

PRECISION DC CURRENT SHUNT STANDARDS

Excellent as a Precision Current Shunt or Standard Resistor



9230A SERIES FEATURES

- ◆ Extremely Low Self-Heating Effects
- ◆ Low Temperature Coefficients
- ◆ Low Thermal EMF's
- ◆ Wide Dynamic Range
- ◆ Controlled Current Distribution Through The Element
- ◆ < 10 ppm Long Term Stability
- ◆ Air or Oil Cooled Applications
- ◆ 3 New Values, 3000 A, 5000 A and 10,000 Ampere!
- ◆ Series Ranges from 10A to 10,000A
- ◆ 3 Point Current Calibration Standard
- ◆ Special Values Available On Request
- ◆ Forced Convection Option Available Improves Power Dissipation

GUILDLINE INSTRUMENTS 9230A SERIES of precision DC current shunts / standards are true 4-terminal devices intended for the precise measurement of DC current. They are constructed from specially selected elements supported on an insulating base for mechanical stability. The 9230A shunts have a perforated metal cover to allow adequate cooling while providing physical protection for the elements and safety for the technician using the shunt. The design of the 9230A includes special features to reduce the effects of power dissipation and associated self heating errors. These shunts are designed to operate in air at full rated current.

The type of material selected for the elements has a very low temperature coefficient and the size and number of elements chosen give the optimum surface area to dissipate the power in air at the specified full scale current for a particular value. The performance of the 9230A shunts can be dramatically improved by operating them in a temperature controlled environment or immersing them in a stirred oil bath where power dissipation levels are less than 10 watts.

The terminations of the shunts are selected to give low thermal emf potentials, and to ensure that the current applied is distributed in a consistent manner.

The 9230A Series of Precision DC Current Shunts are true 4-terminal devices capable of the most demanding measurements of DC current.

The care and attention to the design of the 9230A's has produced a series of shunts with a very wide dynamic range, virtually from zero to full rated current. The 9230A shunts are also heat treated for excellent long term stability. Operated below 30 % of rated current, and maintained in a constant temperature air or oil bath, the 9230A's stability enables it to be used as a standard reference resistor.

Special values in the range of 1 ohm down to 1 $\mu\Omega$ are available on request (maximum resistance/current must be less than 125 watt at full scale current).

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An optional 92310 Forced Air Convection Unit, complete with power supply, is available to allow operation at up to full rated current levels with highly improved repeatability and power coefficient performance in comparison to operation in ambient air. The 92310 is recommended for use with currents above 1/2 of the full rated value of the unit. For currents below 1/2 of full rated current, the Shunt can be used at in ambient air with no additional requirements for use.

The 92310 Forced Air Convection Unit is designed to fit all models of the 9230A Current Shunts. The 9230A-15R is the direct replacement for the older version model 9230/15 shunt for performance and is rated only for a maximum of 25 watts. The 92310 is not designed for use with the older 9230 shunt series.

Three Guildline designs are employed through the range of our shunts. For models requiring 150 Amperes of current and less, specialized wire with a custom alloy is used as shown to the right. Our best selling model falls into this range, the 9230A-30 model. This model has the same ohmic value as the older series 9230/15 but can



9230A-15

handle twice the current (up to 30 A with the optional 92310 Forced Air Convection Unit)! The 9230A-30 standard provides better performance than the 9230/15 and is an excellent replacement providing the same voltage outputs as called out in many established procedures developed by Agilent, Ametek, Tektronix and other leading Power Supply manufacturer's.



9230A-300

For models 300 A to 500 A, Guildline utilizes a higher power copper current input terminal, with a single current terminal connection. The number one selling model in this design is our 9230A-300.

