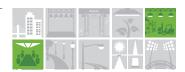




# **LUXEON 2835 Commercial**



# Superior lm/W/\$ choice in LUXEON 2835 portfolio

LUXEON 2835 Commercial mid-power LEDs are the price/performance leader for commercial indoor lighting solutions when lumens per Watt and lumens per dollar are the driving metrics for development. They are available in CCTs from 2700K to 6500K and CRIs of 80 and 90. LUXEON 2835 Commercial has a superior max current rating and features a 1/5<sup>th</sup> color bin structure making it a perfect choice for indoor applications where you want the quality and reliability of LUXEON in a commercial application. LUXEON 2835 Commercial leads its class in flux, color consistency, robustness, and reliability making it the right choice for commercial indoor luminaires.



#### **FEATURES AND BENEFITS**

Complete CCT/CRI offering for various application
Industry standard footprint for drop-in replacement
Reliable package design for commercial applications
5 SDCM MacAdam ellipse enable precise color control

#### PRIMARY APPLICATIONS

Panel / Soft Lights	
Linear	
Troffers	



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### **General Product Information**

#### **Product Test Conditions**

LUXEON 2835 Commercial LEDs are tested and binned with a 20ms monopulse specified below at a junction temperature, T<sub>r</sub>, of 25°C.

65mA - LUXEON 2835S 3V

120mA - LUXEON 2835S 6V

#### Part Number Nomenclature

Part numbers for LUXEON 2835 Commercial follow the convention below:

L 1 2 8 - A A B B S C 3 5 D D E E E

Where:

**A A** - designates nominal ANSI CCT (27=2700K, 30=3000K, 35=3500K, 40=4000K, 50=5000K, 57=5700K, 65=6500K)

**B B** - designates minimum CRI (80=80CRI and 90=90CRI)

c – designates voltage of the part (A=3V, B=6V, C=9V)

**D** D – designates options for product specification

**E E E** – designates options for product specification

Therefore, the following part number is used for a LUXEON 2835 Commercial 4000K 80CRI, 3V LED:

L 1 2 8 - 4 0 8 0 S A 3 5 A 0 0 A 1

#### Lumen Maintenance

Please contact your local Sales Representative or Lumileds Technical Solutions Manager for more information about the long-term performance of this product.

### **Environmental Compliance**

Lumileds LLC is committed to providing environmentally friendly products to the solid-state lighting market. LUXEON 2835 Commercial is compliant to the European Union directives on the restriction of hazardous substances in electronic equipment, namely the ROHS Directive 2011/65/EU including amendments 2015/863/EU & 2017/2102/EU and REACH Regulation (EC) 1907/2006. Lumileds LLC will not intentionally add the following restricted materials to its products: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE).

### **Performance Characteristics**

### **Product Selection Guide**

Table 1. Product performance of LUXEON 2835 Commercial LEDs at specified test conditions.

