VPG Foil Resistors

VFR · ALPHA ELEC. · POWERTRON · APR

Consistent Precision & Reliability

High-Precision Current Sense Resistors

Measuring current flow is essential for managing system performance

Circuit designers and system operators need to know the magnitude of current flowing through a circuit – whether to maximize operating performance, to prevent component and system damage, or to allow proper control and feedback of the numerous sensors and actuators in modern applications.

Current sense resistors offer a cost-effective, yet highly precise solution to measure current flow, allowing improved system efficiency of power supply or battery management applications, while avoiding current conditions potentially causing component damage.

According to Ohm's law, V = I*R, the voltage drop measured across a resistor is proportional to the current flowing through the resistor. With the known value of resistance (R), the voltage drop sensed across the resistor directly indicates the intensity of the current flowing through it.

By mastering the simple principle of a current sensing resistor, circuit designers are offered the most precise current measurement method available

With many decades of resistor manufacturing experience, VPG Foil Resistors offers multiple current sense material technologies: Precision Foil, Bulk Metal Foil®, Thin Film, and Metal Strip, all with the purpose of providing -

Consistent Precision & Reliability.

Sensing the Future of Electronics

Current sense resistors are an integral part of any new technological innovation and trending markets, including equipment for

Telecommunications

5G, data centers and fiber optics, IoT, IIoT

Automotive

Hybrid and Electronic Vehicles battery management (charging, surge protection), drive-by-wire, autonomous driving, automotive test equipment

Energy

Smart grid and renewable energy meters, current converters, energy storage

Industrial

Semiconductor testing, motor drives control, Electronic beam applications, automatic test equipment, precision instrumentation

Medical

Precision measurement and dosing, defibrillator, implants, MRT, UPS, monitoring devices

AMS

Gyro navigation controls, sonar, high-power pulse radio transmitter

Available features

- Four terminal 'Kelvin' configuration as standard, 2-terminal configuration where beneficial
- Networks
- SMD, Power Shunt, Lead Wire constructions
- Hermetically sealed
- RoHS compliant and tin/lead components available
- AEC-Q200 compliant components available
- Sulfur resistant
- Suitable for most types of soldering processes
- Electron beam welded shunts

How to select the best product for your needs

Our Application Engineers are happy to support you with the selection of the best matching product. To facilitate, please provide the following information to foil@vpgsensors.com

- Resistance value
- Tolerance
- Maximum Power/Current/Voltage
- Temperature range
- End Application
- Demand for increased stability using Post Manufacturing Operations (PMO)

Customization options

- Size and type of package, heatsink, mounting method
- Performance specifications
- Matched sets
- In-Process and Post Manufacturing Operations (PMO) tests

What Makes a Difference

Power current-sensing resistors require a **low absolute TCR** to meet today's demand for new and stable resistive products. High absolute TCR response to both ambient temperature and self-heating feeds erroneous signals into the system.

A **Kelvin connection** avoids unwanted influences of lead resistance and lead sensitivity to temperature.

Low resistance values reduce the self-heating (Joule effect), while minimizing the stresses long-term resistance changes cause.

High stability and **fast thermal stabilization** time when the power changes is important for high quality current sense resistors.

Power coefficient of resistance (PCR) reflects the stability (as indicated by change in ohmic value) of a resistor under various levels of power applied at a fixed ambient temperature and depends on two parameters: the rated power (or power rating) and the thermal resistance of the resistor.

The lower the resistance change of a current sense resistor, the less sensitive it is for instabilities under **Rated Power**. The challenge is to have a very stable & reliable current sense resistor.

Thermal EMF (electro-motive force, or voltage) may become a significant offset voltage error or instability for low-value DC applications, caused by the dissimilarity of the materials used in the resistor construction, especially at the junctions of the element and the lead materials (Seebeck effect).

Handling of thermal stress of all kind is essential. Avoiding hot spots in the resistive elements represents a fundamental advantage as increasing performance and reliability.

Current sense resistors and power shunts from VPG Foil Resistors are able to minimize this effect and provide high performances, on all levels of our portfolio and independent of the resistor technology used. While the inherent advantages of our proprietary Bulk Metal® Foil technology takes us very close to the ideal resistor model, providing unparalleled performance in the market, VPG Foil Resistors can serve all other requirement levels as well, providing **a real one-stop-shop solution** to all current resistor needs.

Check our video library for performance demonstrations - Scan QR code below!

