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20

(A)

.(IEC 60904-9)

IEC 60904-9

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The Effect of the Light Diffusers on Spatial Uniformity of the Solar Simulator

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ABSTRACT

In this study, the effect of using photovoltaic light diffusers on the performance of the solar simulator has been demonstrated, which consists of a 20-watt halogen lamp combined with white, green, and blue light emitting diodes of high-power capacities, which has been arranged in this research work so that the halogen lamp is centrally positioned on the unit of the solar simulator and the light emitting diodes distributed regularly around it, where the solar simulator consists of eight solar simulator units. The optical system of the solar simulator include: light diffusers, lenses and filters for the purpose of obtaining better spatial uniformity. The outer structure is built so that the source height is made to be adjustable to control the power light intensity. The spatial uniformity is the main parameters in the development of a solar simulator to obtain the best match for solar radiation in the

laboratory environment and to meet the international standard (IEC 60904-9), where the class (A) has been achieved according to this standard. This study presents a practical investigation of the effect of photovoltaic light diffusers on the spatial distribution of the intensity of the radiation produced by the halogen lamp solar simulator with a set of high-energy light-emitting diodes consisting of nine solar simulators.

Keywords: Solar Simulator, Light Diffuser, Solar Cell Manufacturing, IEC 60904-9, Spectral Spectroscopy in the Solar Simulator. Spatial Uniformity in the Solar Simulator.

()

(ASTM standard E927-05., 2005) (I-V characteristics)

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(LED)

LEDs

(Novičkovas, *et al.*, 2015) 10000 5000 ~)

LED

(Anon Namin., 2013) (IEC 60904-9) B A

(Bliss, 2009)

(IEC., 2007) (I-V)

LED

(JIS ASTM IEC)

1 5 A

(Novičkovas *et al.*, 2015)

(Bazzi *et al.*, 2012) (10x10 cm²) (Kerbs, 2011)

1975 (NASA) (ERDA)

(I-V) 1977

(ERDA/NASA, 1977) 1977

ASTM AM=1.5 ² / 1000

.....

(ASTM standard G173-03., 1992)

(2) (1) :

(4) (3)

.(Pernisz,1982)

1978 .(ERDA/NASA, 1977) 1977

(Brandhorst *et al.*, 1975) 1975

.(Pernisz, 1982) (ASTM E-44)

(LED)

.(Bliss and Betts, 2008)

.(Jang and shin., 2010) (Bliss and Betts, 2008)

2012 .(Kolberg *et al.*, 2011) LED

AM1.5 G LED (UIUC)

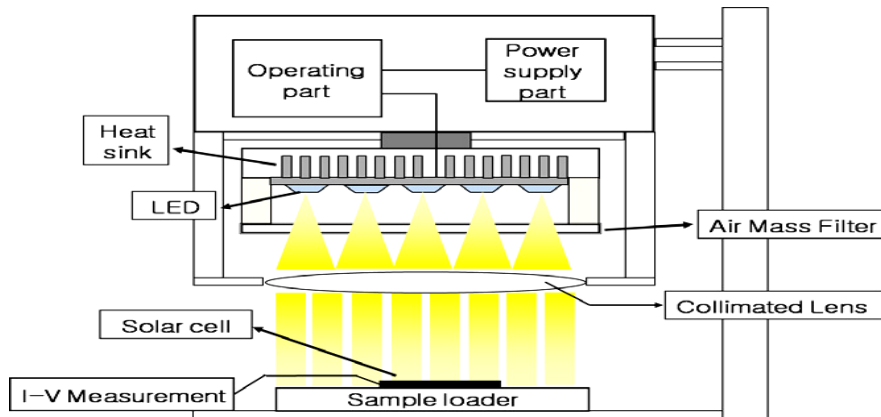
LED .(Bazzi *et al.*, 2012) (10*10 cm²) C

.(Solanki *et al.*, 2009)

.(Kuhn and Hunt, 1991) (Zahler *et al.*, 2005)

.(Jang and Shin, 2010)

(1)



الشكل 1: مخطط نموذجي لمحاكي الطاقة الشمسية للتثايات الباعثة للضوء

(I-V)

(IEC 60904-9)

C B A

(The Non – uniformity of irradiance) (The spectral match)

(1) (The temporal instability of irradiance)

(IEC 60904-3) :1

2 %	2 %	(1.25-0.75)%	A
5 %	5 %	(1.40-0.60)%	B
10 %	10 %	(2.00-0.40)%	C

() . () . () . (IEC 60904-9)

(IEC., 2007)

-1

.Spectroscadiometer (The spectral match)

AM 1.5 G

(2) .

