

SPECIFICATION

1. DESCRIPTION

The DK812 is a single stage AC-DC transformer controlling IC. It integrates 700V high voltage power transistor and primary peak current detecting circuit. It also includes Active Power Factor Correction, Primary Side Current Regulation, Output Voltage Control, Self-Power supply and LED loading circuit auto detection functions, can avoid LED loading damage. Its integrated Active Power Factor Correction circuit can reach high power factor and low harmonic distortion. And because of its highly integrated MOS circuit design, lots of external components are saved, transformer design is simple, only two windings is needed for the transformer in isolated circuit and only one winding is needed in non-isolated circuit.

2. APPLICATIONS

6-32W LED Lighting

3. MAIN FEATURES

- $\pm 3\%$ LED Current Accuracy.
- Build-in 700V power transistor.
- 85V—265V wide range AC power input.
- Quasi-resonant mode, high circuit efficiency, $\eta > 90\%$.
- Patent self-power supply circuit design, no need for external winding power supply.
- Patent Primary Side Regulation control, no need for additional winding power supply.
- Single-Stage Active PFC(Power Factor Correction) for High Power Factor(PF>0.95) and Low THD.
- Suitable for several different circuit designs of constant current and limited voltage.
- Over current, Over loading, Over temperature, Over voltage, LED short circuit and LED open circuit Protection.
- Automatic detection of constant current loading when power is on, to prevent electrical LED lamp burning.

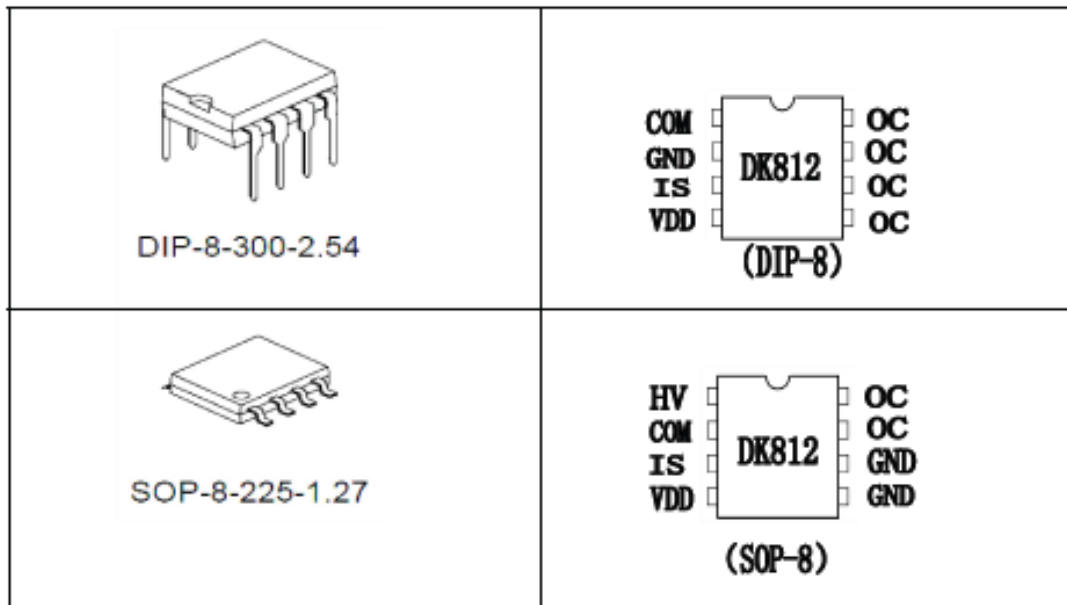
4. POWER RANGE

Input Voltage	85-160V AC	85-265V AC	160-265V AC	Working Situation Remark
MAX. output power	6W	6W	9W	Isolated flyback circuit with high PF
	9W	9W	12W	Isolated flyback circuit with low PF

	9W	9W	12W	Nonisolated Boost-Buck circuit with high PF
	-----	-----	32W	Nonisolated Buck circuit with low PF**

** Nonisolated Buck circuit with low PF design requires special current control on IC, so remark is needed when ordering, “A board” would be marked on the master packing.

5. CONNECTION DIAGRAM



PIN FUNCTION

Pin NO.		Pin Name	Function
DIP-8	SOP-8		
-----	1	HV	High voltage startup pin. This pin connects a 2.2M resistor to OC pin.
1	2	COMP	Loop Compensation Node. This pin connects a 0.1uF-1uF capacitor to GND in high PF circuit. Or connects a 1nF-10nF capacitor to GND in low PF circuit. Or connects to VDD node in nonisolated low PF BUCK circuit.
2	5,6	GND	Ground reference
3	3	IS	Current correction pin. It connects a resistor to GND to sense and control the output current. Rs resistor is requested to be less than 2 Ω
4	4	VDD	Power supply pin. This pin connects a capacitor to GND. Use 47uF-100uFcap for high PF circuit or 10uF-47uF for low PF circuit.
5,6,7,8	7,8	OC	Output pin. Connected with internal high voltage Collector point and switch mode transformer.

