩ Tolerance: ± 0.01 % TCR: ± 0.2 ppm/$^{\circ}\text{C}$ (MIL range) typical PCR: 4 ppm/Watt typical 4-terminal connections Power rating: up to 10 Watt on heat sink 	<ul style="list-style-type: none"> High stability and high reliability under harsh environment conditions 
	Hermetic	VPR247Z, VHP4Z, VHP3Z (Z-Foil)		
	Molded	VFP3, VFP4, VPR220 VPR221, VCS3XX, VCS2XX*	<ul style="list-style-type: none"> Resistance range: 0.25 Ω to 80 kΩ Tolerance: ± 0.01 % TCR: ± 2 ppm/$^{\circ}\text{C}$ (MIL range) typical 4-terminal connections Power rating: up to 10 Watt on heat sink 	<ul style="list-style-type: none"> Low ohmic values High power ratings 
	Hermetic	VPR247, VHP3, VHP4		
Voltage Divider	Molded	300144 300145	<ul style="list-style-type: none"> Any ratio of values between 100 Ω to 20 kΩ TCR tracking: 0.5 ppm/$^{\circ}\text{C}$ Ratio tolerance: 0.005 % Load life stability under 0.05 Watt over 2,000 hours at $+25$ $^{\circ}\text{C}$ $\Delta R = 0.002$ % $\Delta \text{Ratio} = 0.001$ % typical 	<ul style="list-style-type: none"> Nearly zero TCR tracking Provides superior environmental protection and moisture resistance (hermetic packages) 
	Hermetic	VHD200 VHD144	<ul style="list-style-type: none"> Any ratio of values between 100 Ω to 20 kΩ Shelf life stability ratio: 2 ppm typical Ratio tolerance: 0.001 % TCR tracking: 0.1 ppm/$^{\circ}\text{C}$ typical Load life stability ratio under 0.1 Watt over 2,000 hours at 80 $^{\circ}\text{C}$: 0.001 % 	
Hermetic Sealed Networks		1442, 1445, 1446, 1457, 1460	<ul style="list-style-type: none"> TCR tracking: 0.5 ppm/$^{\circ}\text{C}$ Ratio tolerance: 0.005 % Shelf life stability: 2 ppm typical Moisture resistance: $\Delta R = 0.003$ % $\Delta \text{Ratio} = 0.003$ % typical 	<ul style="list-style-type: none"> Mechanically robust Excellent stability Custom designs
		VHAXXX VHP202 H-Series, Oil-Filled Hermetically Sealed Ultra Precision	<ul style="list-style-type: none"> Resistance range: 5 Ω to 1M84 Tolerance: to ± 0.001 % TCR: ± 2 ppm/$^{\circ}\text{C}$ (MIL range) typical Shelf life stability: 2 ppm typical 	
Hermetic Ultra-Precision Resistor with Almost Zero TCR	VHP100, 101, 102, 103	<ul style="list-style-type: none"> Resistance range: 100Ω to 150KΩ Tolerance: 0.005 % TCR of ± 0.3 ppm/$^{\circ}\text{C}$ (15 $^{\circ}\text{C}$ to 45 $^{\circ}\text{C}$, 25$^{\circ}\text{C}$ Ref) ± 0.6 ppm/$^{\circ}\text{C}$ (-55 $^{\circ}\text{C}$ to $+125$ $^{\circ}\text{C}$, $+25$ $^{\circ}\text{C}$ Ref) Shelf life stability: 2 ppm typical 	<ul style="list-style-type: none"> No humidity effect, hermetically sealed against moisture 	

* Conformally coated



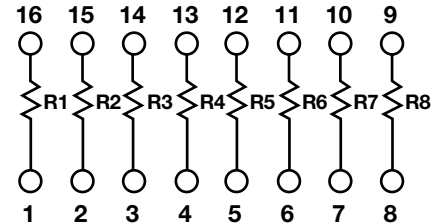
Examples of Medical Equipment Projects

Example 1. End Product: Cardiac Mapping System

Real time display of heart electrical activity

Customer Schematic / Specifications:

- Ohmic value: 10K each
- Absolute tolerance: 0.005 %
- Ratio tolerance: 0.005 % between R1 to R4, and R5 to R8
- Absolute TCR (Temperature Coefficient of Resistance): 2 ppm/°C typical
- TCR tracking: 0.5 ppm/°C between R1 to R4, and R5 to R8



Customer Requirements:

- High ratio stability under working conditions
- Surface mount device



Foil Solution: VSM46

- Hermetically sealed high precision network – 16 terminals gull wing configuration.

The Solution:

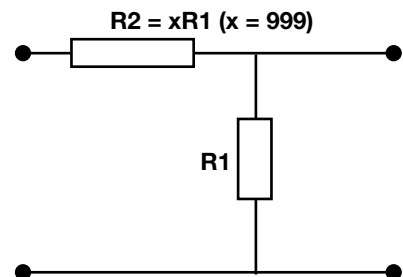
- Offers the best combination of tracking under power temperature during time of service life. The common behaviour of all resistors mounted into the same hermetic package contributes to maintain the excellent load life and ratio stability.
- Saves mounting time and real estate on PCB instead of using discrete resistors.

Example 2. End Product: Tomography

Control of magnetic field activity

Customer Schematic / Specifications:

- Ultra precision attenuator with very high ohmic value ratio: 1:1000
- $R1 < 25 \Omega$
- $R2: 999 \times R1$
- Ratio definition: $R1$ to $(R1 + R2)$
- Initial attenuation accuracy: 0.003 %
- Total attenuation of ratio:
(TCR + Shift Under Load): 0.005 % after 2000 hrs





Foil Solution: VHA512 style – 4 terminals using Z foil technology

- Hermetically sealed oil filled network – custom design

The Solution:

- High ratio stability: 0.005 % under working conditions and ambient temperature variations
- Extremely low absolute TCR of 0.2 ppm/°C
- Non-measurable shelf life drifts

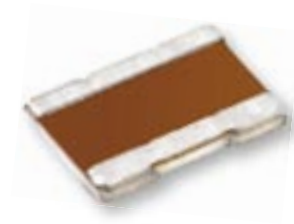


Example 3. End Product: Miniature Sensors

With 3D medical imaging for a precise diagnostics and surgery

Customer Schematic / Specifications:

- Ultra precision current sensor
- Ohmic value: 0R2
- Absolute tolerance: 0.1 %
- Absolute TCR: 4 ppm/°C within +30 °C to +50 °C
- Working power: 0.05 W



Customer Requirements:

- Extremely tight TCR
- Very low PCR (Power Coefficient of Resistance)
- Low total error budget
- Tight absolute tolerance
- Surface mount device

Foil Solution: VCS2516Z

- Ultra precision surface mount current sensing chip resistor – 4 terminals

The Solution:

A small surface mount device with:

- Extremely low TCR: 0.2 ppm/°C - typical
- Very low PCR: 5 ppm at rated power
- Tight tolerance: 0.1 %

SEMICONDUCTORS:

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