

LED Lighting Driver Introduction



BL LED
Mar 2014

Where we Excel: Lighting Segments

Diodes... a proficient provider of LED drivers for BOM cost-effective, reliable, dimming solutions

General Lighting

Simplicity, compatibility and reliable are the hallmarks of Diodes Incorporated's LED driving solutions

Backlights

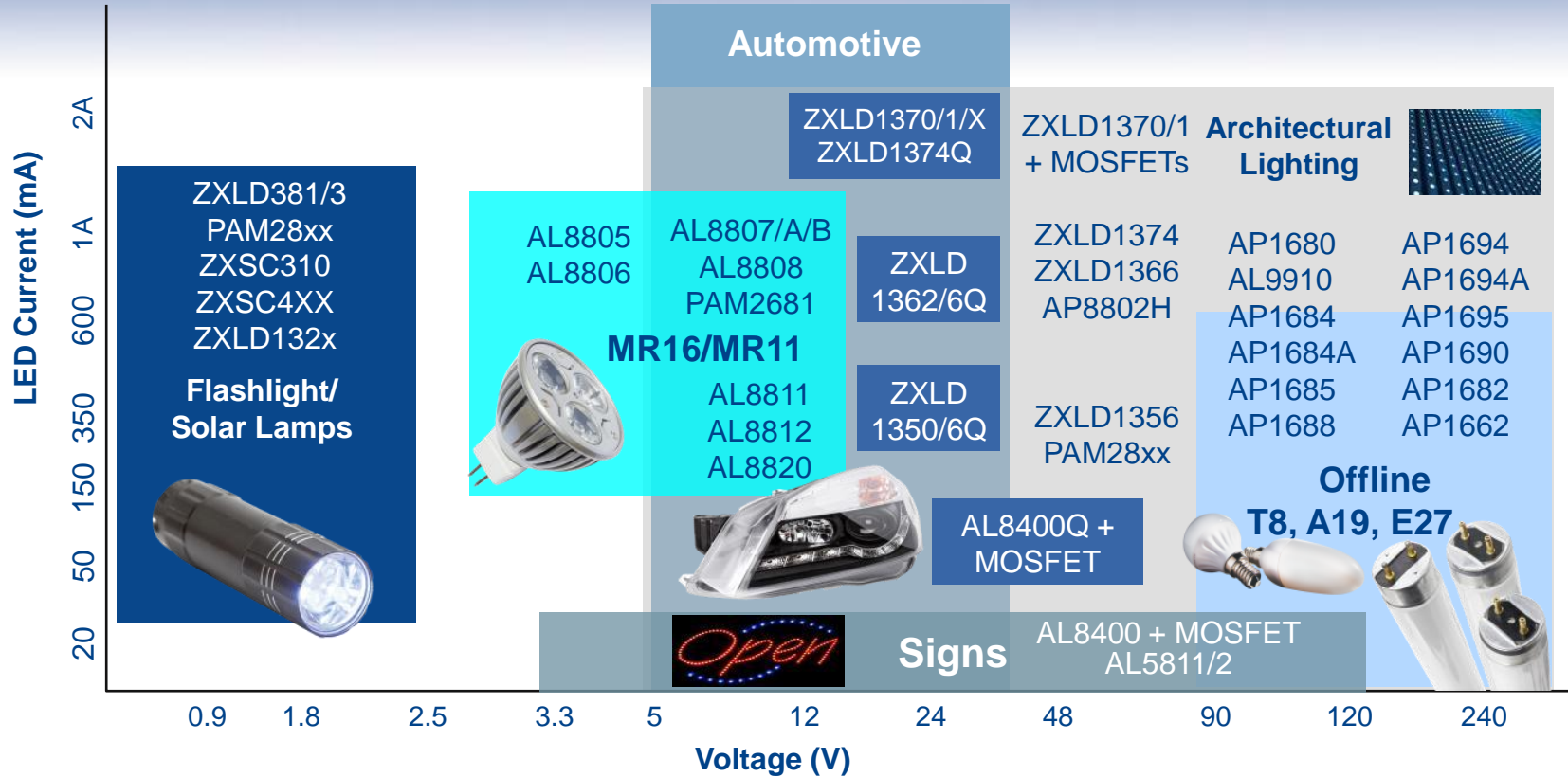
Signage Lighting

Their extensive versatility make them suitable for a wide range of applications

Automotive



LED Lighting: Target Market Segments and Applications



	Application	Power	Topology	PF	Diodes product	BOM	Remark
Non-dimmable	GU10	<7W	Flyback Buck-boost	>0.5	AP1680	~30 comp. ~0.55\$	High current accuracy and reliability, driving BJT
			Buck	>0.9	AP1685	~24 comp. ~0.55\$	High efficiency, 2.5A 500V MOS integrated, SO8
			Buck	>0.5	AL1678-1	~20 comp. ~0.40\$	Compact design, 1A 500V MOS integrated, SO8
	A19/E27	7-13W	Buck	>0.5	AL1678-2	~20 comp. ~0.45\$	Compact design, 2A 500V MOS integrated, SO8
				>0.9	AP1684A	~25 comp. ~0.65\$	High efficiency, single main input, best EMI
	PAR/Down /T8	13-30W	Flyback Buck-boost	>0.9	AP1682E	~35 comp. ~0.95\$	Best on THD, universal main input
			Buck	>0.9	AP1684A	~25 comp. ~0.75\$	High efficiency, single main input, best EMI
			Buck	>0.9	AP1688	~30 comp. ~0.90\$	Universal main input, high efficiency, good EMI
MR16	5-11W	Buck	>0.5	AL8808/7	~15 comp. ~0.50\$	Low BOM and high reliability	
		Boost-buck	>0.9	AL8820	~20 comp. ~0.70\$	Best e-transformer compatibility, 1.2A MOS integrated	
Dimmable	GU10	<7W	Buck	>0.9	AP1695	~27 comp. ~0.70\$	Compact; integrated 2.5A 500V MOS, good dimmer compatibility
	A19/E27	7-13W	Buck/Flyback	>0.9	AP1694A	~28 comp. ~0.80\$	Compact; driving MOS, good dimmer compatibility
	PAR/Down	13-30W	Buck/Flyback	>0.9	AP1694A	~30 comp. ~0.95\$	Compact; driving MOS, good dimmer compatibility
	MR16	5-13W	Boost+Buck	>0.9	AL8811+AL8807	~50 comp. ~1.3\$	Good dimming performance for trailing edge dimmer

