Cree® XLamp® CXA1816 LED

PRODUCT DESCRIPTION

The XLamp CXA1816 LED array expands Cree's family of high-flux, multi-die arrays in a smaller, easy-to-use platform. With XLamp lighting-class reliability, the CXA1816's small, uniform emitting surface enables both directional and non-directional lighting applications including lamp retrofit and luminaire designs. Available in 2-step and 4-step color consistency, and featuring a 12-mm optical source, the CXA1816 brings new levels of flux and efficacy to this form factor.

FEATURES

- Available in ANSI white bins as well as 4-step and 2-step EasyWhite® bins at 2700 K, 3000 K, 3500 K, 4000 K and 5000 K CCT
- Available in ANSI white bins as well as 4-step EasyWhite bins at 5700 K and 6500 K CCT
- Available in 70-, 80-, 90- and 93-minimum CRI options
- Forward voltage: 37 V
- 85 °C binning and characterization
- Maximum drive current: 900 mA
- 115° viewing angle, uniform chromaticity profile
- Top-side solder connections
- Thermocouple attach point
- NEMA SSL-3 2011 standard flux bins
- RoHS- and REACh-compliant
- UL-recognized component (E349212)

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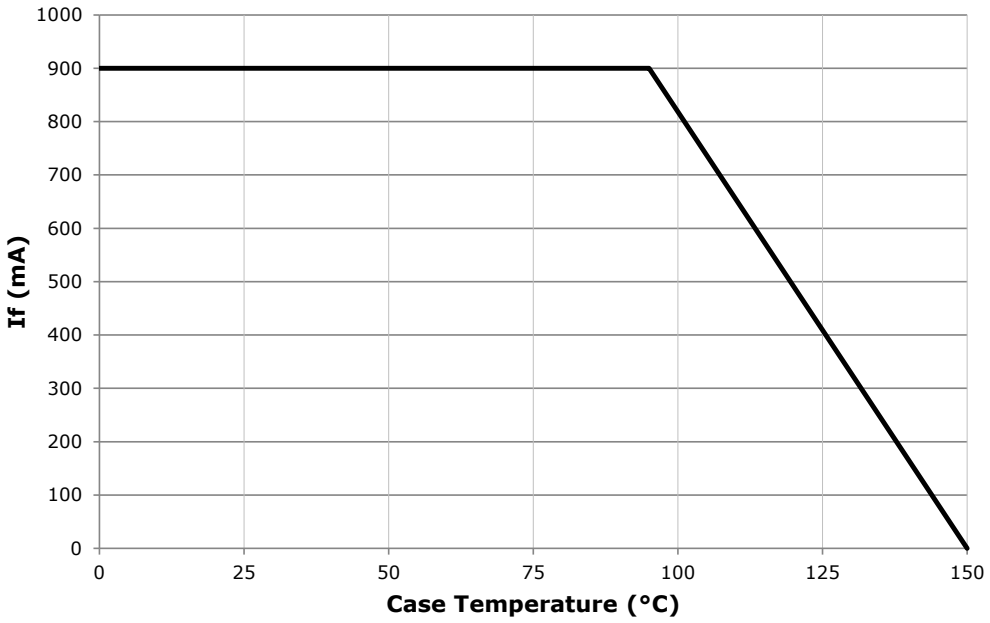
CHARACTERISTICS

Characteristics	Unit	Minimum	Typical	Maximum
Viewing angle (FWHM)	degrees		115	
ESD withstand voltage (HBM per Mil-Std-883D)	V			8000
DC forward current	mA			900*
Reverse current	mA			0.1
Forward voltage (450 mA, 85 °C)	V		37	
Forward voltage (450 mA, 25 °C)	V			42

* Refer to the Operating Limits section.

OPERATING LIMITS

The maximum current rating of the CXA1816 is dependent on the case temperature (Tc) when the LED has reached thermal equilibrium under steady-state operation. Please refer to the Mechanical Dimensions section on page 14 for the location of the Tc measurement point.



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FLUX CHARACTERISTICS, EASYWHITE ORDER CODES AND BINS (I_F = 450 mA, T_J = 85 °C)

The following tables provide order codes for XLamp CXA1816 LEDs. For a complete description of the order code nomenclature, please reference Bin and Order Code Formats (page 14).

CCT Range	CRI		Base Order Codes Min. Luminous Flux @ 450 mA			2-Step Order Code		4-Step Order Code	
	Min	Typ	Group	Flux (lm) @ 85 °C	Flux (lm) @ 25 °C*	Chromaticity Region		Chromaticity Region	
6500 K	70	75	P2	1830	2028			65F	CXA1816-0000-000N00P265F
			P4	1965	2177				CXA1816-0000-000N00P465F
			Q2	2100	2327				CXA1816-0000-000N00Q265F
	80	---	N4	1710	1895			65F	CXA1816-0000-000N0HN465F
			P2	1830	2028				CXA1816-0000-000N0HP265F
			P4	1965	2177				CXA1816-0000-000N0HP465F
5700 K	70	75	P2	1830	2028			57F	CXA1816-0000-000N00P257F
			P4	1965	2177				CXA1816-0000-000N00P457F
			Q2	2100	2327				CXA1816-0000-000N00Q257F
	80	---	N4	1710	1895			57F	CXA1816-0000-000N0HN457F
			P2	1830	2028				CXA1816-0000-000N0HP257F
			P4	1965	2177				CXA1816-0000-000N0HP457F
5000 K	70	75	P2	1830	2028	50H	CXA1816-0000-000N00P250H	50F	CXA1816-0000-000N00P250F
			P4	1965	2177		CXA1816-0000-000N00P450H		CXA1816-0000-000N00P450F
			Q2	2100	2327		CXA1816-0000-000N00Q250H		CXA1816-0000-000N00Q250F
	80	---	N4	1710	1895	50H	CXA1816-0000-000N0HN450H	50F	CXA1816-0000-000N0HN450F
			P2	1830	2028		CXA1816-0000-000N0HP250H		CXA1816-0000-000N0HP250F
			P4	1965	2177		CXA1816-0000-000N0HP450H		CXA1816-0000-000N0HP450F
	90	95	M4	1485	1645	50H	CXA1816-0000-000N0UM450H	50F	CXA1816-0000-000N0UM450F
			N2	1590	1762		CXA1816-0000-000N0UN250H		CXA1816-0000-000N0UN250F
			N4	1710	1895		CXA1816-0000-000N0UN450H		CXA1816-0000-000N0UN450F

Notes

- Cree maintains a tolerance of ±7% on flux and power measurements, ±0.005 on chromaticity (CCx, CCy) measurements and a tolerance of ±2 on CRI measurements.

* Flux values @ 25 °C are calculated and for reference only.

