Technical Data Sheet

Acriche
semiconductor eco lighting

SEOUL SEMICONDUCTOR

Application Note: Designing with Acriche A4

SAWX4A0X

Introduction

The Acriche series of devices are designed for ease of implementation and readily connect to AC sources emitting very high flux while minimizing driver requirements.

Acriche products are long-lasting, environmentally friendly semiconductor light sources that can be attached either directly to AC voltages, or as with the A4, to a simple diode bridge (see Fig 6).

Acriche's thermal management exceeds other power LED solutions incorporating state-of-the-art SMD technology, thermal path design, and low thermal resistant materials.
Whether designing a spot light or tiled array, the Acriche A4 is an ideal light source for general purpose illumination applications.

This application note provides assembly and handling information of the A4 series.

Features

- Connect using a simple diode bridge directly to AC power
- Power Saving
- Long Life Time
- Simple BOM
- Miniaturization
- Low thermal resistance
- SMT solderability
- Lead Free product
- RoHS compliant

Applications

- Architectural lighting
- Residential lighting
- Task lighting
- Decorative/Pathway lighting

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Contents

1. Component

1.1 Description

The ACRICHE A4 emitter is designed to operate off of rectified high voltage AC. The A4 PKG contains a high brightness, high voltage LED chip array on a ceramic substrate that functions as a mechanical support for the chips and connects the LED chip to the anode and cathode of the package. Each A4 emitter contains a zener diode to provide ESD protection. A silicone lens covering the LED chip helps to extract the light and provide environmental protection.

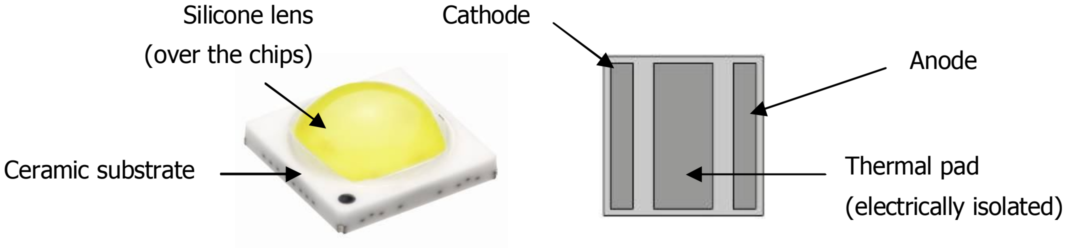


Figure 1. ACRICHE A4 (left) and bottom of A4 (right)

1.2 Mechanical Dimensions

As seen in Fig 2 below, the theoretical optical center is located at the center of the A4 package. The anode, cathode and thermal pads are located on the bottom of the package. The cathode mark indicates the cathode pad location. The ceramic substrate electrically isolates the thermal pad or slug from the cathode and anode. Electrical shocks can occur at high voltage, therefore safety considerations should be taken into account by following UL Recommendations.
The A4 has been UL recognized.

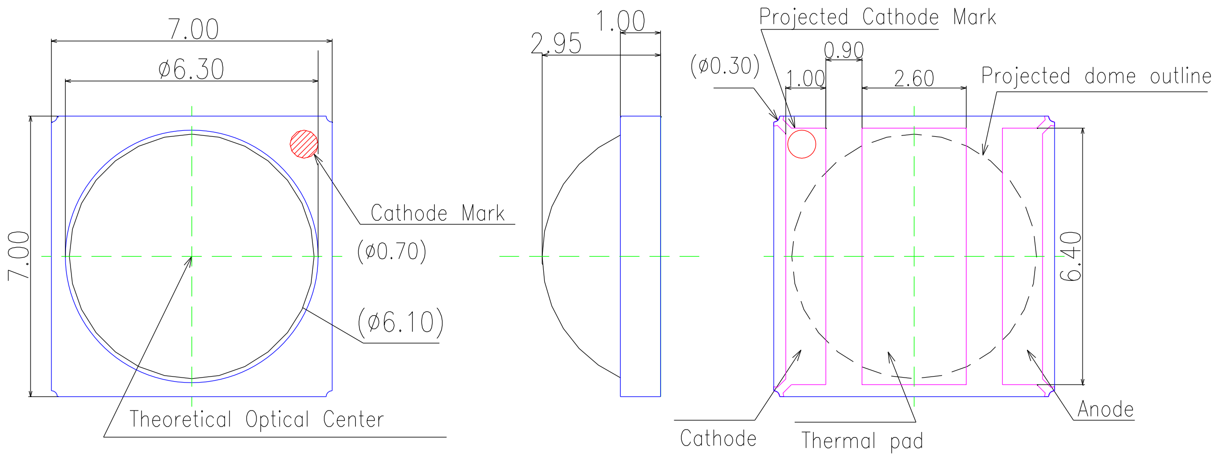


Figure 2. ACRICHE A4 mechanical dimensions(mm)

1.3 PCB solder pad layout

The ACRICHE A4 emitter should be mounted on a printed circuit board for electrical connections and to give a proper thermal path between the LED package and the heat sink. A temperature check point is recommended to be designed into the solder pad layout which can be used to calculate the junction temperature for thermal degradation and life time calculations. The solder pad should not be designed larger than the recommended size as the part may shift and excess solder paste may form solder balls which can create electrical shorts between internal pads on the package (Figure 4).

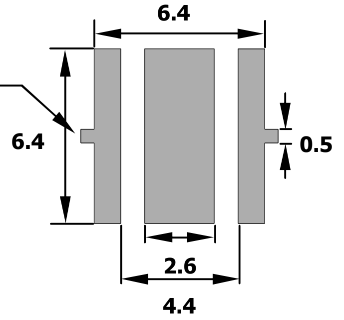


Figure 3. Recommended PCB solder pad layout

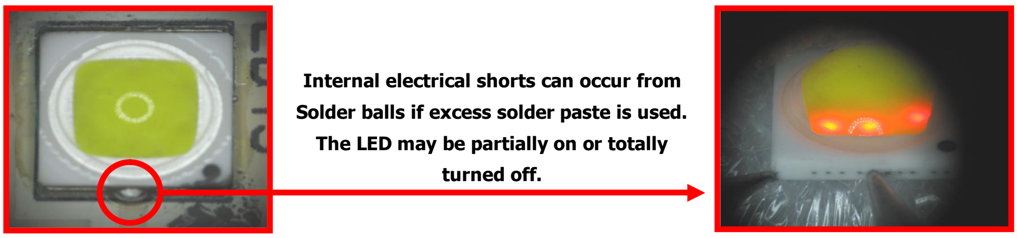


Figure 4. Incorrect soldering of the ACRICHE A4 emitter

1.4 Junction Temperature

The life time of the ACRICHE A4 emitter is most directly related to the junction temperature, but it is impossible to measure the junction temperature directly without any damage. Tj can be theoretically calculated by using the thermal resistance between the LED junction and the board. The equation for Tj is: Tj[℃] = Tb[℃] + RΘ j-b[℃/W] x emitter power[W].

The equation of the emitter power is calculated using the following formula:
P[W] = Input Vrms[V] X Input Irms[A] X Power Factor – Irms^2[A] X Resistor Value[Ω].

The rectifier power dissipation is negligible so we are not using this in the calculations, although we do need the Power Factor(PF) for the A4 emitter. It is about 0.89 in the typical drive configuration consisting of only a rectifier and a resistor. (Note: The PF is 1.00 generally in constant current drive).

