

## 230 Series Temperature Transmitters/Monitors

### Features

- Sensor input fully isolated from power supply potential
- Different models support various sensor types
- 4-lead differential measurement
- Output range of 4 mA to 20 mA or 0 mA to 20 mA (0 V to 10 V)
- Available rack-mount case holds up to 12 units

### Model 231 Features

- Operates from 1.4 K to 500 K with appropriate diode

### Model 231P Features

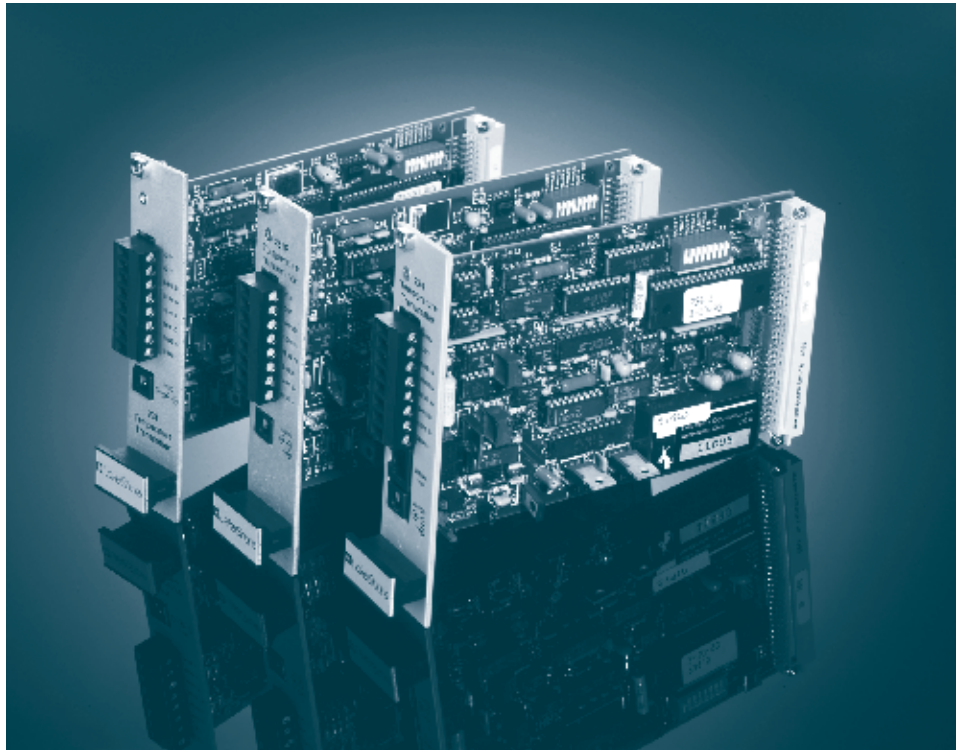
- Operates from 1.4 K to 800 K with appropriate PTC RTD

### Model 234 Features

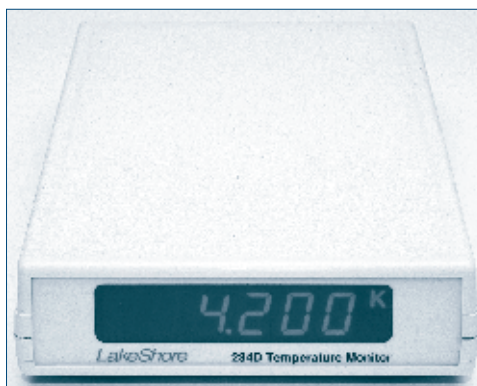
- Operates from 100 mK to 420 K with appropriate NTC RTD
- Includes serial interface

### Model 234D Features

- Operates from 100 mK to 420 K with appropriate NTC RTD
- Includes serial interface
- 6-digit LED display



Model 231, 231P, and 234



Model 234D

The 230 Series Temperature Transmitters include three models: Model 231, Model 231P, and Model 234. Each model supports a different sensor type.

**Model 231**

The Model 231 operates with either silicon diode or gallium-aluminum-arsenide (GaAlAs) diode sensors.

Excited with a 10  $\mu$ A current source from the Model 231, the sensors produce a voltage that depends on temperature. A microcontroller reads the voltage through an A/D converter and translates it into temperature using a temperature response curve. The Model 231 includes two standard curves for DT-470 and DT-670 diode sensors. It also supports a single CalCurve™ option for calibrated sensors (TG-120 diodes require a CalCurve™).

