

REPORT OF CALIBRATION

for

**One UV-Enhanced Silicon Detector
OL 730-5EC, S/N: 1558**

**Calibration Date: July 28, 2011
Certification Date: July 29, 2011
Project No: 914-396**



Gooch & Housego

4632 36th Street, Orlando, Florida 32811 USA

T +1 407 422 3171 F +1 407 648 5412

Visit our website at www.goochandhousego.com

REPORT OF CALIBRATION
for
One UV-Enhanced Silicon Detector
OL 730-5EC

Customer: Rochester Institute of Technology
 Rochester, NY 14623

Purchase Order No: 147682

1. Material.

One Gooch & Housego OL 730-5EC UV-Enhanced Silicon Detector (S/N: 1558) was calibrated for spectral power response in ampere per watt over the wavelength range of 200 nm to 1100 nm.

2. Method of Calibration and Standards.

Calibration of the OL 730-5EC was performed by direct comparison with Gooch & Housego NIST traceable Standard Silicon Detector, S/N: 714. Monochromatic flux was 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

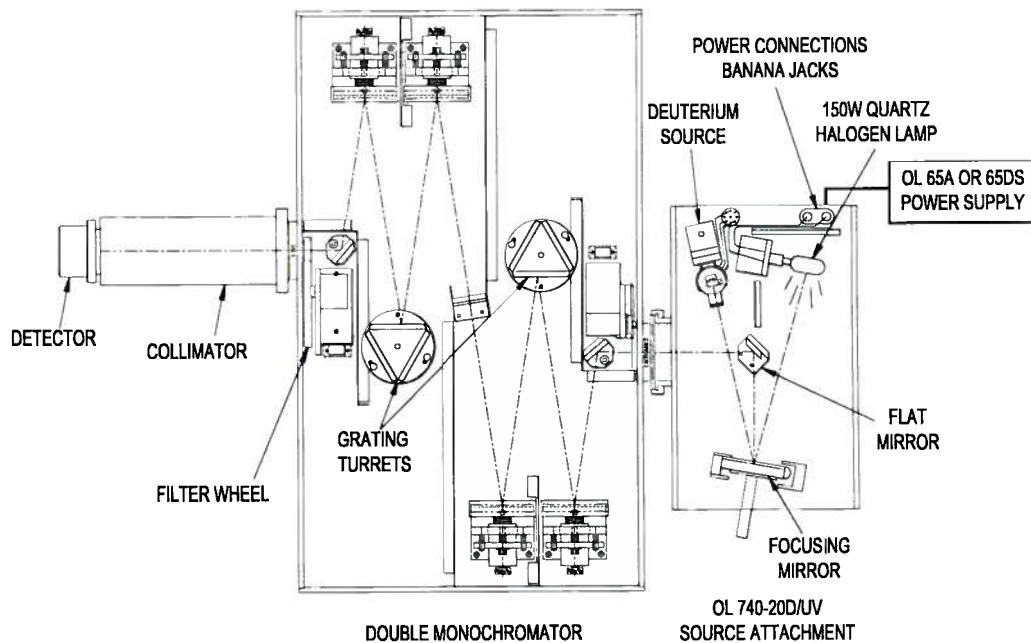


Figure 1

P001562

The detector was operated in the photovoltaic mode and the central 7 mm diameter portion of the receiver was uniformly irradiated ^{1/}. 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 Standard 714 is directly traceable to Standard Detector G704 calibrated by the National Institute of Standards and Technology (NIST Test No. 844/279004).

The ambient temperature was 22.4 °C and the relative humidity was less than 60 %.


3. Results.

Values of spectral power response in ampere per watt are given in Table 1 (a graphical representation is provided). A compact disc containing the spectral values is also provided.

This report of calibration shall not be reproduced, except in full, without written approval of Gooch & Housego, Orlando, Florida.

Calibration Certified By:

GOOCH & HOUSEGO



Michael F. Kelso
Radiometrist

^{1/} It should be noted that silicon detectors may exhibit non-uniformities in spectral sensitivity; therefore, care should be taken when irradiating areas other than the central 7 mm portion of the detector. The non-uniformity in sensitivity can be both spatially and spectrally dependent and is generally more pronounced at wavelengths above 800 nm.