6. ABSOLUTE MAXIMUM RATINGS



SHENZHEN DONGKE SEMICONDUCTOR CO., LTD

PSR Single-Stage APFC LED Driver IC-DK812

Symbol	Parameter	Value	Unit
Vcc	Supply voltage	-0.3--8	V
Ivcc	Current of supply voltage	100	mA
Vpin	Pin voltage	-0.3--Vcc+0.3	V
Vcol	Collector to GND voltage	-0.3--730	V
Ip	Peak current	500	mA
Pd	Dissipation power	1000	mW
Tc	Case operating temperature	-25--125	°C
Tstg	Storage temperature	-55--150	°C
Tsol	Soldering temperature	+280	°C/5S

7. ELECTRICAL CHARACTERISTIC

Parameter	Condition	Value			Unit
		Min.	Typ.	Max.	
Vcc (Work Power Supply)	AC input: 85V-265V	4	5	6	V
Start threshold Voltage	AC input: 85V-265V	4.8	5	5.2	V
Stop threshold Voltage	AC input: 85V-265V	3.6	4	4.2	V
Current of Vcc	Vcc=5V, COM=2.2V	10	20	30	mA
Start time	AC input: 85V	--	--	500	mS
Collector Protection Voltage	L=4.8mH	460	480	500	V
BJT Breakdown voltage	Ioc=1mA	700	--	--	V
Switch tube Current	Vcc=5V	560	600	640	mA
Peak Current Protection	Vcc=5V	640	700	760	mA
Temperature protection	Vcc=5V	120	125	130	°C

8. OPERATION PRINCIPLE

8.1 Start Up

Build-in high voltage starting up power: after power on, outside VDD capacitor will be charged, when VDD's voltage reaches 5V, IC begin to test the input voltage of bus line. If bus line's input voltage is lower than 80V, IC would not start up. Until the bus line's input voltage is higher than 80V, starting up will finish, pulse comes out. At the same time, it would test whether the output circuit is loaded or not. If not, output would be stop for 500mS whenever the output voltage reaches the set maximum volume. Until it is loaded, then it comes to normal working mode.

8.2 Constant Current output control

With patented output current control mode, no need for feedback circuit.

It is easy to set up the LED output current according to below formula:

$$\text{*Isolated High PF circuit: } I_o = \frac{200mV}{R_s} * \frac{N_p}{N_s} * \eta \text{ (mA)}, \text{ (} \eta \text{ is the efficiency of the}$$

circuit, it is set to be 0.80 in isolated design)

*Non-Isolated High PF circuit: (BOOST-BUCK): $I_o = \frac{200mV}{R_s} * \eta$ (mA), (η is the efficiency of the circuit, it is set to be 0.85 in non-isolated design)

*Non-Isolated BUCK circuit: $I_o = \frac{200mV}{R_s} * \eta$ (mA), (η is the efficiency of the circuit, it is set to be 0.90 in Non-isolated BUCK circuit)

According to above formula, the needed output current can be set by changing the winding number ratio of primary and secondary side and the current detecting resistor R_s .

8.3 Power Factor Correction (used in high PFC designs)

With build-in Power Factor Regulation section, in a whole cycle of the bus line input, power transistor's working time T_{on} keep the same. Because $V_{in} = L_p * I_p / T_{on}$, Peaking current I_p is proportional to bus line's input voltage V_{in} , so that it can reach high Power Factor. No need to connect high volume capacitor with bus line input and ground, just a 33nf-100nf CBB capacitor can help to reach high PF.

8.4 Working Frequency

The IC's pulse output frequency varies in the bus line input cycle, average working frequency is proportional to bus line's peak input voltage and inversely proportional to primary winding's inductance. According to different application, average working frequency can be adjusted by changing primary winding's inductance, and the Max. frequency of the IC is 100KHz. The inductance's change has very low affection to the output current.

8.5 Self-Power Supply Circuit (National patent owned)

There is self-power supply circuit inside the IC, which can hold the VDD at about 5V for the electricity consumption of the IC itself. So that can save external winding power supply.