VOLTAGE	PART	NOMINAL	MINIMUM	LUMINOUS	FLUX <sup>[2, 3]</sup> (lm)	TYPICAL	TEST CURRENT	PART NUMBER
OLIAGE	PAKI	CCT <sup>[1]</sup>	CRI [2, 3]	MINIMUM	TYPICAL	EFFICACY (lm/W)	(mA)	
		2700K	80	30.0	33.2	185.1	65	L128-2780SA35A00A
		3000K	80	32.0	34.4	192.0	65	L128-3080SA35A00A
		3500K	80	32.5	35.1	196.0	65	L128-3580SA35A00A
		4000K	80	33.0	35.8	200.0	65	L128-4080SA35A00A
		5000K	80	33.0	35.8	200.0	65	L128-5080SA35A00
		5700K	80	33.0	35.8	200.0	65	L128-5780SA35A00
		6500K	80	32.5	35.4	197.3	65	L128-6580SA35A00
		2700K	90	25.5	27.5	153.3	65	L128-2790SA35A00
		3000K	90	26.8	28.8	160.5	65	L128-3090SA35A00
		3500K	90	28.1	30.2	168.3	65	L128-3590SA35A00
		4000K	90	28.6	30.8	171.7	65	L128-4090SA35A00
		5000K	90	28.6	30.8	171.7	65	L128-5090SA35A00
		5700K	90	28.6	30.8	171.7	65	L128-5790SA35A00
		6500K	90	28.3	30.4	169.5	65	L128-6590SA35A00
		2700K	80	31.3	34.3	194.7	65	L128-2780SA35A00
		3000K	80	32.2	35.4	201.0	65	L128-3080SA35A00
		3500K	80	33.2	36.3	206.1	65	L128-3580SA35A00
		4000K	80	33.8	36.9	209.5	65	L128-4080SA35A00
		5000K	80	33.8	37.1	210.6	65	L128-5080SA35A00
		5700K	80	33.8	37.1	210.6	65	L128-5780SA35A00
2). (	LUXEON	6500K	80	33.3	36.6	207.8	65	L128-6580SA35A00
3V	2835 S	2700K	90	26.8	28.8	163.5	65	L128-2790SA35A00
		3000K	90	27.4	29.9	169.7	65	L128-3090SA35A00
		3500K	90	28.3	30.8	174.9	65	L128-3590SA35A00
		4000K	90	29.4	31.8	180.5	65	L128-4090SA35A00
		5000K	90	29.4	31.8	180.5	65	L128-5090SA35A00
		5700K	90	29.4	31.8	180.5	65	L128-5790SA35A00
		6500K	90	29.4	31.8	180.5	65	L128-6590SA35A00
		2700K	80	29.2	31.4	173.8	65	L128-2780SA35A00
		3000K	80	30.2	32.5	179.9	65	L128-3080SA35A00
		3500K	80	31.1	33.5	185.4	65	L128-3580SA35A00
		4000K	80	31.6	33.9	187.6	65	L128-4080SA35A00
		5000K	80	31.6	34.0	188.2	65	L128-5080SA35A00
		5700K	80	31.6	34.0	188.2	65	L128-5780SA35A00
		6500K	80	31.4	33.7	186.5	65	L128-6580SA35A00
		2700K	90	24.9	26.8	148.3	65	L128-2790SA35A00
		3000K	90	25.8	27.8	153.8	65	L128-3090SA35A00
		3500K	90	26.7	28.8	159.4	65	L128-3590SA35A00
		4000K	90	28.2	30.3	167.7	65	L128-4090SA35A00
		5000K	90	28.2	30.4	168.2	65	L128-5090SA35A00
		5700K	90	28.2	30.4	168.2	65	L128-5790SA35A00
		6500K	90	27.9	30.0	166.0	65	L128-6590SA35A00

<sup>Table 1 continued on next page:
1. Correlated color temperature is cold-targeted at T<sub>j</sub>=25°C.
2. Luminous flux and CRI specs are based upon mounted package on highly reflective surface at T<sub>j</sub>=25°C. Typical CRI is approximately 2 points higher than the minimum CRI specified, but this is not guaranteed.
3. Lumileds maintains a tolerance of ±2 on CRI and ±7.5% on luminous flux measurements.</sup> 

Table 1. Product performance of LUXEON 2835 Commercial LEDs at specified test conditions, Continued.