True 4-Terminal Kelvin Configuration

Four-terminal resistors enable current to be applied through two opposite leads and a sensing voltage to be measured across the other two leads. Such a "Kelvin" configuration* effectively eliminates the resistance and temperature coefficient of the leads hence no influence from the outside to the TCR of the resistor itself. The separation of current and voltage electrodes also eliminates the impedance contribution of the wiring and contact resistances. VPG Foil Resistors current sense resistors typically come with a true, physical 4-terminal Kelvin configuration as a standard, with very few exceptions due to very particular use scenarios of the individual component.

4-Pin Kelvin Resistor

R (I1-I2) > Rnominal
R (S1-S2) > Rnominal
R (I1-S1) ≠ 0 Ohm

* after William Thomson, Lord Kelvin who invented the Kelvin bridge in 1861

Non Hot-Spot Design

We are using chemical or mechanical trimming methods for our resistors, dependent on the best treatment of the production material. Unlike other manufacturers, VPG Foil Resistors applies the trimming always on the complete active surface of our components to avoid any cuts into the material. This assures a non hot-spot design, facilitating an even thermal dissipation all across the maximum available surface.

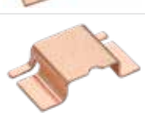
Trimming by standard laser cut (not used by VPG Foil Resistors)

Max. temperature 84.4°C

Trimming with VPG Foil Resistors technology

Max. temperature 43.7°C

SMD Current Sense Resistors

Product	Model	Description	Resistance Range	Best Tolerance	TCR (-55°C to +125°C, +25°C ref.) Typical	Rated Power at +70°C	Load Life Stability 2000 Hours, +70°C Under Power- Typical
	CSM2512	High-precision metal strip current sense resistors (4-terminal)	1 mΩ to 200 mΩ	±0.1%	±15 ppm/°C max	to 1 W	±0.2%
	CSM3637	High-precision metal strip current sense resistors (4-terminal)	1 mΩ to 200 mΩ	±0.1%	±15 ppm/°C max	to 3 W	±0.2%
	CSM2512F	High-precision Foil current sense resistor (4-terminal)	50 mΩ to 200 mΩ	±0.1%	±10 ppm/°C	to 1 W	±0.05%
	CSM3637F	High-precision Foil current sense resistor (4-terminal)	20 mΩ to 200 mΩ	±0.1%	±10 ppm/°C	to 3 W	±0.05%
	CSM3637P	High-precision, current sensing, metal strip resistor (4-terminal)	3 mΩ to 100 mΩ	±0.1%	±15 ppm/°C	to 5 W	±0.2%
	CSM3637PY	High-precision, current sensing, power surface-mount, low profile, metal strip resistor (4-terminal)	20 mΩ to 100 mΩ	±0.1%	±15 ppm/°C	to 4 W	±0.6%
	CSM2512A	Metal Strip current sense SMD resistor	0.2 mΩ - 5 mΩ	±1%	to ±70 ppm/C	to 6 W	±0.5%
	CSM2726Y	Metal Strip current sense SMD resistor	0.5 mΩ - 3 mΩ	±1%	to ±40 ppm/C	5 W	±0.5%
	CSM2817	Metal Strip current sense SMD resistor	1m Ω to 100 mΩ	±0.1%	to ±15 ppm/C	5 W	±0.5%
	CSM3920A	Metal Strip current sense SMD resistor	0.2 mΩ - 4 mΩ	±1%	to ±50 ppm/C	to 12 W	±0.5%
	CSM4026Y	Metal Strip current sense SMD resistor	0.3 mΩ - 3 mΩ	±1%	to ±40 ppm/C	5 W	±0.5%
	CSM5930A	Metal Strip current sense SMD resistor	0.1 mΩ - 3 mΩ	±1%	to ±50 ppm/C	to 15 W	±0.5%

