TECHNICAL NOTE

PhotriX™ TEMPERATURE RESOLUTION

Introduction

In the field of temperature measurement, the term "resolution" is commonly defined as the ability to detect a change in temperature. The Luxtron PhotriX™ Optical Thermometer has the capability to resolve variations in temperatures of 0.01 °C or smaller. How small a variation can be measured will depend on a number of factors, such as:

- Wavelength of the light used to measure temperature,
- Range of temperatures the instrument was designed to measure,
- Type of optics attached to the instrument,
- Operating temperature of the instrument,
- Measurement rate (in readings per second) the user selects.

The minimum and maximum temperatures an instrument can measure are set at the factory. The standard factory temperature ranges are shown in the table below with the following definitions:

- Low Temperature: The lowest temperature where a change of 1.0 °C can easily be measured using a measurement rate of one reading per second. Instrument temperature must be below the target temperature.

- Minimum Temperature: The absolute lowest temperautre that can be measured. To measure accurately to this temperature requires elimination of background radiation, low and stable probe electronics temperature, Low Temperature Singal Averaging enabled, and possibly additional measurement averaging.

- High Temperature: The highest temperature measured before detection electronics approach saturation.

- Maximum Temperature: The absolute maximum temperautre that can be measured. Temperatures above the High Temperature limit may be outside the probe's linear response region causing some loss of accuracy and resolution.

The resolution and range of the instrument depend on the choice of optics. They are also somewhat affected by ambient temperature. The following section contains a series of tables that provide temperature, resolution, and measurement speed for each of the primary optic types. After the tables is a section on the effect of the probe temperature on resolution and a list of suggestions for improving the resolution in your application.

Standard Temperature Range Table

			Min. Temp.	Low Temp.	High Temp.	Max. Temp.
Lens	900nm	Low	260°C	275 °C	2150 °C	2250 °C
		High	290 °C	325 °C	2600 °C	3000 °C
	1600nm	Low	50 °C	65°C	975 °C	1100 °C
		High	110 °C	135 °C	2400 °C	2800 °C
Lightpipe	900nm	2mm	200 °C	220 °C	1300 °C	1350 °C
		3mm	195 °C	215 °C	1250 °C	1300 °C
		4mm	190 °C	210 °C	625 °C	700 °C
	1600nm	2mm	21 °C	35 °C	625 °C	700 °C
		3mm	17 °C	30 °C	590 °C	670 °C
		4mm	15 °C	25 °C	575 °C	630 °C

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Resolution Tables

Pyrometer Low Range 900nm (275 – 2150 °C)	1 reading per second	10 readings per second	100 readings per second	1000 readings per second
1.0 °C Resolution	275 °C	325 °C	390 °C	470 °C
0.1 °C Resolution	325 °C	390 °C	470 °C	570 °C
0.01 °C Resolution	390 °C	470 °C	570 °C	710 °C

Pyrometer High Range 900nm (325 – 2600 °C)	1 reading per second	10 readings per second	100 readings per second	1000 readings per second
1.0 °C Resolution	325 °C	385 °C	465 °C	565 °C
0.1 °C Resolution	385 °C	465 °C	565 °C	700 °C
0.01 °C Resolution	465 °C	560 °C	695 °C	890 °C

Pyrometer Low Range 1600nm (65 – 975 °C)	1 reading per second	10 readings per second	100 readings per second	1000 readings per second
1.0 °C Resolution	65 °C	80 °C	108 °C	148 °C
0.1 °C Resolution	102 °C	125 °C	154 °C	201 °C
0.01 °C Resolution	146 °C	175 °C	215 °C	275 °C

Pyrometer High Range 1600nm (135 – 2400 °C)	1 reading per second	10 readings per second	100 readings per second	1000 readings per second
1.0 °C Resolution	135 °C	160 °C	198 °C	255 °C
0.1 °C Resolution	188 °C	225 °C	270 °C	350 °C
0.01 °C Resolution	258 °C	308 °C	370 °C	485 °C

Lightpipe 2mm / 900nm (220 - 1300 °C)	1 reading per second	10 readings per second	100 readings per second	1000 readings per second
1.0 °C Resolution	220 °C	260 °C	310 °C	372 °C
0.1 °C Resolution	262 °C	310 °C	370 °C	448 °C
0.01 °C Resolution	312 °C	370 °C	442 °C	545 °C

Lightpipe 3mm / 900nm (215 - 1250 °C)	1 reading per second	10 readings per second	100 readings per second	1000 readings per second
1.0 °C Resolution	215 °C	253 °C	302 °C	362 °C
0.1 °C Resolution	255 °C	300 °C	360 °C	435 °C
0.01 °C Resolution	304 °C	360 °C	430 °C	525 °C

Lightpipe 4mm / 900nm (210 - 1200 °C)	1 reading per second	10 readings per second	100 readings per second	1000 readings per second
1.0 °C Resolution	210 °C	248 °C	295 °C	355 °C
0.1 °C Resolution	250 °C	295 °C	350 °C	425 °C
0.01 °C Resolution	297 °C	350 °C	422 °C	525 °C

Lightpipe 2mm / 1600nm (35 - 625 °C)	1 reading per second	10 readings per second	100 readings per second	1000 readings per second
1.0 °C Resolution	35 °C	44 °C	60 °C	90 °C
0.1 °C Resolution	55 °C	75 °C	93 °C	130 °C
0.01 °C Resolution	90 °C	111 °C	138 °C	181 °C

Lightpipe 3mm /1600nm (30 - 590 °C)	1 reading per second	10 readings per second	100 readings per second	1000 readings per second
1.0 °C Resolution	30 °C	40 °C	56 °C	85 °C
0.1 °C Resolution	52 °C	70 °C	90 °C	124 °C
0.01 °C Resolution	85 °C	108 °C	130 °C	175 °C

Lightpipe 4mm / 1600nm (25 - 575 °C)	1 reading per second	10 readings per second	100 readings per second	1000 readings per second
1.0 °C Resolution	25 °C	36 °C	54 °C	82 °C
0.1 °C Resolution	50 °C	68 °C	88 °C	120 °C
0.01 °C Resolution	82 °C	101 °C	126 °C	150 °C

Resolution Tables

Resolution Tables (left) note the optics type, measurement wavelength, and temperature range in the upper left hand corner of each table. Find a measurement resolution on the left hand side and follow it across to a column for the desired measurement rate. There you will find the minimum temperature at which you would expect to achieve the desired performance.