OLTAGE	PART	NOMINAL	MINIMUM	LUMINOUS F	ELUX [2, 3] (lm)	TYPICAL LUMINOUS	TEST CURRENT	PART NUMBER	
OLIAGE	PAKI	CCT <sup>[1]</sup>	CRI [2, 3]	MINIMUM	TYPICAL	EFFICACY (lm/W)	(mA)	FART NOWDER	
		2700K	80	31.6	34.0	190.7	65	L128-2780SA35A00E	
		3000K	80	32.4	34.8	195.1	65	L128-3080SA35A00E	
		3500K	80	33.1	35.5	199.6	65	L128-3580SA35A00E	
		4000K	80	33.8	36.3	204.1	65	L128-4080SA35A00[	
		5000K	80	34.2	36.7	206.3	65	L128-5080SA35A00I	
		5700K	80	34.2	36.7	206.3	65	L128-5780SA35A00I	
		6500K	80	33.8	36.3	204.1	65	L128-6580SA35A00	
		2700K	90	27.2	29.3	164.5	65	L128-2790SA35A00	
		3000K	90	28.4	30.6	171.7	65	L128-3090SA35A00	
		3500K	90	29.4	31.6	177.3	65	L128-3590SA35A00	
		4000K	90	29.7	32.0	179.5	65	L128-4090SA35A00	
		5000K	90	29.7	32.0	179.5	65	L128-5090SA35A00	
		5700K	90	29.6	31.8	178.4	65	L128-5790SA35A00	
		6500K	90	29.4	31.6	177.3	65	L128-6590SA35A00	
		2700K	70	34.7	36.4	207.4	65	L128-2770SA35A00	
		3000K	70	35.7	37.4	213.1	65	L128-3070SA35A00	
		3500K	70	36.1	37.8	215.4	65	L128-3570SA35A00	
		4000K	70	37.2	39.0	222.2	65	L128-4070SA35A00	
		5000K	70	36.8	38.5	219.4	65	L128-5070SA35A00	
		5700K	70	36.8	38.5	219.4	65	L128-5770SA35A00	
		6500K	70	36.5	38.2	217.7	65	L128-6570SA35A00	
		2700K	80	33.8	34.2	195.0	65	L128-2780SA35A00	
			3000K	80	34.3	35.2	200.6	65	L128-3080SA35A00
	LUXEON 2835 S	3500K	80	35.3	35.9	204.6	65	L128-3580SA35A00	
3V		4000K	80	37.2	38.2	218.0	65	L128-4080SA35A00	
		5000K	80	37.2	38.2	218.0	65	L128-5080SA35A00	
		5700K	80	36.7	38.2	218.0	65	L128-5780SA35A00	
		6500K	80	35.7	37.5	214.0	65	L128-6580SA35A00	
		2700K	90	29.8	31.0	176.6	65	L128-2790SA35A00	
		3000K	90	30.6	32.2	183.5	65	L128-3090SA35A00	
		3500K	90	30.8	32.4	184.6	65	L128-3590SA35A00	
		4000K	90	31.3	32.7	186.3	65	L128-4090SA35A00	
		5000K	90	31.3	32.7	186.3	65	L128-5090SA35A00	
		5700K	90	31.3	32.7	186.3	65	L128-5790SA35A00	
		6500K	90	31.8	32.7	186.3	65	L128-6590SA35A00	
		2700K	70	35.8	37.4	213.1	65	L128-2770SA35A00	
		3000K	70	36.9	38.6	219.9	65	L128-3070SA35A00	
		3500K	70	37.3	39.1	222.8	65	L128-3570SA35A00	
		4000K	70	38.8	40.6	231.3	65	L128-4070SA35A00	
		5000K	70	38.3	40.0	228.5	65	L128-5070SA35A00	
		5700K 6500K	70 70	38.3 37.8	40.1	228.5	65 65	L128-5770SA35A00	
					39.6		65	L128-6570SA35A00	
		2700K	80	34.8	35.2	200.6		L128-2780SA35A00	
		3000K	80	35.7	36.1	205.7	65	L128-3080SA35A00	
		3500K	80	36.7	37.3	212.5	65	L128-3580SA35A00	
		4000K	80	37.5	38.6	220.0	65	L128-4080SA35A00	
		5000K	80	37.7	38.6	220.0	65	L128-5080SA35A00	
		5700K	80	37.7	38.6	220.0	65	L128-5780SA35A00	
		6500K	80	37.7	39.5	225.1	65	L128-6580SA35A00	

Table 1 continued on next page:

1. Correlated color temperature is cold-targeted at T<sub>j</sub>=25°C.

2. Luminous flux and CRI specs are based upon mounted package on highly reflective surface at T<sub>j</sub>=25°C. Typical CRI is approximately 2 points higher than the minimum CRI specified, but this is not guaranteed. 3. Lumileds maintains a tolerance of  $\pm 2$  on CRI and  $\pm 7.5\%$  on luminous flux measurements.

Table 1. Product performance of LUXEON 2835 Commercial LEDs at specified test conditions, Continued.