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	VCS1610	High-precision, current sensing foil chip resistor (4-terminal)	0.1 Ω to 10 Ω	±0.5%	±10 ppm/°C	0.25 W	±0.02%
	VCS1610Z	High-precision, current sensing Z-foil chip resistor (4-terminal)	0.3 Ω to 10 Ω	±0.5%	±5 ppm/°C	0.25 W	±0.015%
	VCS1625	High-precision, current sensing foil resistor (4-terminal)	0.01 Ω to 10 Ω	±0.1%	±2 ppm/°C	0.5 W	±0.02%
	VCS1625P	High-precision, Foil surface mount current sensing foil resistor (4-terminal) for high power	0.01 Ω to 10 Ω	±0.2%	±2 ppm/°C	1 W	±0.015%
	VCS1625Z (Z-Foil)	High-precision, current sensing Z foil resistor (4-terminal)	0.3 Ω to 10 Ω	±0.2%	±0.2 ppm/°C	0.5 W	±0.015%
	VCS1625ZP	High-precision, Foil surface mount current sensing Z foil resistor (4-terminal) for high power	0.3 Ω to 10 Ω	±0.2%	±0.2 ppm/°C	1 W	±0.015%
	VPR221S	High-precision, high power, current sensing foil surface mount resistor in TO-220 package	0.5 Ω to 500 Ω	±0.01%	±2 ppm/°C	8 W, on heat sink 1.5 W in free air	±0.05%
	VPR221SZ (Z Foil)	High-precision, high power, current sensing Z foil surface mount resistor in TO-220 package	0.5 Ω to 500 Ω	±0.01%	±0.2 ppm/°C	8 W, on heat sink 1.5 W in free air	±0.005%
	FPS 2-T220	Precision Power Shunt resistor 2 - terminals	0.002 Ω to 10 Ω	±0.5%	±50 ppm/°C	15 W, on heat sink 1.5 W in free air	±0.1% 1000hrs
	FPS 4-T220	Precision Power Shunt resistor 4 - terminals	0.002 Ω to 10 Ω	±0.1%	±30 ppm/°C	15 W, on heat sink 1.5 W in free air	±0.1% 1000hrs
	SPS 4-T220	Precision Power Shunt resistor 4 - terminals	0.005 Ω to 10 Ω	±0.1%	±5 ppm/°C	15 W, on heat sink 1.5 W in free air	±0.1% 1000hrs
	USS 4-T220	High precision power current sense resisto 4-terminals	0.2 Ω to 80 Ω	±0.01%	±3 ppm/°C	10 W, on heat sink 1.5 W in free air	±0.01% 1000hrs

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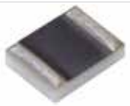
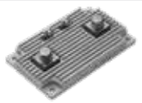
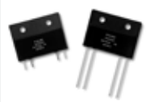
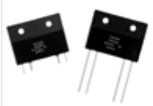
Product	Model	Description	Resistance Range	Best Tolerance	TCR (-55°C to +125°C, +25°C ref.) Typical	Rated Power at +70°C	Load Life Stability 2000 Hours, +70°C Under Power- Typical
	**RBF**	High-precision Foil current sense resistor (Flip Chip 2-terminal)	0.01 Ω to 1 Ω	±0.5%	±10 ppm/°C	1 W	±0.05%
	**RBD**	High-precision Foil current sense resistor (Flip Chip 2-terminal)	0.01 Ω to 1 Ω	±0.5%	±10 ppm/°C	0.5 W	±0.05%
	**FNP Series**	High Power Precision Shunt Resistor, Up to 500W	0.001 Ω to 10 Ω	±0.05%	±5 ppm/°C	500 W, on heat sink	±0.2%
	**PSB Series**	Ultra Precision Shunt Resistor, Up to 40W	0.001 Ω to 10 Ω	±0.1%	±5 ppm/°C	40 W, on heat sink 12 W in free air, at +25°C	±0.05%
	**SNR 4-T227**	Precision power shunt resistor 4-terminals	0.002 Ω to 50 Ω	±0.1%	±2 ppm/°C (20°C to +60°C)	80 W	±0.1% 1000hrs
	**FHS 4-4618**	Precision power shunt resistor 4-terminals	0.001 Ω to 100 Ω	±0.1%	±25 ppm/°C (20°C to +60°C)	50 W, on heat sink 3 W in free air	±0.1% 1000hrs
	**FNR 2-T227**	Precision power shunt resistor 2-terminals	0.001 Ω to 100 Ω	±0.1%	±50 ppm/°C (20°C to +60°C)	80 W	±0.1% 1000hrs
	**FNR 4-T227**	Precision power shunt resistor 4-terminals	0.001 Ω to 50 Ω	±0.1%	±25 ppm/°C (20°C to +60°C)	80 W	±0.1% 1000hrs
	**FPR 2-T227**	Precision power shunt resistor 2-terminals	0.001 Ω to 100 Ω	±0.1%	±50 ppm/°C (20°C to +60°C)	60 W	±0.1% 1000hrs
	**FPR 4-T227**	Precision power shunt resistor 4-terminals	0.001 Ω to 50 Ω	±0.1%	±25 ppm/°C (20°C to +60°C)	60 W	±0.1% 1000hrs
	**KHN 2-T227**	Power shunt resistor 2-terminals	0.05 Ω to 5 MΩ	±1%	±100 ppm/°C (20°C to +60°C)	350 W	±1% 1000hrs
	**KHR 4-T227**	Power shunt resistor 4-terminals	0.05 Ω to 5 MΩ	±1%	±100 ppm/°C (20°C to +60°C)	200 W	±1% 1000hrs