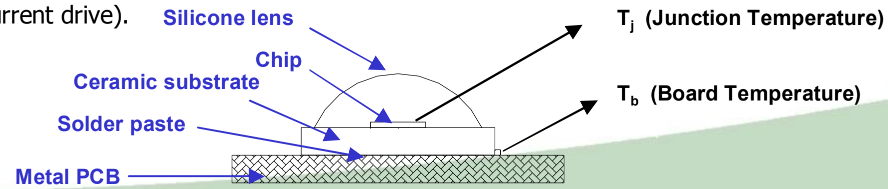


Figure 5. Thermal modeling of the ACRICHE A4 emitter

1.5 Lens handling

Improper handling of the LED packages can damage the silicone lens. Avoid touching the silicone dome of the LED especially with sharp tools. Pick up the LED on the sides of the package. Any physical force to the silicone lens in excess of 3000gf will permanently and fatally damage the part. The silicone dome is sensitive to dust and debris and can cause an optical output decrease. If dust or debris accumulates on the lens, isopropyl alcohol (IPA) can be used to remove dust from the lens.

2. Driver Configurations

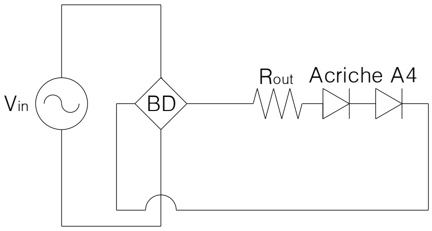
2.1 Description

The ACRICHE A4 emitter is designed to operate directly off of AC line power(e.g 120Vac, 230Vac) with a rectifier, resistors or optional capacitor(s). This compact circuit can minimize the lighting product size, help simplify thermal design, and increase overall product reliability. It is also an economical solution because you do not need to have all the extra components. Typical low voltage DC circuits require a transformer, regulator and multiple discrete components such as capacitors, inductors, resistors.

2.2 Proper resistor selection

Operating the ACRICHE A4 emitter requires a bridge rectifier and resistors at a minimum, since the architecture of the A4 has been modified from the earlier versions of the Acriche family(A2, A3), which did not need a bridge. This architecture has a string of LEDs in one direction only, compared to the previous version which has strings in both directions, thereby not requiring the diode bridge previously. Utilizing the new architecture, we are able to reduce the number of LEDs needed, thereby reducing package size and price.

It is better to use higher than rated power resistors for reliability. The rated power of the resistor should be chosen based on the equation Irms(A)*Irms(A)*Resistor value(ohms). The normal power rating of a 3216 size resistor is 0.25W. If the power consumption in one resistor exceeds the rated power of the resistor it is suggested to use multiple resistors in parallel.



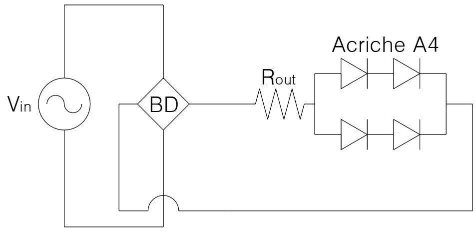


Figure 6. Compact drive circuit configuration 100~120Vac

Input Voltage	Power dissipation	Target Drive Current	VF bins			
			A	B	C	D
100 Vac	2 W	20 mA,rms	630 Ω	480 Ω	330 Ω	180 Ω
	3 W	25 mA,rms	420 Ω	270 Ω	120 Ω	N/A
	4 W	30 mA,rms	285 Ω	135 Ω	N/A	N/A
110 Vac	2 W	20 mA,rms	1060 Ω	910 Ω	760 Ω	610 Ω
	3 W	25 mA,rms	765 Ω	615 Ω	465 Ω	315 Ω
	4 W	30 mA,rms	575 Ω	425 Ω	275 Ω	125 Ω
120 Vac	2 W	20 mA,rms	1510 Ω	1360 Ω	1210 Ω	1060 Ω
	3 W	25 mA,rms	1125 Ω	975 Ω	825 Ω	675 Ω
	4 W	30 mA,rms	870 Ω	720 Ω	570 Ω	420 Ω

Table 1. Resistor values in Figure 6. (left)

Input Voltage	Power dissipation	Target Drive Current	VF bins			
			A	B	C	D
100 Vac	4 W	40 mA,rms	315 Ω	240 Ω	165 Ω	90 Ω
	6 W	50 mA,rms	210 Ω	135 Ω	60 Ω	N/A
	8 W	60 mA,rms	140 Ω	65 Ω	N/A	N/A
110 Vac	4 W	40 mA,rms	530 Ω	455 Ω	380 Ω	305 Ω
	6 W	50 mA,rms	385 Ω	310 Ω	235 Ω	160 Ω
	8 W	60 mA,rms	285 Ω	210 Ω	135 Ω	60 Ω
120 Vac	4 W	40 mA,rms	755 Ω	680 Ω	605 Ω	530 Ω
	6 W	50 mA,rms	565 Ω	490 Ω	415 Ω	340 Ω
	8 W	60 mA,rms	435 Ω	360 Ω	285 Ω	210 Ω

Table 2. Resistor values in Figure 6. (right)

* Notes :
[1] SSC recommends that MS6B (Max input voltage: 420Vrms) would be used as a bridge rectifier.
[2] Applicable Part Numbers are currently SAW04A0A (AW4240-01) and SAW84A0C (AN4240-03)

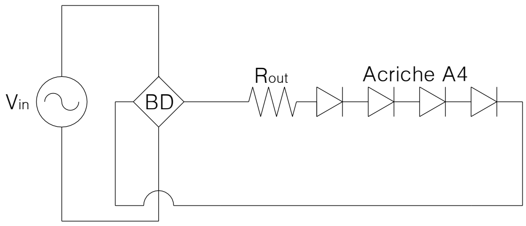


Figure 7. Standard compact drive circuit configuration 220~240Vac

Input Voltage	Power dissipation	Target Drive Current	VF bins			
			A	B	C	D
220 Vac	4 W	20 mA,rms	2200 Ω	1900 Ω	1600 Ω	1300 Ω
	6 W	25 mA,rms	1570 Ω	1270 Ω	970 Ω	670 Ω
	8 W	30 mA,rms	1180 Ω	880 Ω	580 Ω	280 Ω
230 Vac	4 W	20 mA,rms	2640 Ω	2340 Ω	2040 Ω	1740 Ω
	6 W	25 mA,rms	1930 Ω	1630 Ω	1330 Ω	1030 Ω
	8 W	30 mA,rms	1480 Ω	1180 Ω	880 Ω	580 Ω
240 Vac	4 W	20 mA,rms	3080 Ω	2780 Ω	2480 Ω	2180 Ω
	6 W	25 mA,rms	2290 Ω	1990 Ω	1690 Ω	1390 Ω
	8 W	30 mA,rms	1780 Ω	1480 Ω	1180 Ω	880 Ω

Table 3. Resistor values in Figure 7.

2.3 Optional Components/Configurations

Acriche A4 can be operated in three additional optional configurations if higher efficiency or less flicker is needed. These optional configurations can lower power factor as seen in Table 13. The three different component configurations consist of a bridge diode, resistor, and capacitor(s).