VOLTACE	DADT	NOMINAL	MINIMUM	LUMINOUS F	LUX [2, 3] (lm)	TYPICAL	TEST CURRENT	PART NUMBER
OLTAGE	PART	CCT <sup>[1]</sup>	CRI [2, 3]	MINIMUM	TYPICAL	LUMINOUS EFFICACY (lm/W)	(mA)	PART NOWIDER
,		2700K	90	29.8	31.2	177.7	65	L128-2790SA35A00F
		3000K	90	30.8	32.4	184.5	65	L128-3090SA35A00F
		3500K	90	31.8	32.6	185.6	65	L128-3590SA35A00F
		4000K	90	32.3	33.0	187.8	65	L128-4090SA35A00F
		5000K	90	32.3	33.0	187.8	65	L128-5090SA35A00F
		5700K	90	32.3	33.0	187.8	65	L128-5790SA35A00F
		6500K	90	32.3	33.0	187.8	65	L128-6590SA35A00F
		2700K	80	30.2	31.7	175.4	65	L128-2780SA35A000
		3000K	80	30.7	32.3	178.7	65	L128-3080SA35A000
		3500K	80	30.9	32.5	179.9	65	L128-3580SA35A000
3V	LUXEON 2835 S	4000K	80	32.5	34.2	189.3	65	L128-4080SA35A000
	2033 3	5000K	80	32.5	34.2	189.3	65	L128-5080SA35A000
		5700K	80	32.5	34.2	189.3	65	L128-5780SA35A000
		6500K	80	31.8	33.5	185.4	65	L128-6580SA35A000
		2700K	90	25.0	26.1	144.4	65	L128-2790SA35A000
		3000K	90	26.0	27.1	150.0	65	L128-3090SA35A000
		3500K	90	27.0	28.1	155.5	65	L128-3590SA35A000
		4000K	90	28.3	29.5	163.3	65	L128-4090SA35A000
		5000K	90	28.0	29.2	161.6	65	L128-5090SA35A000
		5700K	90	28.0	29.2	161.6	65	L128-5790SA35A000
		6500K	90	27.6	28.8	159.4	65	L128-6590SA35A000
		2700K	80	101.4	109.0	150.1	120	L128-2780SB35B00
		3000K	80	104.1	112.0	154.3	120	L128-3080SB35B00A
		3500K	80	106.9	115.0	158.4	120	L128-3580SB35B00
		4000K	80	110.0	118.3	162.9	120	L128-4080SB35B00
		5000K	80	110.0	118.3	162.9	120	L128-5080SB35B00A
		5700K	80	110.0	118.3	162.9	120	L128-5780SB35B00
C) /	LUXEON	6500K	80	108.6	116.8	160.9	120	L128-6580SB35B00
6V	2835 S	2700K	90	84.8	91.2	125.6	120	L128-2790SB35B00
		3000K	90	88.5	95.2	131.1	120	L128-3090SB35B00
		3500K	90	93.1	100.2	138.0	120	L128-3590SB35B00A
		4000K	90	95.9	103.2	142.1	120	L128-4090SB35B00
		5000K	90	95.9	103.2	142.1	120	L128-5090SB35B00
		5700K	90	95.9	103.2	142.1	120	L128-5790SB35B00
		6500K	90	95.9	103.2	142.1	120	L128-6590SB35B00A

Notes for Table 1:

1. Correlated color temperature is cold-targeted at T<sub>j</sub>=25°C.

2. Luminous flux and CRI specs are based upon mounted package on highly reflective surface at T<sub>j</sub>=25°C. Typical CRI is approximately 2 points higher than the minimum CRI specified, but this is not guaranteed.

3. Lumileds maintains a tolerance of ±2 on CRI and ±7.5% on luminous flux measurements.

### **Optical Characteristics**

Table 2. Optical characteristics for LUXEON 2835 Commercial at specified test current, T,=25°C.

PART NUMBER	TYPICAL TOTAL INCLUDED ANGLE [1]	TYPICAL VIEWING ANGLE [2]
L128-xxxxSx35xxxxx	160°	120°

Notes for Table 2:

#### **Electrical and Thermal Characteristics**

Table 3. Electrical and thermal characteristics for LUXEON 2835 Commercial at specified test current, T,=25°C.

· ,						
PART NUMBER	FORW	ARD VOLTAG	E <sup>[1]</sup> (V <sub>f</sub> )	TYPICAL TEMPERATURE COEFFICIENT OF FORWARD	TYPICAL THERMAL RESISTANCE—JUNCTION	
PART NOMBER	MINIMUM	TYPICAL	MAXIMUM	VOLTAGE [2] (mV/°C)	TO SOLDER PAD (°C/W)	
L128-xxxSA35A00Ax	2.60	2.76	2.90	-1.0 to -2.0	18.0	
L128-xxxxSA35A00Bx	2.60	2.71	2.80	-1.0 to -2.0	10.0	
L128-xxxSA35A00Cx	2.65	2.78	2.85	-1.0 to -2.0	20.5	
L128-xxxxSA35A00Dx	2.65	2.74	2.85	-1.0 to -2.0	14.0	
L128-xxxxSA35A00Ex	2.60	2.70	2.80	-1.0 to -2.0	17.5	
L128-xxxSA35A00Fx	2.60	2.70	2.80	-1.0 to -2.0	15.2	
L128-xxxxSA35A00Gx	2.60	2.78	2.90	-1.0 to -2.0	23.1	
L128-xxxxSB35B00Ax	5.80	6.05	6.30	-2.0 to -4.0	18.0	

Notes for Table 3:

### **Absolute Maximum Ratings**

Table 4. Absolute maximum ratings for LUXEON 2835 Commercial.