8.6 Peak Current Protection

When ever the build-in power transistor's peak current is more then $I_p = \frac{1.2V}{R_s}$, it will be cut off so as to protect itself and the other components. Because the peak current of DK 812 is 600mA, so the R_s is suggested to be not less then 2Ω . It can be little bit less in low PF circuits, but not less then 1.5Ω . When working in non-isolated BUCK circuit, the IC's COM pin is contact connected with the fourth pin, working mode of the circuit is changed, peak current's calculation should be $I_p = \frac{0.4V}{R_s}$, and R_s is suggested to be not less then 0.66Ω

8.7 Abnormal Voltage Protection

Whenever the power voltage (Vcc) abnormally exceeds 6V and drops under 4V, the controller would stop operation and restart again.

8.8 Non-loading Protection

When it is not loaded, the circuit would begin loading testing. If output circuit is not connected with

LED or empty loaded, it would enter intermittent working mode until loading is detected. As to protect the capacitor and LED damage from over output voltage, can set the maximum voltage for the circuit, so that the output voltage will not exceed it when it is not loaded, here below is the formula for calculating this

V_{ovp} :

*Non-isolated circuit: $V_{ovp} = \frac{100 * L_p}{R_s}$, L_p is the inductance's volume, we can get suitable

L_p according to this formula.

*Isolated circuit: $V_{ovp} = \frac{100 * L_p}{R_s * N}$, L_p is the primary inductance's volume of transformer,

N is the winding ratio of the transformer.

For example, in 12W (100V /120mA) Non-isolated circuit application, $R_s=2\Omega$ (take 80% as working efficiency), $L_p=2.4\text{mH}$, $V_{ovp} = \frac{100 * L_p}{R_s} = 100 * 2.4\text{mH} / 2\Omega = 120\text{V}$

Another example, in 6W (20V /300mA) isolated circuit application, $R_s=2\Omega$ (take 80% as working efficiency), $L_p=2.4\text{mH}$, $N=4$, $V_{ovp} = \frac{100 * L_p}{R_s * N} = 100 * 2.4\text{mH} / (2\Omega * 4) = 30\text{V}$

Accordingly to actual situation, can adjust the V_{ovp} by changing L_p .

Remark: V_{ovp} is set voltage, normally 1.2-1.5 times of working voltage, now it is suggested to be 1.5 times in high PF circuit and 1.2 times in low PF circuit design.

8.9 Short Circuit Protection

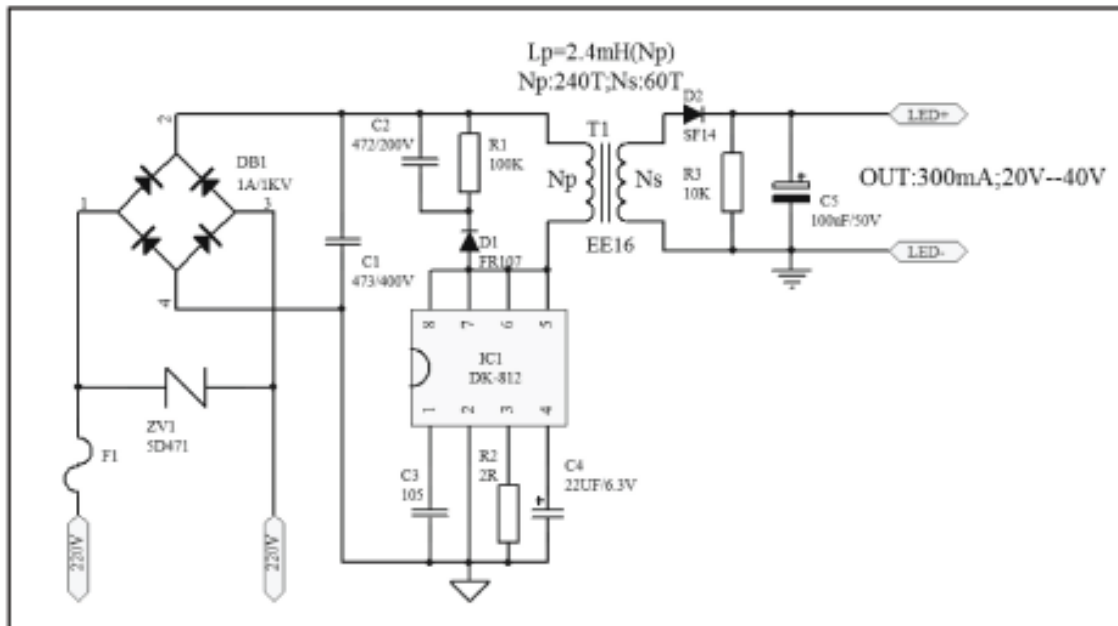
Whenever short circuit is detected, it stops the switching operation immediately and enters into the stop status. The controller will restart to switching operation and pulse output when the temperature falls down.

8.10 Over Temperature Protection (OTP)

When the controller detects the device temperature exceeds 125°C, OTP is activated. It stops the switching operation immediately and enters into the stop status. The controller will restart to switching operation and pulse output when the temperature falls to 120°C.