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FLUX CHARACTERISTICS, EASYWHITE ORDER CODES AND BINS (I_F = 450 mA, T_J = 85 °C) - CONTINUED

CCT Range	CRI		Base Order Codes Min. Luminous Flux @ 450 mA			2-Step Order Code		4-Step Order Code	
	Min	Typ	Group	Flux (lm) @ 85 °C	Flux (lm) @ 25 °C*	Chromaticity Region		Chromaticity Region	
4000 K	70	75	N4	1710	1895	40H	CXA1816-0000-000N00N440H	40F	CXA1816-0000-000N00N440F
			P2	1830	2028		CXA1816-0000-000N00P240H		CXA1816-0000-000N00P240F
			P4	1965	2177		CXA1816-0000-000N00P440H		CXA1816-0000-000N00P440F
	80	---	N2	1590	1762	40H	CXA1816-0000-000N0HN240H	40F	CXA1816-0000-000N0HN240F
			N4	1710	1895		CXA1816-0000-000N0HN440H		CXA1816-0000-000N0HN440F
			P2	1830	2028		CXA1816-0000-000N0HP240H		CXA1816-0000-000N0HP240F
	90	95	M2	1380	1537	40H	CXA1816-0000-000N0UM240H	40F	CXA1816-0000-000N0UM240F
			M4	1485	1645		CXA1816-0000-000N0UM440H		CXA1816-0000-000N0UM440F
			N2	1590	1762		CXA1816-0000-000N0UN240H		CXA1816-0000-000N0UN240F
3500 K	80	---	N4	1710	1895	35H	CXA1816-0000-000N00N435H	35F	CXA1816-0000-000N00N435F
			P2	1830	2028		CXA1816-0000-000N00P235H		CXA1816-0000-000N00P235F
	93	95	K4	1290	1437	35H	CXA1816-0000-000N0YK435H	35F	CXA1816-0000-000N0YK435F
			M2	1380	1537		CXA1816-0000-000N0YM235H		CXA1816-0000-000N0YM235F
			M4	1485	1645		CXA1816-0000-000N0YM435H		CXA1816-0000-000N0YM435F
3000 K	80	---	N2	1590	1762	30H	CXA1816-0000-000N00N230H	30F	CXA1816-0000-000N00N230F
			N4	1710	1895		CXA1816-0000-000N00N430H		CXA1816-0000-000N00N430F
	93	95	K2	1200	1337	30H	CXA1816-0000-000N0YK230H	30F	CXA1816-0000-000N0YK230F
			K4	1290	1437		CXA1816-0000-000N0YK430H		CXA1816-0000-000N0YK430F
			M2	1380	1537		CXA1816-0000-000N0YM230H		CXA1816-0000-000N0YM230F
2700 K	80	---	M4	1485	1645	27H	CXA1816-0000-000N00M427H	27F	CXA1816-0000-000N00M427F
			N2	1590	1762		CXA1816-0000-000N00N227H		CXA1816-0000-000N00N227F
			N4	1710	1895		CXA1816-0000-000N00N427H		CXA1816-0000-000N00N427F
	93	95	J4	1120	1248	27H	CXA1816-0000-000N0YJ427H	27F	CXA1816-0000-000N0YJ427F
			K2	1200	1337		CXA1816-0000-000N0YK227H		CXA1816-0000-000N0YK227F
			K4	1290	1437		CXA1816-0000-000N0YK427H		CXA1816-0000-000N0YK427F

Notes

- Cree maintains a tolerance of ±7% on flux and power measurements, ±0.005 on chromaticity (CCx, CCy) measurements and a tolerance of ±2 on CRI measurements.

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FLUX CHARACTERISTICS, ANSI WHITE ORDER CODES AND BINS (I_F = 450 mA, T_J = 85 °C)

The following tables provide order codes for XLamp CXA1816 LEDs. For a complete description of the order code nomenclature, please reference Bin and Order Code Formats (page 14).

CCT Range	CRI		Base Order Codes Min. Luminous Flux @ 450 mA			Chromaticity Regions	Order Code
	Min	Typ	Group	Flux (lm) @ 85 °C	Flux (lm) @ 25 °C*		
6500 K	70	75	P2	1830	2028	1A0, 1B0, 1C0, 1D0	CXA1816-0000-000N00P20E1
			P4	1965	2177		CXA1816-0000-000N00P40E1
			Q2	2100	2327		CXA1816-0000-000N00Q20E1
	80	---	N4	1710	1895	1A0, 1B0, 1C0, 1D0	CXA1816-0000-000N0HN40E1
			P2	1830	2028		CXA1816-0000-000N0HP20E1
			P4	1965	2177		CXA1816-0000-000N0HP40E1
5700 K	70	75	P2	1830	2028	2A0, 2B0, 2C0, 2D0	CXA1816-0000-000N00P20E2
			P4	1965	2177		CXA1816-0000-000N00P40E2
			Q2	2100	2327		CXA1816-0000-000N00Q20E2
	80	---	N4	1710	1895	2A0, 2B0, 2C0, 2D0	CXA1816-0000-000N0HN40E2
			P2	1830	2028		CXA1816-0000-000N0HP20E2
			P4	1965	2177		CXA1816-0000-000N0HP40E2
5000 K	70	75	P2	1830	2028	3A0, 3B0, 3C0, 3D0	CXA1816-0000-000N00P20E3
			P4	1965	2177		CXA1816-0000-000N00P40E3
			Q2	2100	2327		CXA1816-0000-000N00Q20E3
	80	---	N4	1710	1895	3A0, 3B0, 3C0, 3D0	CXA1816-0000-000N0HN40E3
			P2	1830	2028		CXA1816-0000-000N0HP20E3
			P4	1965	2177		CXA1816-0000-000N0HP40E3
	90	95	M4	1485	1645	3A0, 3B0, 3C0, 3D0	CXA1816-0000-000N0UM40E3
			N2	1590	1762		CXA1816-0000-000N0UN20E3
			N4	1710	1895		CXA1816-0000-000N0UN40E3

Notes

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FLUX CHARACTERISTICS, ANSI WHITE ORDER CODES AND BINS (I_F = 450 mA, T_J = 85 °C) - CONTINUED