PARAMETER	MAXIMUM PERFORMANCE
DC Forward Current [1, 2]	300mA for L128-xxxxSA35A00Ax 300mA for L128-xxxxSA35A00Bx 300mA for L128-xxxxSA35A00Cx 300mA for L128-xxxxSA35A00Dx 300mA for L128-xxxxSA35A00Ex 300mA for L128-xxxxSA35A00Fx 300mA for L128-xxxxSA35A00Gx 150mA for L128-xxxxSB35B00Ax
Peak Pulsed Forward Current [1, 3]	450mA for L128-xxxxSA35A00Ax 480mA for L128-xxxxSA35A00Bx 360mA for L128-xxxxSA35A00Cx 480mA for L128-xxxxSA35A00Dx 480mA for L128-xxxxSA35A00Ex 480mA for L128-xxxxSA35A00Fx 450mA for L128-xxxxSA35A00Gx 225mA for L128-xxxxSB35B00Ax
LED Junction Temperature [1] (DC & Pulse)	125°C for L128-xxxxSx35xxxxx
ESD Sensitivity (ANSI/ESDA/JEDEC JS-001-2012)	Class 2
Operating Case Temperature <sup>[1]</sup>	-40°C to 105°C
LED Storage Temperature	-40°C to 105°C
Soldering Temperature	JEDEC 020c 260°C
Allowable Reflow Cycles	3
Reverse Voltage (V <sub>reverse</sub> )	LUXEON LEDs are not designed to be driven in reverse bias

#### Notes for Table 4:

Total angle at which 90% of total luminous flux is captured.

<sup>2.</sup> Viewing angle is the off axis angle from the LED centerline where the luminous intensity is 1/2 of the peak value.

<sup>1.</sup> Lumileds maintains a tolerance of  $\pm 0.1 V$  on forward voltage measurements. 2. Measured between 25°C and 85°C.

<sup>1.</sup> Proper current derating must be observed to maintain the junction temperature below the maximum allowable junction temperature.

Residual periodic variations due to power conversion from alternating current (AC) to direct current (DC), also called "ripple," are acceptable if the following conditions are met:

- The frequency of the ripple current is 100Hz or higher

<sup>-</sup> The average current for each cycle does not exceed the maximum allowable DC forward current

<sup>–</sup> The maximum amplitude of the ripple does not exceed the maximum peak pulsed forward current 3. At  $\leq$ 50% duty cycle with pulse width of 5ms.

### **Characteristics Curves**

### **Spectral Power Distribution Characteristics**

### **70CRI**

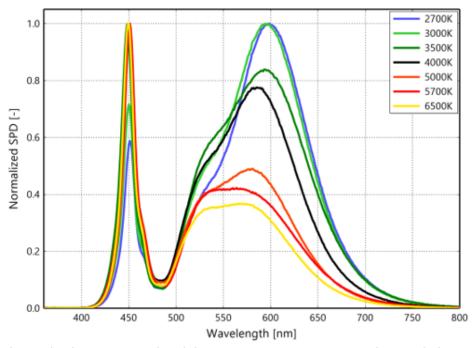


Figure 1a. Typical normalized power vs. wavelength for 70CRI LUXEON 2835 Commercial at specified test current, T<sub>i</sub>=25°C.

#### 80CRI

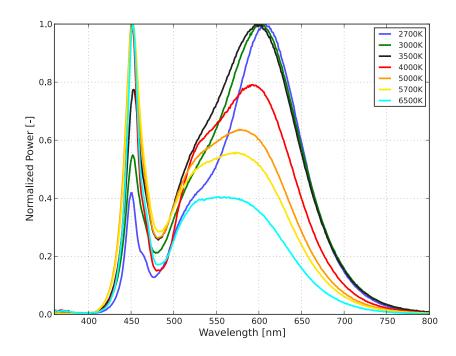


Figure 1b. Typical normalized power vs. wavelength for 80CRI LUXEON 2835 Commercial at specified test current, T<sub>i</sub>=25°C.