**Model 231P**

The Model 231P uses a PT-100 Series platinum sensor. The Model 231P excites the sensor with a 500  $\mu$ A current to produce a measurable signal. Either the standard platinum curve (IEC 751) or a CalCurve™ is used for temperature conversion.

**Model 234**

The Model 234 operates with Cernox™, carbon-glass, germanium, or other negative temperature coefficient (NTC) resistance temperature sensors. The Model 234 excites the sensor with a constant voltage of 10 mV or less to minimize the effects of sensor self-heating at low temperatures.

The Model 234 employs an analog control circuit to maintain a constant voltage signal across the sensor. A series of reference resistors convert the resulting sensor current to a voltage. A microcontroller reads the voltage with an A/D converter, calculates sensor resistance, and converts the resistance to temperature by table interpolation (requires a CalCurve™ for temperature conversion). The sensor excitation voltage is reversed each reading to compensate for thermal voltages and offsets.

Once one of the 230 Series obtains temperature data, it transmits a current of 4 mA to 20 mA. The current output changes linearly with sensor temperature. Output scale depends on the selected temperature range. Several switch-selected ranges are available. Highest accuracy and sensitivity are achieved when the output is set for a narrow temperature band. A 0 mA to 20 mA output is also available to convert output to a voltage scaled from zero. A 500  $\Omega$ ,  $\pm 0.02\%$  output load resistor produces the maximum full-scale output of 10 V.

Circuitry for the Model 230 Series is powered by a single +5 VDC supply applied either from the front panel connector or the power pins on the VME bus connector. The outputs are isolated so several transmitters can be run off the same supply without interference.

Mechanical mounting is easy because the 230 Series is built on a standard size VME card. It fits directly into a single height (3U) VME card holder. The transmitter does not use the electrical bus format, only its physical shape and power supply.

The Model 234 and the Model 234D both include a serial interface. In addition to the Model 234 features, the Model 234D also provides local display of the temperature or resistance of a single sensor via a 6-digit LED display. It maintains full transmitter capabilities, serial interface commands, and curve format of the standard Model 234. The display is updated at one half the rate of the transmitter output.

**Model 234 Measurement Scales, Excitation, Resolution, and Accuracy**

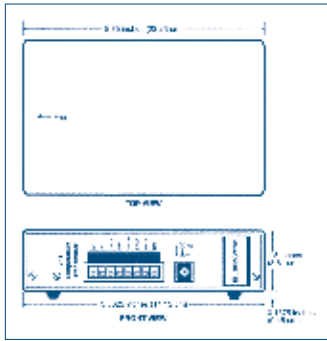
Scale	Sensor resistance	Sensor excitation voltage	Resolution	Accuracy $\pm$ (% rdg + $\Omega$ )
0	1 $\Omega$ to 6 $\Omega$	5 mV	0.0003 $\Omega$	0.5 + 0.0006
1	4.5 $\Omega$ to 12.5 $\Omega$	5 mV	0.0001 $\Omega$	0.1 + 0.0013
2	9 $\Omega$ to 60 $\Omega$	10 mV	0.001 $\Omega$	0.1 + 0.006
3	45 $\Omega$ to 125 $\Omega$	5 mV	0.001 $\Omega$	0.1 + 0.013
4	90 $\Omega$ to 360 $\Omega$	10 mV	0.003 $\Omega$	0.1 + 0.036
5	290 k $\Omega$ to 1.25 k $\Omega$	10 mV	0.01 $\Omega$	0.1 + 0.13
6	900 k $\Omega$ to 3.6 k $\Omega$	10 mV	0.03 $\Omega$	0.1 + 0.36
7	2.9 k $\Omega$ to 12.5 k $\Omega$	10 mV	0.1 $\Omega$	0.1 + 1.3
8	9 k $\Omega$ to 36 k $\Omega$	10 mV	0.3 $\Omega$	0.1 + 3.6
9	29 k $\Omega$ to 300 k $\Omega$	10 mV	6.8 $\Omega$	0.5 + 30