CCT Range	CRI		Base Order Codes Min. Luminous Flux @ 450 mA			Chromaticity Regions	Order Code
	Min	Typ	Group	Flux (lm) @ 85 °C	Flux (lm) @ 25 °C*		
4000 K	70	75	N4	1710	1895	5A0, 5B0, 5C0, 5D0	CXA1816-0000-000N00N40E5
			P2	1830	2028		CXA1816-0000-000N00P20E5
			P4	1965	2177		CXA1816-0000-000N00P40E5
	80	---	N2	1590	1762	5A0, 5B0, 5C0, 5D0	CXA1816-0000-000N0HN20E5
			N4	1710	1895		CXA1816-0000-000N0HN40E5
			P2	1830	2028		CXA1816-0000-000N0HP20E5
	90	95	M2	1380	1537	5A0, 5B0, 5C0, 5D0	CXA1816-0000-000N0UM20E5
			M4	1485	1645		CXA1816-0000-000N0UM40E5
			N2	1590	1762		CXA1816-0000-000N0UN20E5
3500 K	80	---	N4	1710	1895	6A0, 6B0, 6C0, 6D0	CXA1816-0000-000N00N40E6
			P2	1830	2028		CXA1816-0000-000N00P20E6
	93	95	K4	1290	1437	6A0, 6B0, 6C0, 6D0	CXA1816-0000-000N0YK40E6
			M2	1380	1537		CXA1816-0000-000N0YM20E6
			M4	1485	1645		CXA1816-0000-000N0YM40E6
3000 K	80	---	N2	1590	1762	7A0, 7B0, 7C0, 7D0	CXA1816-0000-000N00N20E7
			N4	1710	1895		CXA1816-0000-000N00N40E7
	93	95	K2	1200	1337	7A0, 7B0, 7C0, 7D0	CXA1816-0000-000N0YK20E7
			K4	1290	1437		CXA1816-0000-000N0YK40E7
			M2	1380	1537		CXA1816-0000-000N0YM20E7
2700 K	80	---	M4	1485	1645	8A0, 8B0, 8C0, 8D0	CXA1816-0000-000N00M40E8
			N2	1590	1762		CXA1816-0000-000N00N20E8
			N4	1710	1895		CXA1816-0000-000N00N40E8
	93	95	J4	1120	1248	8A0, 8B0, 8C0, 8D0	CXA1816-0000-000N0YJ40E8
			K2	1200	1337		CXA1816-0000-000N0YK20E8
			K4	1290	1437		CXA1816-0000-000N0YK40E8

Notes
- Cree maintains a tolerance of ±7% on flux and power measurements, ±0.005 on chromaticity (CCx, CCy) measurements and a tolerance of ±2 on CRI measurements.

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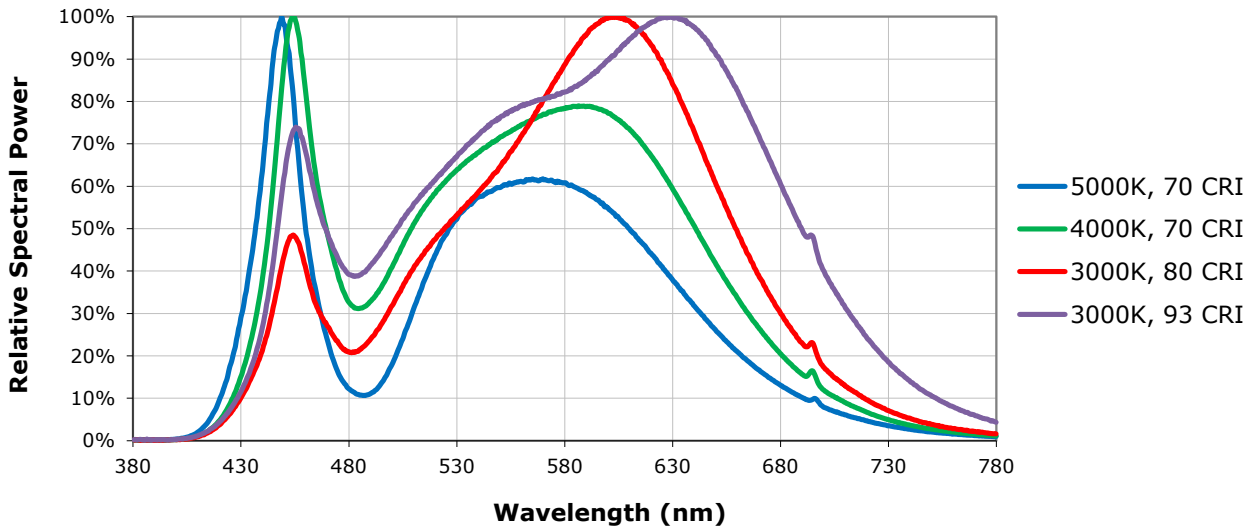
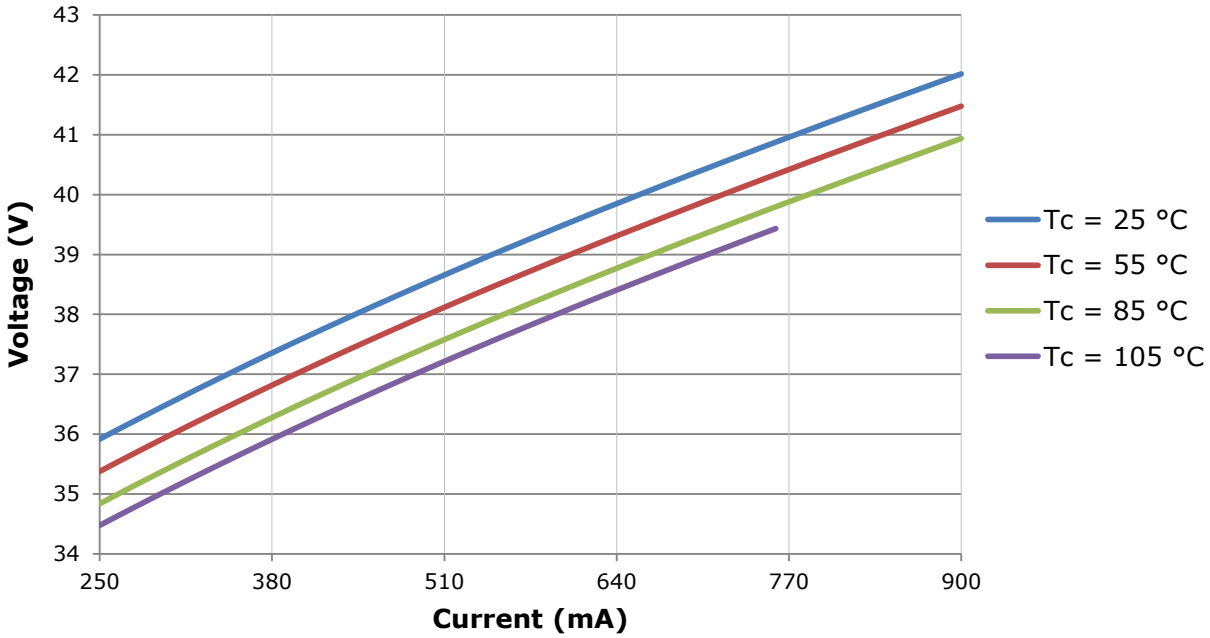
RELATIVE SPECTRAL POWER DISTRIBUTION (I_F = 450 mA, T_J = 85 °C)

The following graph is the result of a series of pulsed measurements at 450 mA and T_J = 85 °C.



ELECTRICAL CHARACTERISTICS

The following graph is the result of a series of steady-state measurements.