Optional Configuration #1 : output resistor + output capcacitor(parallel)
Optional Configuration #2 : Input capacitor(series) + output resistor
Optional Configuration #3 : Input capacitor(series) + output capcacitor(parallel) + output resistor

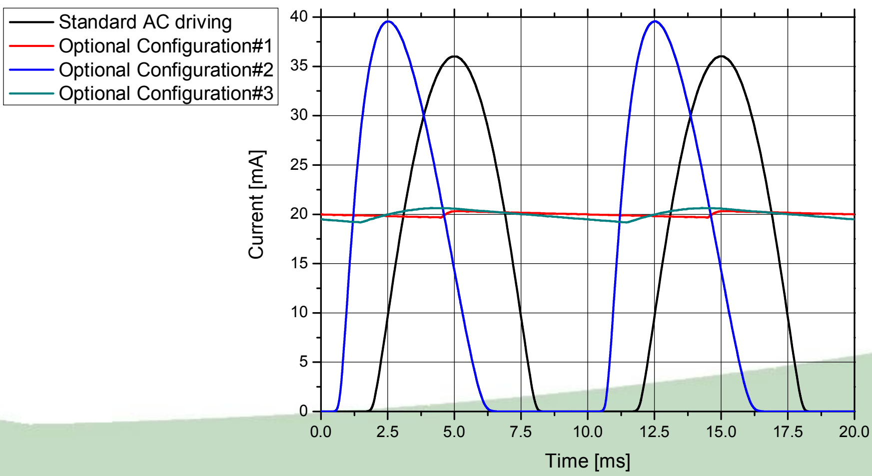


Figure 8. Current waveforms of different circuit configurations

Optional circuit configuration#1: This adds an output capacitor to the standard circuit. This configuration has no flicker. The current shape through the A4 package is similar to DC current, as seen in Figure 8. Input current and LED current are not the same value. The target drive current indicates LED current through A4 PKG. There is no difference in resistor values between 50Hz and 60Hz of frequency.

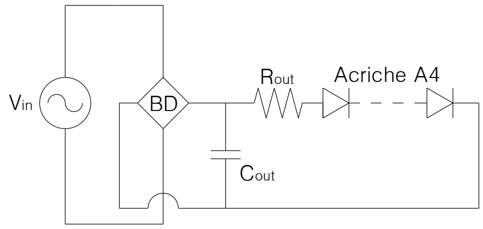


Figure 9. Optional compact drive circuit configuration#1

Input Voltage	Frequency	LED#	Target Drive Current (I_{LED}, not I_{in})	Cout	Rout for VF bins			
					A	B	C	D
220 Vac	50Hz/60Hz	4 ea	20 mA,rms	47 uF	4650 Ω	4350 Ω	4050 Ω	3750 Ω
			30 mA,rms	47 uF	2750 Ω	2450 Ω	2150 Ω	1850 Ω
			40 mA,rms	47 uF	1850 Ω	1550 Ω	1250 Ω	950 Ω
		5 ea	20 mA,rms	47 uF	1960 Ω	1580 Ω	1210 Ω	830 Ω
230 Vac	50Hz/60Hz	4 ea	20 mA,rms	47 uF	5350 Ω	5050 Ω	4750 Ω	4450 Ω
			30 mA,rms	47 uF	3250 Ω	2950 Ω	2650 Ω	2350 Ω
			40 mA,rms	47 uF	2200 Ω	1900 Ω	1600 Ω	1300 Ω
		5 ea	20 mA,rms	47 uF	2670 Ω	2290 Ω	1920 Ω	1540 Ω
			30 mA,rms	47 uF	1370 Ω	1000 Ω	620 Ω	250 Ω
240 Vac	50Hz/60Hz	4 ea	20 mA,rms	47 uF	6050 Ω	5750 Ω	5450 Ω	5150 Ω
			30 mA,rms	47 uF	3700 Ω	3400 Ω	3100 Ω	2800 Ω
			40 mA,rms	47 uF	2550 Ω	2250 Ω	1950 Ω	1650 Ω
		5 ea	20 mA,rms	47 uF	3380 Ω	3000 Ω	2630 Ω	2250 Ω
			30 mA,rms	47 uF	1850 Ω	1470 Ω	1100 Ω	720 Ω
100 Vac	50Hz/60Hz	2 ea	20 mA,rms	100 uF	1580 Ω	1430 Ω	1280 Ω	1130 Ω
			30 mA,rms	100 uF	890 Ω	740 Ω	590 Ω	440 Ω
110 Vac	50Hz/60Hz	2 ea	20 mA,rms	100 uF	2290 Ω	2140 Ω	1990 Ω	1840 Ω
			30 mA,rms	100 uF	1360 Ω	1210 Ω	1060 Ω	910 Ω
			40 mA,rms	100 uF	910 Ω	760 Ω	610 Ω	460 Ω
120 Vac	50Hz/60Hz	2 ea	20 mA,rms	100 uF	2990 Ω	2840 Ω	2690 Ω	2540 Ω
			30 mA,rms	100 uF	1830 Ω	1680 Ω	1530 Ω	1380 Ω
			40 mA,rms	100 uF	1260 Ω	1110 Ω	960 Ω	810 Ω

Table 4. Resistor and capacitor values in Figure 9

Optional circuit configuration#2: This adds an input capacitor to the standard circuit. This Configuration has the same current shape through the A4 package as the standard AC drive (as seen in Figure 8), but since it can only drive one LED string it is very suitable for compact designs like a candle lamp. Additionally the circuit efficiency is very high(see table 13). You can also improve efficiency a little by eliminating the output resistor(Rout), but SSC recommends using Rout for surge immunity.

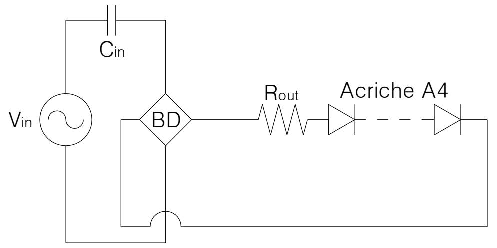


Figure 10. Optional compact drive circuit configuration#2

Input Voltage	Frequency	LED#	Target Drive Current ($I_{LED} = I_{in}$)	Rout	Cin for VF bins			
					A	B	C	D
220 Vac	50 Hz	4 ea	20 mA,rms	100 Ω	560 nF	590 nF	640 nF	700 nF
			30 mA,rms	100 Ω	920 nF	1060 nF	1320 nF	N/A
		3 ea	20 mA,rms	100 Ω	410 nF	420 nF	420 nF	430 nF
			30 mA,rms	100 Ω	630 nF	650 nF	680 nF	710 nF
			40 mA,rms	100 Ω	870 nF	920 nF	980 nF	1060 nF
		2 ea	20 mA,rms	100 Ω	350 nF	350 nF	350 nF	350 nF
			30 mA,rms	100 Ω	530 nF	530 nF	530 nF	540 nF
			40 mA,rms	100 Ω	720 nF	720 nF	720 nF	730 nF
		1 ea	20 mA,rms	100 Ω	310 nF	310 nF	310 nF	310 nF
			30 mA,rms	100 Ω	460 nF	460 nF	460 nF	460 nF
			40 mA,rms	100 Ω	620 nF	620 nF	620 nF	620 nF
	60 Hz	4 ea	20 mA,rms	100 Ω	470 nF	490 nF	530 nF	580 nF
			30 mA,rms	100 Ω	770 nF	880 nF	1100 nF	N/A
		3 ea	20 mA,rms	100 Ω	340 nF	350 nF	350 nF	360 nF
			30 mA,rms	100 Ω	530 nF	550 nF	570 nF	590 nF
			40 mA,rms	100 Ω	730 nF	760 nF	810 nF	880 nF
		2 ea	20 mA,rms	100 Ω	290 nF	290 nF	290 nF	290 nF
			30 mA,rms	100 Ω	440 nF	440 nF	440 nF	450 nF
			40 mA,rms	100 Ω	600 nF	600 nF	600 nF	610 nF
		1 ea	20 mA,rms	100 Ω	260 nF	260 nF	260 nF	260 nF
			30 mA,rms	100 Ω	380 nF	380 nF	390 nF	390 nF
			40 mA,rms	100 Ω	510 nF	510 nF	520 nF	520 nF

