Sensors • Biologically Weighted UV-B Detector

PMA2101

Measures Biologically Effective Ultraviolet Radiation from Sun and Artificial Sources

Applications

- Laboratory and Industrial Radiometry
- Skin and SPF Testing
- Clinical Studies
- Phototherapy
- Environmental Monitoring
- Material Testing
- UV-B Transmission Measurements
- Agriculture

Features and Benefits

- High Sensitivity
- Dynamic Range $2*10^5$
- Excellent Long-Term Stability
- Cosine Corrected
- NIST Traceable Calibration
- Radiometric and Biological Units

The PMA2101 detector gives an accurate measurement of biologically weighted ultraviolet radiation from sunlight or artificial light sources, also called sunburning UV radiation (SUV). Its spectral response follows closely the erythema action spectrum[1]. Due to built-in Teflon diffuser the detector has angular response very close to an ideal cosine function (Lambertian response) making it suitable for measurements of diffuse radiation or radiation generated by extended sources.

The measured irradiance can be displayed in MED/Hr, $\mu W/cm^2$ well as a time to accumulate one MED. High dynamic range allows measurements of very week signals down to 0.01 $\mu W/cm^2$ as well as very strong irradiances over $1mW/cm^2$.

The sensor is based on a phosphor technology, used in Robertson-Berger meters and proven to be extremely stable over long periods of time.

The biologic effectiveness of ultraviolet radiation is strongest for wavelengths between 280 to 315nm, classified as UV-B by the CIE organization. Several biologic action spectra, functions relating wavelength of the radiation and its biologic effectiveness, are shown in Figure 3. The most commonly used, erythema action spectrum, also referred to as CIE 1987 action spectrum, represents the sensitivity of human skin to sunburn.

Other biologic action spectra also exhibit rapid decline in UV effect with an increase of wavelength over the the UV-B range. In general, the reading of an erythemally weighted detector cannot be directly interpreted as biological effectiveness other than erythemal. However, there is a way to make necessary correction numerically[2].

The erythemal power of the UV radiation can be measured in terms of effective irradiance in radiometric units, for example $\mu W/cm^2$. It is often related to the sensitivity of the human skin to sunburn and expressed in Minimal Erythemal Doses per Hour [MED/Hr]. One MED is the effective dose capable of causing minimum skin redness (erythema) in an average number 2 skin. Based on a study[3], the relationship between MED/Hr and radiometric units was assumed:

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1 [MED/Hr] = 5.83 [µW/cm^2]. This formula is programmed into the PMA2101 detector allowing for easy conversion of units. Consequently, the integrated effective dose is expressed in [mJoules/cm^2] or MED. It takes 1/2 hour to accumulate 1 MED when the subject is exposed to an irradiance of 2 MED/Hr.

Many sources produce UV radiation with a spectral irradiance changing rapidly over narrow wavelengths range. Spectral irradiance of the solar UV (Fig. 4) is an extreme example of such steep slope due to the UV-B and UV-C absorbing ozone layer. Combination of a sharply changing spectral irradiance and a rapidly changing spectral response of the detector create a need for an extreme stability of the detector in order to produce repeatable results.

Calibration

The PMA2101 detector is calibrated by transfer from a reference detector. The reference detector, UV-Biometer Model 501A, is periodically calibrated spectroradiometrically to show accurate values of the erythemal irradiance when exposed to a "reference sun". The "reference sun" is defined based on a solar UV radiation under 30 solar zenith angle and 2.7mm total ozone column. The basic calibration uncertainty is approximately 10% for UV-B detectors. Due to a small difference between an ideal erythemal action spectrum and the detector's response there measurement can be loaded with an additional error for sources of various spectral composition. Full description of the calibration procedure is available upon request. Yearly re-calibration is required.

