

REPORT OF CALIBRATION

for

**One Cooled Lead Selenide (PbSe) Detector
OL 730-PbSe-C, S/N: 12100016**

**Calibration Date: October 29, 2012
Certification Date: October 31, 2012
Project No: 915-326**



Gooch & Housego

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for
One Cooled Lead Selenide (PbSe) Detector

Customer: Rochester Institute of Technology
Rochester, NY 14623

Purchase Order No: 153196

1. Material.

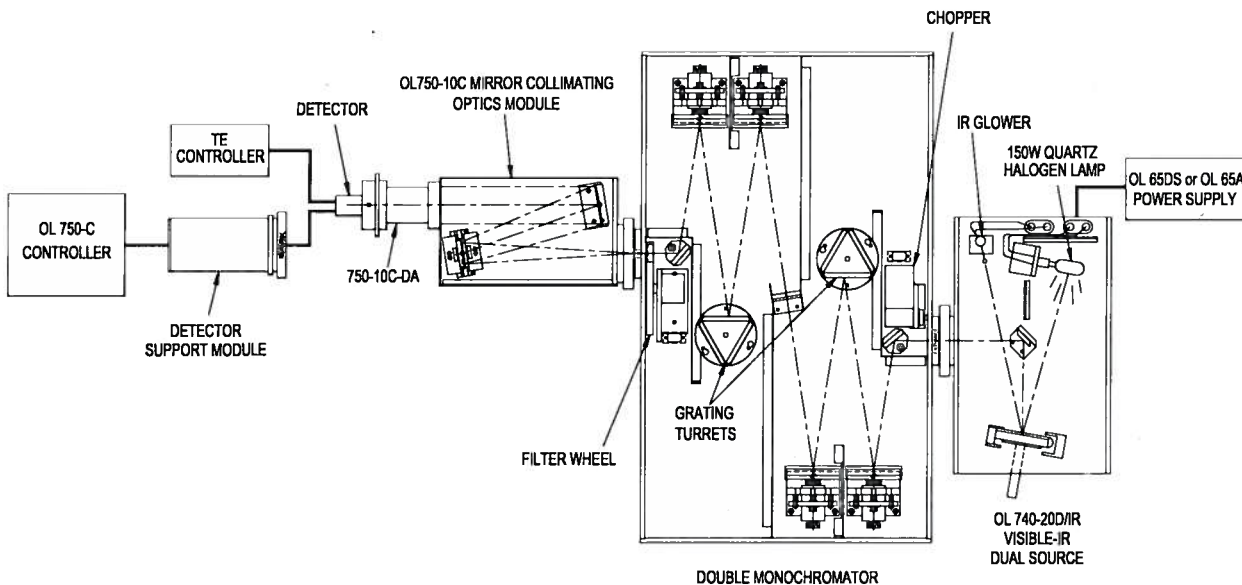
One Gooch & Housego OL 730-PbSe-C Cooled PbSe Detector (S/N: 12100016), consisting of a 3 mm x 3 mm detector and an OL 730-TE Cooler Controller (S/N: 12100079) was calibrated for spectral irradiance response in $[V_{SQP \cdot P}/(W/cm^2)]^{1/}$ when modulated at a frequency of 167 Hz.

2. Method of Calibration and Standards.

Calibration of the OL 730-PbSe Detector for spectral irradiance response involves the following two step procedure:

- 1) An absolute spectral irradiance response calibration (167 Hz) is performed at a wavelength of 1400 nm relative to NIST calibrated OL 740-16C Standard Detector 93101092. Monochromatic irradiance is obtained using a Gooch & Housego Double Monochromator Optical Radiation Measurement System configured for measuring the spectral response of detectors (see Figure 1).

GOOCH & HOUSEGO GENERAL SETUP FOR DETECTOR RESPONSE MEASUREMENTS



P002372

Figure 1

^{1/} The units $[V_{SQUARE \text{ PEAK-PEAK}}/(W/cm^2)]$ will be referred to as $[V_{SQP \cdot P}/(W/cm^2)]$.