Table 5. Resistor and capacitor values in Figure 10 (220Vac)

Input Voltage	Frequency	LED#	Target Drive Current ($I_{LED} = I_{in}$)	Rout	Cin for VF bins			
					A	B	C	D
230 Vac	50 Hz	4 ea	20 mA,rms	100 Ω	500 nF	520 nF	550 nF	590 nF
			30 mA,rms	100 Ω	800 nF	890 nF	1020 nF	1280 nF
			40 mA,rms	100 Ω	1180 nF	1430 nF	N/A	N/A
		3 ea	20 mA,rms	100 Ω	380 nF	390 nF	390 nF	400 nF
			30 mA,rms	100 Ω	590 nF	600 nF	620 nF	640 nF
			40 mA,rms	100 Ω	800 nF	840 nF	880 nF	940 nF
		2 ea	20 mA,rms	100 Ω	330 nF	330 nF	330 nF	330 nF
			30 mA,rms	100 Ω	500 nF	500 nF	500 nF	500 nF
			40 mA,rms	100 Ω	680 nF	680 nF	680 nF	690 nF
		1 ea	20 mA,rms	100 Ω	290 nF	290 nF	290 nF	290 nF
			30 mA,rms	100 Ω	440 nF	440 nF	440 nF	440 nF
			40 mA,rms	100 Ω	590 nF	590 nF	590 nF	590 nF
	60 Hz	4 ea	20 mA,rms	100 Ω	420 nF	430 nF	460 nF	490 nF
			30 mA,rms	100 Ω	670 nF	740 nF	850 nF	1060 nF
			40 mA,rms	100 Ω	980 nF	1190 nF	N/A	N/A
		3 ea	20 mA,rms	100 Ω	320 nF	320 nF	330 nF	330 nF
			30 mA,rms	100 Ω	490 nF	500 nF	520 nF	540 nF
			40 mA,rms	100 Ω	670 nF	700 nF	730 nF	780 nF
		2 ea	20 mA,rms	100 Ω	270 nF	270 nF	270 nF	270 nF
			30 mA,rms	100 Ω	420 nF	420 nF	420 nF	420 nF
			40 mA,rms	100 Ω	560 nF	560 nF	560 nF	570 nF
		1 ea	20 mA,rms	100 Ω	240 nF	240 nF	240 nF	240 nF
			30 mA,rms	100 Ω	370 nF	370 nF	370 nF	370 nF
			40 mA,rms	100 Ω	490 nF	490 nF	490 nF	490 nF

Table 6. Resistor and capacitor values in Figure 10 (230Vac)

Input Voltage	Frequency	LED#	Target Drive Current ($I_{LED} = I_{in}$)	Rout	Cin for VF bins			
					A	B	C	D
240 Vac	50 Hz	4 ea	20 mA,rms	100 Ω	450 nF	470 nF	490 nF	510 nF
			30 mA,rms	100 Ω	720 nF	770 nF	860 nF	990 nF
			40 mA,rms	100 Ω	1030 nF	1180 nF	1500 nF	N/A
		3 ea	20 mA,rms	100 Ω	360 nF	360 nF	370 nF	370 nF
			30 mA,rms	100 Ω	550 nF	560 nF	570 nF	590 nF
			40 mA,rms	100 Ω	750 nF	770 nF	810 nF	850 nF
		2 ea	20 mA,rms	100 Ω	310 nF	310 nF	310 nF	310 nF
			30 mA,rms	100 Ω	470 nF	470 nF	470 nF	480 nF
			40 mA,rms	100 Ω	640 nF	640 nF	640 nF	650 nF
		1 ea	20 mA,rms	100 Ω	280 nF	280 nF	280 nF	280 nF
			30 mA,rms	100 Ω	420 nF	420 nF	420 nF	420 nF
			40 mA,rms	100 Ω	560 nF	560 nF	560 nF	560 nF
	60 Hz	4 ea	20 mA,rms	100 Ω	380 nF	390 nF	410 nF	430 nF
			30 mA,rms	100 Ω	600 nF	640 nF	710 nF	820 nF
			40 mA,rms	100 Ω	860 nF	990 nF	1250 nF	N/A
		3 ea	20 mA,rms	100 Ω	300 nF	300 nF	300 nF	310 nF
			30 mA,rms	100 Ω	460 nF	470 nF	480 nF	490 nF
			40 mA,rms	100 Ω	620 nF	640 nF	670 nF	710 nF
		2 ea	20 mA,rms	100 Ω	260 nF	260 nF	260 nF	260 nF
			30 mA,rms	100 Ω	390 nF	390 nF	390 nF	400 nF
			40 mA,rms	100 Ω	530 nF	530 nF	530 nF	540 nF
		1 ea	20 mA,rms	100 Ω	230 nF	230 nF	230 nF	230 nF
			30 mA,rms	100 Ω	350 nF	350 nF	350 nF	350 nF
			40 mA,rms	100 Ω	470 nF	470 nF	470 nF	470 nF

Table 7. Resistor and capacitor values in Figure 10 (240Vac)

Input Voltage	Frequency	LED#	Target Drive Current ($I_{LED} = I_{in}$)	Rout	Cin for VF bins			
					A	B	C	D
100Vac	50 Hz	2 ea	20 mA,rms	100 Ω	1600 nF	1850 nF	2340 nF	N/A
		1 ea	20 mA,rms	100 Ω	780 nF	790 nF	800 nF	800 nF
			30 mA,rms	100 Ω	1200 nF	1210 nF	1230 nF	1250 nF
			40 mA,rms	100 Ω	1630 nF	1660 nF	1700 nF	1740 nF
	60 Hz	2 ea	20 mA,rms	100 Ω	1340 nF	1550 nF	1950 nF	N/A
		1 ea	20 mA,rms	100 Ω	650 nF	660 nF	660 nF	670 nF
			30 mA,rms	100 Ω	1000 nF	1010 nF	1020 nF	1040 nF
			40 mA,rms	100 Ω	1350 nF	1380 nF	1410 nF	1450 nF
110 Vac	50 Hz	2 ea	20 mA,rms	100 Ω	1150 nF	1230 nF	1330 nF	1490 nF
			30 mA,rms	100 Ω	1950 nF	2290 nF	3100 nF	N/A
		1 ea	20 mA,rms	100 Ω	690 nF	690 nF	700 nF	700 nF
			30 mA,rms	100 Ω	1050 nF	1060 nF	1070 nF	1080 nF
			40 mA,rms	100 Ω	1420 nF	1440 nF	1470 nF	1500 nF
	60 Hz	2 ea	20 mA,rms	100 Ω	960 nF	1020 nF	1110 nF	1250 nF
			30 mA,rms	100 Ω	1620 nF	1910 nF	2550 nF	N/A
		1 ea	20 mA,rms	100 Ω	580 nF	580 nF	580 nF	590 nF
			30 mA,rms	100 Ω	870 nF	880 nF	890 nF	900 nF
			40 mA,rms	100 Ω	1180 nF	1200 nF	1220 nF	1250 nF
120 Vac	50 Hz	2 ea	20 mA,rms	100 Ω	920 nF	950 nF	1000 nF	1060 nF
			30 mA,rms	100 Ω	1480 nF	1620 nF	1810 nF	2150 nF
			40 mA,rms	100 Ω	2170 nF	2570 nF	3500 nF	N/A
		1 ea	20 mA,rms	100 Ω	620 nF	620 nF	620 nF	630 nF
			30 mA,rms	100 Ω	940 nF	940 nF	950 nF	960 nF
			40 mA,rms	100 Ω	1260 nF	1280 nF	1300 nF	1320 nF
	60 Hz	2 ea	20 mA,rms	100 Ω	760 nF	800 nF	930 nF	880 nF
			30 mA,rms	100 Ω	1240 nF	1350 nF	1510 nF	1800 nF
			40 mA,rms	100 Ω	1810 nF	2140 nF	2900 nF	N/A
		1 ea	20 mA,rms	100 Ω	510 nF	520 nF	520 nF	520 nF
			30 mA,rms	100 Ω	780 nF	790 nF	790 nF	800 nF
			40 mA,rms	100 Ω	1050 nF	1070 nF	1080 nF	1100 nF