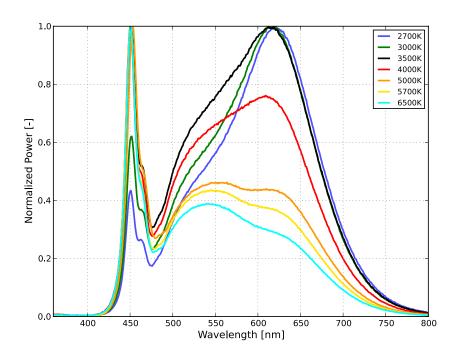


Figure 1c. Typical normalized power vs. wavelength for 90CRI LUXEON 2835 Commercial at specified test current,  $T_j$ =25°C

### **Light Output Characteristics**

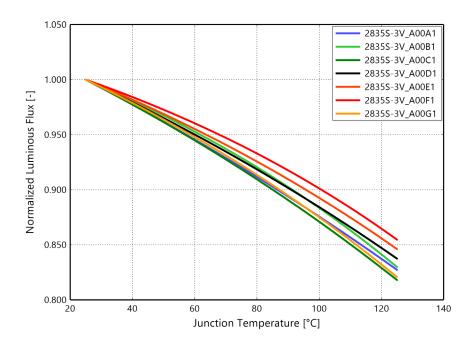


Figure 2a. Typical normalized luminous flux vs. junction temperature for LUXEON 2835S 3V Line at specified test current.

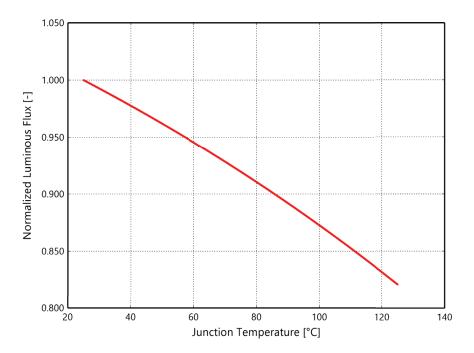


Figure 2b. Typical normalized luminous flux vs. junction temperature for LUXEON 2835S 6V Line at specified test current.

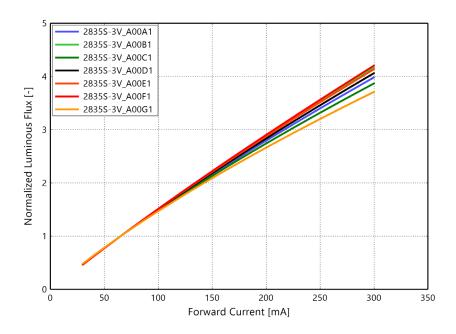


Figure 3a. Typical normalized luminous flux vs. forward current for LUXEON 2835S 3V Line at T<sub>i</sub>=25°C.

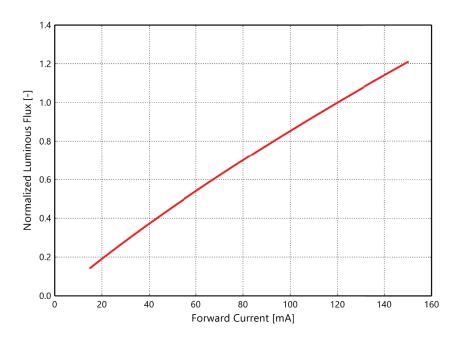


Figure 3b. Typical normalized luminous flux vs. forward current for LUXEON 2835S 6V Line at T<sub>i</sub>=25°C.

### **Forward Current Characteristics**

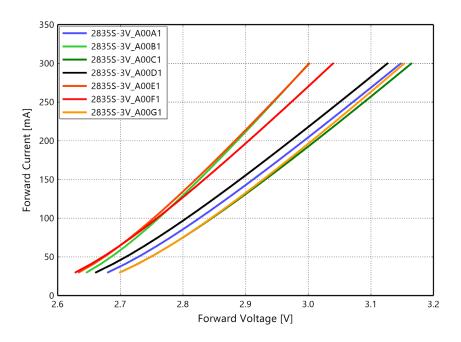


Figure 4a. Typical forward current vs. forward voltage for LUXEON 2835S 3V at T<sub>i</sub>=25°C.

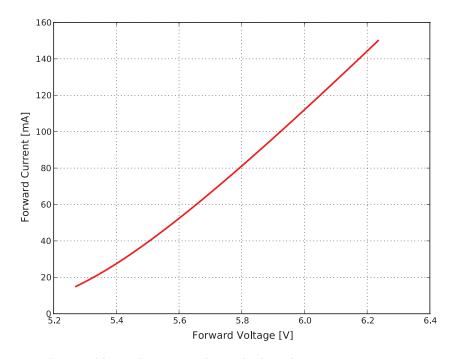


Figure 4b. Typical forward current vs. forward voltage for LUXEON 2835S 6V at  $T_i$ =25°C.