For these measurements, the entire receivers of both the standard and test detectors are uniformly irradiated. The half-bandwidth of the monochromator is set to 8 nm. The uncertainty in the calibration of the test detector relative to the NIST detector scale is estimated to be $\pm 1.0\%$. General Information on the calibration procedure along with the NIST traceable standards and estimated uncertainties are described in the attached Information Sheet, "The Gooch & Housego Calibration of Photodetectors."

The calibration of OL 740-16C Standard 93101092 is directly traceable to Gooch & Housego's NIST calibrated Standard Germanium Detector 07200011 (NIST Test No.: 844/278921).

- 2) The relative spectral response of the test detector is determined relative to a heavily blackened thermal detector using a Gooch & Housego Double Monochromator Optical Radiation Measurement System configured for operation over the entire 1 μm to 5.5 μm wavelength range. The National Physical Laboratory performed the relative spectral response calibration for the thermal detector (Reference: 2011090249). The estimated uncertainty in the transfer calibration from the thermal detector to the OL 730-PbSe-C TE Cooled PbSe Detector from 1.0 μm to 5.0 μm is estimated to be $\pm 3\%$. The estimated uncertainty beyond 5.0 μm increases considerably with wavelength.

3. Results.

Spectral irradiance response values (167 Hz) in $[\text{V}_{\text{SQ P-P}}/(\text{W}/\text{cm}^2)]$ are given in Table 1 (a graphical representation is provided). A compact disc containing the spectral values is also provided. The bias voltage from the OL 730-TE Cooler Controller was recorded at -65.89 volts. The operating temperature of the OL 730-PbSe-C Cooled PbSe Detector (S/N: 12100016) is $-11\text{ }^\circ\text{C}$.

The ambient temperature was $21.8\text{ }^\circ\text{C}$ and the relative humidity was less than 60 %.

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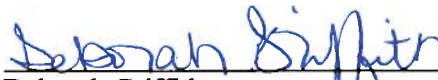
Calibration Certified by:

GOOCH & HOUSEGO



Michael F. Kelso
Radiometrist

Reviewed by:



Deborah Griffith
Calibration Lab Manager

GOOCH & HOUSEGO CALIBRATION REPORT

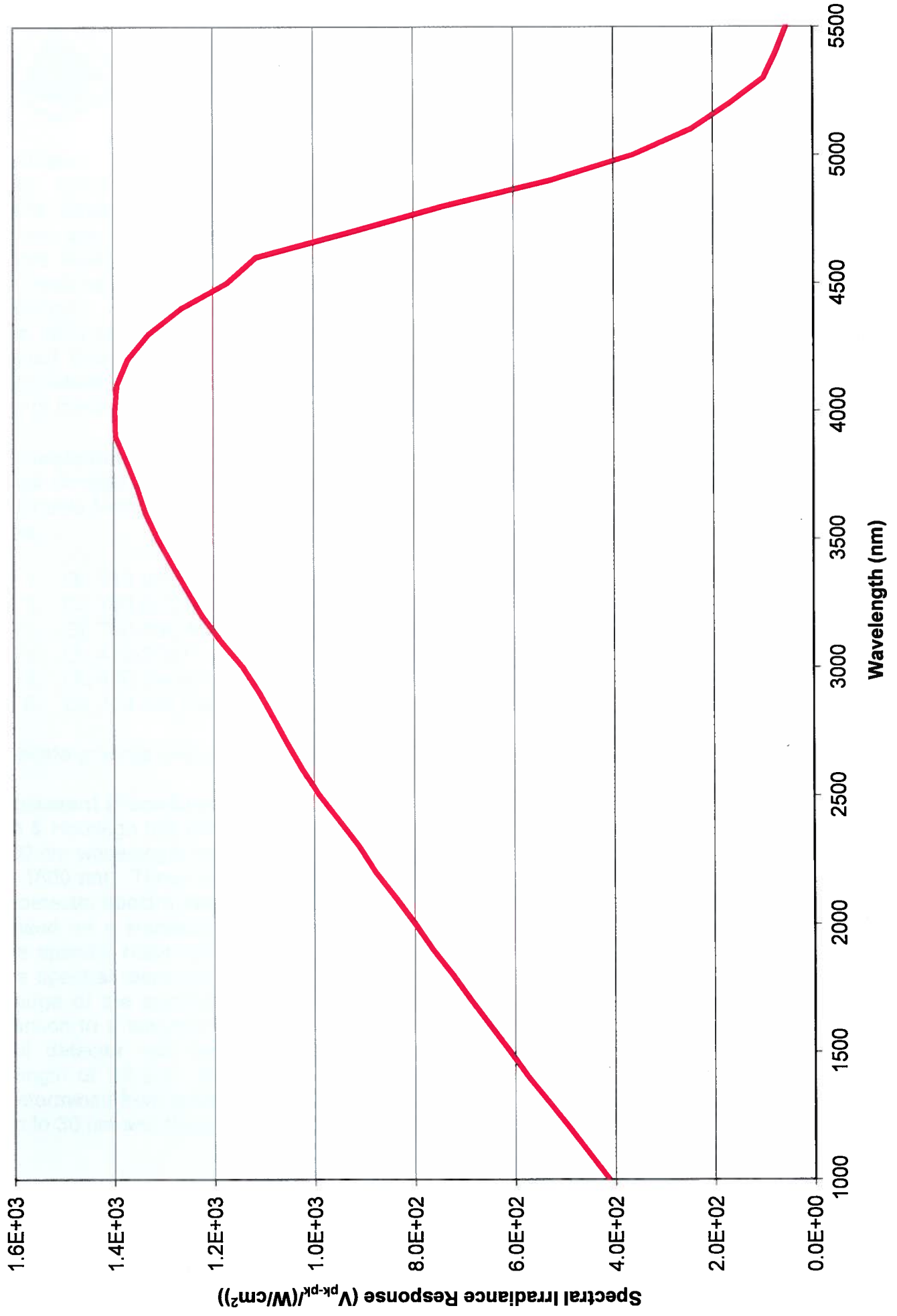
TABLE 1

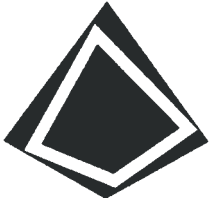
Spectral Irradiance Response of One Cooled Selenide (PbSe) Detector
OL 730-PbSe-C, S/N: 12100016

Wavelength [nm]	Response [$V_{SQ} \cdot P \cdot P / (W / cm^2)$]
1000	4.128E+02
1100	4.523E+02
1200	4.914E+02
1300	5.323E+02
1400	5.743E+02
1500	6.112E+02
1600	6.494E+02
1700	6.881E+02
1800	7.254E+02
1900	7.655E+02
2000	8.005E+02
2100	8.383E+02
2200	8.790E+02
2300	9.115E+02
2400	9.510E+02
2500	9.906E+02
2600	1.024E+03
2700	1.054E+03
2800	1.082E+03
2900	1.110E+03
3000	1.144E+03
3100	1.186E+03
3200	1.225E+03

Wavelength [nm]	Response [$V_{SQ} \cdot P \cdot P / (W / cm^2)$]
3300	1.254E+03
3400	1.284E+03
3500	1.313E+03
3600	1.337E+03
3700	1.354E+03
3800	1.375E+03
3900	1.397E+03
4000	1.398E+03
4100	1.394E+03
4200	1.372E+03
4300	1.329E+03
4400	1.264E+03
4500	1.172E+03
4600	1.115E+03
4700	9.232E+02
4800	7.404E+02
4900	5.261E+02
5000	3.603E+02
5100	2.439E+02
5200	1.673E+02
5300	9.878E+01
5400	7.421E+01
5500	5.399E+01

Spectral Irradiance Response for OL 730-PbSe-C S/N: 12100016





Gooch & Housego

Introduction

Detector spectral response measurements over the wavelength range of 200 nm to 1800 nm are based directly on standard detectors supplied to Gooch & Housego by NIST (National Institute of Standards and Technology). All measurements made beyond 1800 nm are referenced to a heavily

blackened thermal detector, which covers the entire 1.0 μm to 30 μm wavelength range. All primary detectors are calibrated in a uniform, semi-collimated beam, which irradiates the central portion of the detector's active area.