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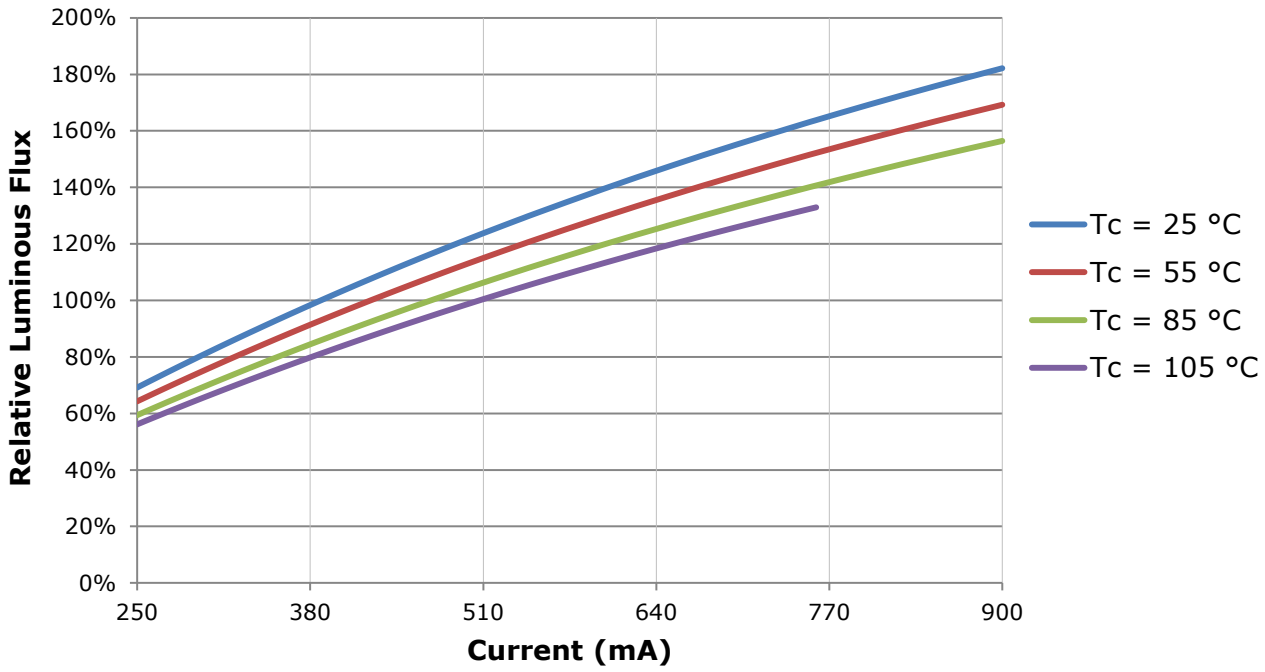
RELATIVE LUMINOUS FLUX

The relative luminous flux values provided below are the ratio of:

- Measurements of CXA1816 at steady-state operation at the given conditions, divided by
- Flux measured during binning, which is a pulsed measurement at 450 mA at T_J = 85 °C.

For example, at steady-state operation of Tc = 25 °C, I_F = 500 mA, the relative luminous flux ratio is 120% in the chart below. A CXA1816 LED that measures 2100 lm during binning will deliver 2340 lm (2100 * 1.2) at steady-state operation of Tc = 25 °C, I_F = 500 mA.



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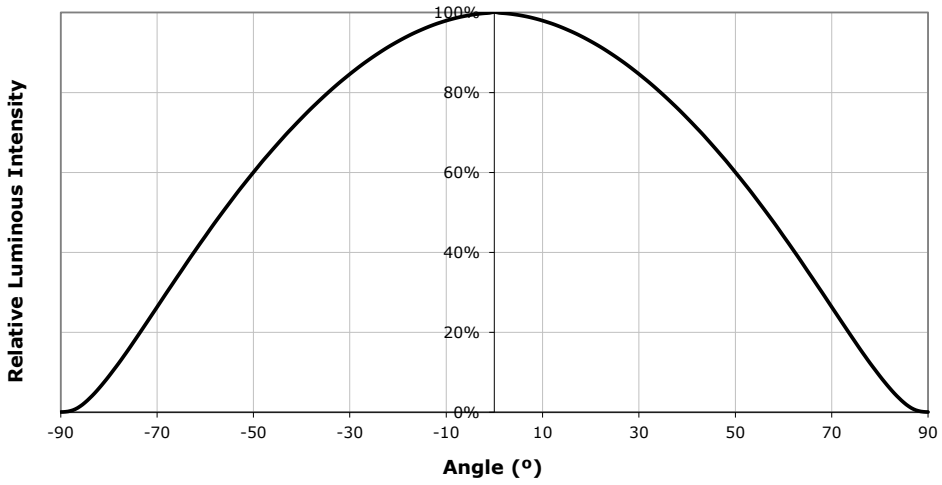
TYPICAL SPATIAL DISTRIBUTION



PERFORMANCE GROUPS - BRIGHTNESS (I_F = 450 mA, T_J = 85 °C)

XLamp CXA1816 LEDs are tested for luminous flux and placed into one of the following bins.

Group Code	Min. Luminous Flux @ 450 mA	Max. Luminous Flux @ 450 mA
J4	1120	1200
K2	1200	1290
K4	1290	1380
M2	1380	1485
M4	1485	1590
N2	1590	1710
N4	1710	1830
P2	1830	1965
P4	1965	2100
Q2	2100	2260
Q4	2260	2420

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PERFORMANCE GROUPS - CHROMATICITY (T_J = 85 °C)

XLamp CXA1816 LEDs are tested for chromaticity and placed into one of the regions defined by the following bounding coordinates.

EasyWhite Color Temperatures – 4-Step			
Code	**CCT**	**x**	**y**
65F	6500 K	0.3253	0.3325
		0.3249	0.3439
		0.3331	0.3514
		0.3330	0.3393
57F	5700 K	0.3097	0.3196
		0.3079	0.3297
		0.3164	0.3382
		0.3176	0.3275
50F	5000 K	0.3407	0.3459
		0.3415	0.3586
		0.3499	0.3654
		0.3484	0.3521
40F	4000 K	0.3744	0.3685
		0.3782	0.3837
		0.3912	0.3917
		0.3863	0.3758
35F	3500 K	0.3981	0.3800
		0.4040	0.3966
		0.4186	0.4037
		0.4116	0.3865
30F	3000 K	0.4242	0.3919
		0.4322	0.4096
		0.4449	0.4141
		0.4359	0.3960
27F	2700 K	0.4475	0.3994
		0.4573	0.4178
		0.4695	0.4207
		0.4589	0.4021