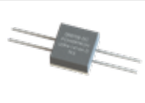
Leaded Current Sense Resistors

Product	Model	Description	Resistance Range	Best Tolerance	TCR (-55° to +125°C, 25°C ref.) Typical	Rated Power at +25°C	Load Life Stability 2000 Hours, +25°C at rated power - Typical
	**VCS232**	High -precision power current sense resistor, conformally coated (4-terminal)	0.2 Ω to 500 Ω	±0.02%	±2 ppm/°C	2 W, free air	±0.01%
	**VCS232Z**	High -precision power current sense Z Foil resistor (4-terminal)	0.25 Ω to 500 Ω	±0.02%	±0.2 ppm/°C	2 W, free air	±0.005%
	**VCS301 VCS302**	High-precision, high power, current sensing resistors (4-terminal)	5 mΩ to 250 mΩ	±0.5%	±3 ppm/°C	10 W, on heat sink 3 W in free air	±0.02%
	**VCS331 VCS332**	High-precision, high power, current sensing foil resistors (4-terminal)	0.25 Ω to 500 Ω	±0.1%	±1 ppm/°C (0°C to +60°C)	10 W, on heat sink 3 W in free air	±0.01%
	**VCS331Z VCS332Z**	High-precision, high power, current sensing Z foil resistors (4-terminal)	0.25 Ω to 500 Ω	±0.01%	±0.2 ppm/°C	10 W, on heat sink 3 W in free air	±0.005% on heat sink
	**CSNG**	Ultra High-precision, high power, Z Foil customized current sense resistors	>6 mΩ to 500 Ω	±0.01%	±0.2 ppm/°C (0°C to +60°C)	20 W, free air	±0.005%
	**VPR247**	Hermetically-sealed and molded power high-precision current sensing foil resistors (4-terminal)	0.05 Ω to 500 Ω	±0.01%	±2 ppm/°C	10 W, on heat sink 3 W in free air	±0.01%
	**VPR247Z**	Hermetically-sealed and molded power high-precision current sensing Z foil resistors (4-terminal)	0.25 Ω to 500 Ω	±0.01%	± 0.2 ppm/°C	3 W, free air 10 W, heat sink"	±0.005% on heat sink
	**VPR221**	High-precision, high power, current sensing foil resistor in TO-220 package (4-terminal)	0.5 Ω to 500 Ω	±0.01%	±2 ppm/°C	8 W, on heat sink 1.5 W in free air	±0.05%
	**VPR221Z (Z Foil)**	High-precision, high power, current sensing Z foil resistor in TO-220 package (4-terminal)	0.5 Ω to 500 Ω	±0.01%	±0.2 ppm/°C	8 W, on heat sink 1.5 W in free air	±0.005%

