A Very Cheap, Flexible and Retrofittable Method for the Low Irradiance Test

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ABSTRACT: Standards IEC 61215 and 61646 set that the purpose of "Performance at low irradiance" test is to determine how the electrical performance of the module varies with load at 25 °C and at irradiance of 200 Wm-2 using natural sunlight or a simulator class BBB or better conforming to the requirements of IEC 60904-9, instead of 1000 Wm-2 standard conditions. The use the solar simulator is not possible since only by changing the power and consequently modifying the intensity of the lamps the spectrum varies with the current passing through the lamps. So a special device to change the irradiance to 200 Wm-2 is required and it shouldn't affect the relative spectral irradiance distribution and the spatial uniformity in accordance with IEC 60904-10. To this purpose the IEC 60904-10 recommends the use of mesh filters or neutral density filters. Mesh filters are believed to be the best method for large surfaces. But if the metallic mesh is put near the lamp house even the reference cell would be irradiated at the low irradiance intensity and it is not easy to have a reference cell calibrated at 200 W/m2 and in anyway the light would be almost completely scattered, making the measurement not completely realistic. The aim of this work is to propose the use of a plastic film for an acceptable neutral reduction of the irradiation. It is cheap and can be retrofitted to many existing simulators.
Keywords: Reliability, Energy Performance, Characterisation

1 INTRODUCTION

The purpose of the test "Performance at low irradiance" is to determine how the electrical performance of the module varies with load at 25 °C and at irradiance of 200 Wm-2 using natural sunlight or a simulator class BBB or better conforming to the requirements of IEC 60904-9, instead of 1000 Wm-2 standard conditions. A device to change the irradiance to 200 Wm-2 is required; its implementation shouldn't affect the relative spectral irradiance distribution and the spatial uniformity in accordance with IEC 60904-10. To this purpose the IEC 60904-10 recommends the use of mesh filters or neutral density filters. Mesh filters are believed to be the best method for large surfaces. In principle it could be possible to use the solar simulator only by changing the power and consequently modifying the intensity of the lamps; unfortunately the spectrum varies with the current passing through the lamps and in any case the use of the lamps at very low electrical power could result to be dangerous for the equipment electronic. Another possibility is to use metallic mesh applied to the lamp. But if the metallic mesh is put near the lamp house even the reference cell would be irradiated at the low irradiance intensity and it is not easy to have a reference cell calibrated at 200 W/m2 and in anyway the light would be almost completely scattered, making the measurement not completely realistic. The aim of this work is to investigate a method that consider the use of a plastic film. Spectrophotometric measurements of transmittance for different samples were carried over; the best of them presented a neutral behaviour, a spectral constant transmission, within an error of 15 % that is less than the best neutral filters.

2 THE ADVANTAGE FOR USING PLASTICS

The general use of plastics in optics is very interesting due to the potentials of plastics to be produced in a cheaper way respect to the glass. Other positive effects are their lightness and the easiest way to be manufactured even in very large dimension. The main advantage for the test is that it is possible to cover only the module and not the reference cell. So during the flash the reference cell remains illuminated at 1000 W/m2 while the module is irradiated at a reduced level. Besides this method is easy to use, very low cost and flexible to be conveniently retrofitted to each solar simulator so avoiding the complexity to change the power and the consequently modification of the spectrum. Of course the accuracy and uncertainties are to be estimated and compared with the ones of other techniques.

3 SAMPLES

Samples of film produced by Solamatrix Inc., FL, USA, and provided by their dealer for Italy Sun-Gard Italia have been investigated at ENEA Portici laboratory.

4 EXPERIMENTAL

4.1 Measurements

At the ENEA Portici spectrophotometric measurements of transmittance for different samples were carried over some of the results are shown on the figure 1. As it can be seen the best seems to be the StainlessSteel20 that within the range from 400 to 1100 nm is the less sensitive to the variation of the wavelengths. So the stainless steel 20 sample was selected as the best one.