Table 8. Resistor and capacitor values in Figure 10 (100~120 Vac)

We can also see based on Figure 10, the peak currents and waveforms are different based on number of LEDs in the circuit. The more LEDs in the circuit the higher the peak current in identical currents(i.e. 20mA rms). This translates into lower luminous output because of droop, but we will see higher power factors with more LEDs. Flicker can be more prominent with a higher number of LEDs as you can see there is more off time with more LEDs.

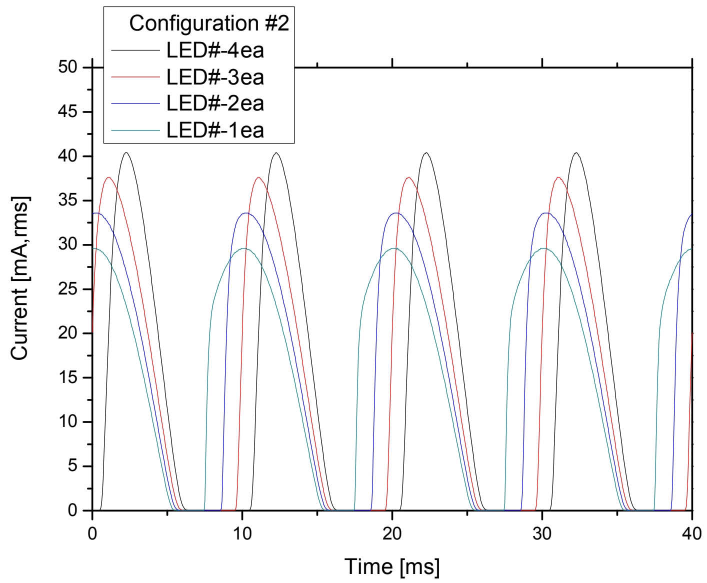


Figure 11. LED current shape for 1-4 LEDs.
Input Voltage is 230Vac@50Hz and target LED current is 20mA,rms.

Figure 12 shows LED current vs input voltage variation on A4 with 1-4 emitters. When quantities of LEDs decrease, the current variation is less.

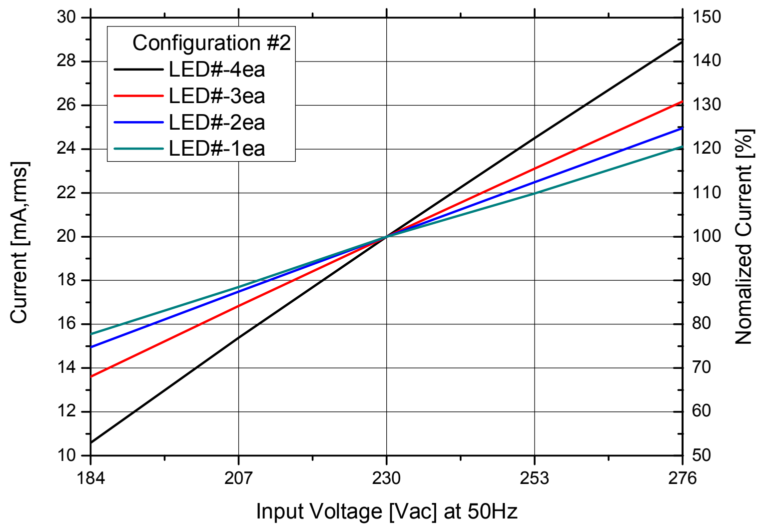


Figure 12. LED current variation at input voltage range (230Vac ± 20%) in Figure10.

Optional circuit configuration#3: This adds an input capacitor and output capacitor to the standard circuit. This configuration has no flicker and the current shape through the A4 package is similar to DC current, as seen in Figure 8. This means we get a combination of configurations #1 & 2, higher efficiency and no flicker issues.

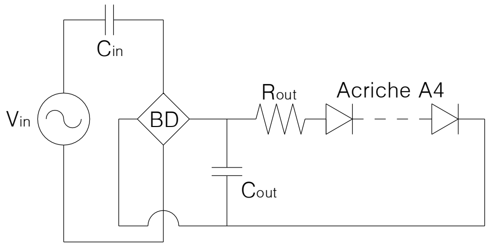


Figure 13. Optional compact drive circuit configuration#3

Input Voltage	Frequency	LED#	Target Drive Current (I_{LED}, not I_{in})	Cout	Rout	Cin for VF bins A	B	C	D
220 Vac	50 Hz	4 ea	20 mA,rms	47 uF	390 Ω	1160 nF	1250 nF	1350 nF	1470 nF
			30 mA,rms	47 uF	390 Ω	2060 nF	2350 nF	2760 nF	N/A
		3 ea	20 mA,rms	47 uF	300 Ω	700 nF	730 nF	760 nF	780 nF
			30 mA,rms	47 uF	300 Ω	1140 nF	1200 nF	1270 nF	1350 nF
			40 mA,rms	47 uF	300 Ω	1630 nF	1760 nF	1920 nF	2100 nF
		2 ea	20 mA,rms	47 uF	200 Ω	510 nF	510 nF	520 nF	530 nF
			30 mA,rms	47 uF	200 Ω	780 nF	800 nF	820 nF	840 nF
			40 mA,rms	47 uF	200 Ω	1080 nF	1120 nF	1160 nF	1200 nF
		1 ea	20 mA,rms	47 uF	100 Ω	390 nF	400 nF	400 nF	400 nF
			30 mA,rms	47 uF	100 Ω	600 nF	600 nF	610 nF	610 nF
			40 mA,rms	47 uF	100 Ω	800 nF	820 nF	830 nF	840 nF
	60 Hz	4 ea	20 mA,rms	47 uF	390 Ω	960 nF	1040 nF	1120 nF	1220 nF
			30 mA,rms	47 uF	390 Ω	1710 nF	1960 nF	2280 nF	N/A
		3 ea	20 mA,rms	47 uF	300 Ω	590 nF	610 nF	630 nF	650 nF
			30 mA,rms	47 uF	300 Ω	950 nF	1000 nF	1060 nF	1120 nF
			40 mA,rms	47 uF	300 Ω	1360 nF	1470 nF	1600 nF	1750 nF
		2 ea	20 mA,rms	47 uF	200 Ω	420 nF	430 nF	430 nF	440 nF
			30 mA,rms	47 uF	200 Ω	650 nF	670 nF	690 nF	700 nF
			40 mA,rms	47 uF	200 Ω	900 nF	930 nF	960 nF	1000 nF
		1 ea	20 mA,rms	47 uF	100 Ω	330 nF	330 nF	330 nF	330 nF
			30 mA,rms	47 uF	100 Ω	500 nF	500 nF	510 nF	510 nF
			40 mA,rms	47 uF	100 Ω	670 nF	680 nF	690 nF	700 nF