Leaded Current Sense Resistors

Product	Model	Description	Resistance Range	Best Tolerance	TCR (-55° to +125°C, 25°C ref.) Typical	Rated Power at +25°C	Load Life Stability 2000 Hours, +25°C at rated power - Typical
	UNR 4-3425	High precision power current sense resistor 4-terminals	0.05 Ω to 650 Ω	±0.01%	±3 ppm/°C	50 W	±0.01% 1000hrs
	UNR 4-4020	High precision power current sense resistor 4-terminals	0.05 Ω to 100 Ω	±0.01%	±3 ppm/°C	50 W, on heat sink 2.5 W in free air	±0.01% 1000hrs
	USR 4-3425	High precision power current sense resistor 4-terminals	0.05 Ω to 650 Ω	±0.01%	±3 ppm/°C	30 W	±0.01% 1000hrs
	USR 4-4020	High precision power current sense resistor 4-terminals	0.05 Ω to 100 Ω	±0.01%	±3 ppm/°C	30 W, on heat sink 2.5 W in free air	±0.01% 1000hrs
	FHR 4-2321	Precision power shunt resistor 4-terminals	0.001 Ω to 50 Ω	±0.1%	±15 ppm/°C (20°C to +60°C)	40 W, on heat sink 3 W in free air	±0.1% 1000hrs
	FPR 2-T218	Precision power shunt resistor 2-terminals	0.002 Ω to 50 Ω	±0.25%	±50 ppm/°C (20°C to +60°C)	30 W, on heat sink 3 W in free air	±0.1% 1000hrs
	SHR 4-2321	Precision power shunt resistor 4-terminals	0.001 Ω to 0.005 Ω	±0.1%	±2 ppm/°C (20°C to +60°C)	40 W, on heat sink 3 W in free air	±0.1% 1000hrs
	UNR/USR 4-1410	High precision power current sense resistor 4-terminals	0.1 Ω to 100 Ω	±0.01%	±3 ppm/°C	0.8 W	±0.01% 1000hrs
	FPR 2-T220/ T221	Precision power shunt resistor 2-terminals	0.002 Ω to 10 Ω	±0.5%	±50 ppm/°C (20°C to +60°C)	15 W, on heat sink 1.5 W in free air	±0.1% 1000hrs
	FPR 4-T220/ T221	Precision power shunt resistor 4-terminals	0.002 Ω to 10 Ω	±0.1%	±25 ppm/°C (20°C to +60°C)	15 W, on heat sink 1.5 W in free air	±0.1% 1000hrs
	SPR 4-T220	Precision power shunt resistor 4-terminals	0.005 Ω to 10 Ω	±0.1%	±2 ppm/°C (20°C to +60°C)	15 W, on heat sink 1.5 W in free air	±0.1% 1000hrs
	UNR 4-T220B	High precision power current sense resistor 4-terminals	0.2 Ω to 80 Ω	±0.01%	±3 ppm/°C	15 W, on heat sink 1.5 W in free air	±0.01% 1000hrs

Leaded Current Sense Resistors

Product	Model	Description	Resistance Range	Best Tolerance	TCR (-55° to +125°C, 25°C ref.) Typical	Rated Power at +25°C	Load Life Stability 2000 Hours, +25°C at rated power - Typical
	USR 4-T220B	High precision power current sense resistor 4-terminals	0.2 Ω to 80 Ω	±0.01%	±3 ppm/°C	10 W, on heat sink 1.5 W in free air	±0.01% 1000hrs
	FHR 4-3825/4618	Precision power shunt resistor 4-terminals	0.001 Ω to 100 Ω	±0.1%	±10 ppm/°C (20°C to +60°C)	50 W, on heat sink 3 W in free air	±0.1% 1000hrs
	FPN Network	Precision shunt network resistors	0.001 Ω to 90 Ω	±0.1%	±25 ppm/°C (20°C to +60°C)	2 W	±0.1% 1000hrs
	FPR 2-2614	Precision shunt resistor 2-terminals	0.01 Ω to 100 Ω	±0.1%	±50 ppm/°C (20°C to +60°C)	2 W	±0.1% 1000hrs
	FPR 4-3316	Precision shunt resistor 4-terminals	0.001 Ω to 50 Ω	±0.1%	±25 ppm/°C (20°C to +60°C)	2 W	±0.1% 1000hrs
	PCS 302	Precision power current sense resistor 4-terminals	0.001 Ω to 10 Ω	±0.1%	±3 ppm/°C (0°C to +60°C)	30 W, on heat sink 3 W in free air	±0.1% 1000hrs
	SHN Networks	Precision shunt network resistors	0.001 Ω to 90 Ω	±0.1%	±2 ppm/°C (20°C to +60°C)	20 W, on heat sink 2 W in free air	±0.1% 1000hrs
	SHR 4-3825/4618	Precision power shunt resistor 4-terminals	0.005 Ω to 50 Ω	±0.1%	±2 ppm/°C (20°C to +60°C)	50 W, on heat sink 3 W in free air	±0.1% 1000hrs
	SPN Networks	Precision shunt network resistors	0.001 Ω to 90 Ω	±0.1%	±2 ppm/°C (20°C to +60°C)	2 W	±0.1% 1000hrs
	SPR 4-3316	Precision shunt resistor 4-terminals	0.005 Ω to 50 Ω	±0.1%	±2 ppm/°C (20°C to +60°C)	2 W	±0.1% 1000hrs
	USR 4-1414	High precision power current sense resistor 4-terminals	0.5 Ω to 100 Ω	±0.01%	±3 ppm/°C	25 W, on heat sink 0.8 W in free air	±0.01% 1000hrs
	MSR Series	Bare Metal Element Current Sense through-hole Resistors	0.005 Ω to 0.1 Ω	±1%	±20 ppm/C	to 5 W	-

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Contact us at foil@vpgsensors.com | vpgfoilresistors.com

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