9. TYPICAL APPLICATION SAMPLE 1

6W—20V/0.3A ISOLATED HIGH PF LED DRIVER CIRCUIT DESIGN



9.1 Components list

NO.	NAME	SPEC. / MODEL NO.	POSITION	USED QTY	REMARK
1	Fuse	F1A/AC250V	F1	1	
2	Varistor	5D471	ZV1	1	
3	Rectifier	DB06S	DB1	1	
4	Diode	FR107	D1	1	
5	Diode	SF14	D2	1	
6	Electrolytic capacitor	22uF/6.3V	C4	1	
7	Electrolytic capacitor	1000uF/50V	C5	1	
8	CBB capacitor	47nF/400V	C1	1	
9	Dacron capacitor	472/200V	C2	1	
10	Ceramic capacitor	105	C3	1	
11	Resistance	100K/0.25W	R1	1	
12	Resistance	4R/0.25W	R2	1	1% accuracy
13	Resistance	10K/0.25W	R3	1	
14	IC	DK812	U1	1	
15	Transformer	EE16	T1	1	

9.2 TRANSFORMER DESIGN (ISOLATED HIGH PF LED DRIVER CIRCUIT)

9.2.1 Parameter confirmation: confirm the below parameter before transformer design

- (1) Input voltage range (for example :AC85V-265V)
- (2) Output Voltage and current (for example DC20V 0.3A)

9.2.2 Core selecting

- (1) Input power calculation

$P = P_{out} / \eta$ (η is the efficiency of the power supply, take it 0.8 for example),
 $P_{out} = V_{out} * I_{out} = 20V * 0.3A = 6W$, so $P_{in} = 6 / 0.8 = 7.5W$. Because the peak power of Active Power Factor circuit is twice of the average power, we can know that $P_{MAX} = P_{in} * 2 = 15W$

- (2) Choose the core:

Checking via supplier or the correlative chart can know that EE19 core is suitable for 7.5W power supply. So we choose EE19 for below calculation.

9.2.3 Turn ratio of transformer

Flyback voltage of transformer (V_{or}) is normally set to be 60V—120V, and 80V is recommended for the high PF situation.

$$N = \frac{V_{or}}{V_{out}} = \frac{80V}{20V} = 4$$

9.2.4 Current-limiting resistance calculation

$$I_o = \frac{200mV}{R_s} * \frac{N_p}{N_s} * \eta \quad \left(\frac{N_p}{N_s} = N \right), \text{ so } R_s = \frac{200mV}{I_o} * N * \eta$$

$$R_s = \frac{200mV}{300mA} * 4 * 0.8 = 2.1\Omega, \text{ as to make the calculation easier, we take } R_s = 2\Omega$$

9.2.5 Non loading limited voltage (V_{ovp}) confirmation and input inductance value (L_p) calculation

Normally V_{ovp} is 1.2-1.5 times of output voltage, and it is set to be 1.5 times in high PF circuit. So $V_{ovp} = V * 1.5 = 20 * 1.5 = 30V$.

$$L_p = \frac{V_{ovp} * R_s * N}{100} = \frac{30V * 2 * 4}{100} = 2.4mH$$

$$V_{ovp} = \frac{100 * L_p}{R_s * N}, \text{ so}$$

9.2.6 Number of the original(input) turns (N_p)

Because the saturation magnetization of Ferrite material is about 0.4T, the designed Magnetic flux density in transformer should be no more than 0.4T. However, Single-ended Flyback circuits works in the first quadrant of B-H, and residual magnetism of the core is about 0.1T, so the maximum working magnetic flux density should be $0.4 - 0.1 = 0.3T$. According to formula $B_{max} = (I_p * L_p) / (N_p * A_e) = 0.3T$, here below takes 0.25T for calculation, A_e in EE19 transformer is $20mm^2$,

$$I_p = \frac{1.2V}{R_s} = 1200 / 2 = 600, \text{ so we can get that } N_p = I_p * L_p / B_{max} * A_e = 600 * 2.4 / (0.25 * 20) \approx$$

260

9.2.7 Number of the output turns (N_s)

$$N_s = N_p / N = 260 / 4 \approx 65$$

9.2.8 Leakage inductance of a transformer

It is suggested to use P/S/P way to wind the transformer so that to reduce the leakage inductance.

10. TYPICAL APPLICATION SAMPLE 2

12W—40V/0.3A ISOLATED LOW PF LED DRIVER CIRCUIT DESIGN

Checking via supplier or the correlative chart can know that EE19 core is suitable for 15W power supply. So we choose EE19 for below calculation.