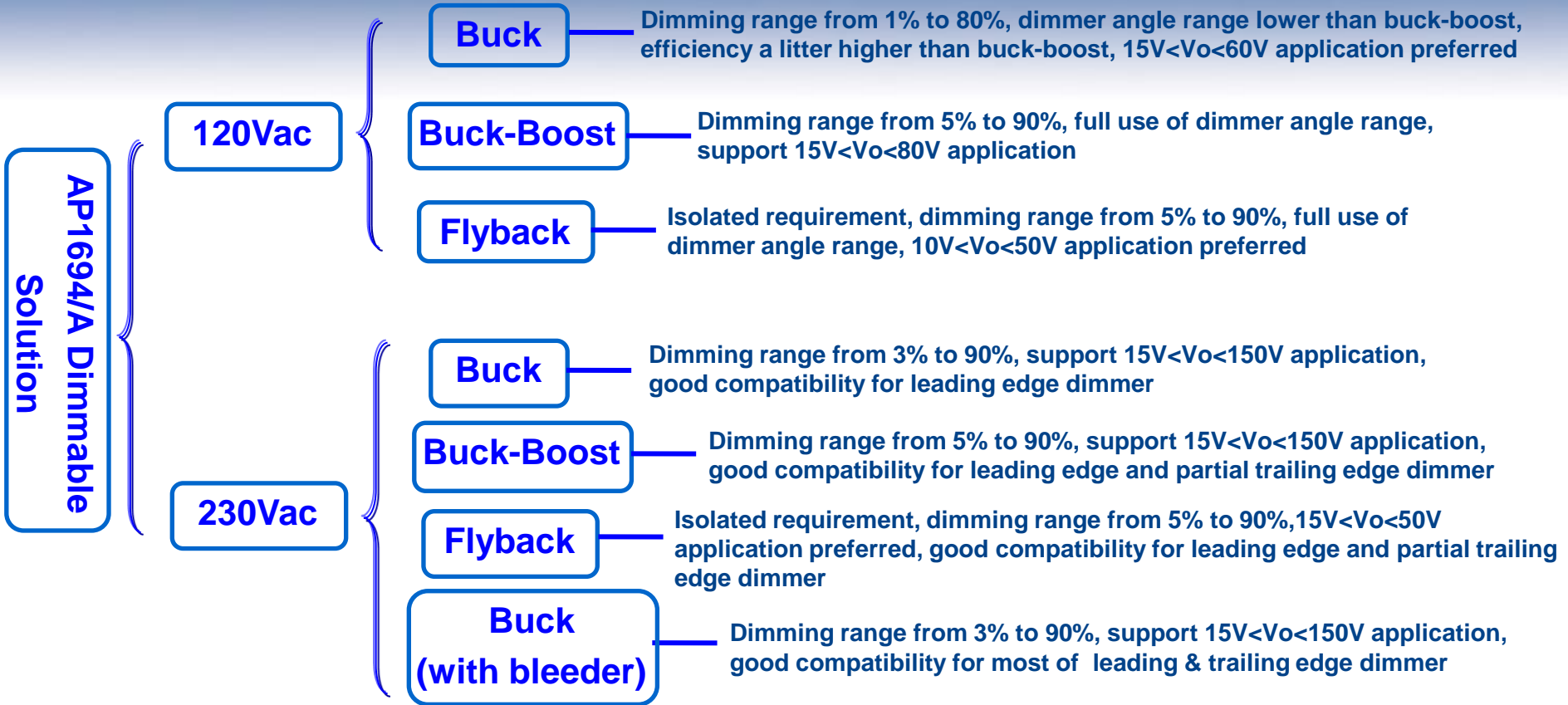
Key feature of AP1694/A

- **Dimmable PSR controller with 4% system current accuracy**
- **Support Buck, Buck-Boost and Flyback topology**
- **BCM Mode to minimize the switching loss**
- **Good line and load regulation (+/-3%)**
- **High efficiency >84%**
- **High Power Factor >0.9**
- **Natural dimming curve and deep dimming down to 1%**
- **Built-in OVP/Open /Short /OTP protection**
- **No active damping**
- **SOIC-8 package to drive external BJT/MOS**
- **Support 5-30W dimmable applications**
- **Suit for GU10,Candle, A19, A60, E27,Par20, Par30, Par38 lamps**
- **Low BOM cost**

Typical Dimmable Solution

Items	AP1694A Typical Dimmable Solution						
Input Voltage	120VAC			230VAC			
Topology	Buck	Buck-Boost	Flyback	Buck	Buck-Boost	Flyback	Buck (with Bleeder)
Application	GU10	A40	Par30	GU10	A40	Par30	GU10
Isolated	No	No	Yes	No	No	Yes	No
Output power	6W	6W	15W	6W	6W	15W	6W
Efficiency	84%	83%	85%	84%	83%	85%	81%
Dimmer compatibility	Good	Good	Good	Good (leading edge dimmer only)	Good (leading edge & partial trailing edge dimmer)	Good (leading edge & partial trailing edge dimmer)	Better (most of leading & trailing edge dimmer)
Dimming range	1%~80%	5%~90%	5%~90%	3%~90%	5%~90%	5%~90%	3%~90%
Components	27	27	43	30	30	49	36
BOM Cost	\$0.72	\$0.72	\$0.98	\$0.73	\$0.73	\$1.0	\$0.82
Demo Board	Y	Y	Y	Y	Y	Y	Y