Specifications	
Spectral Response	Follows Erythema Action Spectrum Figure 1
Angular Response	5% for Angles <60°, Figure 2
Range	200 [MED/Hr], 1,160 [µW/cm^2]
Display Resolution	0.001 [MED/Hr], 0.01[µW/cm^2]
Operating Environment	32 to 120 °F (0 to +50 °C) No Precipitation
Temperature Coefficient	1% /°C for Solar Radiation
Cable	6 ft. Straight Cable (1.82m)
Diameter	1.6" (40.6mm)
Height	1.8" (45.8mm)
Weight	7.1 oz. (200 grams)
Irradiance from Typical Sources	Solar Radiation, 30°. SZA, 3mm Ozone, Clear Sky: Approx. 4 mW/cm^2
150W Xenon Lamp at 8"	Approx. 0.5 mW/cm^2
Solar Simulator Model 16S	50 mW/cm^2
Ordering Information	
PMA2101	Biologically Weighted UV-B Detector
See list of accessories for mounting hardware available.	

References

[1] McKinlay A.F. and B.L. Diffey, "A reference action spectrum for ultraviolet induced erythema in human skin", CIE Journal, 6, 17-22, 1987
[2] Morys M., D. Berger, "Accurate measurements of biologically effective ultraviolet radiation" SPIE Proc. 2049, pp. 152-161, 1993.
[3] Parrish J.A., K.F.Jaenicke, R.R. Anderson "Erythema and melanogenesis action spectra of normal human skin" Photochem. Photobiol. 36, pp. 87-191 (1982)

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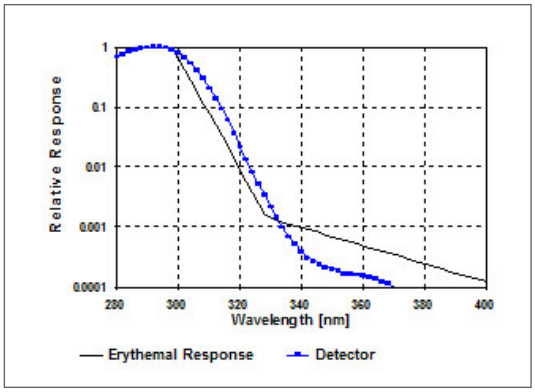

Fig. 1. PMA2101 Spectral Response

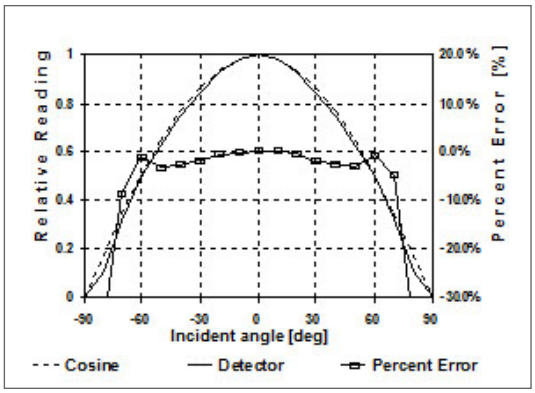

Fig. 2. PMA2101 Angular Response

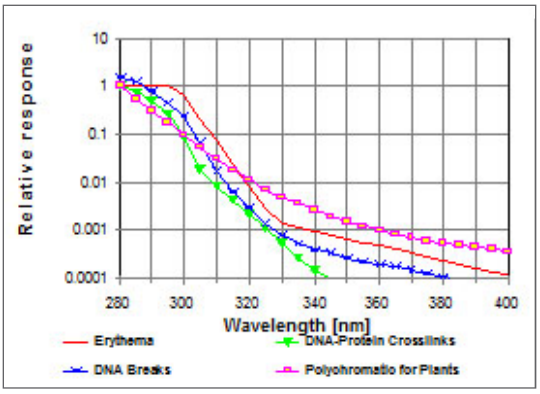

Fig.3. PMA2101 Selected Biologic Action Spectra

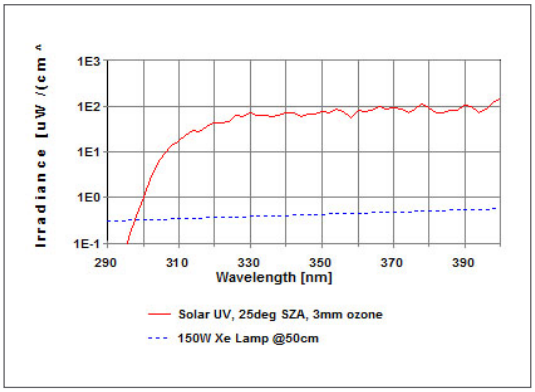

Fig. 4. PMA2101 Example of Spectral Irradiance