10.2.3 Turn ratio of transformer

Flyback voltage of transformer (V_{or}) is normally set to be 60V—120V, and 120V is recommended for the low PF situation.

$$N = \frac{V_{or}}{V_{out}} = \frac{120V}{40V} = 3$$

10.2.4 Current-limiting resistance calculation

$$I_o = \frac{200mV}{R_s} * \frac{N_p}{N_s} * \eta \quad \left(\frac{N_p}{N_s} = N \right), \text{ so } R_s = \frac{200mV}{I_o} * N * \eta$$

$$R_s = \frac{200mV}{300mA} * 3 * 0.8 = 1.6\Omega$$

10.2.5 Non loading limited voltage (V_{ovp}) confirmation and input inductance value (L_p) calculation

Normally V_{ovp} is 1.2-1.5 times of output voltage, and it is set to be 1.2 times in low PF circuit. So $V_{ovp} = V * 1.5 = 40 * 1.2 = 48V$.

$$V_{ovp} = \frac{100 * L_p}{R_s * N}, \text{ so } L_p = \frac{V_{ovp} * R_s * N}{100} = \frac{48V * 1.6 * 3}{100} = 2.3mH \approx 2.4mH$$

10.2.6 Number of the original(input) turns (N_p)

Because the saturation magnetization of Ferrite material is about 0.4T, the designed Magnetic flux density in transformer should be no more than 0.4T. However, Single-ended Flyback circuits works in the first quadrant of B-H, and residual magnetism of the core is about 0.1T, so the maximum working magnetic flux density should be $0.4 - 0.1 = 0.3T$. According to formula $B_{max} =$

$$(I_p * L_p) / (N_p * A_e) = 0.3T, \text{ and } A_e \text{ in EE19 transformer is } 20mm^2, \quad I_p = \frac{1.2V}{R_s} = 1200/2 = 600, \text{ so}$$

we can get $N_p = I_p * L_p / B_{max} * A_e = 600 * 2.4 / (0.3 * 20) \approx 260$

10.2.7 Number of the output turns (N_s)

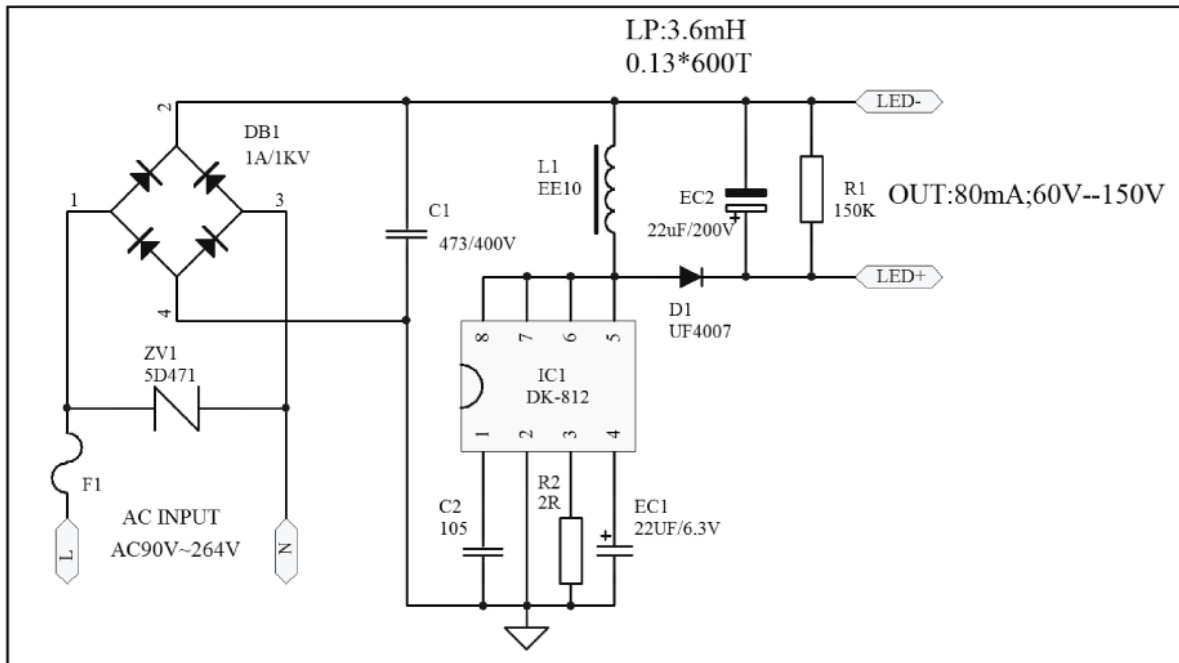
$$N_s = N_p / N = 260 / 3 \approx 87$$

10.2.8 Leakage inductance of a transformer

It is suggested to use P/S/P way to wind the transformer so that to reduce the leakage inductance.