EasyWhite Color Temperatures – 2-Step			
Code	**CCT**	**x**	**y**
50H	5000 K	0.3429	0.3507
		0.3434	0.3571
		0.3475	0.3604
		0.3469	0.3539
40H	4000 K	0.3784	0.3741
		0.3804	0.3818
		0.3867	0.3857
		0.3844	0.3778
35H	3500 K	0.4030	0.3857
		0.4061	0.3941
		0.4132	0.3976
		0.4099	0.3890
30H	3000 K	0.4291	0.3973
		0.4333	0.4062
		0.4395	0.4084
		0.4351	0.3994
27H	2700 K	0.4528	0.4046
		0.4578	0.4138
		0.4638	0.4152
		0.4586	0.4060

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PERFORMANCE GROUPS - CHROMATICITY (T_j = 85 °C) - CONTINUED

ANSI White Bins				
Code	CCT	Bin Code	x	y
0E1	6500 K	1A0	0.3048	0.3207
			0.3130	0.3290
			0.3144	0.3186
			0.3068	0.3113
		1B0	0.3028	0.3304
			0.3115	0.3391
			0.3130	0.3290
			0.3048	0.3207
		1C0	0.3115	0.3391
			0.3205	0.3481
			0.3213	0.3373
			0.3130	0.3290
		1D0	0.3130	0.3290
			0.3213	0.3373
			0.3221	0.3261
			0.3144	0.3186

ANSI White Bins				
Code	CCT	Bin Code	x	y
0E2	5700 K	2A0	0.3215	0.3350
			0.3290	0.3417
			0.3290	0.3300
			0.3222	0.3243
		2B0	0.3207	0.3462
			0.3290	0.3538
			0.3290	0.3417
			0.3215	0.3350
		2C0	0.3290	0.3538
			0.3376	0.3616
			0.3371	0.3490
			0.3290	0.3417
		2D0	0.3290	0.3417
			0.3371	0.3490
			0.3366	0.3369
			0.3290	0.3300

ANSI White Bins				
Code	CCT	Bin Code	x	y
0E3	5000 K	3A0	.3371	.3490
			.3451	.3554
			.3440	.3427
			.3366	.3369
		3B0	.3376	.3616
			.3463	.3687
			.3451	.3554
			.3371	.3490
		3C0	.3463	.3687
			.3551	.3760
			.3533	.3620
			.3451	.3554
		3D0	.3451	.3554
			.3533	.3620
			.3515	.3487
			.3440	.3427

ANSI White Bins				
Code	CCT	Bin Code	x	y
0E5	4000 K	5A0	.3670	.3578
			.3702	.3722
			.3825	.3798
			.3783	.3646
		5B0	.3702	.3722
			.3736	.3874
			.3869	.3958
			.3825	.3798
		5C0	.3825	.3798
			.3869	.3958
			.4006	.4044
			.3950	.3875
		5D0	.3783	.3646
			.3825	.3798
			.3950	.3875
			.3898	.3716

ANSI White Bins				
Code	CCT	Bin Code	x	y
0E6	3500 K	6A0	.3889	.3690
			.3941	.3848
			.4080	.3916
			.4017	.3751
		6B0	.3941	.3848
			.3996	.4015
			.4146	.4089
			.4080	.3916
		6C0	.4080	.3916
			.4146	.4089
			.4299	.4165
			.4221	.3984
		6D0	.4017	.3751
			.4080	.3916
			.4221	.3984
			.4147	.3814

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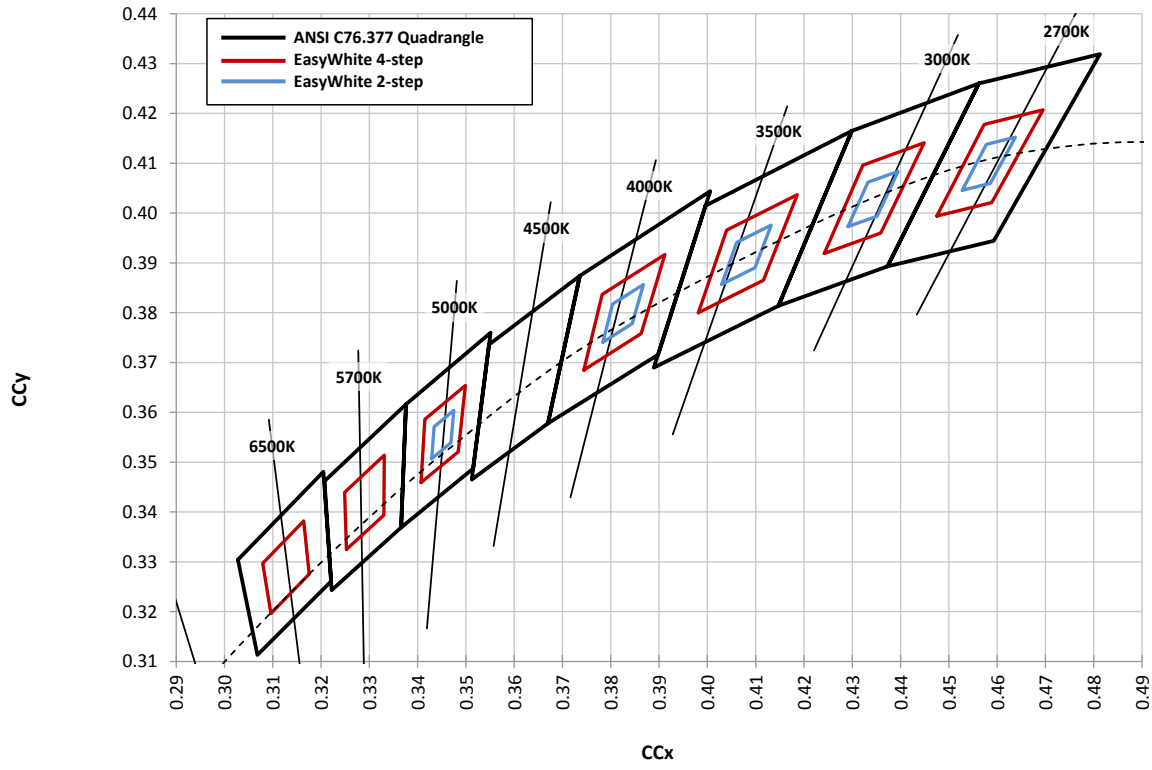
PERFORMANCE GROUPS - CHROMATICITY (T_J = 85 °C) - CONTINUED

ANSI White Bins				
Code	CCT	Bin Code	x	y
0E7	3000K	7A0	.4147	.3814
			.4221	.3984
			.4342	.4028
			.4259	.3853
		7B0	.4221	.3984
			.4299	.4165
			.4430	.4212
			.4342	.4028
		7C0	.4342	.4028
			.4430	.4212
			.4562	.4260
			.4465	.4071
		7D0	.4259	.3853
			.4342	.4028
			.4465	.4071
			.4373	.3893

ANSI White Bins				
Code	CCT	Bin Code	x	y
0E8	2700K	8A0	.4373	.3893
			.4465	.4071
			.4582	.4099
			.4483	.3919
		8B0	.4465	.4071
			.4562	.4260
			.4687	.4289
			.4582	.4099
		8C0	.4582	.4099
			.4687	.4289
			.4813	.4319
			.4700	.4126
		8D0	.4483	.3919
			.4582	.4099
			.4700	.4126
			.4593	.3944