For models from 1000 A to 10,000 Amperes, a new Guildline design is employed. This design incorporates plates made of a custom alloy with specially designed current connections providing the best in specifications and stabilities. Available now are three NEW models for precision High Current measurements. The Model 9230A- 3000 with a $10 \mu\Omega$ resistance value is designed for currents up to 1500 A with natural air convection and up to 3000 A with the 92310. The Model 9230A – 5000 has a resistance value of $5 \mu\Omega$ and can handle currents to 2500 A with natural air convection and up to 5000 A with the 92310 Forced Air Convection Unit. The Model 9230A-10,000 has a resistance value of $1 \mu\Omega$ and can handle currents to 5,000 A in ambient air or up to a full 10,000 amperes with the model 92310. No other manufacturer can provide these levels of accuracy for currents of this magnitude.

These shunts are the result of over 55 years of Guildline research and design in building precision shunts and incorporate many unique design features. Voltage terminals are provided at the top for easy access. Round current connections are provided on each model to allow for symmetric cable connections regardless of the number of cables used, and to provide a consistent contact surface area for cable connections. Many other Guildline proprietary features go into this shunt giving it the best high current measurement capabilities ever provided for these values.



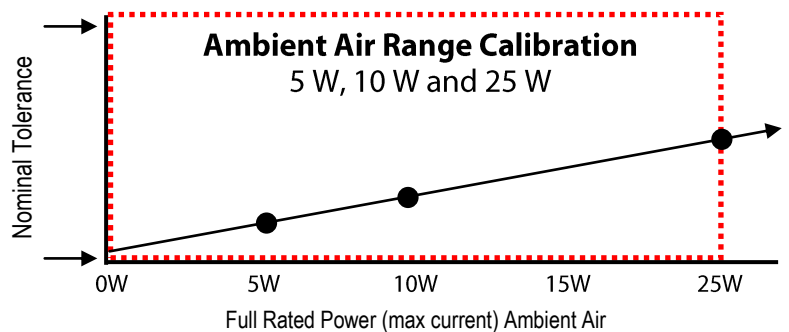
9230A-3000

9230A SERIES OF PRECISION DC CURRENT SHUNT STANDARDS

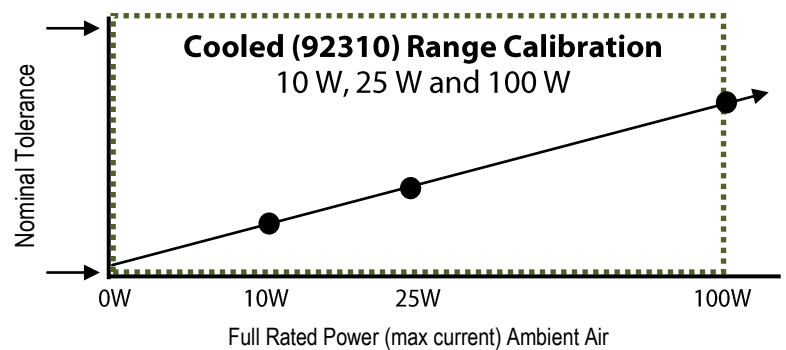
All shunts have a power coefficient which may be positive or negative so that as the current is increased the resistance value will shift. It does not matter whose shunts you have, the resistance will change with power. The 9230A Series are designed so that for values less than 1000 A, the resistance change will be near linear across the full scale rated current range and only a small change in this linearity affect above 25 W dissipation levels. The design includes proprietary adjustment methods for power coefficients as well as for temperature coefficients. These are the only shunts that are designed and manufactured today that produce this linear characteristic as well as excellent power and temperature coefficients. For 9230A values greater than 1000 A, the slope of the resistance / power curve is much less than any other commercially available shunts. For the 9230A series, this amount of change will not exceed the Nominal Tolerance Stated Value. The nominal tolerance is the maximum delta (Δ) resistance from minimum current applied to full rated current.

The 9230A Series Full Rated Current Specifications are provided for calibration with either natural convection or with forced air cooling. Power coefficient uncertainties should be taken into account when calibration results are extrapolated above the calibrated test current values up to the full scale current capability of a specific shunt. All 9230A shunts are calibrated at 3 current levels designed to provide users with calibrated resistance values for different current levels. When used in either natural or forced air test conditions the shunt resistance value will not change by more than the nominal tolerance value over the entire full rated current range.