	231	231P	234/234D
<b>Thermometry</b>			
<b>Number of inputs</b>	1	1	1
<b>Measurement type</b>	4-lead differential	4-lead differential	4-lead differential
<b>Sensor type</b>	Silicon diode, GaAlAs diode	Platinum	Carbon-glass, germanium, Cernox™
<b>Sensor temperature coefficient</b>	Negative	Positive	Negative
<b>Sensor units</b>	Volts (V)	Ohms ( $\Omega$ )	Ohms ( $\Omega$ )
<b>Input range</b>	0 V to 5 V	0 $\Omega$ to 312 $\Omega$	1 $\Omega$ to 300 k $\Omega$
<b>Sensor excitation</b>	10 $\mu$ A $\pm$ 0.1% DC current	500 $\mu$ A $\pm$ 0.02% DC current	Constant voltage pinned at 5 mV or 10 mV dependent on resistance range
<b>Update rate</b>	5 readings per s	5 readings per s	4 readings per s (2 readings per s on Scale 0 only)
<b>Precision curve storage</b>	One curve loaded at factory	One curve loaded at factory	One curve, loaded at the factory or in the field via serial interface
<b>Example Lake Shore sensor</b>	DT-470-CO	PT-103	CGR-1-1000 with 1.4L calibration
<b>Sensor temperature range</b>	1.4 K to 475 K	30 K to 800 K	1.4 K to 325 K
<b>Standard curve</b>	Lake Shore Curve 10	IEC 751	Requires calibrated sensor and CalCurve™
<b>Typical sensor sensitivity<sup>1</sup></b>	-30 mV/K at 4.2 K -1.9 mV/K at 77 K -2.4 mV/K at 300 K	0.19 $\Omega$ /K at 30 K 0.42 $\Omega$ /K at 77 K 0.39 $\Omega$ /K at 300 K 0.34 $\Omega$ /K up to 800 K	-700 $\Omega$ /K at 4.2 K -24 $\Omega$ /K at 10 K -0.15 $\Omega$ /K at 77 K -0.02 $\Omega$ /K at 300 K
<b>Measurement resolution<sup>1</sup></b>			
<b>Sensor units</b>	76.3 $\mu$ V	4.8 m $\Omega$	Range dependent
<b>Temperature equivalence</b>	2.5 mK at 4.2 K 40 mK at 77 K 32 mK at 300 K	22 mK at 30 K 11 mK at 77 K 13 mK at 300 K 14 mK up to 800 K	$\pm$ 0.04 mK at 4.2 K $\pm$ 0.12 mK at 30 K $\pm$ 6.6 mK at 77 K $\pm$ 67 mK at 300 K
<b>Electronic measurement accuracy<sup>1</sup></b>			
<b>Sensor units</b>	$\pm$ 75 $\mu$ V $\pm$ 0.01% of reading	$\pm$ 0.05 $\Omega$ $\pm$ 0.05% of reading	Range dependent (see table on page 119)
<b>Temperature accuracy</b>	$\pm$ 0.07 K at 4.2 K $\pm$ 0.16 K at 77 K $\pm$ 0.12 K at 300 K	$\pm$ 0.2 K at 30 K $\pm$ 0.15 K at 77 K $\pm$ 0.3 K at 300 K $\pm$ 0.7 K up to 800 K	$\pm$ 2 mK at 4.2 K $\pm$ 8 mK at 10 K $\pm$ 18 mK at 77 K $\pm$ 1.2 K at 300 K
<b>Measurement temperature coefficient</b>			
<b>Sensor units</b>	0.0006% of resistance rdg / $^{\circ}$ C	0.002% of resistance rdg / $^{\circ}$ C	0.0125% of resistance rdg / $^{\circ}$ C
<b>Temperature equivalence</b>	3 mK/ $^{\circ}$ C at 4.2 K 3 mK/ $^{\circ}$ C at 77 K 1.2 mK/ $^{\circ}$ C at 300 K	0.4 mK/ $^{\circ}$ C at 30 K 1 mK/ $^{\circ}$ C at 77 K 6 mK/ $^{\circ}$ C at 300 K 18 mK/ $^{\circ}$ C at 800 K	$\pm$ 0.18 mK/ $^{\circ}$ C at 4.2 K $\pm$ 0.8 mK/ $^{\circ}$ C at 10 K $\pm$ 18 mK/ $^{\circ}$ C at 77 K $\pm$ 100 mK/ $^{\circ}$ C at 300 K
<b>Magnetic field use</b>			
<b>Silicon diode</b>	Recommended for T $\geq$ 60 K and B $\leq$ 3 T	NA	NA
<b>GaAlAs diode</b>	Recommended for T $\geq$ 4.2 K and B $\leq$ 5 T	NA	NA
<b>Platinum</b>	NA	Recommended for T > 40 K and B $\leq$ 2.5 T	NA
<b>Carbon-Glass</b>	NA	NA	Recommended for T $\geq$ 2 K and B $\leq$ 19 T
<b>Germanium</b>	NA	NA	Not recommended
<b>Cernox™</b>	NA	NA	Recommended