CREE EASYWHITE BINS PLOTTED ON THE 1931 CIE COLOR SPACE (T_J = 85 °C)



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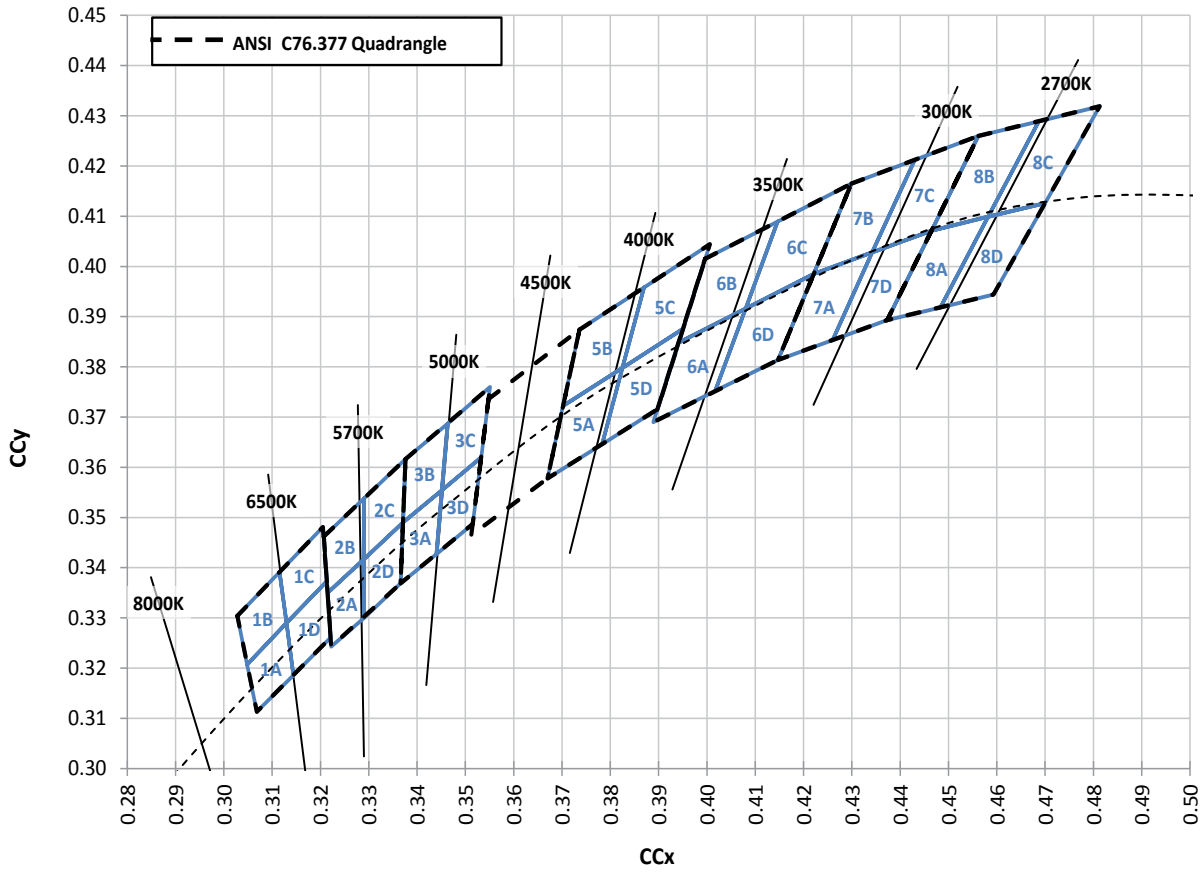
CREE ANSI WHITE BINS PLOTTED ON THE 1931 CIE COLOR SPACE (T_J = 85 °C)



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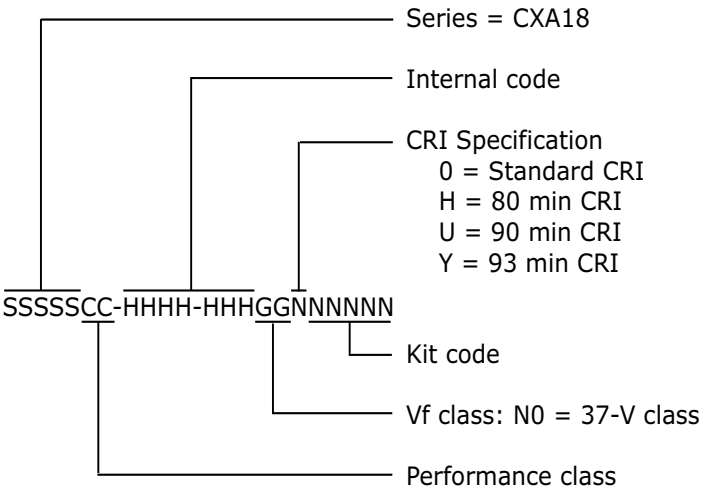
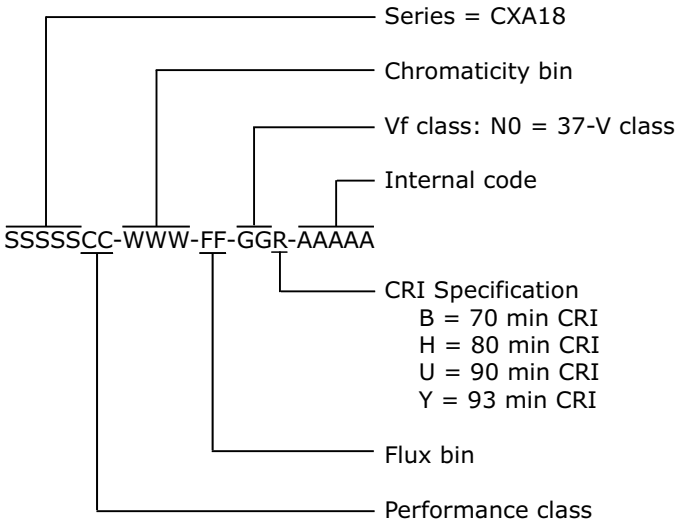
BIN AND ORDER CODE FORMATS

Bin codes and order codes are configured as follows:

Order Code



Bin Code



MECHANICAL DIMENSIONS

Dimensions are in mm.

