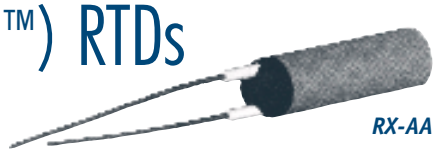
Ruthenium Oxide (Rox™) RTDs



RX-AA

PACKAGING OPTIONS AA, CB, BR

Ruthenium oxide temperature sensors are thick-film resistors used in applications involving magnetic fields. These composite sensors consist of bismuth ruthenate, ruthenium oxides, binders, and other compounds that allow them to obtain the necessary temperature and resistance characteristics. Each Lake Shore Rox™ model adheres to a single resistance versus temperature curve.

RX-102A

The RX-102A (1000 Ω at room temperature) is useful down to 50 mK and has better interchangeability than the RX-202A as well as low magnetic field-induced errors below 1 K.

RX-102B-CB *–10 mK calibrations coming soon!*

The RX-102B-CB (1000 Ω at room temperature) is useful down to 10 mK (calibrations available down to 20 mK) and monotonic from 10 mK to 300 K. The unique package design maximizes thermal connection and minimizes heat capacity at ultra low temperatures. The RX-102B-CB is not interchangeable to a standard curve and not recommended for use in magnetic fields.

RX-202A

The RX-202A (2000 Ω at room temperature) has a 4× improvement in magnetic field-induced errors over other commercially available ruthenium oxide temperature sensors with similar resistances and sensitivities. Most ruthenium oxide sensors have a maximum useful temperature limit well below room temperature, where the sensitivity changes from negative to positive. The RX-202A however, is designed to have a monotonic response from 0.05 K up to 300 K.

RX-103A

The RX-103A (10,000 Ω at room temperature) has a unique resistance and temperature response curve combined with low magnetic field-induced errors, and is the best choice for interchangeability from 1.4 K to 40 K.

RX-102A Features

- Standard curve interchangeable
- Good radiation resistance
- Useful down to 50 mK
- Low magnetic field-induced errors

RX-102B Features

- Useful down to 10 mK; calibrations down to 20 mK available
- Monotonic from 10 mK to 300 K

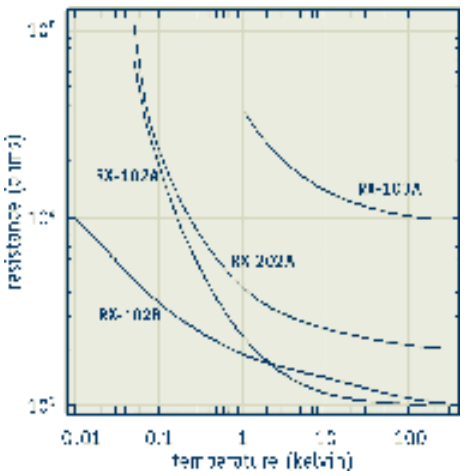
RX-202A Features

- Standard curve interchangeable
- Good radiation resistance
- Monotonic from 50 mK to 300 K
- 4× improvement in magnetic field-induced errors over other ruthenium oxides

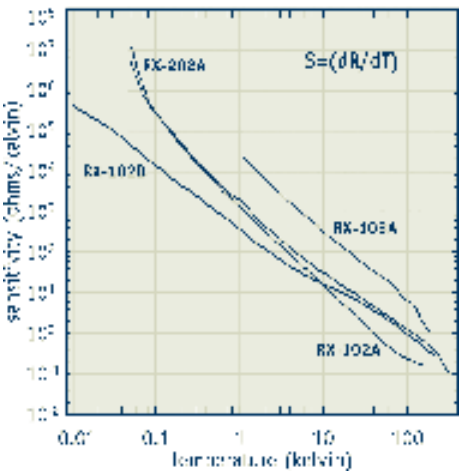
RX-103A Features

- Standard curve interchangeable
- Good radiation resistance
- Best choice for interchangeability from 1.4 K to 40 K
- Low magnetic field-induced errors