<sup>1</sup> See Appendix F for sample calculations of typical sensor performance

	231	231P	234/234D
<b>Output</b>			
<b>Number of outputs</b>	1	1	1
<b>Output type</b>	Current source, isolated from power source – output or sensor can be grounded, but not both (all models)		
<b>Output range</b>	4 mA to 20 mA or 0 mA to 20 mA (for 0 V to 10 V with provided 500 $\Omega$ 0.02%, 25 ppm resistor) (all models)		
<b>Output compliance</b>	10 V (500 $\Omega$ max load)	10 V (500 $\Omega$ max load)	10 V (500 $\Omega$ max load)
<b>Output temperature ranges</b>			
Range 1	0 K to 20 K	0 K to 20 K	0 K to 10 K
Range 2	0 K to 100 K	0 K to 100 K	0 K to 20 K
Range 3	0 K to 200 K	0 K to 200 K	0 K to 100 K
Range 4	0 K to 325 K	0 K to 325 K	0 K to 200 K
Range 5	0 K to 475 K	0 K to 475 K	0 K to 300 K
Range 6	0 K to 1000 K	0 K to 1000 K	75 K to 325 K
<b>4 mA to 20 mA output</b>			
<b>Output resolution</b>			
<b>Current</b>	1.22 $\mu$ A (0.006% of full scale)	1.22 $\mu$ A (0.006% of full scale)	1.22 $\mu$ A (0.006% of full scale)
<b>Temperature equivalence</b>			
Range 1	1.5 mK	Not used	0.8 mK
Range 2	7.6 mK	7.6 mK	1.5 mK
Range 3	15.3 mK	15.3 mK	7.6 mK
Range 4	24.8 mK	24.8 mK	15.3 mK
Range 5	36.2 mK	36.2 mK	22.9 mK
Range 6	76.3 mK	76.3 mK	19.1 mK
<b>Output accuracy</b>			
<b>Current</b>	$\pm 2 \mu$ A ( $\pm 0.01\%$ of full scale)	$\pm 2 \mu$ A ( $\pm 0.01\%$ of full scale)	$\pm 5 \mu$ A ( $\pm 0.025\%$ of full scale)
<b>Temperature equivalence</b>			
Range 1	2.5 mK	Not used	3.1 mK
Range 2	12.5 mK	12.5 mK	6.2 mK
Range 3	25 mK	25 mK	31.2 mK
Range 4	41 mK	41 mK	62.5 mK
Range 5	59 mK	59 mK	93.7 mK
Range 6	125 mK	125 mK	78.1 mK
<b>Output temperature coefficient</b>			
<b>Current (%/°C ambient)</b>	$\pm 0.0055\%$ of output current per °C	$\pm 0.0055\%$ of output current per °C	$\pm 2 \mu$ A/°C ( $\pm 0.01\%$ /°C)
<b>Temperature equivalence</b>			
Range 1	1 mK/°C	Not used	$\pm 1$ mK/°C
Range 2	6 mK/°C	6 mK/°C	$\pm 2$ mK/°C
Range 3	12 mK/°C	12 mK/°C	$\pm 10$ mK/°C
Range 4	18 mK/°C	18 mK/°C	$\pm 20$ mK/°C
Range 5	26 mK/°C	26 mK/°C	$\pm 30$ mK/°C
Range 6	55 mK/°C	55 mK/°C	$\pm 25$ mK/°C

