Non-Isolation T8 LED Driver Module with Valley-Fill Power Factor Correction

AC Input Voltage Range	LED DC Output Voltage/Current	Output Power
$100V_{AC}$/60Hz ~ $260V_{AC}$/50Hz	52V/350mA	18.2W

Key Features

- Universal input from $100V_{AC}$/60Hz to $260V_{AC}$/50Hz, LED DC 52V/350mA output
- Active Power Factor Correction (PFC) and typical PF value > 0.93
- Constant Off-time buck converter and maximum efficiency > 88%
- Average current mode control and LED output current variation within 1±%
- Dimension : 300mm x 16mm x 19mm
- Typical application : T8

Introduction

This application note describes a constant current T8 power module with passive power factor correction for full range input voltage from $100V_{AC}$ ~ $264V_{AC}$ by adopting the SQ9961. Based on buck PFC topology, the SQ9961 is able to achieve high power factor value for T8 lighting application. Schematics, PCB Gerber, BOM, as well as typical performance are covered in details by this application note. A complete application circuit is depicted in Figure 5, which can work on universal input voltage range from $100V_{AC}$ ~ $264V_{AC}$.

Specification

The Table 1 represents the specification that this design intends to achieve.

Performance

It is to drive output at 52V/350mA targeting to achieve high efficiency (η_{MAX} > 88%), high power factor (typical PF > 0.93) and current accuracy for AC universal input voltage range $100V_{AC}$ ~ $260V_{AC}$. Actual performance is shown on Table 2. Figure 1, 2, 3 and 4 depict power factor, output current, current variation and efficiency at AC input voltage range $100V_{AC}$ ~ $264V_{AC}$ for this module.

BOM

BOM is shown in Table 3.

Components Selection

The fuse F1 provides protection from component failure while MOV provides a clamp to limit the maximum component stress. Output current is determined by R5, R6 and R7 in parallel. There are few combinations to reach the same value. In this case, these values are chosen R5 = 1.2Ω, R6 = 2.2Ω and R7 = 10Ω in order to generate R_{CS} = 0.72Ω. Based on non-isolated solution, there is no need to have bulky transformer for energy storage during switching. It needs only two inductors, L3 and L4 together which can handle power up to 20W.

Output Capacitor

A 4.7μF/400V rating capacitor (C6) is needed at the output, so when the output LED is accidently open or when LED is not properly installed the output capacitor would not get exploded due to its high voltage rating at 400V.

V_{CC} Pin Capacitor (C3)

A 100pF/50V capacitor is added to reduce the high frequency noise influence on V_{CC} Pin.

PCB Layout

The PCB layout has dimension at 300mm 16mm x 1.6mm in order to fit T8 space. Detail layout is shown in Figure 6.

Power Module Photo

Pictures of power module and key components are shown in Figure 7, 8 and 9.

Table 1. Related Specification

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
AC input voltage	V_{AC}	100		264	V	
LED DC output voltage	V_{OUT}		52		V	
LED output current	$I_{OUT(SET)}$		350		mA	

Table 2. Actual Performance

AC Input	Input Power (W)	OutputCurrent (I_{OUT}, mA)	Output Voltage (V_{OUT}, V)	Current Variation (%) (Note)	Efficiency (η, %)	PF
100V_{AC}/60Hz	20.64	348	52	-0.6	87.7	0.928
110V_{AC}/60Hz	20.63	348	52	-0.6	87.7	0.932
120V_{AC}/60Hz	20.61	348	52	-0.6	87.8	0.933
132V_{AC}/60Hz	20.57	348	52	-0.6	88.0	0.933
180V_{AC}/50Hz	20.14	347	52	-0.9	89.6	0.934
200V_{AC}/50Hz	20.19	347	52	-0.9	89.4	0.936
220V_{AC}/50Hz	20.27	348	52	-0.6	89.3	0.936
240V_{AC}/50Hz	20.36	348	52	-0.6	88.9	0.935
264V_{AC}/50Hz	20.50	349	52	-0.3	88.5	0.936