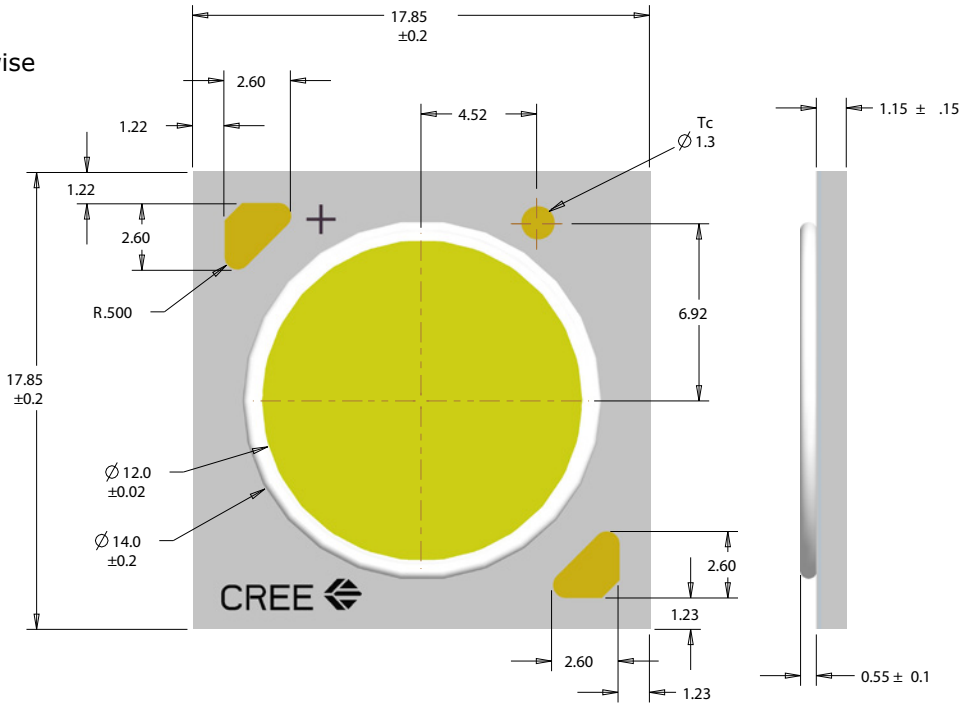
Tolerances unless otherwise specified:

.x ± .10

.xx ± .03

.xxx ± .010

x° ± 1°



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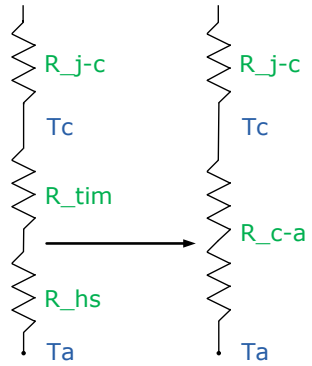
THERMAL DESIGN

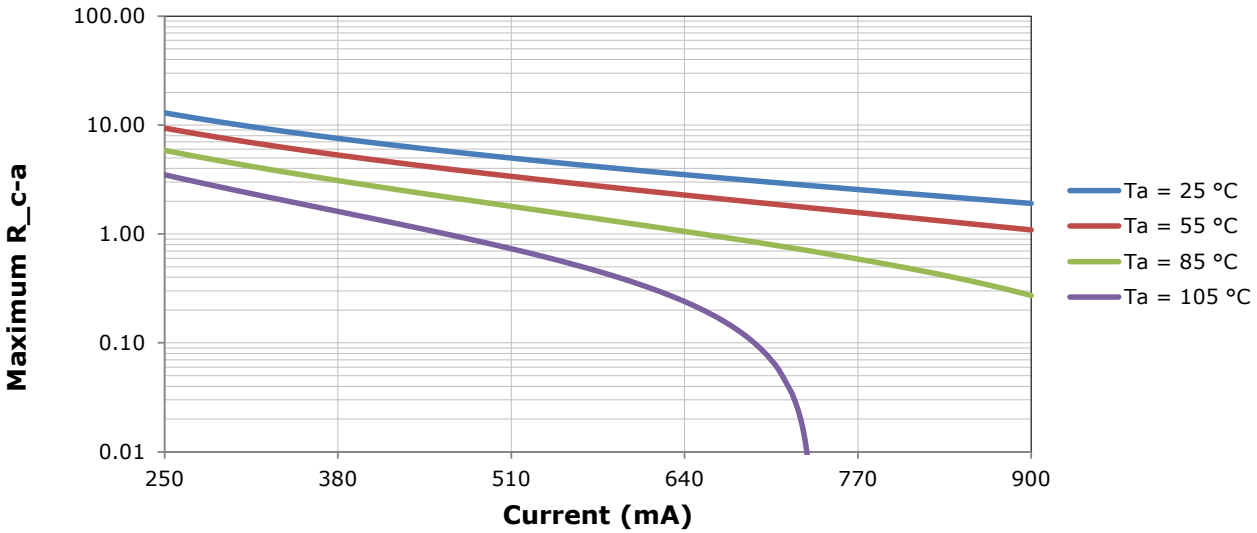
The CXA family of LED arrays can include over a hundred different LED die inside one package, and thus over a hundred different junction temperatures (T_J). Cree has intentionally removed junction-temperature-based operating limits and replaced the commonplace maximum T_J calculations with maximum ratings based on forward current (I_F) and case temperature (Tc). No additional calculations are required to ensure the CXA LED is being operated within its designed limits. Please refer to page 2 for the Operating Limit specification.

Cree has measured the temperature at the bottom of the package, commonly referred to as the solder point (T_{SP}), and found this value to be equivalent to the temperature at the Tc location at the top of the package once the LED has reached thermal equilibrium. There is no need to calculate for T_J inside the package, as the thermal management design process, specifically from T_{SP} to ambient (T_a), remains identical to any other LED component. For more information on thermal management of Cree XLamp LEDs, please refer to the XLamp Thermal Management application note at www.cree.com/xlamp_app_notes/thermal_management. For CXA soldering recommendations and more information on thermal interface materials (TIM) and connection methods, please refer to the Cree XLamp CXA Family LEDs soldering and handling document at www.cree.com/xlamp_app_notes/CXA_SH.

To keep the CXA1816 LED at or below the maximum rated Tc, the case to ambient temperature thermal resistance (R_c-a) must be at or below the maximum R_c-a value shown on the following graph, depending on the operating environment. The y-axis in the graph is a base 10 logarithmic scale.

As the figure at right shows, the R_c-a value is the sum of the thermal resistance of the TIM (R_tim) plus the thermal resistance of the heat sink (R_hs).





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NOTES

Lumen Maintenance Projections

Cree now uses standardized IES LM-80-08 and TM-21-11 methods for collecting long-term data and extrapolating LED lumen maintenance. For information on the specific LM-80 data sets available for this LED, refer to the public LM-80 results document at www.cree.com/xlamp_app_notes/LM80_results.

Please read the XLamp Long-Term Lumen Maintenance application note at www.cree.com/xlamp_app_notes/lumen_maintenance for more details on Cree's lumen maintenance testing and forecasting. Please read the XLamp Thermal Management application note at www.cree.com/xlamp_app_notes/thermal_management for details on how thermal design, ambient temperature, and drive current affect the LED junction temperature.