AP1694/A Dimmable Solution Selection Guide

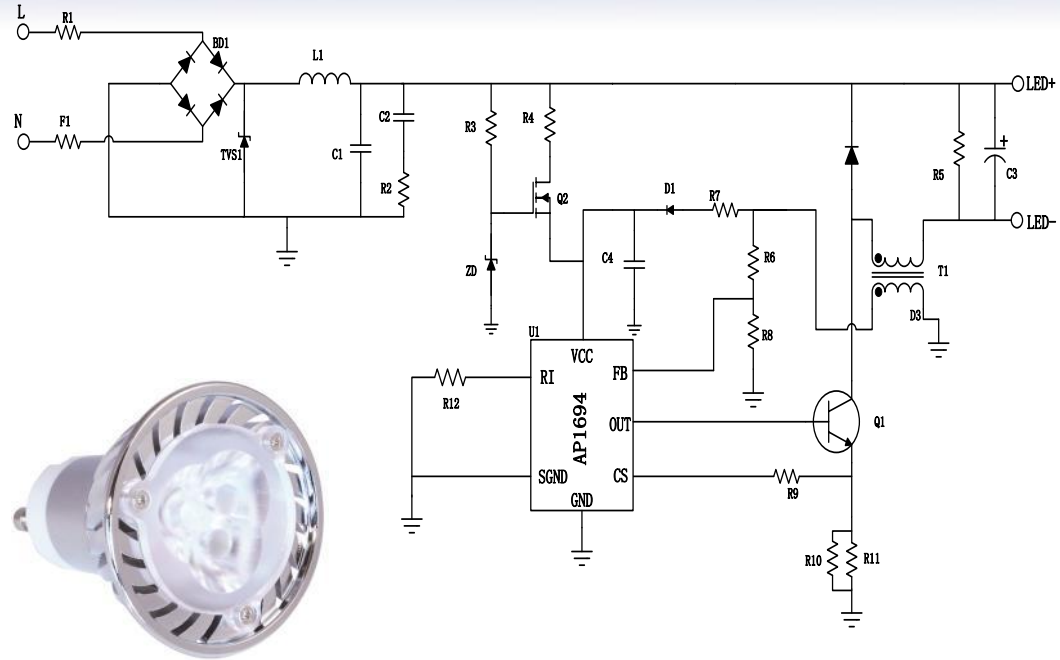


Requirements

- Design for GU10 Spotlight
- Input range 108V-132V
- 55V 120mA LED
- PASS EMI test

Diodes Advantage

- 85% efficiency @ 120V
- 27 external components
- ~0.72\$ BOM cost
- Good dimmer compatible
- LED open and short protection



BOM List

AP1694 6W 120VAC 54V 100mA BOM List

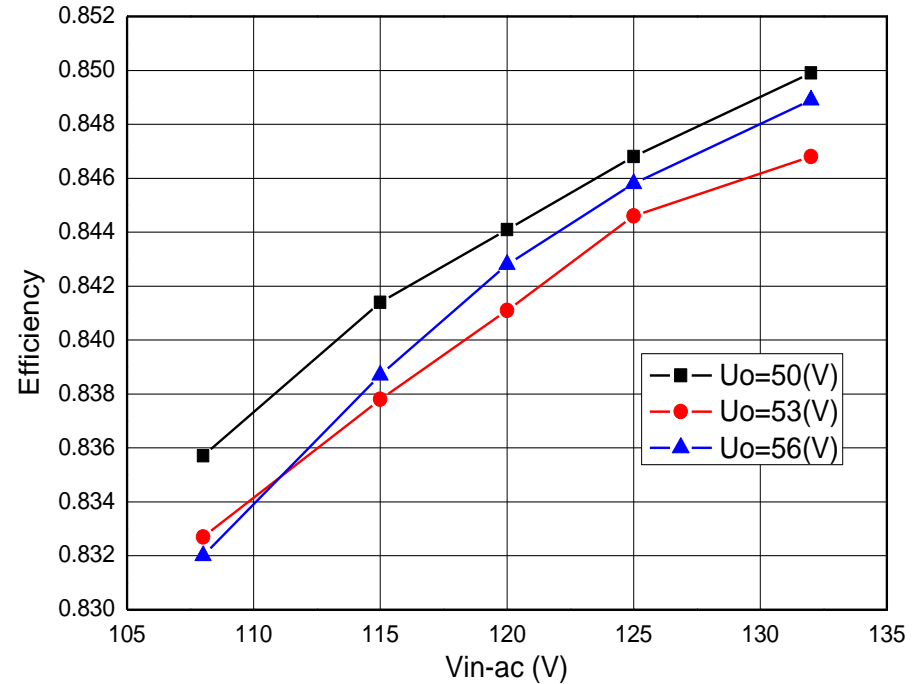
C1	330nF/250V, CBB capacitor	1
C2	220nF/250V, CBB capacitor	1
C3	4.7uF/50V, 1206, Ceramic Capacitor	1
C4	150uF/63V,105°C,10*13mm,electrolytic capacitor	1
BD1	MB6S, 1A/600V, Bridge Rectifier	1
D1	BAV20WS, 0.4A/200V, SOD-323	1
D2	ES1J, 1A/600V, SMA, Fast Recovery Diode	1
D3	24V Zener Diode, SOD-123	1
RF	100 ohm,1W,Resistor	1
R1	10K ohm,1206, 5%,Resistor	1
R2	330 ohm,0.5W Resistor	1
R3	330K ohm,1206, 5%,Resistor	1
R4	2.7K ohm,1W Resistor	1
R5	68K ohm,0603, 5%, Resistor	1

R5	68K ohm,0603, 5%, Resistor	1
R6	10 ohm,0603, 5%,Resistor	1
R7	68K ohm, 0603, 5%, Resistor	1
R8	11K ohm,0603, 5%, Resistor	1
R9	3.3K ohm,0603, 5%,Resistor	1
R10	3.9 ohm, 0603, 1%, Resistor	1
R11	3.9 ohm, 0603, 1%, Resistor	1
R12	100K ohm,0603, 5%,Resistor	1
R13	5.1M ohm,0603, 5%,Resistor	1
L1	4.7mH,Inductor, 6mm*8mm	1
T1	1.97mH,EE10 Transformer	1
Q1	Power Transistor 13003,1.5A/700V, TO-92	1
Q2	Mosfet,1N60,1A/600V,TO-92	1
U1	IC,AP1694, SOP-8	1
Total		27