Ambient Air - when used in ambient air, (natural air convection) full rated current is considered a nominal 25 W but will vary for specific shunt values from 22.5 up to 31.5 W. Shunts used in ambient air will be calibrated at nominal 5 W, 10 W and the specified full scale current unless otherwise requested.



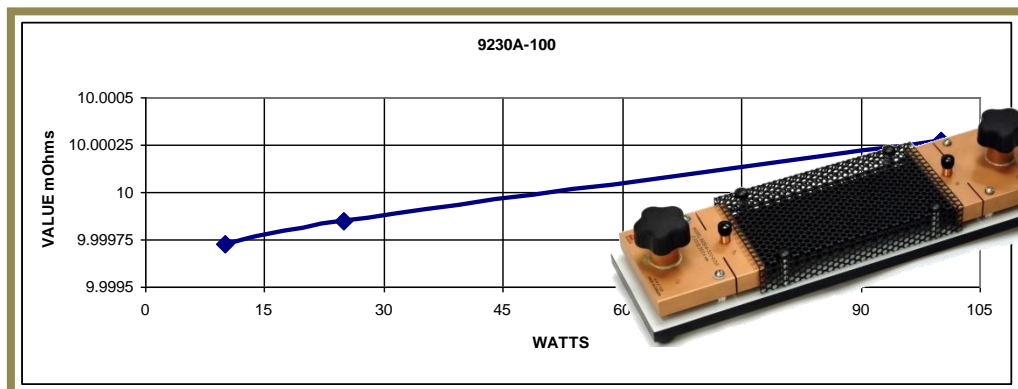
Cooled (92310 Option or Oil) - when the shunt is used with the 92310 option, (forced air convection) the shunt can be used up to a maximum nominal power dissipation level of 100 watts and will vary for specific shunt values from 90 W up to 125 W. The calibration points are nominal 10 W, 25 W and the specified full scale current for cooled operation. Additional or optional points can be specified for a nominal fee.



For optimal results, the time constant must be considered for both calibration and usage. The time constant is a typical specification and defined as the time for the resistance value to settle to within 10 parts in 10^6 of its final value for any change in applied current. Note that the time constant is typically less than 1 minute in a flowing oil bath. Measurement time is also dependent on the measurement device such as a 6622A Direct Current Comparator Bridge or Long Scale DMM.

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9230A DC Shunts are initially calibrated at three current points (up to maximum of 1000 A). ISO/IEC 17025 accredited calibrations are also available (maximum accredited current is 300 A). The standard calibration points for ambient air are: nominal 5 W, 10 W, and the specified full scale current. When calibrated with the 92310, the following standard calibration points are: nominal 10 W, 25 W and the specified full scale current. These power based points allow customers to graph the performance of their shunts. A report of calibration is provided stating measured values and uncertainties. Expanded Uncertainty is expressed as a total uncertainty with a coverage factor of $k = 2$ (level of confidence of 95 %). Calibration at 1 W level, or special points in air or flowing oil is available upon request.



The listed Stability specification applies if the Shunt is used as a Resistance Standard at a 1 W level or less. If the shunt is to be used above the 1 W level, then the shunt should be calibrated at this point for best calibration uncertainties. Power Coefficients only need to be considered when a 9230A shunt is used outside the calibrated range. For example, you have a shunt calibrated in ambient air and you need to make a measurement at 50 W. You can do this without the fan, but your power coefficient must be added to the total uncertainty. Hence in the above case, you would take 50 W (used) – 25 W (Last ambient calibration point) for a total of 25 W multiplied by the power coefficient. This value would be added to the Nominal tolerance. When used outside calibrated ranges, end users should account for changes in settling time as well.