GOOCH & HOUSEGO CALIBRATION REPORT

TABLE 1

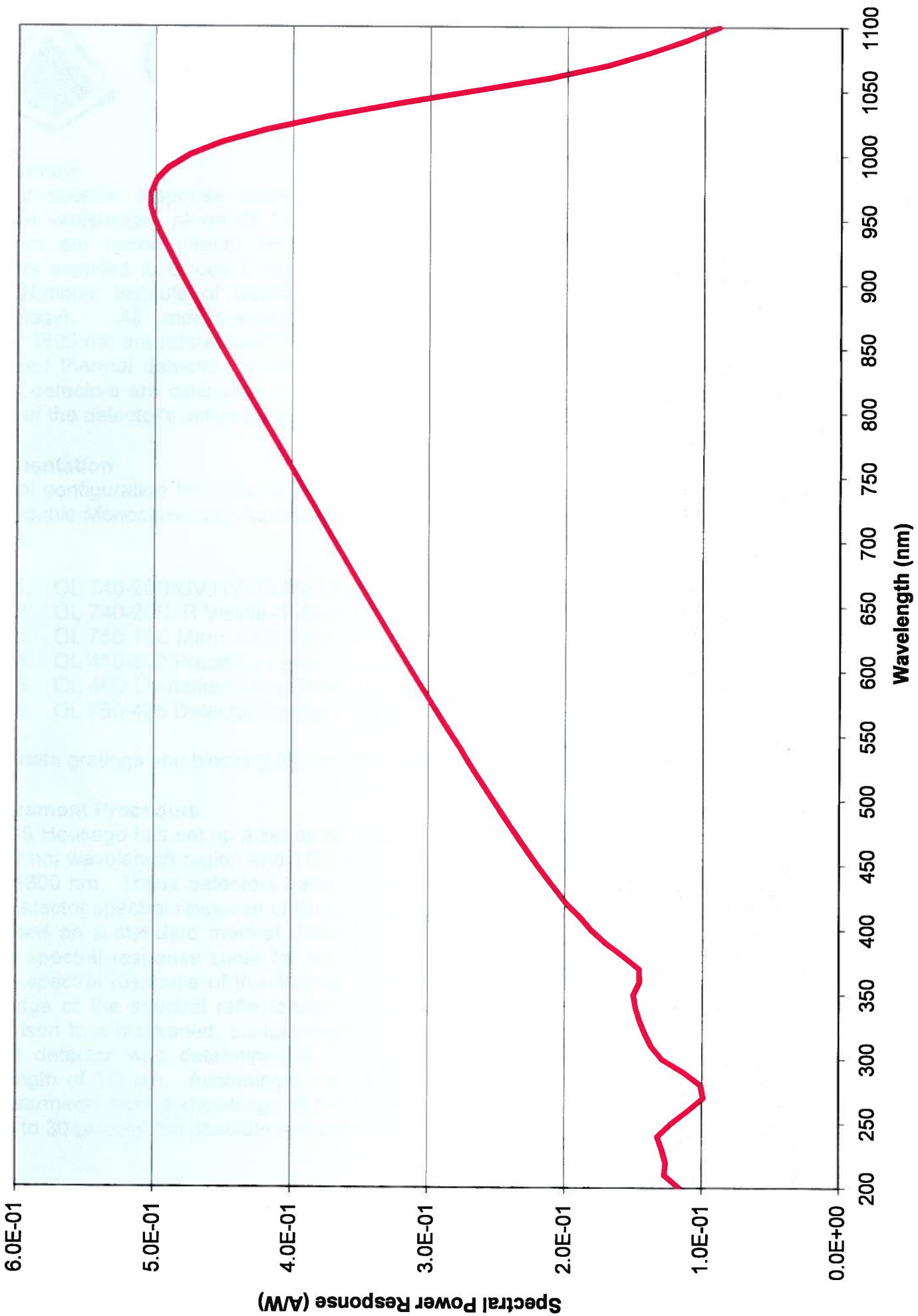
Spectral Power Response for
One OL 730-5EC Silicon Photodetector (S/N: 1558)