Electrical Characteristics

Efficiency

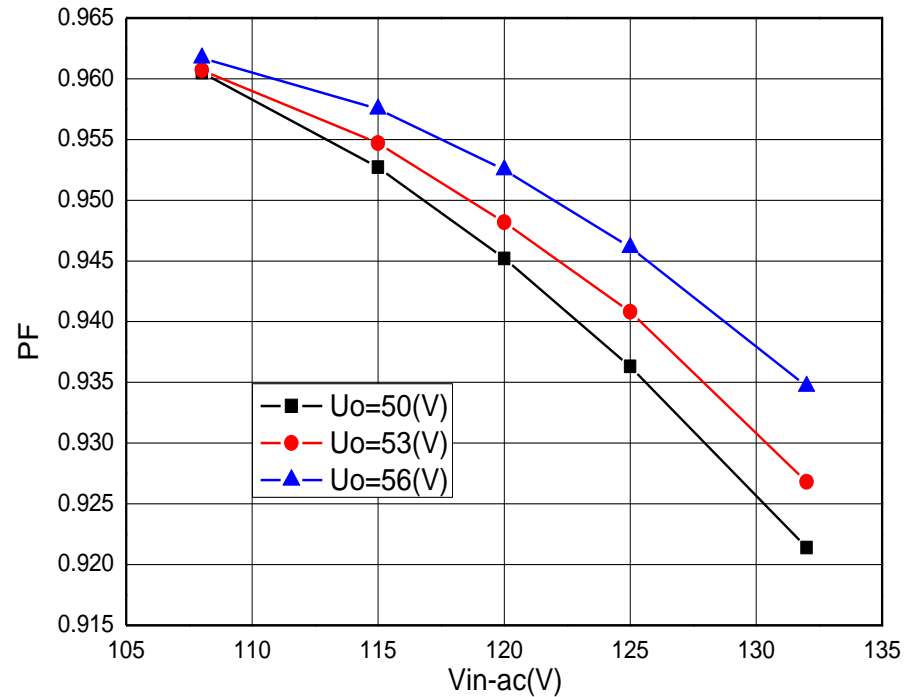
Vin(V)	Efficiency		
	Uo=50V	Uo=53V	Uo=56V
108	83.57%	83.27%	83.20%
115	84.14%	83.78%	83.87%
120	84.41%	84.11%	84.28%
125	84.68%	84.46%	84.58%
132	84.99%	84.68%	84.89%



Electrical Characteristics

PF

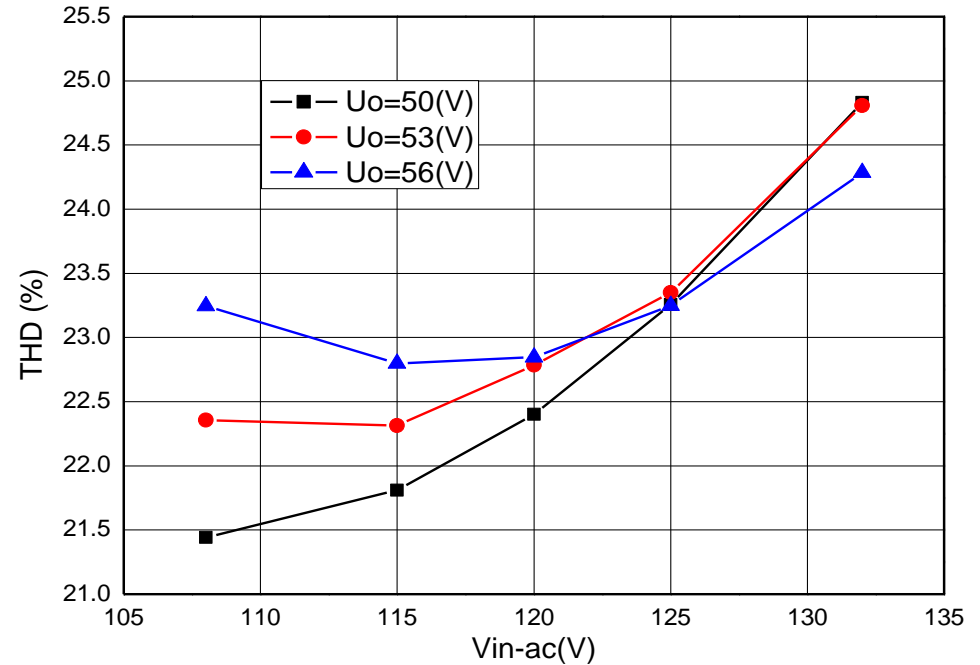
Vin(V)	PF		
	Uo=50V	Uo=53V	Uo=56V
108	0.9605	0.9607	0.9617
115	0.9527	0.9547	0.9575
120	0.9452	0.9482	0.9525
125	0.9363	0.9408	0.9461
132	0.9214	0.9268	0.9347



Electrical Characteristics

THD

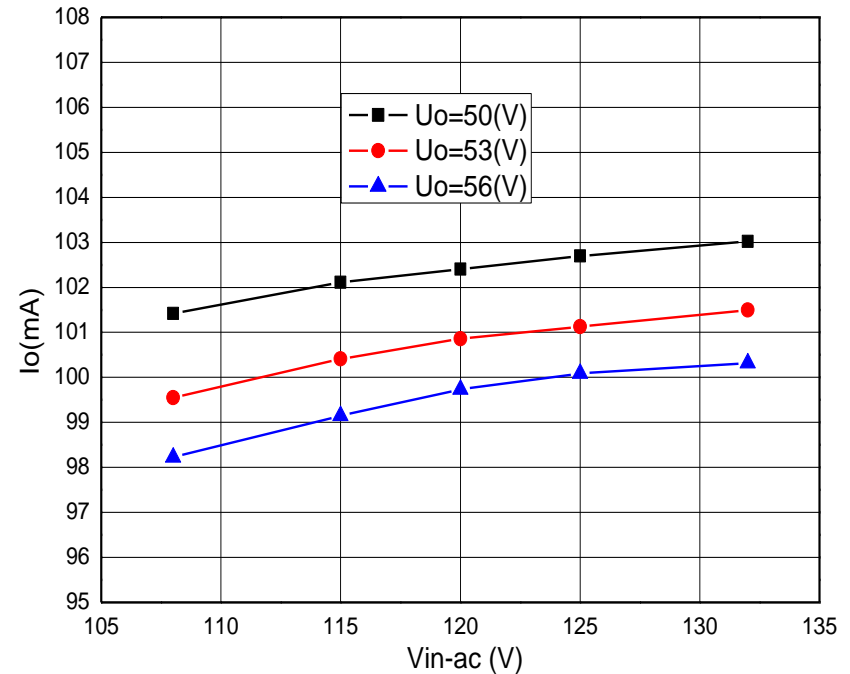
Vin(V)	THD (%)		
	Uo=50V	Uo=53V	Uo=56V
108	21.442	22.356	23.246
115	21.81	22.313	22.798
120	22.402	22.785	22.846
125	23.257	23.35	23.25
132	24.83	24.807	24.286



Electrical Characteristics

LED Current Line Regulation

Vin(V)	Io(mA)		
	Uo=50V	Uo=53V	Uo=56V
108	101.423	99.546	98.226
115	102.114	100.41	99.147
120	102.403	100.857	99.73
125	102.696	101.125	100.09
132	103.02	101.495	100.321