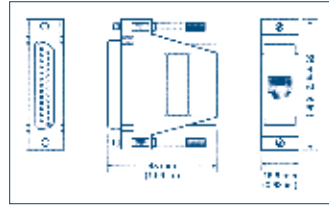
	231	231P	234/234D
<b>0 mA to 20 mA output (0 V to 10 V with 500 <math>\Omega</math>, 0.02% load resistor)</b>			
<b>Output resolution</b>			
<b>Voltage</b>	0.6 mV	0.6 mV	0.61 mV
<b>Temperature equivalence</b>			
<b>Range 1</b>	1.2 mK	Not used	0.6 mK
<b>Range 2</b>	6.1 mK	6.1 mK	1.2 mK
<b>Range 3</b>	12.2 mK	12.2 mK	6.1 mK
<b>Range 4</b>	19.8 mK	19.8 mK	12.2 mK
<b>Range 5</b>	29 mK	29 mK	18.3 mK
<b>Range 6</b>	61 mK	61 mK	15.2 mK
<b>Output accuracy</b>			
<b>Voltage</b>	3 mV (0.03% of full scale)	3 mV (0.03% of full scale)	$\pm 4.5$ mV ( $\pm 0.025\%$ of full scale $\pm 0.02\%$ resistor accuracy)
<b>Temperature equivalence</b>			
<b>Range 1</b>	6 mK	Not used	4.5 mK
<b>Range 2</b>	30 mK	30 mK	9.0 mK
<b>Range 3</b>	60 mK	60 mK	45.0 mK
<b>Range 4</b>	98 mK	98 mK	90.0 mK
<b>Range 5</b>	143 mK	143 mK	135.0 mK
<b>Range 6</b>	300 mK	300 mK	112.5 mK
<b>Output temperature coefficient</b>			
<b>Voltage (% output/<math>^{\circ}</math>C ambient)</b>	$\pm 0.008\%/^{\circ}$ C	$\pm 0.008\%/^{\circ}$ C	$\pm 1.25$ mV/ $^{\circ}$ C ( $\pm 0.01\%/^{\circ}$ C $\pm 0.0025\%/^{\circ}$ C of load resistor)
<b>Temperature equivalence</b>			
<b>Range 1</b>	2 mK/ $^{\circ}$ C	Not used	$\pm 1.2$ mK/ $^{\circ}$ C
<b>Range 2</b>	8 mK/ $^{\circ}$ C	8 mK/ $^{\circ}$ C	$\pm 2.5$ mK/ $^{\circ}$ C
<b>Range 3</b>	16 mK/ $^{\circ}$ C	16 mK/ $^{\circ}$ C	$\pm 12$ mK/ $^{\circ}$ C
<b>Range 4</b>	26 mK/ $^{\circ}$ C	26 mK/ $^{\circ}$ C	$\pm 25$ mK/ $^{\circ}$ C
<b>Range 5</b>	38 mK/ $^{\circ}$ C	38 mK/ $^{\circ}$ C	$\pm 36$ mK/ $^{\circ}$ C
<b>Range 6</b>	80 mK/ $^{\circ}$ C	80 mK/ $^{\circ}$ C	$\pm 30$ mK/ $^{\circ}$ C
<b>Display (234D only)</b>			
<b>Display type</b>	NA	NA	6-digit LED
<b>Display units</b>	NA	NA	Temperature in K; sensor units in $\Omega$
<b>Sensor units resolution</b>	NA	NA	Range dependent (see table)
<b>Temperature resolution</b>	NA	NA	Range dependent to 1 mK – no better than measurement resolution
<b>Serial interface baud rate</b>	NA	NA	9600
<b>Timing format</b>	NA	NA	Asynchronous
<b>Bits/character</b>	NA	NA	1 start, 8 data, 1 stop
<b>Parity type</b>	NA	NA	None
<b>Voltage levels</b>	NA	NA	EIA
<b>Terminators</b>	NA	NA	Carriage return (CR), line feed (LF)
<b>Connector</b>	NA	NA	RJ11 telephone type jack
<b>General</b>			
<b>Ambient temperature range</b>	15 $^{\circ}$ C to 35 $^{\circ}$ C	15 $^{\circ}$ C to 35 $^{\circ}$ C	15 $^{\circ}$ C to 35 $^{\circ}$ C
<b>Power requirements</b>	$\pm 5$ ( $\pm 0.25$ ) VDC, (500 mA), 2.5 W	$\pm 5$ ( $\pm 0.25$ ) VDC, (500 mA), 2.5 W	234: $\pm 5$ ( $\pm 0.25$ ) VDC, (500 mA), 2.5 W; 234D: 750 mA, 3.75 W
<b>Enclosure type</b>	see diagrams	see diagrams	see diagrams
<b>Mounting</b>	VME end panel and back plane: transmitters do not use electrical bus format, only its physical shape and power	VME end panel and back plane: transmitters do not use electrical bus format, only its physical shape and power	VME end panel and back plane: transmitters do not use electrical bus format, only its physical shape and power
<b>Size</b>	100 mm H $\times$ 160 mm D $\times$ 30.5 mm W	100 mm H $\times$ 160 mm D $\times$ 30.5 mm W	234: 100 mm H $\times$ 160 mm D $\times$ 30.5 mm W 234D: 43.18 mm H $\times$ 228.6 mm D $\times$ 139.7 mm W
<b>Weight</b>	0.25 kg (0.5 lb)	0.25 kg (0.5 lb)	0.25 kg (0.5 lb)