Optimizing Measurement Resolution

If the target temperature is in the upper two thirds of the measurement range, the resolution will be 0.01 °C or better. If the temperature is in the lower third, or the process naturally varies, several techniques can be used to optimize the measurement resolution.

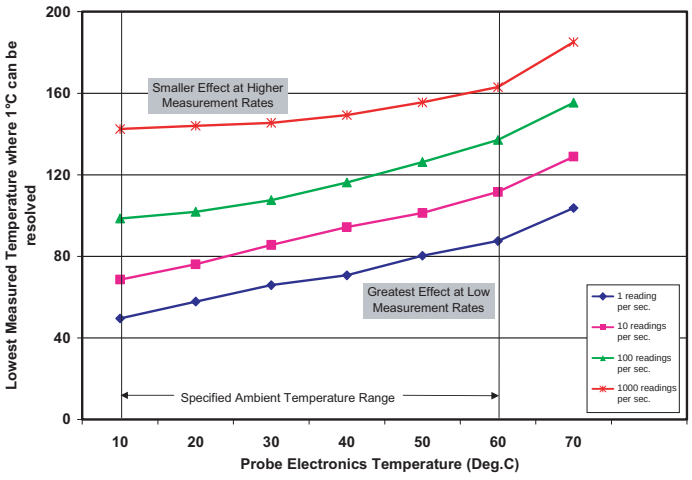
Measurement averaging

The Luxtron PhotriX probe can be configured so that each reading is based on a user-selectable number of previous readings. For example, if the measurement rate is set at 100 readings per second, and the Averaging Buffer Depth is set to 10, then each of the 100 readings will be based on the average of the measurements taken over the previous one tenth (0.10) second.

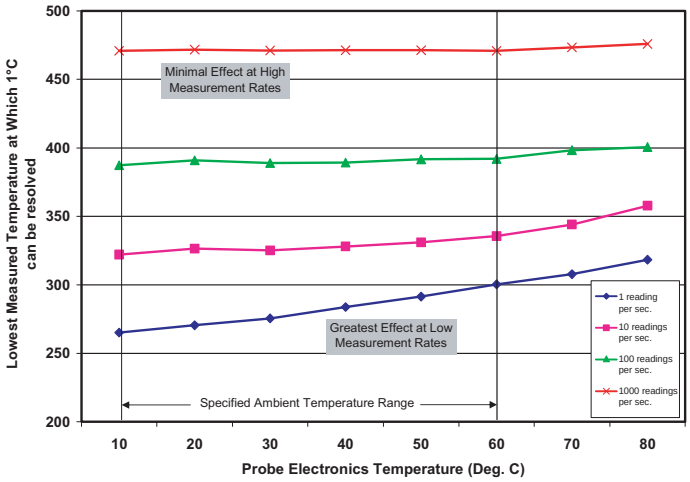
The Averaging Buffer Depth may also be programmed so the number of points averaged changes as the process temperature changes. For example, if the probe measurement rate is set for 10 readings per second, the user can program the Averaging Buffer to use no averaging above 500 °C, average 3 readings between 375 and 500 °C, average 6 readings between 325 and 375 °C, and average 10 readings for any temperature below 325 °C.

Low Temperature Signal Averaging

There is also a feature found on the "Advanced" tab of the probe configuration menu called "Low Temperature Signal Averaging". Selecting the "Low Temperature Averaging" feature will instruct the probe to automatically optimize the amount of averaging (up to 1 second of averaging time), in the generation of each reading. As the temperature increases, the amount of averaging will decrease until the probe has sufficient light so that averaging is no longer required.



Temperature at Which 1°C Change can be Resolved for Different Probe Electronic Temperatures - 1600nm / Low Range / Pyrometer Optics



Temperature at Which a 1°C Change Can Be Resolved for Different Probe Electronic Temperatures - 900nm / Low Range / Pyrometer Optics

Cooling the electronics

Reducing the temperature of the probe electronics will generally improve the measurement resolution (see graphs and discussion on the following page). The TemperaSure™ data acquisition software will record the probe operating temperature along with the temperature measurement data. Please see the PhotriX™ user manual for more details. The recommended minimum temperature for the probe electronics is 10 °C (50 °F).

Increasing Available Light

The reason resolution degrades at the low end of a measurement range is due to a decreased level of light at the lower temperatures. If the measurement requirements allow for optics that will gather more light from the target, the measurement resolution will improve at lower temperatures. Some of the methods for gaining light include larger spot size pyrometers, larger diameter lightpipes, or possibly custom optics engineered for your process. Please consult a Luxtron applications engineer for assistance.

Ambient Temperature Effects

The preceding data is based on an ambient probe temperature of 30 °C. The internal electronics of a Luxtron PhotriX temperature probe will reach a temperature of approximately 30 °C when running in a mildly warm room for an extended period of time. The measurement resolution will improve for cooler probe temperatures and degrade somewhat for warmer probe temperatures. For details on a particular probe configuration, please contact a factory applications engineer.