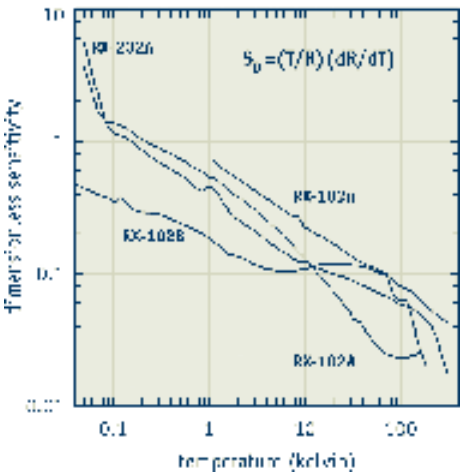
Typical Rox™ Resistance Values



Typical Rox™ Sensitivity Values



Typical Rox™ Dimensionless Sensitivity Values



Specifications

Standard Curve[1] 102 and 202: 0.05 K to 40 K; 103: 1.4 K to 40 K

Recommended excitation[2] *RX-102 and RX-202*: 20 μV (0.05 K to 0.1 K); 63 μV (0.1 K to 1.2 K); 10 mV or less for T > 1 K. *RX-103:* 10 mV or less for T > 1 K.

Dissipation at recommended excitation 102 and 202: 7.5×10^{-8} W at 4.2 K; 103: 3.2×10^{-9} W at 1.4 K, 5.5×10^{-9} W at 4.2 K, 9.6×10^{-9} W at 77 K

Thermal response time 0.5 s at 4.2 K, 2.5 s at 77 K

Use in radiation Recommended – see Appendix B

Use in magnetic field[3] Recommended – see Appendix B

Reproducibility[4] ±15 mK

[1] 102B does not follow a standard curve
[2] Recommended excitation for T < 1 K based on Lake Shore calibration procedures using an AC resistance bridge – for more information refer to Appendix D and Appendix E
[3] 102B not recommended for use in magnetic fields
[4] Short-term reproducibility data is obtained by subjecting sensor to repeated thermal shocks from 305 K to 4.2 K

Range of Use

	Minimum Limit	Maximum Limit
RX-102A-AA	0.05 K	40 K
RX-102B-CB	0.01 K[5]	40 K
RX-202A-AA	0.05 K	40 K
RX-103A-AA	1.4 K	40 K

[5] Calibrations down to 20 mK available; 10 mK calibrations coming soon

Calibrated Accuracy[6]

	RX-102A-AA	RX-102B-CB	RX-202A-AA	RX-103A-AA
20 mK	—	±2 mK	—	—
50 mK	—	±4 mK	—	—
1.4 K	±16 mK	±16 mK	±16 mK	±16 mK
4.2 K	±16 mK	±16 mK	±16 mK	±17 mK
10 K	±18 mK	±18 mK	±18 mK	±22 mK

[6] $[(\text{Calibration uncertainty})^2 + (\text{reproducibility})^2]^{0.5}$ for more information see Appendices B, D, and E

Long-Term Stability

	RX-102A-AA	RX-102B-CB	RX-202A-AA	RX-103A-AA
4.2 K	±30 mK	±30 mK	±50 mK	±15 mK

Accuracy: Interchangeability

	RX-102A-AA-M Matched	RX-102A-AA Unmatched	RX-202A-AA-M Matched	RX-202A-AA Unmatched	RX-103A-AA-M Matched	RX-103A-AA Unmatched
0.05 K	±5 mK	±10 mK	±10 mK	±15 mK	—	—
0.3 K	±15 mK	±20 mK	±20 mK	±25 mK	—	—
0.5 K	±20 mK	±25 mK	±25 mK	±30 mK	—	—
1.4 K	±25 mK	±50 mK	±50 mK	±100 mK	±50 mK	±150 mK
4.2 K	±75 mK	±125 mK	±150 mK	±250 mK	±100 mK	±400 mK
20 K	±500 mK	±1.25 K	±1 K	±2.5 K	±700 mK	±2 K
40 K	±1.5 K	±4 K	±2 K	±5 K	±1.5 K	±4 K

Typical Magnetic Field-Dependent Temperature Errors ΔT/T (%) at B (magnetic induction)