11. TYPICAL APPLICATION SAMPLE 3

12W—150V/80mA NON ISOLATED HIGH PF LED DRIVER CIRCUIT DESIGN



11.1 Components list

NO.	NAME	SPEC. / MODEL NO.	POSITION	USED QTY	REMARK
1	Fuse	F2A/AC250V	F1	1	
2	Varistor	5D471	ZV1	1	
3	Rectifier	DB06S	DB1	1	
4	Diode	UF4007	D1	1	
5	CBB capacitor	47nF/400V	C1	1	
6	Electrolytic capacitor	22uF/6.3V	EC1	1	
7	Electrolytic capacitor	22uF/200V	EC2	1	
8	Ceramic capacitor	105	C2	1	
9	Resistance	150K/0.25W	R1	1	
10	Resistance	2R/0.25W	R2	1	1% accuracy
11	IC	DK812	IC1	1	
12	Lp Inductance	EE10	L1	1	

11.2 TRANSFORMER DESIGN (NON ISOLATED HIGH PF LED DRIVER CIRCUIT)

11.2.1 Parameter confirmation: confirm the below parameter before transformer design

- (5) Input voltage range (for example :AC100V-265V)
- (6) Output Voltage and current (for example DC150V 0.08A)

**There is no transformer in non isolated circuit, so the maximum current is 80mA.

11.2.2 Core selecting

- (3) Input power calculation

$P = P_{out} / \eta$ (η is the efficiency of the power supply, take it 0.85 for example),
 $P_{out} = V_{out} * I_{out} = 150V * 0.08A = 12W$, so $P_{in} = 12 / 0.85 = 14W$. Because the peak power of Active Power Factor circuit is twice of the average power, we can know that $P_{MAX} = P_{in} * 2 = 28W$

- (2) Choose the core:

According to the structure of LP inductance, we choose EE10 for the core.

11.2.3 Current-limiting resistance calculation

$$I_o = \frac{200mV}{R_s} * \eta, \text{ so } R_s = \frac{200mV}{I_o} * \eta$$

$$R_s = \frac{200mV}{80mA} * 0.85 \approx 2.1\Omega, \text{ as to make the calculation easier, we take } R_s = 2\Omega$$

11.2.4 Non loading limited voltage (V_{ovp}) confirmation and input inductance value (L_p) calculation

Output Voltage is 150V, we take V_{ovp} to be 180V.

$$V_{ovp} = \frac{100 * L_p}{R_s * N}, \text{ so } L_p = \frac{V_{ovp} * R_s}{100} = \frac{180V * 2}{100} = 3.6mH$$

11.2.5 Number of the original(input) turns (N_p)

Because the saturation magnetization of Ferrite material is about 0.4T, the designed Magnetic flux density in transformer should be no more than 0.4T. However, Single-ended Flyback circuits works in the first quadrant of B-H, and residual magnetism of the core is about 0.1T, so the maximum working magnetic flux density should be $0.4-0.1=0.3T$. According to formula $B_{max} = (I_p * L_p) / (N_p * A_e) = 0.3T$, and A_e in EE13 transformer is $17mm^2$, so we can get that

$$N_p = \frac{I_p * L_p}{B_{max} * A_e} = \frac{600 * 3.6}{0.3 * 17} \approx 420$$