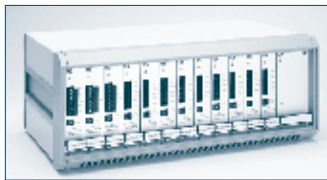
2308-1



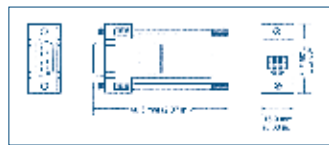
2001



2002



2308-12



2003

### Single Card Case (part number 2308-1)

The single card enclosure can hold 1 temperature transmitter. Typical physical dimensions of the Model 2308-1 Benchtop Enclosure are provided in the drawing. A wall plug-in power supply is required for the transmitter in this enclosure. See the ordering information for the model numbers of the transmitters with a wall mount power supply.

### Multiple Card Enclosure (part number 2308-12)

The Model 2308-12 VME card case holds up to 12 temperature transmitters. A +5 VDC power supply with universal input is provided with the case. Wall mount power supplies are not necessary with a 2308-12.

<b>Card slots</b>	12
<b>Output voltage</b>	+5 VDC, 100 mV peak to peak ripple
<b>Output current</b>	6 A (max)
<b>Input power</b>	Universal 85 to 265 VAC, 47 to 440 Hz, 60 W
<b>Ambient temp range</b>	15 °C to 35 °C (59 °F to 95 °F)
<b>Enclosure mounting</b>	Bench or full (19 in) rack
<b>Size</b>	450 mm W × 178 mm H × 260 mm D (17.7 in × 7 in × 10.25 in)
<b>Weight</b>	5.5 kg (12 lb)

### Power Connections

Lake Shore temperature transmitters are powered by a +5 VDC supply if the transmitter card is ordered without a rack or plug-in supply. The voltage must be regulated to within  $\pm 0.25$  VDC. Each transmitter draws up to 500 mA from the supply (750 mA for 234D).

## Ordering Information

Part number	Description
<b>231</b>	Transmitter card for use with Silicon Diode
<b>231-115</b>	231 transmitter with a 115 VAC (50/60 Hz) wall plug-in power supply
<b>231-230</b>	231 transmitter with 230 VAC wall plug-in power supply
<b>231P</b>	Transmitter for use with Platinum Resistor
<b>231P-115</b>	231P transmitter with 115 VAC (50/60 Hz) wall plug-in power supply
<b>231P-230</b>	231P transmitter with 230 VAC wall plug-in power supply
<b>234</b>	Transmitter for use with Carbon-Glass, Germanium, and Cernox™
<b>234-115</b>	234 transmitter with 115 VAC (50/60 Hz) wall plug-in power supply
<b>234-230</b>	234 transmitter with 230 VAC wall plug-in power supply
<b>234D</b>	Transmitter with single enclosure display and for use with Carbon-Glass, Germanium, and Cernox™
<b>234D-115</b>	234D transmitter with 115 VAC (50/60 Hz) wall plug-in power supply
<b>234D-230</b>	234D transmitter with 230 VAC wall plug-in power supply

### Accessories included

<b>106-739</b>	Sensor and output mating connector
<b>103-626</b>	500 $\Omega$ , 0.02%, 25 PPM output resistor
	Calibration certificate
<b>MAN-231/231P</b>	Model 231 and 231P user manual
<b>MAN-234</b>	Model 234 and 234D user manual

### Options and accessories

<b>2001</b>	RJ11 4 m (14 ft) modular serial cable
<b>2002</b>	RJ11 to DB25 adapter – connects RJ11 cable to a 25-pin RS-232C serial port on rear of computer
<b>2003</b>	RJ11 to DB9 adapter – connects RJ11 cable to a 9-pin RS-232C serial port on rear of computer
<b>2308-1</b>	VME single card enclosure
<b>2308-12</b>	VME rack and power supply (holds up to 12 transmitters)
<b>2308-BP</b>	VME rack blank panel
<b>8001</b>	231/231P CalCurve™ data, factory installed
<b>8001-234</b>	234/234D CalCurve™ data, factory installed
<b>8002-231</b>	231 CalCurve™ data, field installed
<b>8002-231P</b>	231P CalCurve™ data, field installed
<b>8002-234</b>	234/234D CalCurve™ data, field installed
<b>CAL-231-CERT</b>	Instrument recalibration with certificate
<b>CAL-231P-CERT</b>	Instrument recalibration with certificate
<b>CAL-234-CERT</b>	Instrument recalibration with certificate