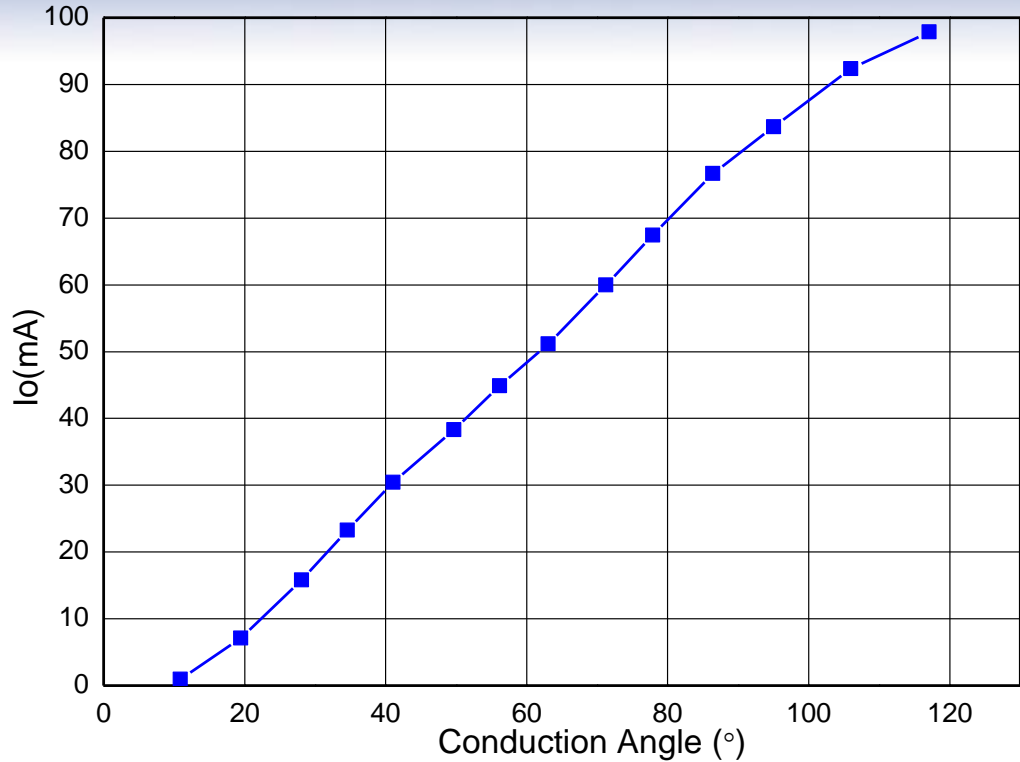
Dimmer Compatibility and Dimming Range

Dimmer Type	Io(mA)		Dimming percentage (%)		Flicker or not?
	min	max	min	max	
LUTRON CTCL-153P	3.60	275.58	1.13	86.12	No
LUTRON S-600P	0	282.86	0	88.39	No
LEVITON Cat.NO.6683	0	318.97	0	99.68	No
LUTRON LISTED6B38	0.369	287.79	0.12	89.93	No
LUTRON DIVA DVCL-153P	1.833	274.69	0.57	85.84	No
LUTRON LXLV-600PL	0	281.60	0	88.00	No
LEVITON 1F30I1	0	318.12	0	99.41	No
LUTRON DIDA DV-603P	0	282.40	0	88.25	No
LUTRON MAW-603	12.430	280.43	3.88	87.63	No
LEVITON Cat NO.VP106	7.538	289.38	2.36	90.43	No
LUTRON TG-603PG	0	230.56	0	72.05	No
LEVITON Cat NO.6674	5.761	286.01	1.80	89.38	No
LEVITON 1K12I1	2.716	318.42	0.85	99.51	No
LUTRON MAW-600	12.241	291.65	3.83	91.14	NO

Deep dimming down to <1% for most of the dimmers

Dimming Curve

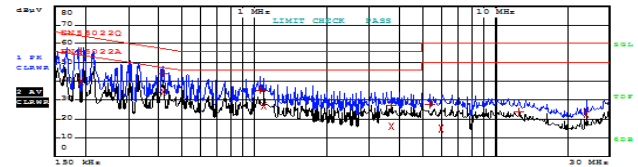
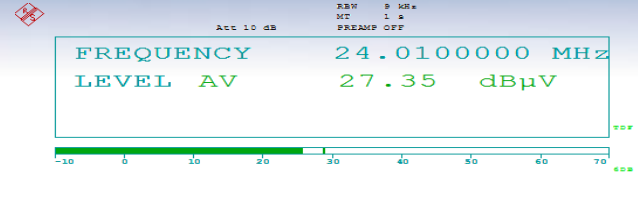
Conduction Angle(°)	I _o (mA)
117.11088	97.86
105.9804	92.352
95.04	83.68
86.4	76.69
77.868	67.43
71.2584	59.98
63.0288	51.168
56.16	44.87
49.68	38.315
41.04	30.45
34.56	23.242
28.08	15.806
19.44	7.12
10.908	0.93



EMI Conduction Test

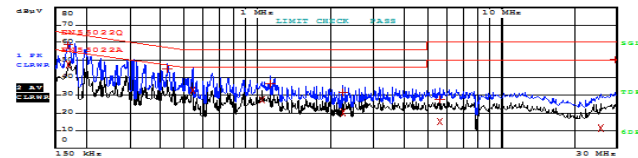
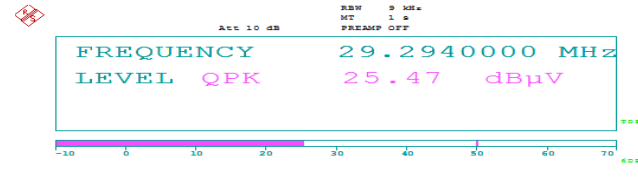
Line Terminal