The Gooch & Housego Calibration of Photodetectors

Instrumentation

A typical configuration for spectral response measurements consists of Gooch & Housego's OL 750D Double Monochromator Automated Spectroradiometric Measurement System supplemented with the:

1. OL 740-20D/UV UV-Visible Dual Source Attachment
2. OL 740-20D/IR Visible-IR Dual Source Attachment
3. OL 750-10C Mirror Collimating Optics Module
4. OL 410-200 Precision Lamp Sources
5. OL 46D Deuterium Lamp Precision Current Source
6. OL 750-425 Detector Spectral Response Software Package

Appropriate gratings and blocking filters supplement the above equipment.

Measurement Procedure

Gooch & Housego has set up a series of calibrated UV-enhanced silicon detectors for the 200 nm to 1100 nm wavelength region and TE cooled germanium detectors for use over the range of 800 nm to 1800 nm. These detectors have been compared directly to the NIST calibrated detectors. All IR detector spectral response calibrations (with the exception of the Ge and InGaAs detectors) are based on a standard thermal detector. NPL (National Physical Laboratory) performed the relative spectral response curve for the standard thermal detector from 1.0 μm to 20 μm . The relative spectral response of the thermal detector from 20 μm to 30 μm was determined from a knowledge of the spectral reflectance of the blackened receiver and independently verified by comparison to a blackened, conical-shaped, thermopile detector. The absolute response of the thermal detector was determined by comparison to a NIST-traceable silicon detector at a wavelength of 1.0 μm . Accordingly, the absolute spectral response of the OL thermal detector was determined from a knowledge of the relative spectral response over the wavelength range of 1.0 μm to 30 μm and the absolute response at 1.0 μm .

Uncertainty ($k = 2$)

The uncertainty in the calibration of the NIST supplied standard silicon photodiodes and the estimated transfer uncertainty to the Gooch & Housego's Standard Detector varies as follows:

Wavelength Range (nm)	NIST Uncertainty ^{1/} (%)	Transfer Uncertainty (%)
200	± 3.8%	± 1.5
205 to 215	± 3.0 to 3.4	± 1.0 to ± 1.5
220 to 355	± 0.68 to 1.7	± 0.75 to 1.5
360 to 375	± 0.52 to 0.62	± 0.5
380 to 400	± 0.38 to 0.50	± 0.5
405 to 450	± 0.24 to 0.36	± 0.5
455 to 950	± 0.20 to 0.24	± 0.5
955 to 1020	± 0.66 to 1.4	± 0.5 to 1.0
1025 to 1040	± 1.5 to 1.8	± 0.5 to 1.0
1045 to 1070	± 1.9 to 2.4	± 0.5 to 1.0
1075 to 1100	± 2.6 to 3.0	± 1.0 to 1.5

The uncertainty in the NIST^{1/} calibrated germanium detector varies from ± 0.32% to ± 4.0%, and the estimated transfer uncertainty to the Optronic Laboratories' Standard Detectors is ± 1.0%.

The estimated transfer uncertainty in the relative spectral response of the pyroelectric detectors supplied by Gooch & Housego varies with wavelength as follows:

Wavelength Range (µm)	Transfer Uncertainty (%)
1.0 to 2.5	± 1.0
2.5 to 5.0	± 1.5
5.0 to 15	± 2.0
15 to 20	± 2.5
20 to 30	± 4.0

The estimated uncertainty in the absolute spectral response of the pyroelectric detector at 1.0 µm is ± 1% to 2%.

^{1/} Relative expanded uncertainty at $k=2$.