OPTICAL CALIBRATION SERVICES
MODEL OCS-LAB

BULLETIN CAL

Overview

The R&D of solar radiation instrumentation have significant calibration requirements. The specialized optical laboratory YES operates to characterize products includes three major facilities for the measurement of spectral, cosine and absolute responses of optical radiation detectors. Our optical laboratory facilities give us the capability to fully characterize the performance of radiometric instrumentation referenced to NIST standards. As standard policy, we also execute any outstanding Engineering Change Orders on instruments returned for calibration, effectively offering a free technology upgrade to our customers. Customers have the option of having a benchmark pre-calibration for data taken prior to modifications.

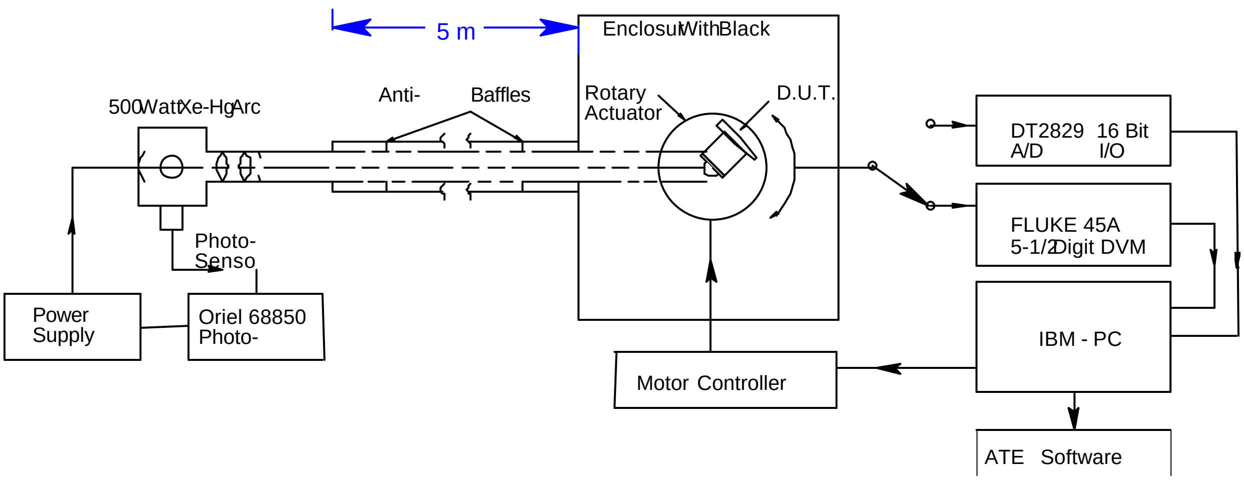

Figure 1. Schematic diagram of the Cosine Response Facility

Cosine Response Facility (CRF)

A schematic diagram of the YES Cosine Response Facility (CRF) is shown in Figure 1. The purpose of this facility is to measure the cosine response of a detector. Radiometric instruments are designed to detect radiation incident on a flat surface and attempt to reproduce a Lambertian response. The output signal of an "ideal" instrument would look like the cosine of the angle of incidence of the light (0° is orthogonal to the radiometer's fore optic). This reflects the fact that the effective illuminated sensitive surface of an instrument is proportional to the cosine of the angle of incidence of the light. Deviations from an ideal cosine response lead to measurement errors for moving light sources, such as the sun, which illuminate the detector at a range of incidence angles. To illustrate the true error visually, measured cosine response is traditionally expressed as the ratio of the measured response to an ideal cosine response function.

The Detector Under Test (DUT) is mounted vertically on a rotary table and illuminated by a uniform, parallel light beam. The DUT is rotated over ±90° and its output signal is recorded, then it is rotated 90° axially (horizontal position) and then re-measured. The ratio of DUT response to the response with the DUT at 0° (with respect to the beam) yield the cosine response of the instrument. The entire process is conducted under computer control.

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Spectral Response Facility (SRF)

The schematic diagram of the YES Spectral Response Facility (SRF) is shown in Figure 2. The purpose of this facility is to measure the relative spectral response of an optical instrument. The DUT is illuminated by a monochromatic light beam and its output signal is measured. A portion of the light beam is directed onto a broadband photodetector via a beam splitter that permits normalization of beam intensity during a scan. The output signals of the DUT and the reference detector are recorded as the beam wavelength is varied. The DUT's relative spectral response at each wavelength is determined by dividing its output signal at that wavelength by the beam intensity, as determined by the reference detector. This facility can be configured to permit spectral response measurements in the range of 270 to 1100 nm, with a wavelength resolution of 0.01 nm.