EDIT PEAK LIST (Final Measurement Results)			
Trace1:	EN55022Q		
Trace2:	EN55022A		
Trace3:	---		
TRACE	FREQUENCY	LEVEL dB μ V	DELTA LIMIT dB
1 Quasi Peak	194 KHz	56.10	-7.75
2 Average	194 KHz	40.11	-13.74
1 Quasi Peak	414 KHz	44.37	-13.19
2 Average	414 KHz	34.44	-13.12
1 Quasi Peak	1.062 MHz	35.23	-20.76
2 Average	1.094 MHz	26.92	-19.07
1 Quasi Peak	3.698 MHz	27.13	-28.86
2 Average	3.698 MHz	16.25	-29.74
1 Quasi Peak	5.398 MHz	27.61	-32.38
2 Average	5.998 MHz	14.54	-35.45
1 Quasi Peak	12.514 MHz	23.78	-36.21
2 Average	24.01 MHz	22.91	-27.08



Neutral Terminal

EDIT PEAK LIST (Final Measurement Results)			
Trace1:	EN55022Q		
Trace2:	EN55022A		
Trace3:	---		
TRACE	FREQUENCY	LEVEL dB μ V	DELTA LIMIT dB
1 Quasi Peak	170 KHz	58.53	-6.43
2 Average	170 KHz	47.66	-7.29
1 Quasi Peak	426 KHz	45.09	-12.23
2 Average	542 KHz	32.88	-13.11
2 Average	1.05 MHz	27.55	-18.44
1 Quasi Peak	1.13 MHz	36.52	-19.47
1 Quasi Peak	2.25 MHz	31.65	-24.34
2 Average	2.25 MHz	20.39	-25.60
1 Quasi Peak	5.642 MHz	27.86	-32.13
2 Average	5.642 MHz	15.32	-34.69
2 Average	23.858 MHz	11.28	-38.71
1 Quasi Peak	29.294 MHz	50.07	-9.92

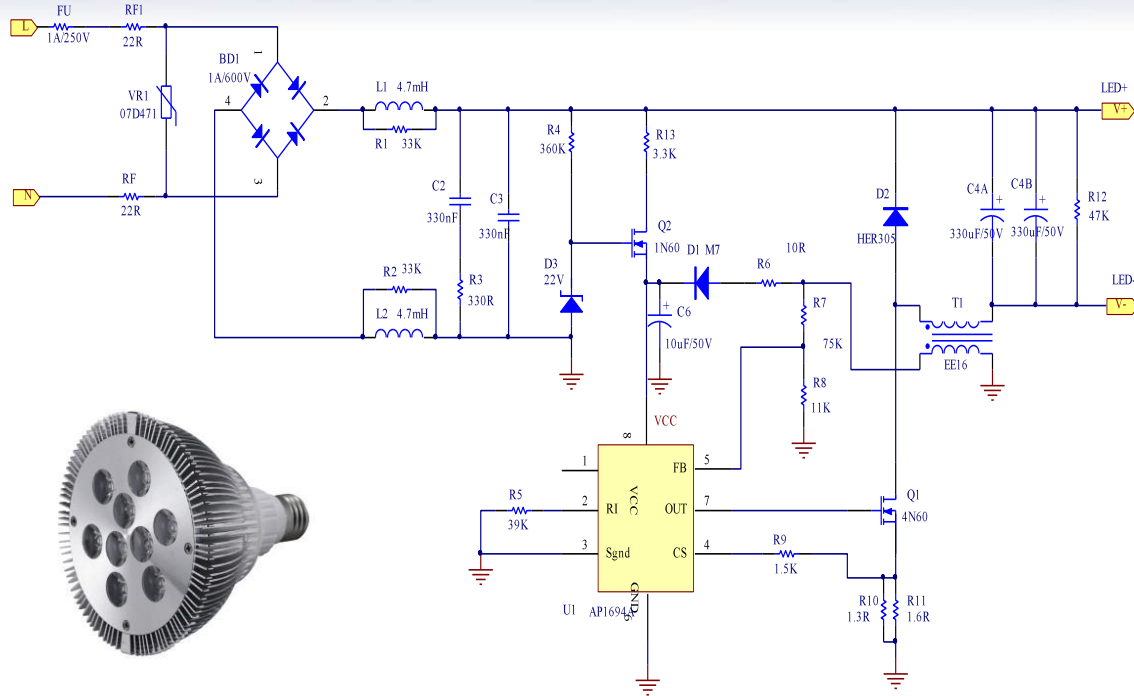


Requirements

- Design for PAR lamp
- High voltage input range 108V-132V
- 38V 320mA LED
- PASS EMI test

Diodes Advantage

- 86% efficiency @120V
- Good dimmer compatible
- +/-3% Line regulation
- LED open and short protection
- Pass EN55022 Class B with 6dB margin
- BOM cost 0.80\$

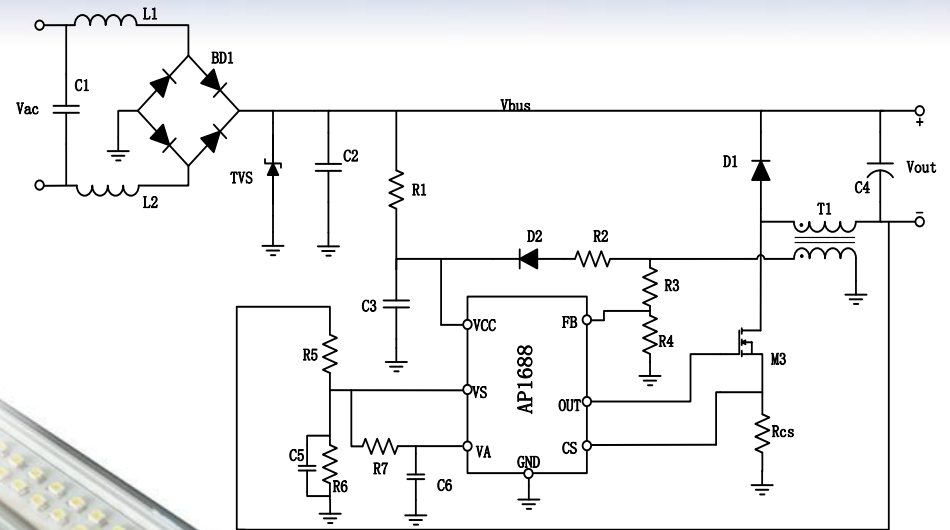


Requirements

- Universal Input Voltage
- 30% current ripple
- 500ms soft start time
- 80*15*18 L*W*H
- PASS EMI and surge test

Diodes Advantage

- THD~20, PF>0.9
- 93% efficiency
- +/- 5% MP current accuracy
- EMI Pass EN55022 Class B with >6dB margin
- Surge Pass IEC61000-4-5 Class 3
- ESD Pass IEC6100-4-2 Class 4
- BOM cost: 0.85\$