12 Month Specifications

Model ¹	Nominal Resistance Value (Ω)	Initial Tolerance ² $\pm \mu\Omega/\Omega$ (ppm)	Full Rated Current (A) ³		Full Rated Current Accuracy ⁴ $\pm \mu\Omega/\Omega$ (ppm) @ 23 °C \pm 1 °C	Stability ⁵ $\pm \mu\Omega/\Omega$ (ppm)	Time Constant (Minutes) ⁶	
			AMBIENT AIR (22W TO 31 W)	W/COOLING (90W TO 125 W)			92310 Option	Ambient Air
9230A-10	1.0	100	5	10	100	10	3	6
9230A-15	0.5	100	7.5	15	100	10	3	6
9230A-15R ⁷	0.1	400	15	NA	400	10	3	6
9230A-30	0.1	100	15	30	100	10	3	6
9230A-50	0.05	100	25	50	100	10	3	6
9230A-100	0.01	100	50	100	100	10	4	8
9230A-150	0.005	100	75	150	100	10	4	8
9230A-300	0.001	100	150	300	100	10	8	16
9230A-500	0.5m	100	250	500	100	10	8	16
9230A-1000	0.1m	250	500	1000	250	25	15	30
9230A-1500	0.05m	250	750	1500	250	25	15	30
9230A-3000	10 μ	500	1500	3000	500	50	20	45
9230A-5000	5 μ	600	2500	5000	600	70	20	45
9230A-10,000	1 μ	1000	5000	10,000	1000	100	25	60

9230A SERIES OF PRECISION DC CURRENT SHUNT STANDARDS

12 Month Specifications (continued)

Model	Temperature Coefficient ⁸ ± μΩ/Ω (ppm)	Power Coefficient ⁹ (± μΩ/Ω (ppm))			Size (W x L x H)		Weight	
		92310 OPTION	AMBIENT AIR	FLOWING OIL	mm	inches	kg	lbs
9230A-10	4	2	8	0.5	114 x 356 x 85	4.5 x 14 x 3.4	1.4	3.1
9230A-15	4	2	8	0.5	114 x 356 x 85	4.5 x 14 x 3.4	1.4	3.1
9230A-15R	4	2	8	0.5	114 x 356 x 85	4.5 x 14 x 3.4	1.4	3.1
9230A-30	4	2	8	0.5	114 x 356 x 85	4.5 x 14 x 3.4	1.4	3.1
9230A-50	4	2	8	0.5	114 x 356 x 85	4.5 x 14 x 3.4	2.1	4.6
9230A-100	4	2	8	0.5	114 x 356 x 139	4.5 x 14 x 5.5	2.2	4.9
9230A-150	4	2	8	0.5	114 x 356 x 139	4.5 x 14 x 5.5	2.5	5.5
9230A-300	4	2	8	0.5	114 x 406 x 96	4.5 x 16x 3.8	5.0	11.2
9230A-500	4	3	10	0.8	114 x 406 x 96	4.5 x 16 x 3.8	5.8	12.9
9230A-1000	20	8	20	2	117 x 539 x 145	4.6 x 21.2 x 5.3	13.0	28.7
9230A-1500	25	10	30	3	117 x 530 x 145	4.6 x 17.2 x 5.3	12.8	28.1
9230A-3000	30	15	30	5	122 x 424 x 216	4.8 x 16.7 x 8.5	29.1	64
9230A-5000	30	20	35	8	122 x 399 x 216	4.8 x 15.7 x 8.5	30.9	68
9230A-10,000	35	25	40	10	226 x 338 x 216	8.9 x 13.3 x 8.5	40.9	90
92310 Option					121 x 242 x 69	4.75 x 9.5 x 2.7	1.0	2.2
Environmental	Operating: 10 °C to 40 °C <80 % RH non-condensing			Storage Operating: -30 °C to 70 °C <90 % RH non-condensing				