Table 9. Resistor and capacitor values in Figure 12 (220Vac)

Input Voltage	Frequency	LED#	Target Drive Current (I_{LED}, not I_{in})	Cout	Rout	Cin for VF bins			
						A	B	C	D
230 Vac	50 Hz	4 ea	20 mA,rms	47 uF	390 Ω	990 nF	1060 nF	1130 nF	1210 nF
			30 mA,rms	47 uF	390 Ω	1720 nF	1930 nF	2180 nF	2520 nF
		3 ea	20 mA,rms	47 uF	300 Ω	640 nF	660 nF	680 nF	710 nF
			30 mA,rms	47 uF	300 Ω	1030 nF	1080 nF	1130 nF	1190 nF
			40 mA,rms	47 uF	300 Ω	1460 nF	1570 nF	1690 nF	1830 nF
		2 ea	20 mA,rms	47 uF	200 Ω	470 nF	480 nF	490 nF	490 nF
			30 mA,rms	47 uF	200 Ω	730 nF	750 nF	760 nF	780 nF
			40 mA,rms	47 uF	200 Ω	1000 nF	1040 nF	1070 nF	1100 nF
		1 ea	20 mA,rms	47 uF	100 Ω	370 nF	370 nF	380 nF	380 nF
			30 mA,rms	47 uF	100 Ω	560 nF	570 nF	570 nF	580 nF
			40 mA,rms	47 uF	100 Ω	760 nF	770 nF	780 nF	790 nF
	60 Hz	4 ea	20 mA,rms	47 uF	390 Ω	830 nF	880 nF	940 nF	1010 nF
			30 mA,rms	47 uF	390 Ω	1430 nF	1600 nF	1810 nF	2100 nF
		3 ea	20 mA,rms	47 uF	300 Ω	530 nF	550 nF	570 nF	590 nF
			30 mA,rms	47 uF	300 Ω	850 nF	900 nF	940 nF	990 nF
			40 mA,rms	47 uF	300 Ω	1220 nF	1300 nF	1400 nF	1520 nF
		2 ea	20 mA,rms	47 uF	200 Ω	390 nF	400 nF	400 nF	410 nF
			30 mA,rms	47 uF	200 Ω	610 nF	620 nF	630 nF	650 nF
			40 mA,rms	47 uF	200 Ω	840 nF	860 nF	890 nF	920 nF
		1 ea	20 mA,rms	47 uF	100 Ω	310 nF	310 nF	310 nF	310 nF
			30 mA,rms	47 uF	100 Ω	470 nF	480 nF	480 nF	480 nF
			40 mA,rms	47 uF	100 Ω	630 nF	640 nF	650 nF	660 nF

Table 10. Resistor and capacitor values in Figure 12 (230Vac)

Input Voltage	Frequency	LED#	Target Drive Current (I_{LED}, not I_{in})	Cout	Rout	Cin for VF bins			
						A	B	C	D
240 Vac	50 Hz	4 ea	20 mA,rms	47 uF	390 Ω	870 nF	920 nF	970 nF	1030 nF
			30 mA,rms	47 uF	390 Ω	1480 nF	1630 nF	1810 nF	2030 nF
		3 ea	20 mA,rms	47 uF	300 Ω	590 nF	600 nF	620 nF	640 nF
			30 mA,rms	47 uF	300 Ω	940 nF	980 nF	1020 nF	1070 nF
			40 mA,rms	47 uF	300 Ω	1330 nF	1410 nF	1500 nF	1620 nF
		2 ea	20 mA,rms	47 uF	200 Ω	440 nF	450 nF	450 nF	460 nF
			30 mA,rms	47 uF	200 Ω	680 nF	700 nF	710 nF	720 nF
			40 mA,rms	47 uF	200 Ω	940 nF	960 nF	990 nF	1020 nF
		1 ea	20 mA,rms	47 uF	100 Ω	350 nF	350 nF	360 nF	360 nF
			30 mA,rms	47 uF	100 Ω	530 nF	540 nF	550 nF	550 nF
			40 mA,rms	47 uF	100 Ω	720 nF	730 nF	740 nF	750 nF
	60 Hz	4 ea	20 mA,rms	47 uF	390 Ω	730 nF	770 nF	810 nF	860 nF
			30 mA,rms	47 uF	390 Ω	1230 nF	1350 nF	1500 nF	1680 nF
			40 mA,rms	47 uF	390 Ω	1880 nF	2170 nF	2600 nF	3200 nF
		3 ea	20 mA,rms	47 uF	300 Ω	490 nF	500 nF	520 nF	540 nF
			30 mA,rms	47 uF	300 Ω	780 nF	810 nF	850 nF	890 nF
			40 mA,rms	47 uF	300 Ω	1100 nF	1170 nF	1250 nF	1350 nF
		2 ea	20 mA,rms	47 uF	200 Ω	370 nF	370 nF	380 nF	380 nF
			30 mA,rms	47 uF	200 Ω	570 nF	580 nF	590 nF	600 nF
			40 mA,rms	47 uF	200 Ω	780 nF	800 nF	830 nF	850 nF
		1 ea	20 mA,rms	47 uF	100 Ω	300 nF	300 nF	300 nF	300 nF
			30 mA,rms	47 uF	100 Ω	450 nF	450 nF	460 nF	460 nF
			40 mA,rms	47 uF	100 Ω	600 nF	610 nF	620 nF	620 nF

Table 11. Resistor and capacitor values in Figure 12 (240Vac)

Input Voltage	Frequency	LED#	Target Drive Current (I_{LED}, not I_{in})	Cout	Rout	Cin for VF bins			
						A	B	C	D
100 Vac	50 Hz	1 ea	20 mA,rms	100 uF	100 Ω	1180 nF	1210 nF	1230 nF	1250 nF
			30 mA,rms	100 uF	100 Ω	1850 nF	1910 nF	1960 nF	2020 nF
			40 mA,rms	100 uF	100 Ω	2570 nF	2680 nF	2790 nF	2910 nF
	60 Hz	1 ea	20 mA,rms	100 uF	100 Ω	990 nF	1010 nF	1030 nF	1050 nF
			30 mA,rms	100 uF	100 Ω	1530 nF	1590 nF	1640 nF	1690 nF
			40 mA,rms	100 uF	100 Ω	2140 nF	2230 nF	2320 nF	2420 nF
110 Vac	50 Hz	2 ea	20 mA,rms	100 uF	200 Ω	2360 nF	2550 nF	2770 nF	3000 nF
		1 ea	20 mA,rms	100 uF	100 Ω	1010 nF	1030 nF	1050 nF	1070 nF
			30 mA,rms	100 uF	100 Ω	1580 nF	1620 nF	1660 nF	1700 nF
			40 mA,rms	100 uF	100 Ω	2170 nF	2250 nF	2330 nF	2410 nF
	60 Hz	2 ea	20 mA,rms	100 uF	200 Ω	1970 nF	2120 nF	2300 nF	2500 nF
		1 ea	20 mA,rms	100 uF	100 Ω	850 nF	860 nF	870 nF	890 nF
			30 mA,rms	100 uF	100 Ω	1310 nF	1350 nF	1380 nF	1410 nF
			40 mA,rms	100 uF	100 Ω	1810 nF	1870 nF	1940 nF	2010 nF
120 Vac	50 Hz	2 ea	20 mA,rms	100 uF	200 Ω	1780 nF	1890 nF	2010 nF	2100 nF
		1 ea	20 mA,rms	100 uF	100 Ω	890 nF	900 nF	910 nF	920 nF
			30 mA,rms	100 uF	100 Ω	1370 nF	1400 nF	1430 nF	1460 nF
			40 mA,rms	100 uF	100 Ω	1880 nF	1940 nF	2000 nF	2060 nF
	60 Hz	2 ea	20 mA,rms	100 uF	200 Ω	1480 nF	1570 nF	1640 nF	1750 nF
		1 ea	20 mA,rms	100 uF	100 Ω	740 nF	750 nF	760 nF	770 nF
			30 mA,rms	100 uF	100 Ω	1140 nF	1170 nF	1190 nF	1220 nF
			40 mA,rms	100 uF	100 Ω	1570 nF	1610 nF	1660 nF	1710 nF