Note :

Current Variation is defined as follows :

$$\% = \frac{I_{OUT} - I_{OUT(SET)}}{I_{OUT(SET)}} \times 100\%$$

where $I_{OUT(SET)} = 350mA$

Figure 1. Power Factor for AC Input Voltage Range $100V_{AC}$ ~ $264V_{AC}$

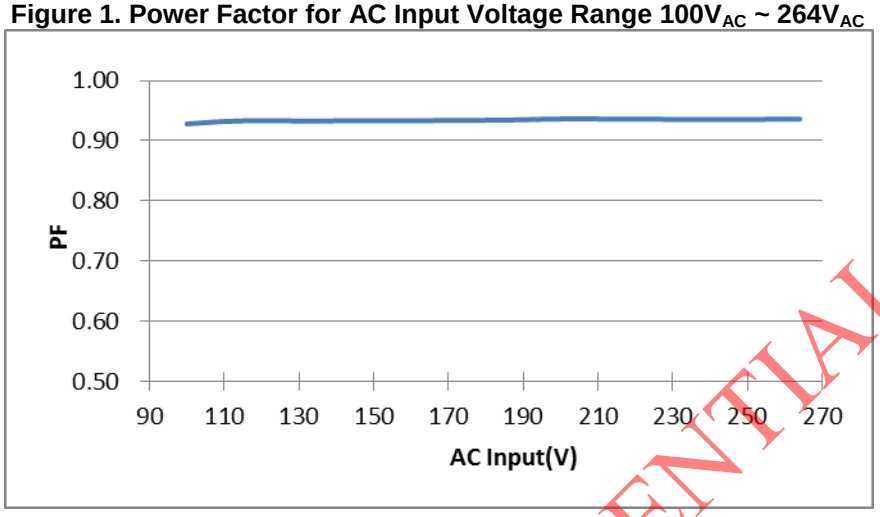

Figure 2. Output Current for AC Input Voltage Range $100V_{AC}$ ~ $264V_{AC}$

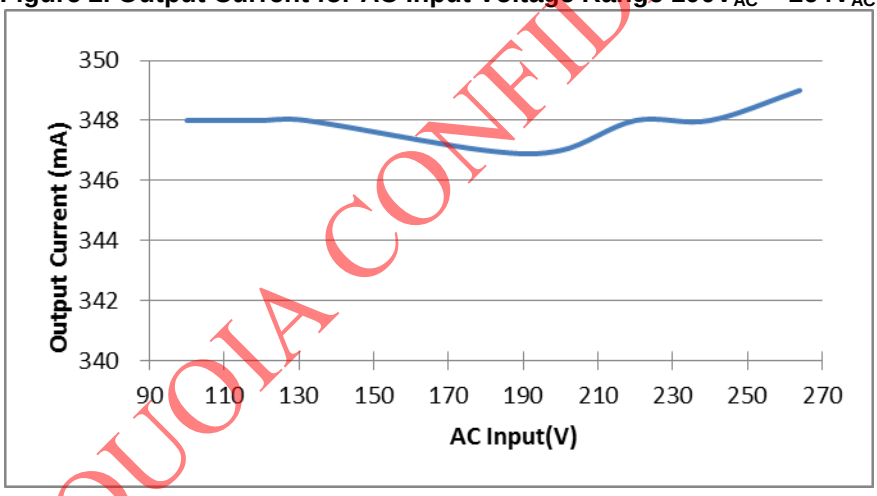

Figure 3. Current Variation for AC Input Voltage Range $100V_{AC}$ ~ $264V_{AC}$

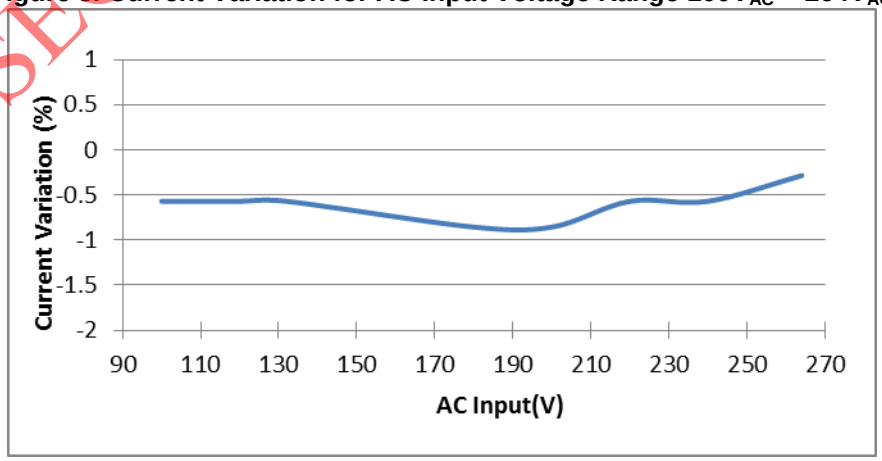

Figure 4. Efficiency for AC Input Voltage Range $100V_{AC}$ ~ $264V_{AC}$

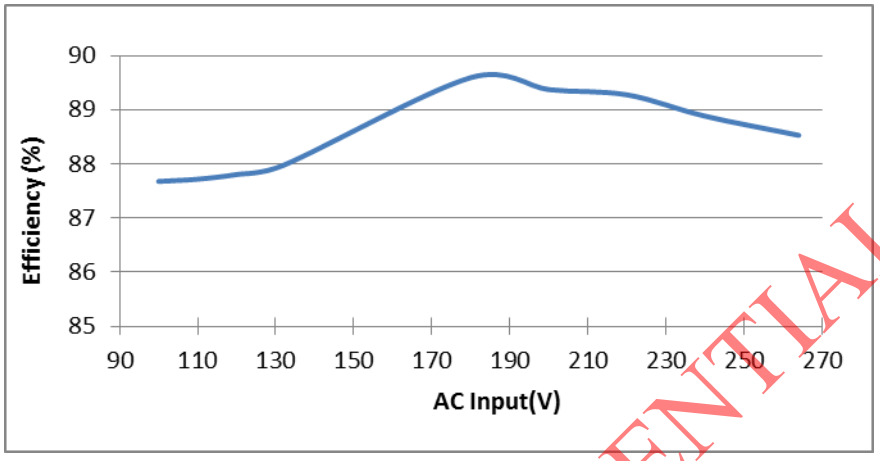