- Note 1:** Custom values (Customer specified) of nominal resistance from 1 μΩ to 1 Ω with maximum power to 100 Watts are available by special order.
- Note 2:** Defined as maximum variation of resistance value as initially adjusted at time of sale, temperature 23 °C ± 2 °C.
- Note 3:** Maximum current for natural air convection use without damage to the unit is the same as the maximum current when used with the 92310 forced convection unit.
- Note 4:** When used as a shunt, Full Rated Power is defined as 1/2 current level (approx 25W) for ambient air and full rated current level (approx 100W) for forced air-cooling or use in flowing oil
- Note 5:** When used as a standard resistor at 1 watt Level only.
- Note 6:** Typical specification defined as the time for the resistance value to settle to within 10 parts in 10⁶ of the final value for any change in applied current. The time constant is typically 1 minute for flowing oil.
- Note 7:** The 9230A-15R is the direct replacement for the 9230/15 version shunt. The 9230A-30 has the same resistance value as the 9230A-15R and can be used up to 30 A (with the 92310).
- Note 8:** Temperature Coefficient must be added to the uncertainty when working at temperatures outside 23 ° ± 2 °C.
- Note 9:** Power coefficient must be added to the uncertainty when used as a shunt above the calibrated range of currents.

Lead Sets - Guildline also produces the best High Current Leads to work with your 9230A Series Shunts. Incorporating a unique, high compression connection (i.e. up to 30,000 psi) that reduces thermal stability effects at the terminals, these leads are available in current ratings of 20 A, 30 A, 100 A, 150 A, 300 A, and 500 A currents. Standard lengths vary from 1 to 2 meters and Guildline can make them in any length and with many different terminations. Lead sets include a shielded low thermal twisted pair lead for the voltage measurement on the potential terminals.



9230A SERIES OF PRECISION DC CURRENT SHUNT STANDARDS

Guildline continues to manufacturer 9200, 9210, 9211B and 9711B Series of multi-tap shunts/resistance standards. Available models provide from 6 to 9 self-contained ranges with maximum currents up to 300 amperes. These shunts are a true 4 terminal shunt. The design optimizes a number of important factors such as the effects of self-heating, temperature coefficient, size, weight, ease of operation and total measuring range. They provide wide range precise current measuring capability when used with a potentiometer or digital voltmeter as a readout.



The shunt resistors are mounted in air to minimize size and weight, yet self heating is a negligible source of error from 20°C to 30°C.

Self-heating has only a small effect for a still wider range of ambient temperatures. The resistors are made of selected zeranin wire and are non-inductively wound, up to 1 ampere. The unit consists of nine (9) shunts, of the 4-terminal configuration.

AC Shunts - Need to have AC as well as DC performance! Our 7340 and 7350 Series of AC/DC Shunts are available in a variety of ohmic and current values and provide some of the lowest uncertainties found in any AC/DC Shunt. Housed in a ruggedized EMI case, these models provide a wide frequency bandwidth of up to 100 kHz and with currents to 100 A for the 7340 Series and 25 A for the 7350 Series. Adaptors and cables sets are also available for these models.



ORDERING INFORMATION

9230A-Model	DC Current Shunt (List Amperage Value For Model)
9230A-X	Customer Specified Value (State Amperage and Ohmic Value)
/TM9230A	Technical Manual included at no charge.
92310	Forced Air Convection Unit (fits all standard models)
92301/92304	20 A, 1 Meter/x Meter Lead set (Current and Sense Leads)
92318/92319	30 A, 1.5 Meter/x Meter Lead set (Current and Sense Leads)
92302/92305	100 A, 1 Meter/x Meter Lead set (Current and Sense Leads)
92321/92322	150 A, 1.5 Meter/x Meter Lead set (Current and Sense Leads)
92303/92306	300 A, 1 Meter/x Meter Lead set (Current and Sense Leads)
92307/92308	500 A, 1 Meter/x Meter Lead set (Current and Sense Leads)
92309/92311	1000 A, 2 Meter/x Meter Lead set (Current and Sense Leads)
92312/92313	2000 A, 2 Meter/x Meter Lead set (Current and Sense Leads)
92314/92315	3000 A, 2 Meter/x Meter Lead set (Current and Sense Leads)
92316/92317	5000 A, 2 Meter/x Meter Lead set (Current and Sense Leads)
92323/92324	10,000A, 2 Meter/x Meter Lead set (Current and Sense Leads)
Specify length x for special length cables – Please Contact Guildline	
Optional Calibration Services (ISO 17025 Service Available)	
/Temp	Additional Customer Specified Temp Cal Point (Charge)
/Current	Additional Customer Specified Current Point (Charge)

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