Table 12. Resistor and capacitor values in Figure 12 (100~120Vac)

2.4 Circuit configuration performance

The ACRICHE A4 emitter can be operated in diverse configurations. Configuration #1 has no flicker, but has lower power factor and lower efficiency. On the contrary using Configuration #2, there are characteristics of high efficiency, higher power factor. Lastly, configuration #3 has the merit from configuration#1 & 2. It has high efficiency, no flicker, but power factor is a little low.

Table 13 shows detail circuit charateristic of four configurations that are operated in 230Vac/50Hz.

	Standard AC Drive	Optional Configuration #1	Optional Configuration #2	Optional Configuration #3
LED #	4 ea	4 ea	4 ea	4 ea
LED VF rank	C	C	C	C
Vin	230 Vac	230 Vac	230 Vac	230 Vac
Frequency	50 Hz	50 Hz	50 Hz	50 Hz
Rout	2040 Ω	4750 Ω	100 Ω	390 Ω
Cin	N/A	N/A	550 nF	1130 nF
Cout	N/A	47 uF	N/A	47 uF
LED current	20 mA,rms	20 mA,rms	20 mA,rms	20 mA,rms
Input current	20 mA,rms	100 mA,rms	20 mA,rms	40 mA,rms
P_{in}	4.16 W	6.52 W	3.23 W	4.71 W
P_{led}	3.33 W	4.54 W	3.17 W	4.53 W
Effciency(P_{led}/P_{in})	80.15%	69.56%	98.19%	96.23%
Noticeable flicker	100Hz	no	100Hz	no
PF	0.90	0.28	0.70	0.51

Table 13. Circuit characteristic of four configurations with input 230Vac/50Hz

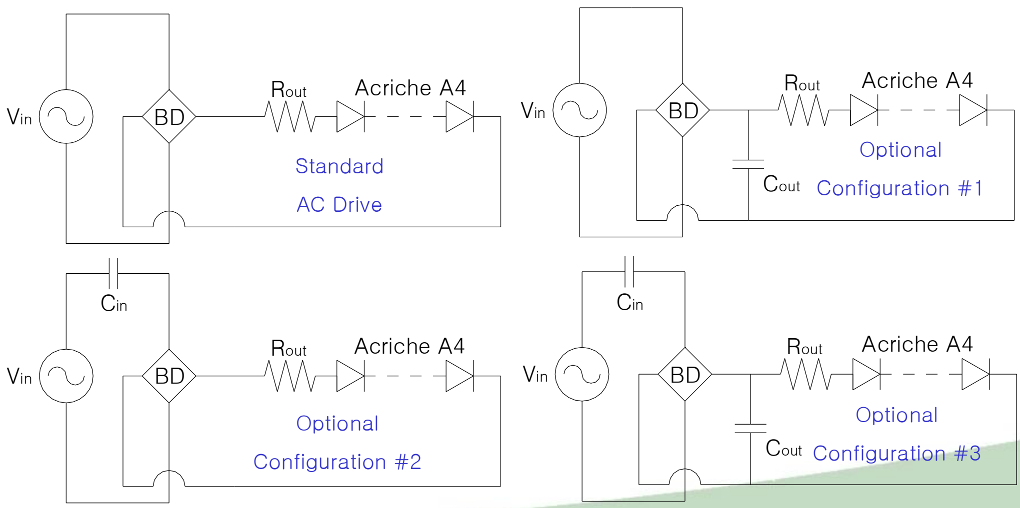


Figure 14. Four circuit configurations

2.5 Relative light output between AC and DC

The ACRICHE A4 emitter is binned at rectified AC 20mA,rms, not at constant current 20mA. Figure 15 shows relative luminous flux vs current of an AC circuit and a DC circuit. Relative flux results are normalized luminous flux at AC 20mA,rms. The AC drive current can simply be changed by modifying the resistor value in the circuit.

Optional circuit configurations 1 and 3 are similar to driving at a constant current, therefore they will have similar luminous flux characteristics.

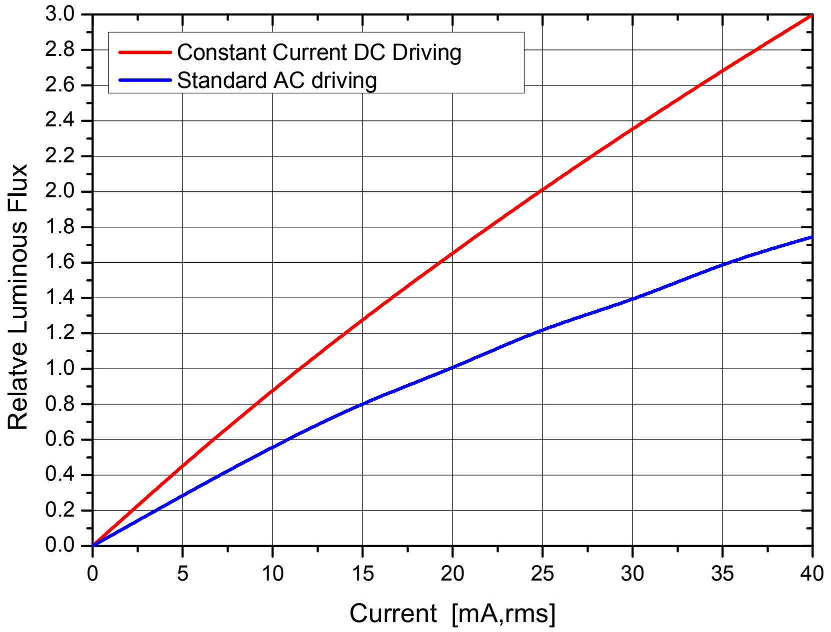


Figure 15. Relative luminous flux between AC and DC driving.

2.6 Vf bin combination

If we can combine multiple Vf bins, we can allow for more part acceptability in the system application, thereby allowing a wider availability of parts. The ACRICHE A4 emitter can be operated by mixing VF bins. The left picture of Figure 16 is an example of a series combination of 2 VF bin Cs in a 100/110/120V application. The right picture of Figure 15 would result in the same current draw as the left using the same resistor, but this time we are combining 2 Vf B bins and 2 Vf D bins.