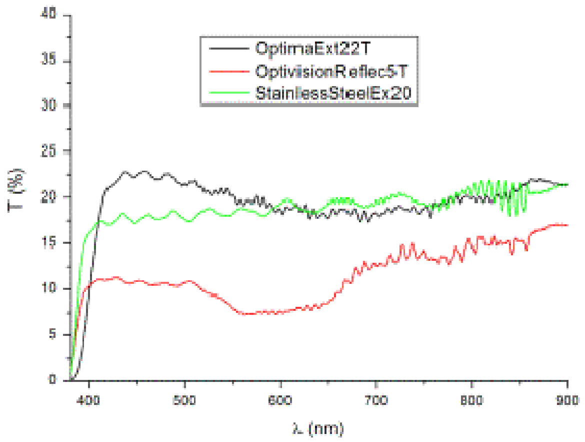

Figure 1: Transmittance curves for some types of film.

The figure 2 shows the reflectance and the transmittance within the range of interest.

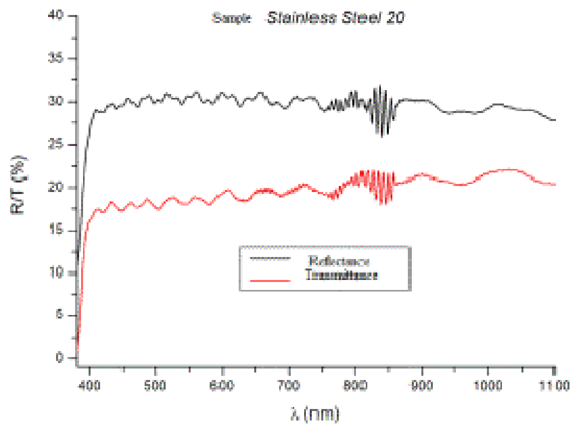

Figure 2: Reflectance and transmittance curves for the Stainless Steel 20

The graph in figure 3 shows the spectral transmittance of the film, the blue line, within the range of wavelengths between 400 and 1100 nm. In the figure Y errors bars of 15 % are also reported. .

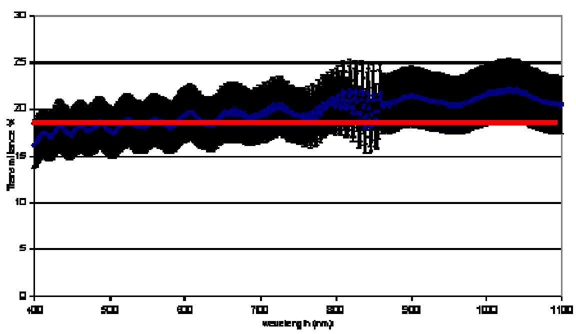

Figure 3: Spectral transmittance curve, blue line, and error bars for the Stainless Steel 20.

The average value is 19.71 and the standard deviation is 1.38. Minimum and maximum respectively are 16.1 and 22.1

4.2 Uncertainty evaluation

The above estimated error of 15 % should be compared to the error of optical neutral filters and metallic mesh in order to understand its acceptability limit.

Fig.4 shows the transmittance of a neutral commercial filter within the range of wavelengths between 400 and 1100 nm. That was one of the best we found. In the figure Y errors bars of 20 % are also reported.

The average value is 67.5 and the standard deviation is 6.46. Minimum and maximum respectively are 46 and 71.3.

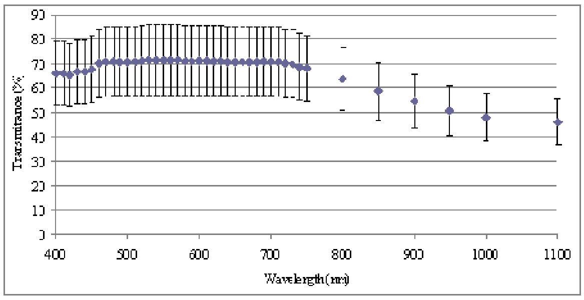

Figure 4: Spectral transmittance curve, blue line, and error bars for a commercial neutral optic filter

So it is pretty obvious that even in the use of neutral density filters there always is a change of spectral distribution within the range of interest. The use of metallic mesh does not heavily affect the spectrum but results in a greater diffused component.

The perfect neutral filter doesn't exist and this result suggests that the uncertainty of the film can be considered acceptable

4.3 Spectral modification of the irradiance

Since it is impossible to have a perfect filter that does not modify the energy distribution it is interesting to understand if the class of the simulator regarding the spectral mismatch can be affected.

Only in the range from 800 to 900 nm the measured irradiance percentage is 15.9 just a bit higher than the maximum allowed value of 15.6 stated by the Standard.

So the class A is lost. The following table compares the results with a class B spectrum.