### **Radiation Pattern Characteristics**

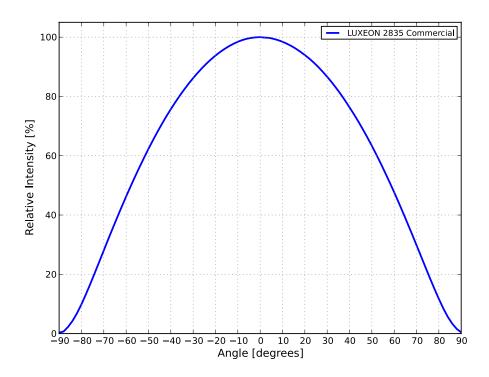


Figure 5. Typical radiation pattern for LUXEON 2835 Commercial at test current, T<sub>i</sub>=25°C.

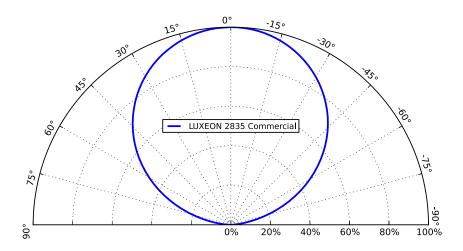


Figure 6. Typical polar radiation pattern for LUXEON 2835 Commercial at test current, T<sub>i</sub>=25°C.

### **Mechanical Dimensions**

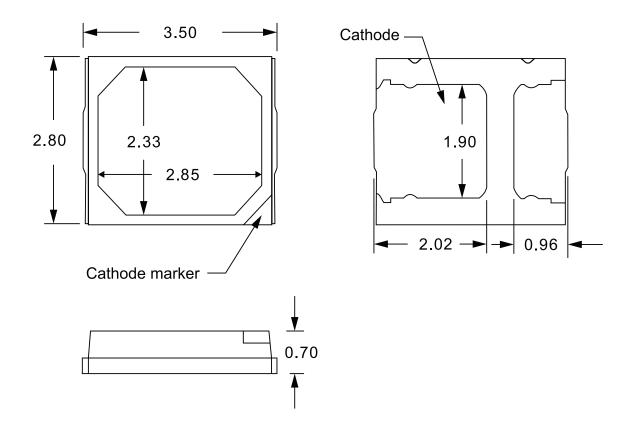


Figure 7. Mechanical dimensions for LUXEON 2835 Commercial.

- Notes for Figure 7:
  1. Drawings are not to scale.
  2. All dimensions are in millimeters.
  3. Tolerance: ±0.1 mm.

### **Reflow Soldering Guidelines**

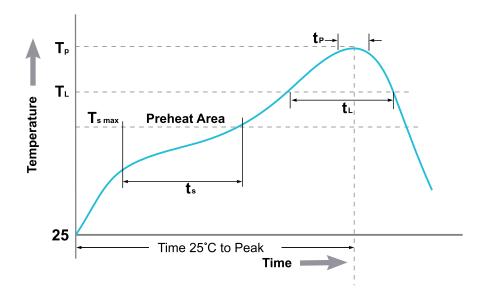


Figure 8. Visualization of the acceptable reflow temperature profile as specified in Table 5.

Table 5. Reflow profile characteristics for LUXEON 2835 Commercial.

PROFILE FEATURE	LEAD-FREE ASSEMBLY
Preheat Maximum Temperature (T <sub>smax</sub> )	180°C
Preheat Time (t <sub>s</sub> )	120 seconds maximum
Ramp-Up Rate $(T_{smax} \text{ to } T_p)$	5°C / second maximum
Liquidus Temperature (T <sub>L</sub> )	220°C
Time Maintained Above Temperature $T_L(t_L)$	60 seconds maximum
Peak / Classification Temperature $(T_p)$	260°C
Time Within 5°C of Actual Peak Temperature $(t_p)$	10 seconds maximum
Time 25°C to Peak Temperature	3.5 minutes maximum

### JEDEC Moisture Sensitivity

Table 6. Moisture sensitivity levels for LUXEON 2835 Commercial.