RoHS Compliance

The levels of RoHS restricted materials in this product are below the maximum concentration values (also referred to as the threshold limits) permitted for such substances, or are used in an exempted application, in accordance with EU Directive 2011/65/EC (RoHS2), as implemented January 2, 2013. RoHS Declarations for this product can be obtained from your Cree representative or from the Product Documentation sections of www.cree.com.

REACh Compliance

REACh substances of high concern (SVHCs) information is available for this product. Since the European Chemical Agency (ECHA) has published notice of their intent to frequently revise the SVHC listing for the foreseeable future, please contact a Cree representative to insure you get the most up-to-date REACh SVHC Declaration. REACh banned substance information (REACh Article 67) is also available upon request.

UL Recognized Component

Level 4 enclosure consideration. The LED package or a portion thereof has been investigated as a fire and electrical enclosure per ANSI/UL 8750.

Vision Advisory Claim

Users should be cautioned not to stare at the light of this LED product. The bright light can damage the eye.

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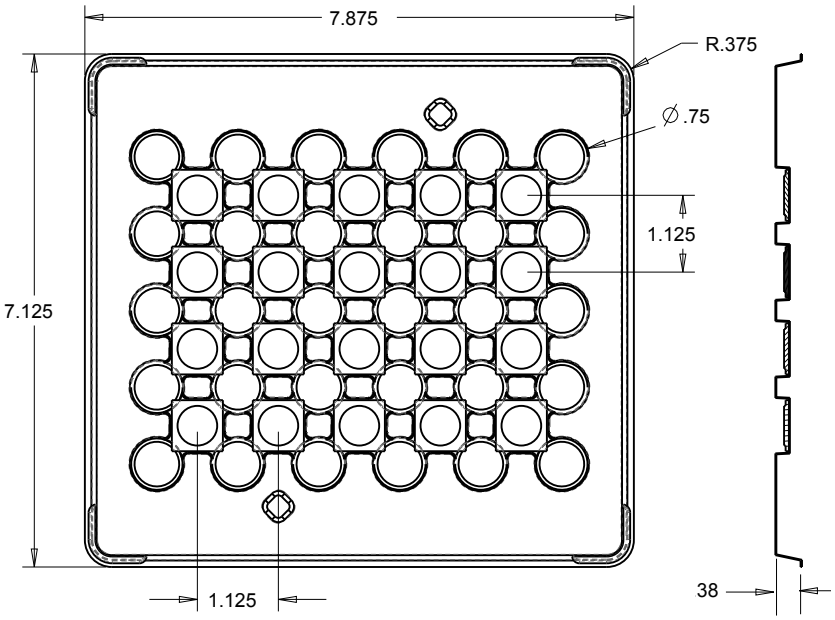
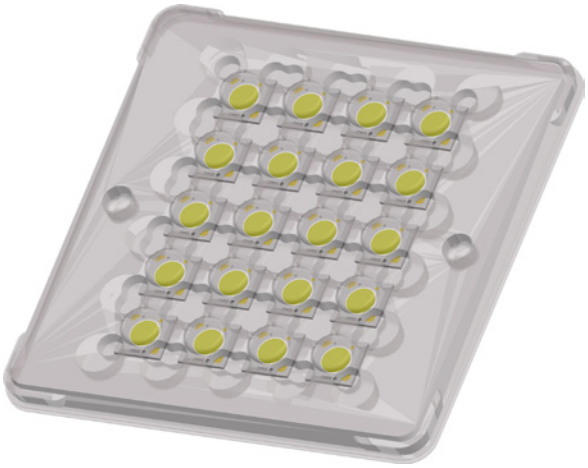
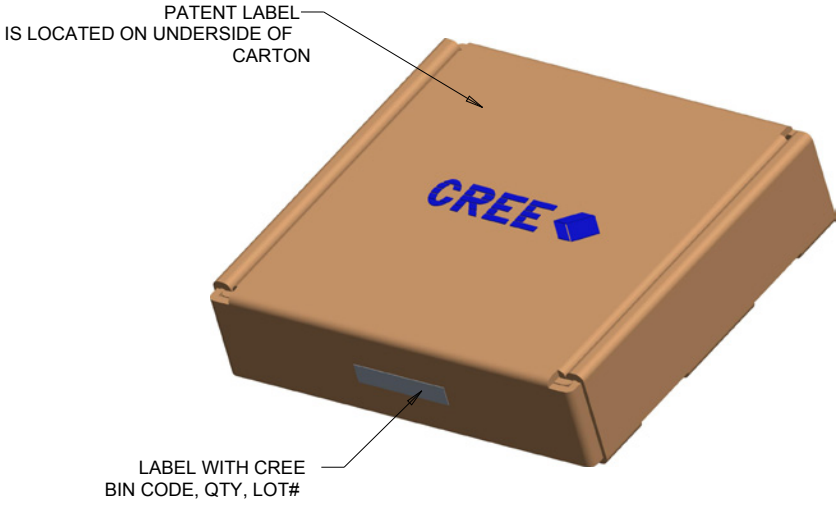
PACKAGING

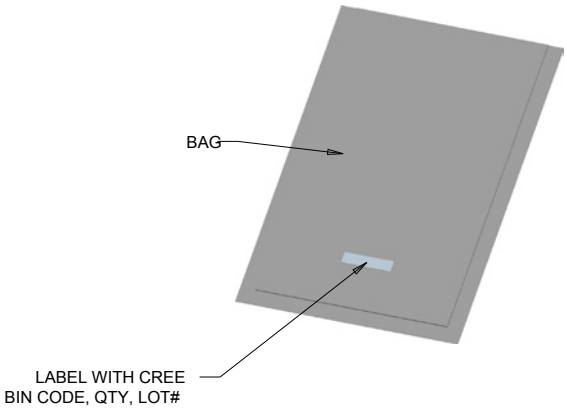
Cree CXA1816 LEDs are packaged in trays of 20. Five trays are sealed in an anti-static bag and placed inside a carton, for a total of 100 LEDs per carton. Each carton contains 100 LEDs from the same performance bin.

Dimensions are in inches.
Tolerances:
.x ± .1
.xx ± .05
.xxx ± .005
x° ± 1°









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LifeElectronics
Живое партнерство

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Компания «Life Electronics» занимается поставками электронных компонентов импортного и отечественного производства от производителей и со складов крупных дистрибьюторов Европы, Америки и Азии.

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- *Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.*

- *Приемлемые сроки поставки, возможна ускоренная поставка.*
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- *Работу по проектам и поставку образцов.*
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- *Тестирование поставляемой продукции.*
- *Поставку компонентов, требующих военную и космическую приемку.*
- *Входной контроль качества.*
- *Наличие сертификата ISO.*

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- *Техническую поддержку проекта.*
- *Защиту от снятия компонента с производства.*
- *Оценку стоимости проекта по компонентам.*
- *Изготовление тестовой платы монтаж и пусконаладочные работы.*

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