(IEC 60904-3) :2

.(1100 - . 400)	(nm)	
18.4 %	400-500	1
19.9 %	500-600	2
18.4%	600-700	3
14.9 %	700-800	4
12.5 %	900-1000	5
15.9 %	1000-1100	6

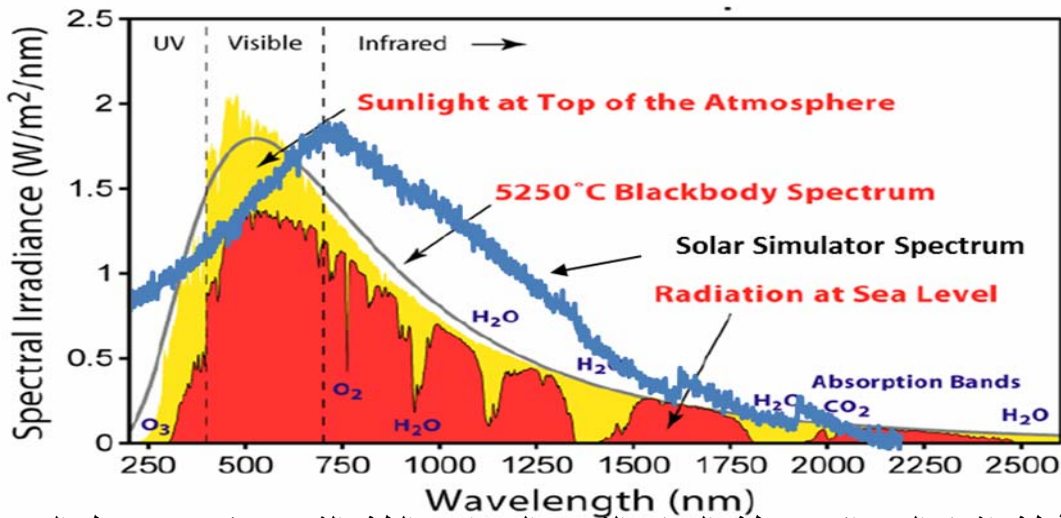
(AM1.5G) (M1.5D) (M0) :

.AM1.5G 1100 400 A
 .(Z)
 220 (36.35°) (43.10°)

. (Al-Moula and Al-Abdullah, 2018) (1.24)

(5250° C) (2)

.(Rhode, 2007) AM1.5G



الشكل 2: مقارنة طيف اشعاع الجسم الاسود وطيف المحاكي الشمسي المستخدم والطيف الشمسي عند مستوى سطح البحر وعند قمة الغلاف الجوي.

-2

(The Non – uniformity of irradiance)

68

(IEC., 2007) (IEC 60904-9)

.(Napat, 2017) (1)

$$Non - uniformity(\%) = \left[\frac{Q_{max} - Q_{min}}{Q_{max} + Q_{min}} \right] \times 100\% \text{ ----- (1)}$$

Q_{max} is the measured value of the maximum irradiance (W/m^2)
 Q_{min} is the measured value of the minimum irradiance (W/m^2)

-3

(The temporal instability of irradiance)

(LTI)

(STI)

.(IEC., 2007) (I-V)

(2 %)

(0.5 %)

(A)

:(Napat, W., 2017)

$$\text{Temporal - instability(\%)} = \left[\frac{Q_{max} - Q_{min}}{Q_{max} + Q_{min}} \right] \times 100\% \text{ ----- (2)}$$

.(3)

.(1)



:

:1

:1-1

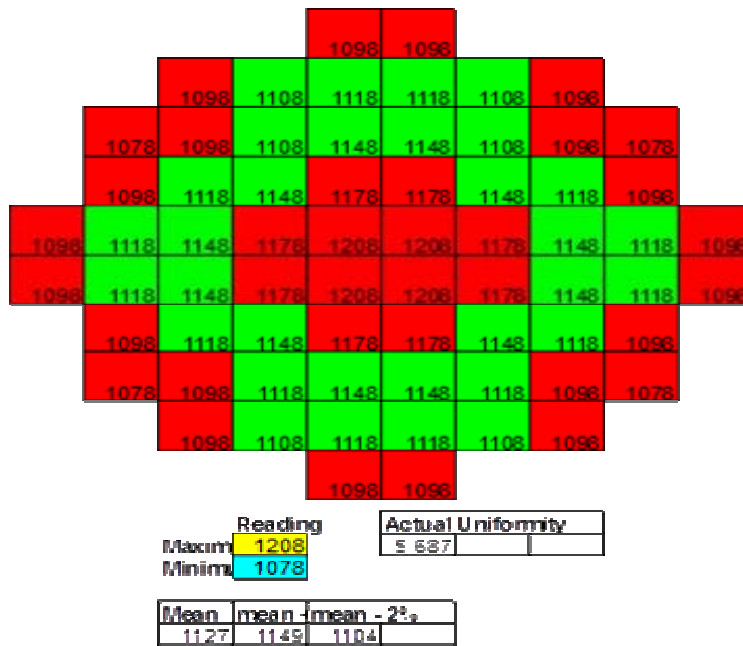
.(4)

50

.(IEC 60904-3)

B

5.68



5.68

:4

50

:2-1

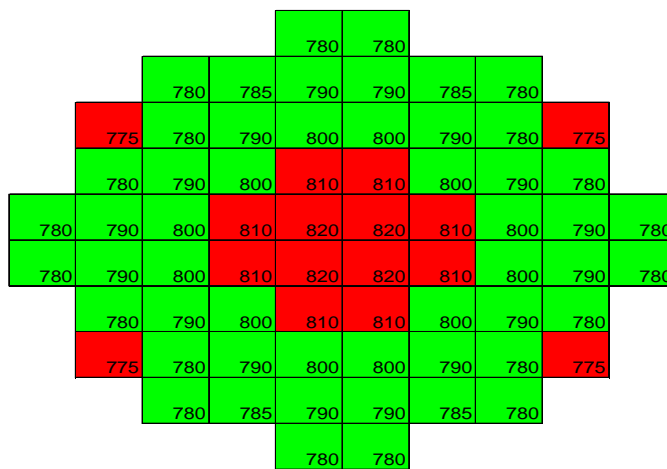
.(5)

60

.(IEC 60904-3)

B

2.82



Reading		Actual Uniformity	
Maximum	820	2.8213	
Minimum	775		
Mean	mean +	mean - 2%	
791.76	807.6	775.9	

2.82

:5

60

:3-1

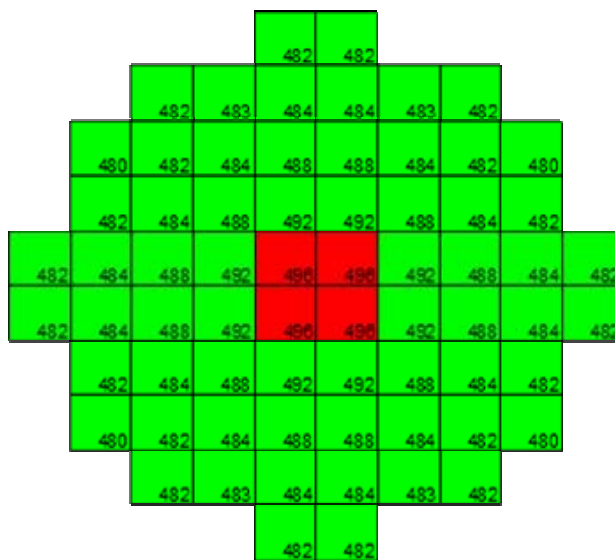
(6)

70

(IEC 60904-3)

A

1.63



Reading		Actual Uniformity	
Maximum	496	* 1.63	
Minimum	480		
Mean	mean +	mean - 2%	
488.6	489.2	487.3	

1.36

:6

70

.....