Rox™ 102A

T(K)	2.5 T	8 T	14 T	19 T
2	-1.4	-7.9	-13	-17
3	-1.5	-7	-14	-18
4	-0.56	-6.7	-14	-18
8	-1.3	-6.1	-13	-21
16	-0.40	-3.4	-9.6	-16
23	-0.31	-2.2	-6.2	-11

Rox™ 102B

T(K)	2.5 T	8 T	14 T	19 T
2	3.29	13.82	22.53	27.95
3	3.96	14.68	23.12	29.12
4	3.53	13.92	22.57	28.20
8	1.53	7.53	13.50	17.86
16	0.27	2.14	4.66	6.58
23	0.06	0.79	2.01	3.11

Rox™ 202A

T(K)	2.5 T	8 T	14 T	19 T
2	-0.13	-2.2	-3.9	-5.2
3	0.18	-0.68	-2.7	-3.7
4	0.77	0.046	-1.8	-3.2
8	-0.023	0.16	-0.65	-3.0
16	0.03	0.16	-0.48	-1.5
23	-0.05	-0.08	-0.39	-0.92

Rox™ 103A

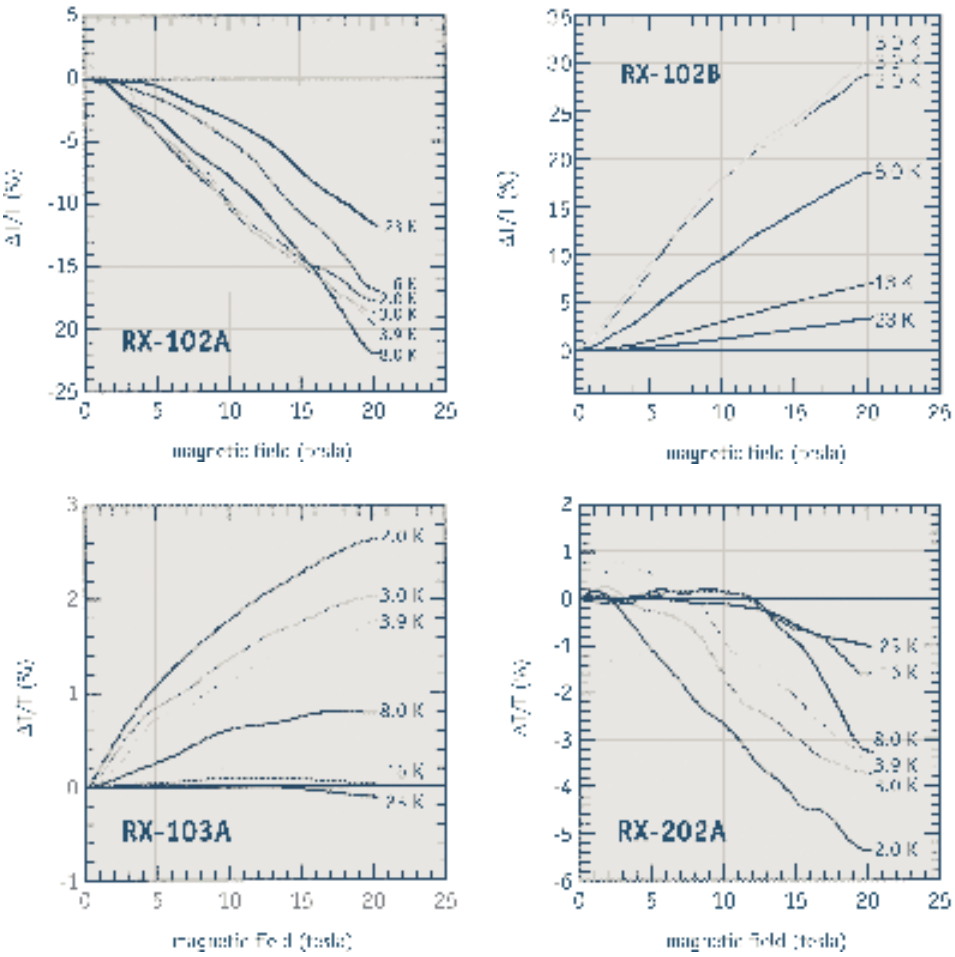
T(K)	2.5 T	8 T	14 T	19 T
2	0.58	1.5	2.2	2.6
3	0.44	1.1	1.7	2.0
4	0.27	0.95	1.4	1.7
8	0.11	0.49	0.71	0.80
16	0.018	0.076	0.089	0.040
23	0.0051	0.0058	-0.0060	-0.095