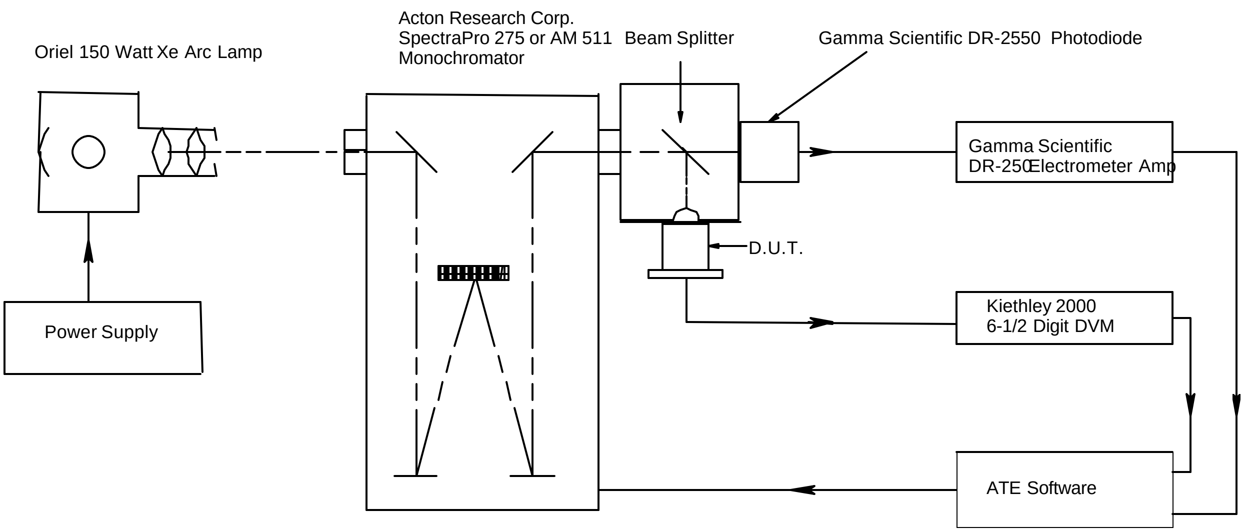

Figure 2. Schematic diagram of the Spectral Response Facility.

Absolute Response Facility (ARF)

A schematic diagram of the YES Absolute Response Facility (ARF) is shown on the next page in Figure 3. The purpose of this facility is to measure the absolute response of a detector to incident irradiance (sometimes referred to as the instrument voltage sensitivity). An essential element of the system is a 1,000 Watt calibrated NIST-traceable FEL lamp, a spectral irradiance standard. The prior characterization of the lamp results in an accurate determination of the lamp's absolute spectral irradiance at a distance of 50 cm from the lamp. Comparison of the response of the DUT to the lamp irradiance, normalized against the DUT's relative spectral response and the FEL lamp's absolute spectral irradiance determine the absolute response of the DUT.

WMO and WRC Calibrations

The World Meteorological Organization requires radiation data reported via calibrations traceable to the World Radiation Centre (WRC) in Davos, CH. These radiation instruments are calibrated every 5 years with standards referenced to the WRC. There is a fundamental difference between the NIST/NPL/PTB-type FEL lamp standard laboratory irradiance standard scale vs. the irradiance scale that the WRC uses derived by absolute cavity radiometer measurements using the sun. Both temperature scales have advantages and disadvantages but practical matters tend to govern the way things get manufactured, (for example, when you can't see the sun due to weather, or when the sun is too low in the sky and a radiometer's imperfect cosine response begins to dominate its response). But despite the fact it moves, the sun is an incredibly constant spectral source and has a higher black body temperature than any FEL lamp, thus ideally one would like to use an absolute cavity radiometer and the sun to derive absolute calibrations. To make matters worse there are several ways to transfer the calibrations from pyranometers using the sun; ANSI and ISO specs

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differ slightly resulting in debates and confusion over which method is "the best."

YES uses an indoor hybrid calibration using a NIST traceable FEL lamp and a sun-calibrated WRC-traceable pyranometer to derive the absolute calibration for a MFR-7 or SDR-1 broadband channel. First, a WMO-traceable calibrated pyranometer is used to characterize a NIST-traceable FEL lamp, and then the pyranometer is exchanged with a SDR-1 head to tie the response of its broadband channel back to the pyranometer's output. This method also eliminates the sun angle factor that outdoor calibrations suffer from.

ISO/ASTM calibration standards tend to pre-date the technology that the SDR-1 represents. For example, the SDR-1's cosine-correction significantly improves the overall accuracy, and because it has only axis of rotation (vs. two for a conventional sun-tracker) it has excellent long term tracking accuracy vs. a NIP+pyranometer which tend to experience solar tracker errors.