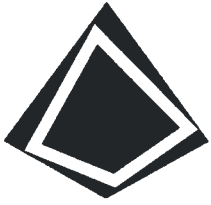
| Wavelength [nm] | Spectral Response [A/W] |
|-----------------|-------------------------|
| 200 | 1.160E-01 |
| 210 | 1.270E-01 |
| 220 | 1.263E-01 |
| 230 | 1.288E-01 |
| 240 | 1.324E-01 |
| 250 | 1.223E-01 |
| 260 | 1.102E-01 |
| 270 | 9.903E-02 |
| 280 | 1.009E-01 |
| 290 | 1.132E-01 |
| 300 | 1.292E-01 |
| 310 | 1.368E-01 |
| 320 | 1.417E-01 |
| 330 | 1.454E-01 |
| 340 | 1.484E-01 |
| 350 | 1.499E-01 |
| 360 | 1.456E-01 |
| 370 | 1.459E-01 |
| 380 | 1.573E-01 |
| 390 | 1.700E-01 |
| 400 | 1.804E-01 |
| 410 | 1.886E-01 |
| 420 | 1.982E-01 |
| 430 | 2.057E-01 |
| 440 | 2.131E-01 |
| 450 | 2.203E-01 |
| 460 | 2.270E-01 |
| 470 | 2.336E-01 |
| 480 | 2.400E-01 |
| 490 | 2.463E-01 |
| 500 | 2.526E-01 |
| 510 | 2.587E-01 |
| 520 | 2.649E-01 |
| 530 | 2.710E-01 |
| 540 | 2.765E-01 |
| 550 | 2.826E-01 |
| 560 | 2.887E-01 |
| 570 | 2.947E-01 |
| 580 | 3.006E-01 |
| 590 | 3.065E-01 |

| Wavelength [nm] | Spectral Response [A/W] |
|-----------------|-------------------------|
| 600 | 3.123E-01 |
| 610 | 3.181E-01 |
| 620 | 3.238E-01 |
| 630 | 3.295E-01 |
| 640 | 3.351E-01 |
| 650 | 3.408E-01 |
| 660 | 3.463E-01 |
| 670 | 3.519E-01 |
| 680 | 3.575E-01 |
| 690 | 3.630E-01 |
| 700 | 3.686E-01 |
| 710 | 3.741E-01 |
| 720 | 3.796E-01 |
| 730 | 3.852E-01 |
| 740 | 3.907E-01 |
| 750 | 3.962E-01 |
| 760 | 4.017E-01 |
| 770 | 4.072E-01 |
| 780 | 4.127E-01 |
| 790 | 4.183E-01 |
| 800 | 4.238E-01 |
| 810 | 4.292E-01 |
| 820 | 4.347E-01 |
| 830 | 4.402E-01 |
| 840 | 4.456E-01 |
| 850 | 4.510E-01 |
| 860 | 4.564E-01 |
| 870 | 4.617E-01 |
| 880 | 4.669E-01 |
| 890 | 4.721E-01 |
| 900 | 4.772E-01 |
| 910 | 4.823E-01 |
| 920 | 4.872E-01 |
| 930 | 4.921E-01 |
| 940 | 4.968E-01 |
| 950 | 5.009E-01 |
| 960 | 5.035E-01 |
| 970 | 5.035E-01 |
| 980 | 4.996E-01 |
| 990 | 4.905E-01 |

| Wavelength [nm] | Spectral Response [A/W] |
|-----------------|-------------------------|
| 1000 | 4.750E-01 |
| 1010 | 4.517E-01 |
| 1020 | 4.183E-01 |
| 1030 | 3.747E-01 |
| 1040 | 3.237E-01 |
| 1050 | 2.691E-01 |
| 1060 | 2.133E-01 |
| 1070 | 1.706E-01 |
| 1080 | 1.397E-01 |
| 1090 | 1.124E-01 |
| 1100 | 8.954E-02 |

Spectral Power Response for UL / 3U-3EL S/N: 1000





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 $k=2$.