(6) (5) (4)

(3)

:3

(IEC 60904-3)

		(cm)	
C	5.68	50	1
B	2.82	60	2
A	1.36	70	3

70

:2

:1-2

(7)

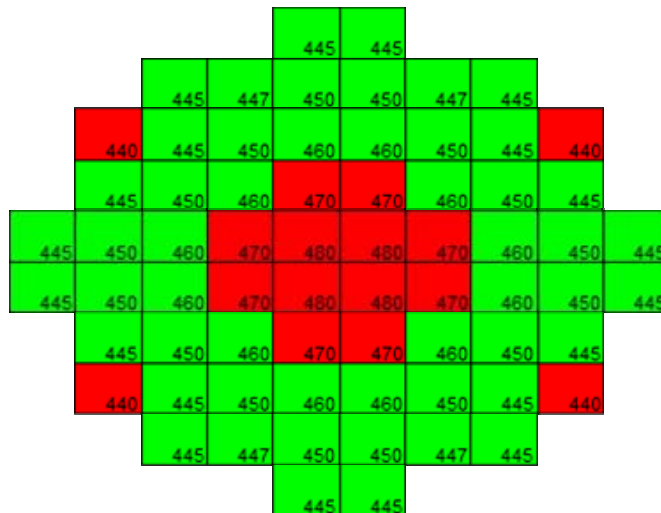
50

IEC 60904-)

B

4.34

(3)



Reading	Actual Uniformity
Maximum 480	± 3.4%
Minimum 440	

Mean	mean	mean - 2σ
453.6	462.7	444.6

4.34

:7

50

:2-2

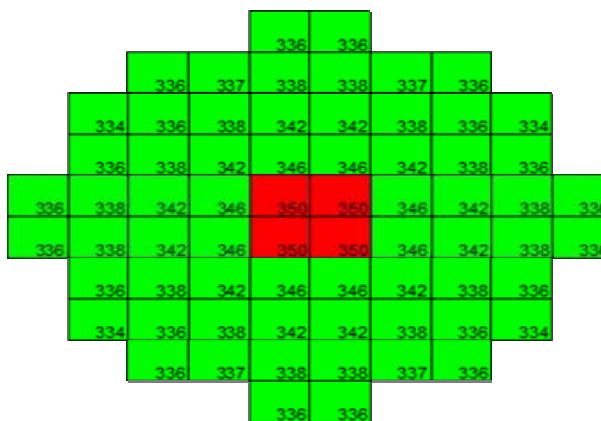
(8)

60

B

2.33

(IEC 60904-3)



Reading		Actual Uniformity	
Maximum	350	2.33	
Minimum	334		

Mean	mean + 2%	mean - 2%
339.5	345.3	332.7

2.33

:8

60

:3-2

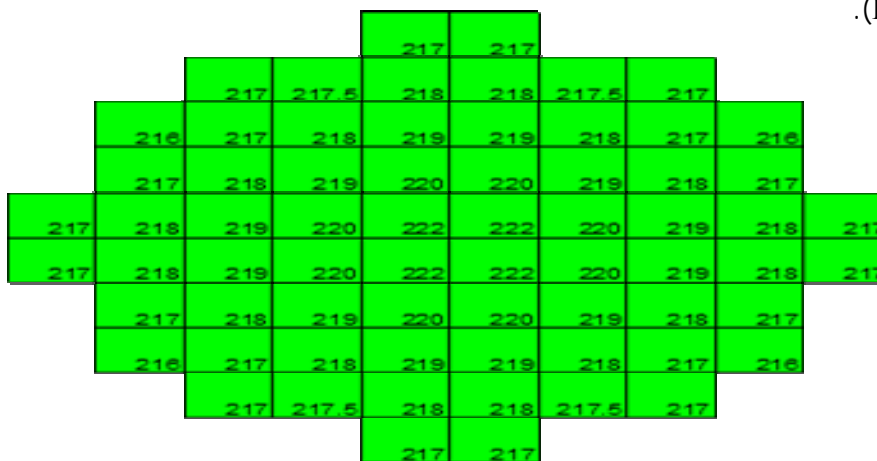
(9)

70

A

1.37

(IEC 60904-3)



Reading		Actual Uniformity	
Maximum	222	1.37	
Minimum	216		

Mean	mean + 2%	mean - 2%
218.5	220.5	216.5

1.37

:9

70

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(9) (8) (7)

70

.(4)

:4

		(cm)	
C	4.34	50	1
B	2.23	60	2
A	1.27	70	3

70

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