Table I: Electrical values for the PV tile

Wavelength range	Energy subtotal	Meas. %	Nominal %	Lowest value for class B	Highest value for class A	Checking Class B
400-500 nm	7.70	20.5	18.4	11.0	25.8	Yes
500-600 nm	6.80	18.1	19.9	11.9	27.9	Yes
600-700 nm	5.64	15.0	18.4	11.0	25.8	Yes
700-800 nm	4.53	12.0	14.9	8.9	20.9	Yes
800-900 nm	5.99	15.9	12.5	7.5	17.5	Yes
900-1050nm	6.94	18.5	15.9	9.5	22.3	Yes
Total	37.6					Yes

4.4 The weighted attenuation factor

Then we measured the average transmittance of the film by weighting the spectral values within the relative irradiance levels at the different wavelengths, between 400 and 1100 nm, of our lamp and a value of 19.3 % was obtained

400-500 nm	17.6989552	3.95646318
500-600 nm	18.3935453	3.49340331
600-700 nm	19.2098347	2.89692661
700-800 nm	19.8101202	2.32719094
800-900 nm	20.5879018	3.07834871
900-1050 nm	21.1404115	3.56704051
Sum		19.3

So the irradiance weighted average value of the transmittance of the film is estimated as 19.3 %.

At the end we tested the method on a module covered and uncovered to the light (Figs 5 and 6). By taking the ratio between the two values of the short circuit currents we obtained the surprising value of 19.3, the same as the one we measured by spectroradiometer measurements. So an irradiation of 200 W/m2 within an uncertainty of less than 2 % was obtained. This is the evidence that the method is quite accurate.

Isc (A)	8.91
PMax (W)	238.3
Voc (V)	37.2

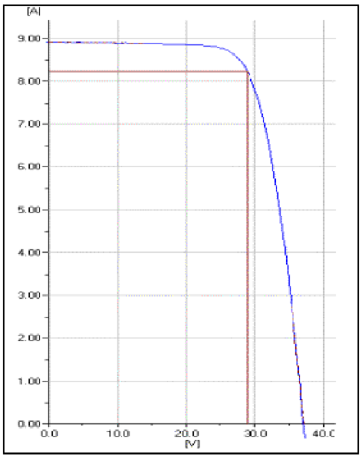

Figure 5 Measurements at STC for the sample

Isc (A)	1.72
PMax (W)	45.6
Voc (V)	34.5

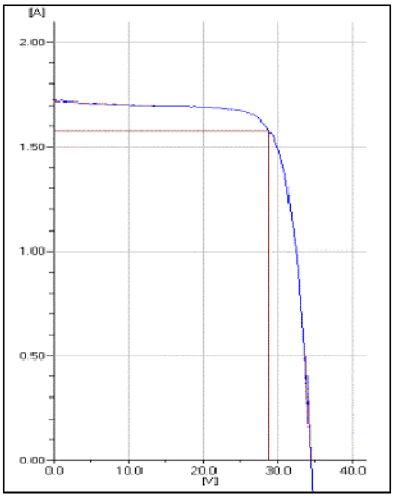

Figure 6: Measurements at low irradiance for the sample.

CONCLUSION

Spectrophotometric measurements of transmittance for different samples were carried over; the best of them presented a neutral behaviour, a spectral constant transmission, within 15 %. The error of 15 % has been compared to that of optical neutral filters and metallic mesh in order to understand its acceptability limit; by making a research on main commercial optical filters it came out that the best neutral filters are really neutral only within 20 % of error. The use of metallic mesh does not heavily affect the spectrum but results in a greater diffused component. The perfect neutral filter doesn't exist and this result suggests that the uncertainty of the film can be considered acceptable. The spectrum of the light of our solar simulator, class A, was just a bit changed by passing through the plastic filter so degrading the class from A to class B. Anyway the standard requires that at least a class B should be used so the compliance to the Standard is however fulfilled. We also estimated the average transmittance of the film by weighting the spectral values within the relative irradiance levels at the different wavelengths, between 400 and 1100 nm, of our lamp and a value of 19.3 % was obtained. Then we tested a module at STC with and without the sunscreen film. By taking the ratio between the two values of the short circuit currents the same value of 19.3 was surprisingly obtained, as the one we measured by spectroradiometer measurements. So an irradiation of 200 W/m2 within an uncertainty of less than 2 % was reached. This is the evidence that the method is quite accurate.