LEVEL	FLOO	R LIFE	SOAK REQUIREMENTS STANDARD		
LEVEL	TIME	CONDITIONS	TIME	CONDITIONS	
4	72 Hours	≤30°C / 60% RH	96 Hours +2 / -0	30°C / 60% RH	

Note for Figure 8:

1. This general guideline may not apply to all designs and configurations of reflow soldering equipment.

### Solder Pad Design

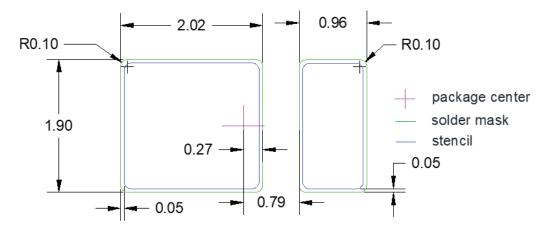


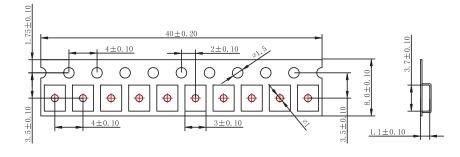
Figure 9. Recommended PCB solder pad layout for LUXEON 2835 Commercial.

#### Notes for Figure 9:

- Drawings are not to scale.
   All dimensions are in millimeters.

## **Packaging Information**

### **Pocket Tape Dimensions**



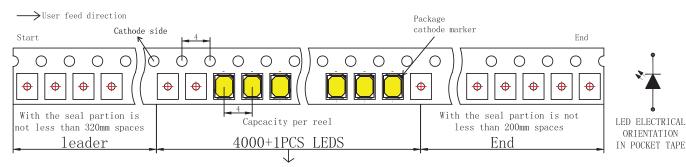
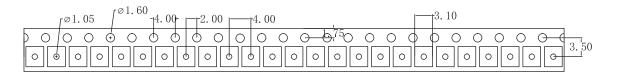


Figure 10a. Pocket tape dimensions for LUXEON 2835 Commercial.

#### Notes for Figure 10a:

- Drawings are not to scale.
   All dimensions are in millimeters.







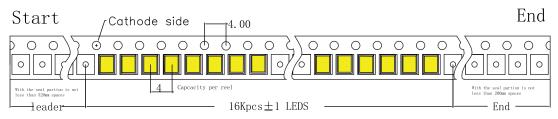


Figure 10b. Pocket tape dimensions for LUXEON 2835 Commercial L128-xxxxSA35A00Gx.

- Notes for Figure 10b:
  1. Drawings are not to scale.
  2. All dimensions are in millimeters.

#### **Reel Dimensions**

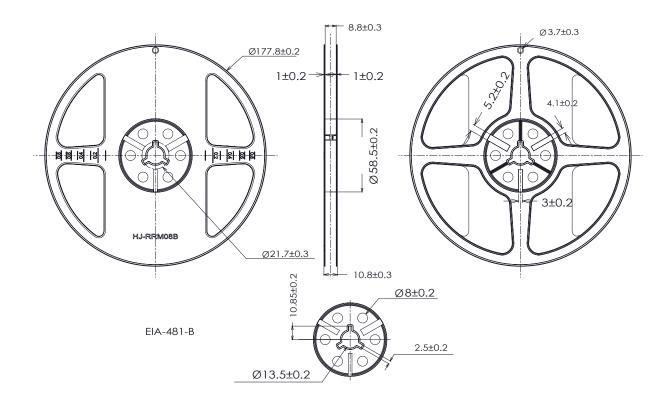


Figure 11a. Reel dimensions for LUXEON 2835 Commercial.

#### Notes for Figure 11a:

- Drawings are not to scale.
  All dimensions are in millimeters.

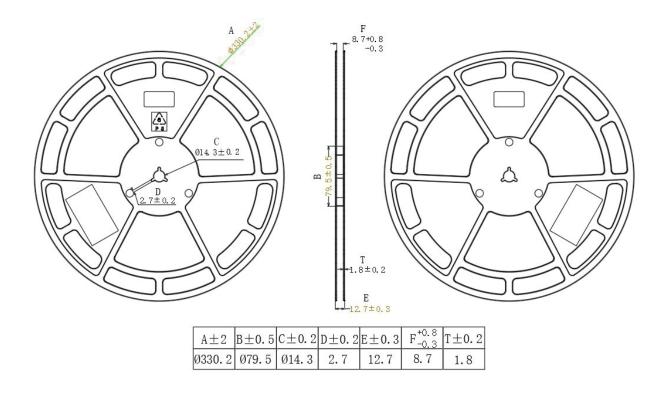


Figure 11b. Reel dimensions for LUXEON 2835 Commercial L128-xxxxSA35A00Gx.

#### Notes for Figure 11b:

- Drawings are not to scale.
   All dimensions are in millimeters.

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