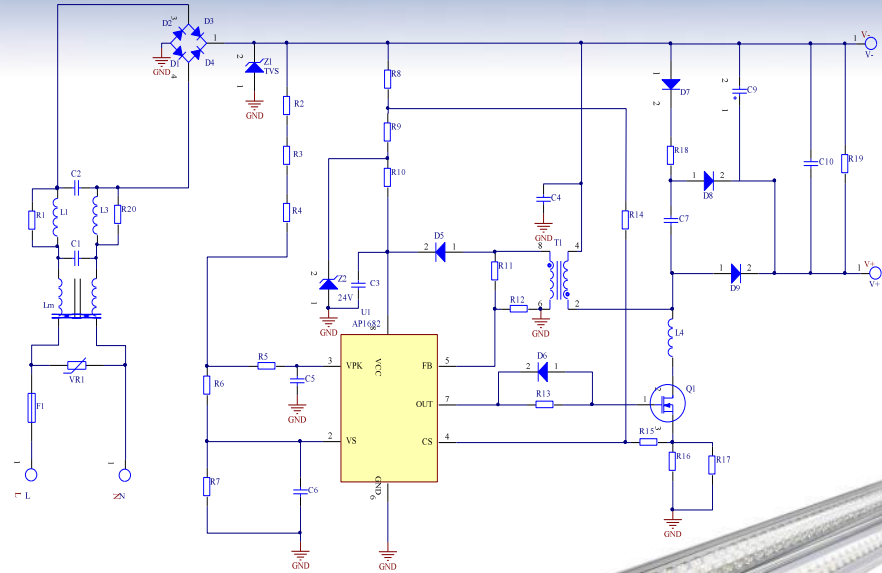


Requirements

- Universal Input Voltage
- 30% current ripple
- 500ms soft start time
- PASS EMI and surge test
- 80*15*18 L*W*H

Diodes Advantage

- THD~10, PF>0.9
- 91% efficiency
- +/- 5% MP current accuracy
- EMI Pass EN55022 Class B with 6dB margin
- Surge Pass IEC61000-4-5 Class 3
- ESD Pass IEC6100-4-2 Class 4
- MP experience

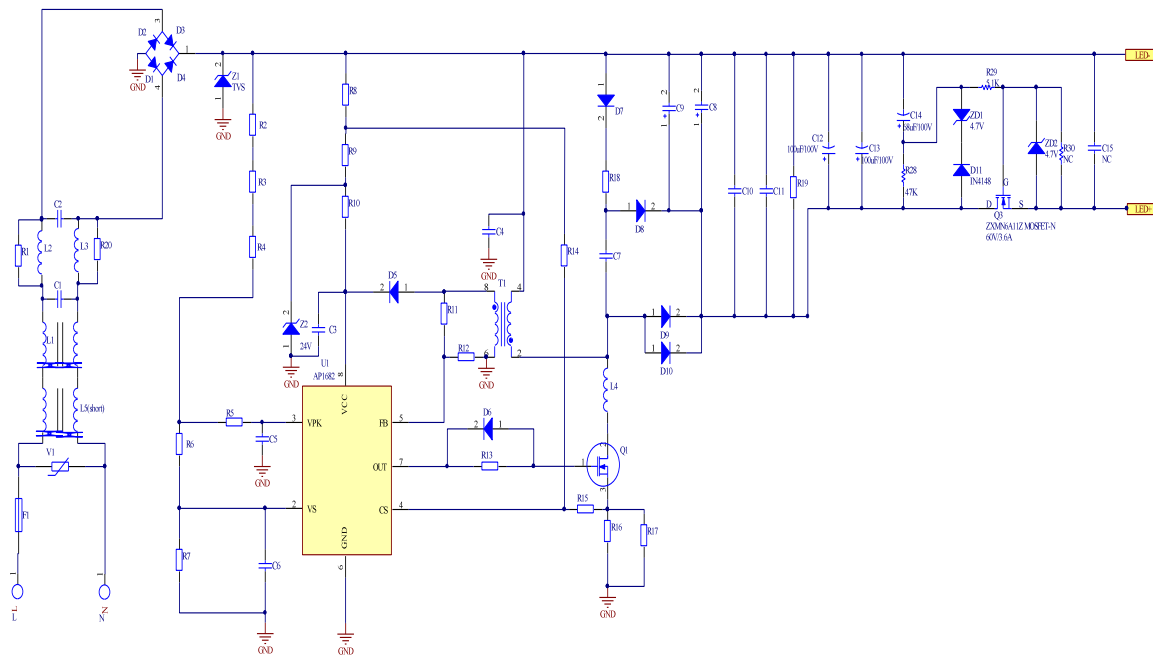


Requirements

- PF > 0.9
- Low Current Ripple < 5%
- Current Accuracy < 2%
- High Power > 20W

Diodes Advantage

- Ultra-low start up current with internal start up timer
- Zero current detection control for DCM boundary conduction mode
- Suit for 5W-30W LED driver