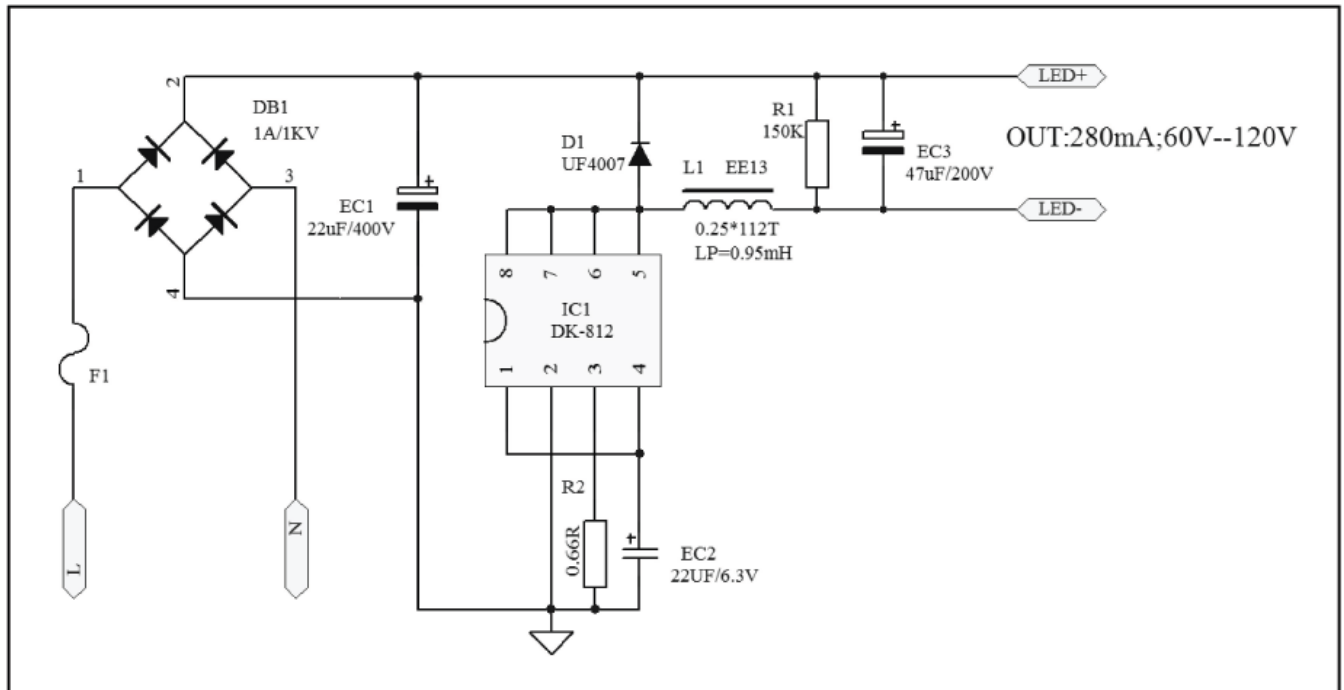
11.2.6 Copper wire diameter

The current capacity of copper wire is $6A/mm^2$, we can get its diameter as below:

$$\Phi = 2 * \sqrt{\frac{I_{out}}{6 * 3.14}} = 2 * \sqrt{\frac{0.08}{6 * 3.14}} \approx 0.13mm$$

12. TYPICAL APPLICATION SAMPLE 4

32W—60~120V/280mA NONISOLATED LOW PF LED DRIVER CIRCUIT DESIGN



12.1 Components list

NO.	NAME	SPEC. / MODEL NO.	POSITION	USED QTY	REMARK
1	Fuse	F2A/AC250V	F1	1	
2	Rectifier	DB06S	DB1	1	
3	Diode	UF4007	D1	1	
4	Electrolytic capacitor	22uF/400V	EC1	1	
5	Electrolytic capacitor	22uF/6.3V	EC2	1	
6	Electrolytic capacitor	47uF/200V	EC3	1	
7	Resistance	0.66R/0.25W	R2	1	1% accuracy
8	Resistance	150K/0.25W	R1	1	
9	IC	DK812	IC1	1	
10	Lp Inductance	EE13	L1	1	

12.2 TRANSFORMER DESIGN (NON ISOLATED LOW PF LED DRIVER CIRCUIT)

12.2.1 Parameter confirmation: confirm the below parameter before transformer design

(7) Input voltage range (for example :AC160V-265V)

(8) Output Voltage and current (for example DC120V 0.28A)

**Non isolated low PF BUCK circuit is a special working mode for this IC, output current

$$I_o = \frac{200mV}{R_s} * \eta, \text{ peak current } I_p = \frac{0.4V}{R_s}, \text{ so minimum value of } R_s \text{ is } 0.66 \Omega. \text{ And there}$$

is no transformer in non isolated circuit, so the maximum current would be

$$I_o = \frac{200mV}{R_s} * \eta = \frac{200mV}{0.66} \times 0.92 \approx 280mA$$

12.2.2 Core selecting

(4) Input power calculation

$P = P_{out}/\eta$ (η is the efficiency of the power supply, take it 0.85 for example),
 $P_{out} = V_{out} * I_{out} = 120V * 0.28A = 32W$, so $P_{in} = 32/0.92 = 35W$.

(2) Choose the core:

According to the structure of LP inductance, we choose EE13 for the core.