The calibration of the SDR-1 broadband channel is performed in the laboratory and is referenced to NIST standards. Standard ISO 1990c describes the characteristics of pyranometers of various levels of performance. Both the SDR-1 and TSP-700 can be referenced as 'good quality' according to characteristics stated in ISO 1990c. Extensive testing of the SDR-1 has shown that the data are of sufficiently high accuracy to compete with standard setups including a NIP/shaded/unshaded pyranometer. ISO recently changed its pyranometer naming conventions that used to be "primary standard", "secondary standard", "first class", "second class." TSP-700, TSP-400 and MFR-7/SDR-1 broadband channel data can be reported as from a "'good quality'" via ISO1990c.

Outdoor Test Facility

In addition to the indoor optical laboratory, YES maintains a fully instrumented field test station for monitoring solar radiation, evaluating new designs and performing calibrations using the sun as a source of irradiance. The outdoor facility includes:

- Ventilated Total Solar Pyranometers,

Normal Incidence Pyrheliometers,

- NIST-traceable, shielded and aspirated platinum resistance thermometer for monitoring ambient temperature,
- Ref. UV-B and UV-A broadband instruments,
- NIST-traceable optical chilled mirror hygrometer, for monitoring water vapor.

The outdoor test area uses redundant data acquisition systems, which allow dozens of analog instruments to be placed under test concurrently.

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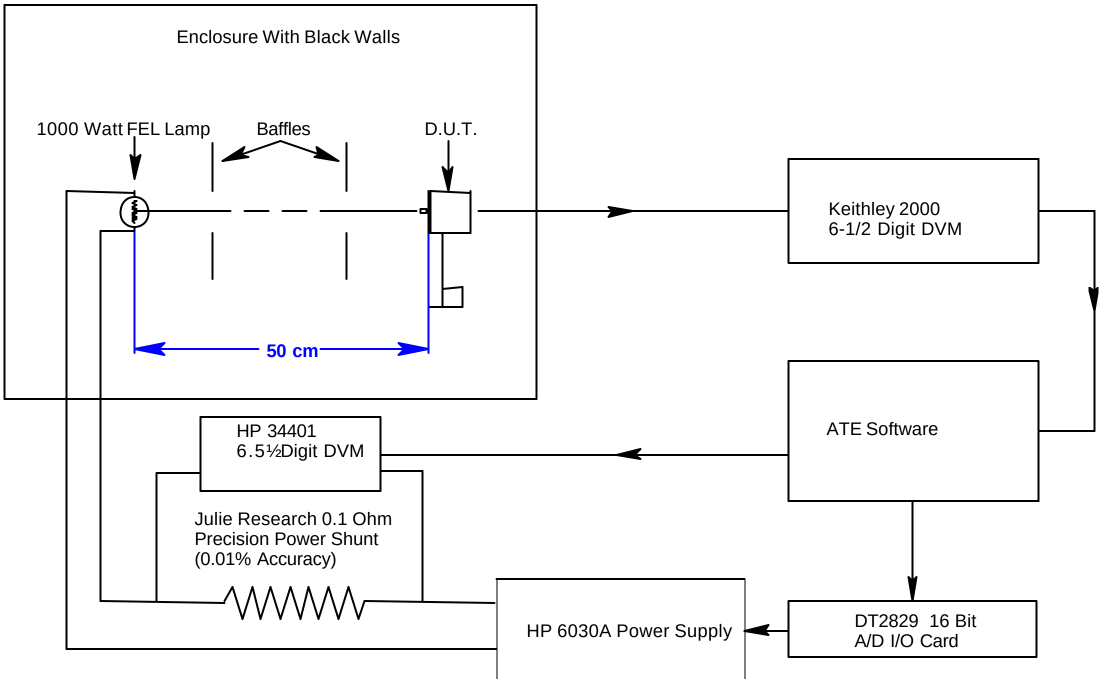

Figure 3. Schematic diagram of the Absolute Response Facility.

Calibration Schedule/Procedures

INSTRUMENT MODEL	RESPONSE MEASURED	RECOMMENDED CAL INTERVAL
MFR-4/MFR-7	Cosine, Spectral, Absolute	12 months
SDR-1/SDP-1	Cosine, Absolute	12 months
SPUV-6/10	Spectral, Absolute	12-18 months
TSP-700	Absolute	12-18 months*
UVB-1/UVB-1	Spectral, Absolute	12-18 months*
UVMFR-7/UVMFR-4	Cosine, Spectral, Absolute	12 months
YESDAS-2	Channel Offset & Gain,	2-3 years

*Since we use the sun to calibrate these instruments, plan shipments to YES between March and October when the sun reaches its maximum elevation and we can provide the most accurate absolute calibrations.

NOTE: You must contact YES for a return authorization number before returning instruments for service or recalibration-please review our RMA policy on the tech support area of our web site. If you would like to discuss specialized optical calibration needs, please contact us.

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