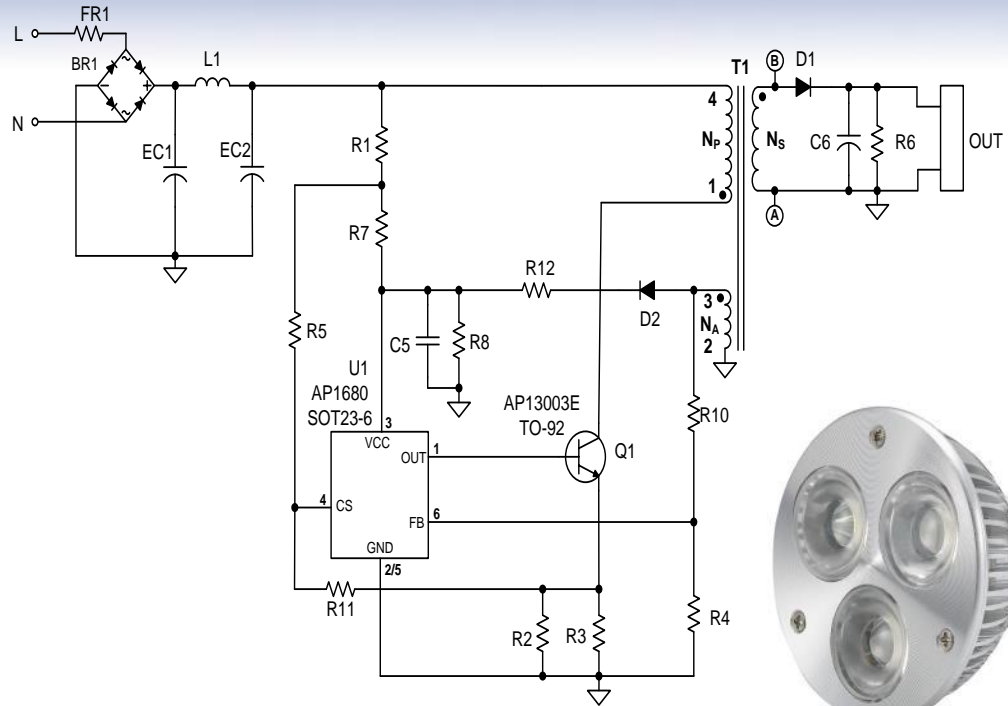


Requirements

- Design for GU10 Spotlight
- Full voltage input range 90V-264V
- 13V 320mA LED (3*1W or 4*1W)
- PASS EMI and Surge test

Diodes Advantage

- +/-1.9% Linear regulation
- 0.5s start time
- 77.5% efficiency @ 220V
- LED open and short protection
- Pass EN55022 Class B with 6dB margin
- IEC61000-4-5 Class 3
- BOM cost 0.5\$
- Reference Design No:1680IU4A1

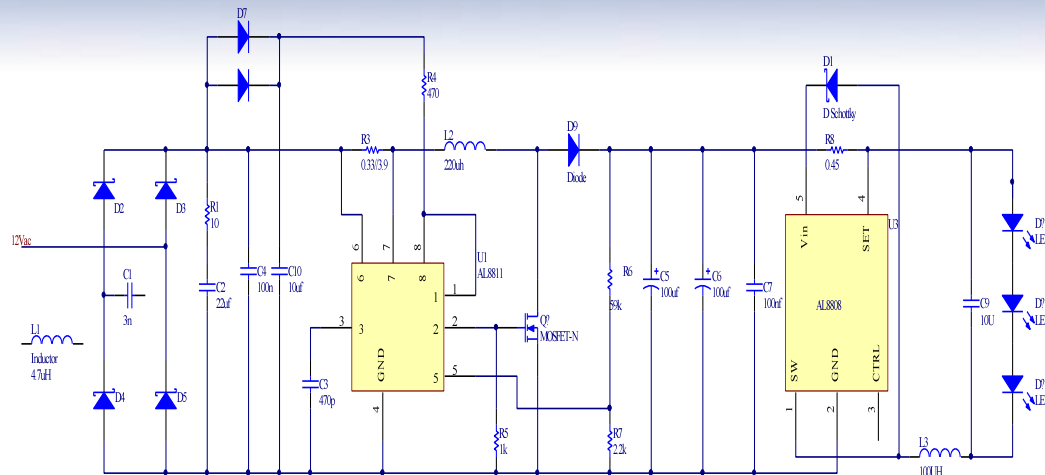


Requirements

- High-reliability, long life solution
- Small footprint solution
- Ability to drive up to 10W LED power
 - Three 3W LED
 - One Multi-Die 10W LED

Diodes Advantage

- MSOP8-EP footprint
- >90% efficiency driving 3W LEDs
→ reduced temperature rise
- $R_{DS(ON)} \sim 0.25 \rightarrow$ increased efficiency
- Low thermal resistance package, cost-effective, simple, reliable solution for MR16



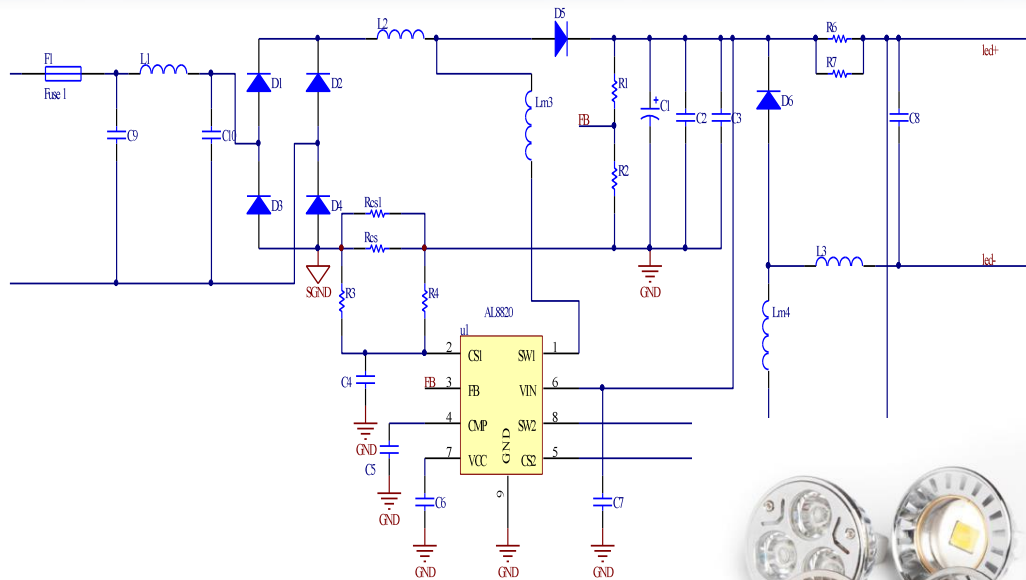
Part	Min Vin	Max Vin	Iout	Effi	OTP	Temp Range	Package
	V	V				°C	
AL8808	6	30	1	96	Y	-40~+125	TSOT25
AL8807A	6	36	1.3	96	Y	-40~+125	MSOP-8EP
AL8807	6	36	1.3	96	N	-40~+125	MSOP-8EP

Requirements

- Input voltage: Typ AC12V, DC12V
- Good ET compatibility
- High-reliability, long life time
- Small footprint
- Ability to drive up to 10W LED power

Diodes Advantage

- Boost + Buck topology for best Electronic Transformer compatibility
- Output Current accuracy: $\pm 3\%$
- Power Factor: >0.9
- Integrated NMOS
- Protection: OTP, UVLO, Soft Start, OVP, Open, Short
- Working temperature: $T_a: -40 \sim 125^\circ \text{C}$



Diodes' LED Driver design tools links

Application / Technical support:

<http://www.diodes.com/destools/>