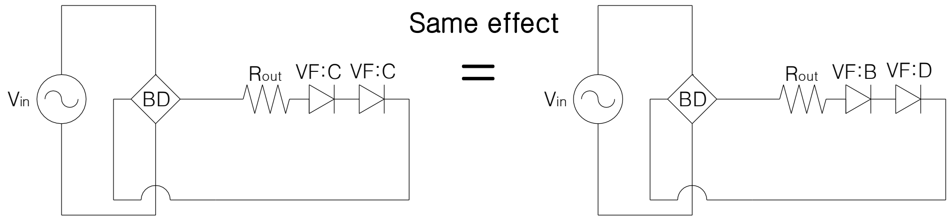


Figure 16. Same effect of Vf bin combination

The same idea can be applied for 2 Vf bin Bs in series. These can be replaced with 1 Vf bin A and 1 Vf bin C. If we take a look at the resistor settings, for example a 120Vac application on page 6(Fig 17), we can see how the math works. The easy calculation is to take the resistor setting for Vf bin A and the resistor setting for Vf bin C, add them together and divide by 2.

If we look at the 2W configuration:
(1510ohms + 1210ohms) / 2 = 1360ohms, which is the same resistor value as Vf bin B.

We can further expand this to other combinations of Vf if we modify Rout for setting the current. This technique can be easily modified for 220/230/240Vac applications. We just add the four resistor values together and divide by 4 since we have 4 LEDs in series.

Input Voltage	Power dissipation	Target Drive Current	VF bins			
			A	B	C	D
120 Vac	2 W	20 mA,rms	1510 Ω	1360 Ω	1210 Ω	1060 Ω
	3 W	25 mA,rms	1125 Ω	975 Ω	825 Ω	675 Ω
	4 W	30 mA,rms	870 Ω	720 Ω	570 Ω	420 Ω

Figure 17. 120Vac resistor settings pulled from page 6

2.7 Color bin selection

Color coordinates of the part AN4240-03 can change over temperature. Color shift can be inimized with a good thermal system design. If color stability is important in a system, it is recommended to design the system based on the specific application temperature. An example of color shift over temperature is shown below in Figure 18. We can see as the board temperature gets hotter we have a color shift to the left. Each application is specific and should be verified in application.

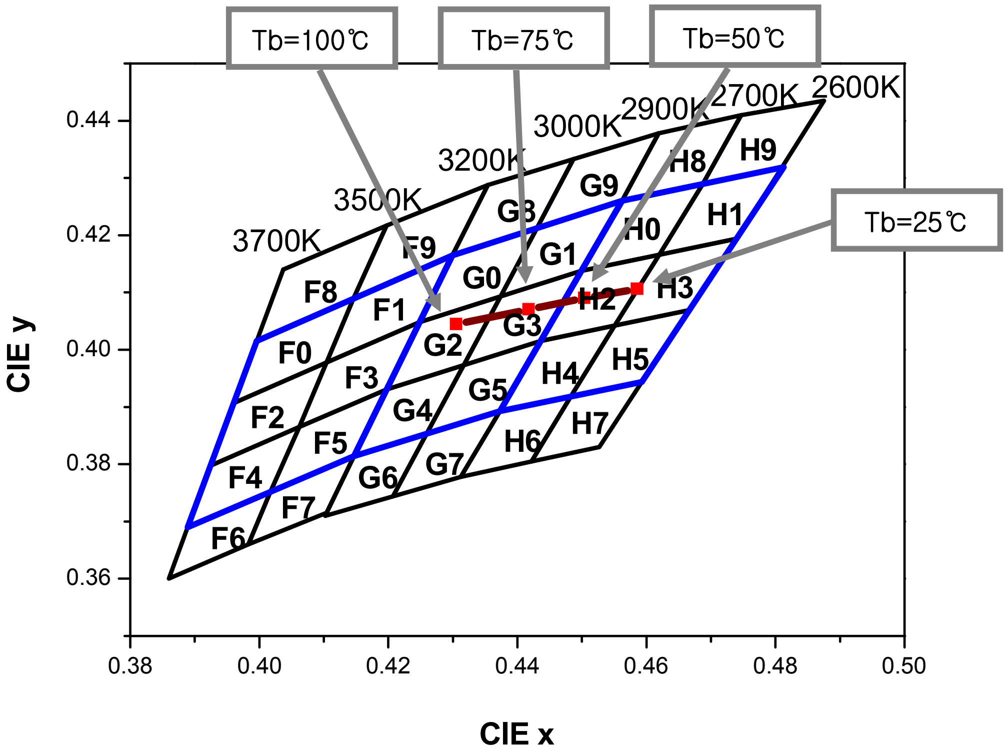


Figure 18. Color coordinate depends on board temperature for AN4240-03

3. Protection

3.1 Description

AC-LEDs are susceptible to line transients just as DC LEDs which can overheat the components, either causing immediate failure or greatly shortening the useful life of the LEDs. Circuit-protection should be utilized to protect against over-voltage, over-current and over temperature conditions.

3.2 Lightning surges, Voltage spikes or Ring Wave Protection

A metal oxide varistor (MOV) is often used to help protect lighting systems from lightning surges and ring-wave effects, and helps manufacturers meet safety and performance standards. The MOV clamps short-duration voltage impulses. Lightning tests according to IEC 61000-4-5 and ring-wave tests according to IEEE C.62.41 can be used to simulate these real-life threats in the lab.

3.3 Over-current and Over-temperature Protection

In both AC-LEDs and DC-LEDs alike, excessive heat at the LED junction can dramatically reduce both the light output and lifespan of the LED.

TE Circuit Protection's PolySwitch polymeric positive temperature coefficient (PPTC) devices help provide over-current and over-temperature protection and can be easily integrated onto a circuit board with the AC-LED. The PPTC acts like a fuse to limit current in a series circuit that drives the LED, yet can automatically reset itself when the fault clears.

An example circuit of a MOV and PPTC is shown in figure 19 below.

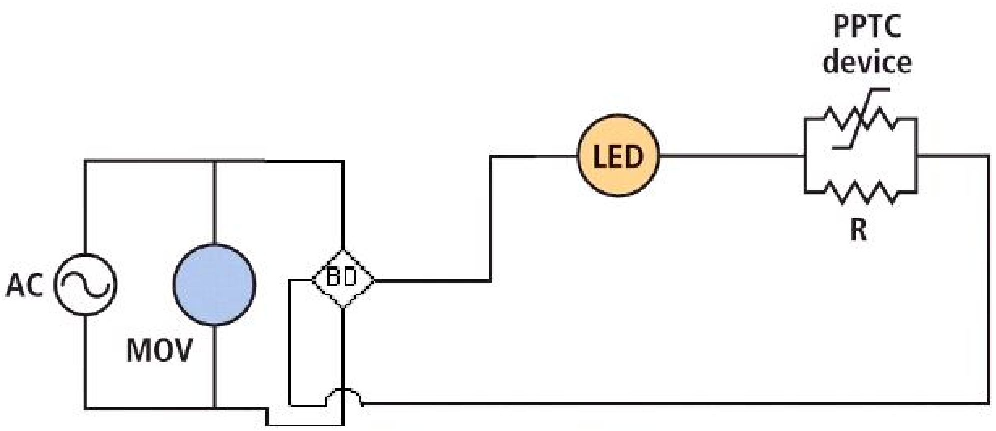


Figure 19. Example protection circuit