12.2.3 Current-limiting resistance calculation

$$I_o = \frac{200mV}{R_s} * \eta, \text{ so } R_s = \frac{200mV}{I_o} * \eta$$

$$R_s = \frac{200mV}{280mA} * 0.92 = 0.66\Omega$$

12.2.4 Non loading limited voltage (V_{ovp}) confirmation and input inductance value (L_p) calculation

Output Voltage is 120V, we take V_{ovp} to be 144V.

$$V_{ovp} = \frac{100 * L_p}{R_s}, \text{ so } L_p = \frac{V_{ovp} * R_s}{100} = \frac{144V * 0.66}{100} \approx 0.95mH$$

12.2.5 Number of the original(input) turns (N_p)

Because the saturation magnetization of Ferrite material is about 0.4T, the designed Magnetic flux density in transformer should be no more than 0.4T. However, Single-ended Flyback circuits works in the first quadrant of B-H, and residual magnetism of the core is about 0.1T, so the maximum working magnetic flux density should be $0.4 - 0.1 = 0.3T$. According to formula $B_{max} = (I_p * L_p) / (N_p * A_e) = 0.3T$, and A_e in EE13 transformer is $17mm^2$, $I_p = \frac{1.2V}{R_s} = 1200/2 = 600$, so

$$\text{we can get } N_p = \frac{I_p * L_p}{B_{max} * A_e} = \frac{600 * 0.95}{0.25 * 17} \approx 135$$

12.2.6 Copper wire diameter

The current capacity of copper wire is $6A/mm^2$, we can get its diameter as below:

$$\Phi = 2 * \sqrt{\frac{I_{out}}{6 * 3.14}} = 2 * \sqrt{\frac{0.28}{6 * 3.14}} = 0.243 \approx 0.25 mm^2$$

13. SPECIAL NOTICE FOR PBC LAYOUT DESIGN

13.1 Heat dissipation: A good estimate is that the controller will dissipate the output power. So enough cooper area connected to the OC pin and tin-plating are necessary to provide the controller heat sink.

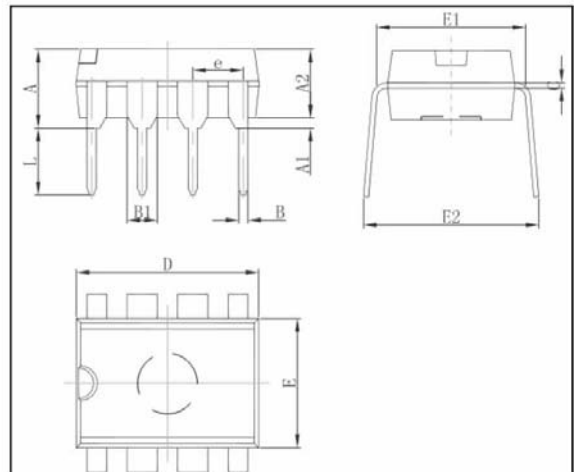
13.2 The OC pin is high voltage part of the IC, peak voltage is as high as 600V, so it should be at least 1.5mm far away from the low voltage part in the PCB as to avoid circuit breakdown and discharging.

13.3 The self-power supply circuit in IC works in high frequency situation, too long or too thin cable would cause abnormal working of the IC, so the capacitor connected to pin No. 4 should be near to IC and the cable area should be enlarged.

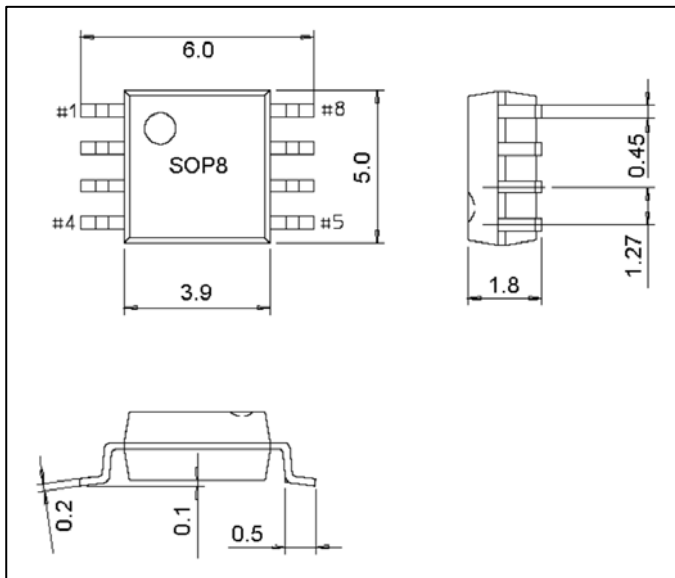
14. MECHANICAL AND PACKING INFORMATION

DIP-8

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	4.310	0.146	0.170
A1	0.510		0.020	
A2	3.200	3.600	0.126	0.142
B	0.380	0.570	0.015	0.022
B1	1.524 (BSC)		0.060 (BSC)	
C	0.204	0.360	0.008	0.014
D	9.000	9.400	0.354	0.370
E	6.200	6.600	0.244	0.260
E1	7.320	7.920	0.288	0.312
e	2.540 (BSC)		0.100 (BSC)	
L	3.000	3.600	0.118	0.142
E2	8.400	9.000	0.331	0.354



SOP-8



• Packing quantity

QTY/tube	QTY/inner carton	QTY/master carton
50	2000	20000