Temperature Response Data Table (typical)

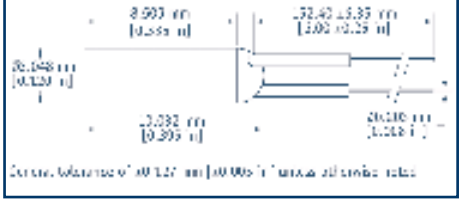
	102A			102B			202A			103A		
	R (Ω)	dR/dT (Ω/K)	(T/R)·(dR/dT)	R (Ω)	dR/dT (Ω/K)	(T/R)·(dR/dT)	R (Ω)	dR/dT (Ω/K)	(T/R)·(dR/dT)	R (Ω)	dR/dT (Ω/K)	(T/R)·(dR/dT)
0.01 K	—	—	—	9856.38	-413888	-0.4199	—	—	—	—	—	—
0.02 K	—	—	—	7289.79	-170565	-0.4680	—	—	—	—	—	—
0.05 K	70020	-5090000	-3.6	4676.87	-41480	-0.4435	110000	-12300000	-5.6	—	—	—
0.1 K	19390	-266000	-1.4	3548.94	-12578	-0.3544	23340	-274000	-1.2	—	—	—
0.3 K	5615	-16600	-0.89	2502.26	-2365	-0.2836	8364	-19400	-0.69	—	—	—
1.4 K	2005	-667	-0.47	1779.33	-197.7	-0.1555	3797	-935	-0.34	30750	-13570	-0.62
4.2 K	1370	-80.3	-0.25	1546.44	-40.04	-0.1087	2918	-121	-0.17	18150	-1560	-0.36
10 K	1167	-15.3	-0.13	1410.19	-15.43	-0.1094	2579	-31.6	-0.12	14060	-315	-0.22
40 K	1049	-1.06	-0.04	1198.80	-3.411	-0.1138	2244	-4.58	-0.08	11150	-21.7	-0.08

See Appendix G for expanded response table

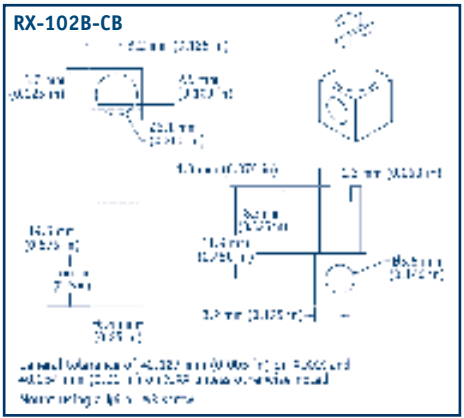
Magnetic Field Dependance Data for Sample Rox™ RTDs



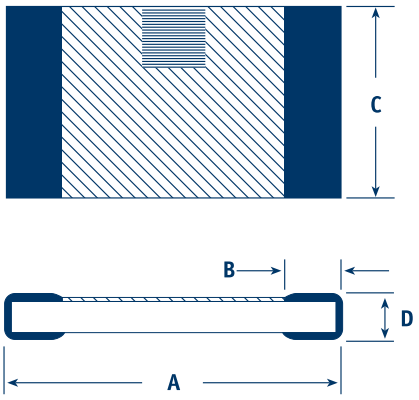
RX-AA



RX-102B-CB



Bare Chip

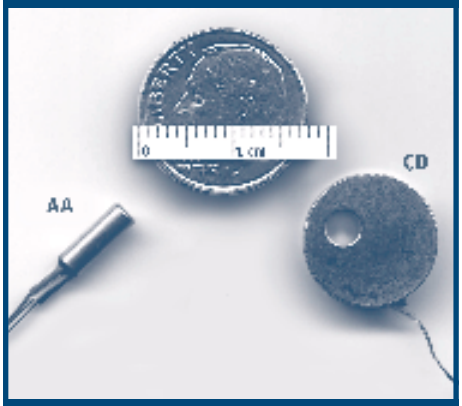


Physical Specifications

	Mass	Lead type	Internal atmosphere	Materials used
RX-102A-AA	3.3 g	Two 6 in 32 AWG copper leads with heavy build Formvar® attached with epoxy strain relief at sensor –user should branch to 4 (no polarity)	Air	Thick ruthenium dioxide and bismuth ruthenate films with palladium silver contacts, indium solder, aluminum oxide substrate, sapphire header and copper canister with epoxy seal
RX-202A-AA	3.28 g			
RX-103A-AA	3.36 g			
RX-102B-CB	3.5 g	Two 6 in 36 AWG copper leads with heavy build polyimide insulation	NA	Thick ruthenate dioxide and bismuth ruthenate films on aluminum dioxide substrate with palladium silver contacts; epoxy attachment to OFHC adapter; copper leads indium soldered to chip and heat sunk to copper adapter using VGE 7031 varnish

Bare Chip	A (chip length)	B (pad width)	C (chip width)	D (thickness)	Materials used
RX-102A-BR	1.45 mm (0.057 in)	0.30 mm (0.012 in)	1.27 mm (0.050 in)	0.65 mm (0.022 in)	Thick ruthenium dioxide and bismuth ruthenate films with palladium silver contacts
RX-103A-BR	1.40 mm (0.070 in)	0.21 mm (0.010 in)	1.23 mm (0.060 in)	0.41 mm (0.016 in)	

PACKAGING OPTIONS **For information on mounting adapters and packages available for Rox™ sensors, see page 25.**



To add length to sensor leads (SMOD), see page 28.

Packaging

The Rox™ 202A, 102A, and 103A sensors are available in the Lake Shore standard copper AA canister and the 102B is available in the CB copper block package. Two are available as bare chips for applications requiring a smaller sensor or a faster thermal response time. The RX-102A-BR is a bare chip version of RX-102A. This bare chip features wrap-around noble metal contacts that can be soldered to using standard lead/tin solder. The RX-103A-BR is a bare chip version of the RX-103A. This bare chip has wrap-around pretinned contacts that can be soldered to using standard lead/tin solder. The pretinned contacts increase the sensor thickness from 0.25 mm to 0.41 mm. Leads are not attached to these models, so they are not available as matched or calibrated.

See the Specifications for details and individual dimensions.

Ordering Information

Rox™ RTD	Calibration Range Suffix Codes Numeric figure is the low end of the calibration Letters represent the high end: C=1 K, B=40 K, M = matched *(calibration of matched sensors is available – consult Lake Shore)*					
Model number	**Uncal**	**0.02C**	**0.02B**	**0.05B**	**0.3B**	**1.4B**
RX-102B-CB	■	■	■			
RX-202A-AA, CD	■			■	■	■
RX-202A-AA-M	■					
RX-102A-AA, CD	■			■	■	■
RX-102A-AA-M	■					
RX-102A-BR	■					
RX-103A-AA, CD	■					■
RX-103A-AA-M	■					
RX-103A-BR	■					

Note: the RX-102B-CB is not interchangeable to a standard curve and is not available as matched. Other packaging available through special order – consult Lake Shore

Accessories available for sensors

ECRIT	Expanded interpolation table
8000	Calibration report on CD-ROM
COC-SEN	Certificate of conformance

USD VISA

Accessories suggested for installation – see Accessories section for full descriptions

Stycast® epoxy
Apiezon® grease
90% Pb, 10% Sn solder
Indium solder
VGE-7031 varnish
Phosphor bronze wire
Manganin wire

See the appendices for a detailed description of:

Self-heating
Installation
Uncalibrated sensors
Calibrated sensors
CalCurve™
Sensor packages