Figure 5. A Complete Application Circuit by Adopting the SQ9961

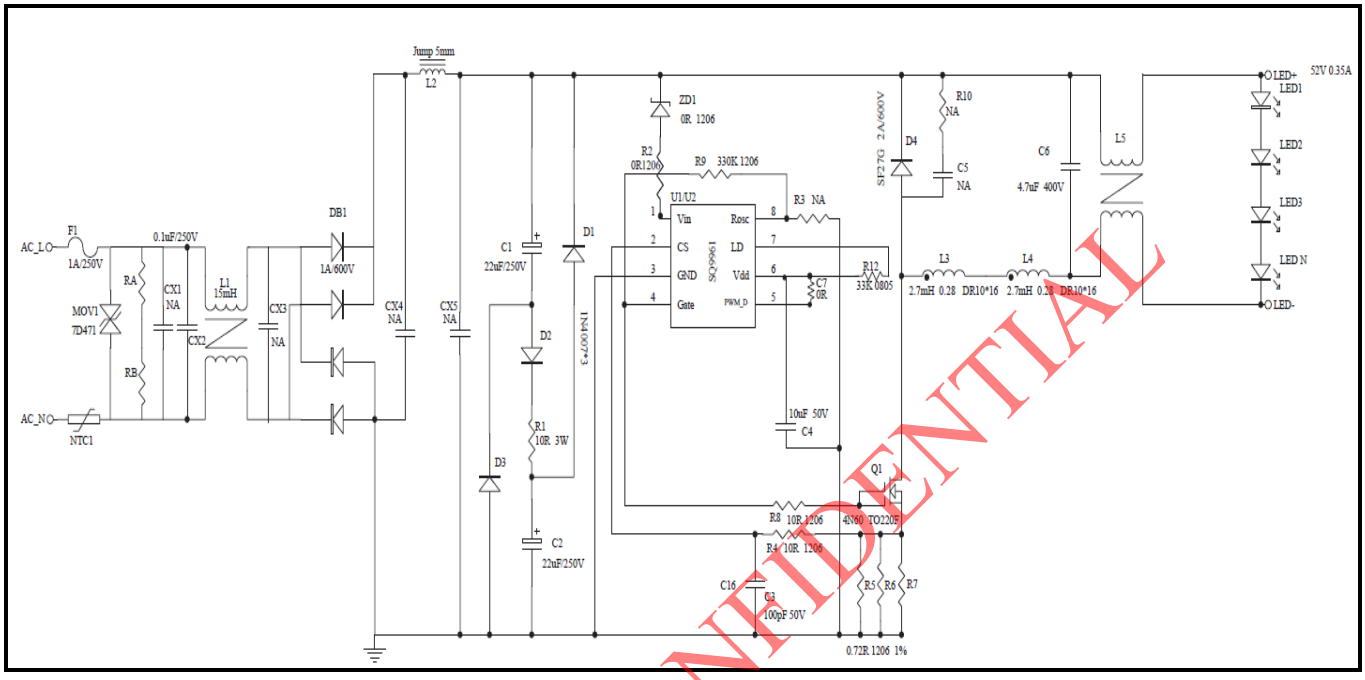

Table 3 : Bill of Material

Item	Symbol	Description	Category	Qty	Note
1	R1	10R 2W	RESISTOR	2	
2	$R_{A,B}$	562k / 1206	RESISTOR	2	
3	R4	10R/1206	RESISTOR	1	
4	R5	1R2 /1206/F	RESISTOR	1	
5	R6	2R2 /1206/F	RESISTOR	1	
6	R7	10R/1206/F	RESISTOR	1	
7	R8	10R /1206	RESISTOR	1	
8	R9	330k/1206	RESISTOR	1	
9	ZD1,R2,C7	0R / 1206	RESISTOR	3	
10	R12	33.2k / 0805	RESISTOR	1	
11	MOV	TVR07471	VARISTOR	1	
12	CX1	104 / 300V X1	CAPACITOR	1	
13	C4,5	CBB103/400V J	CAPACITOR	2	
14	C1	SK 22uF/250V 10*20	CAPACITOR	1	
15	C2	SK 22uF/250V 10*20	CAPACITOR	1	
16	C3	100pF / 50V 1206	CAPACITOR	1	
17	C6	4.7uF, 400V, 8*12mm	CAPACITOR	1	
18	C4	10uF 50V 5*11.5mm	CAPACITOR	1	
19	D1-D3	M7 1A/1000V SMA	DIODE	3	
20	DB1	DB106S A/600V	DIODE	1	
21	D4	SF26G	DIODE	1	
22	Q1	Mosfet 4A/600V TO-220F	MOSFET	1	
23	L1	15mH ,Toroidal coils	CHOKE	1	
24	L5	1.5mH ,Toroidal coils	CHOKE	1	
25	L2,L6,J2	JUMP P=5mm	JUMP	1	
26	L3,4	2.7mH, DR1016	CHOKE	2	
27	F1	T1A/250V, BOX	FUSE	1	
28	NTC1	SCK052	NTC	1	
29	U1	SQ9961	IC	1	
30	PCB	PCB：FR-4 L300mm*W16mm*T1.2MM	PCB	1	
		TOTAL		38	

Figure 6. Picture of PCB Layout (Dimension at 300mm x 16mm x 1.2mm)

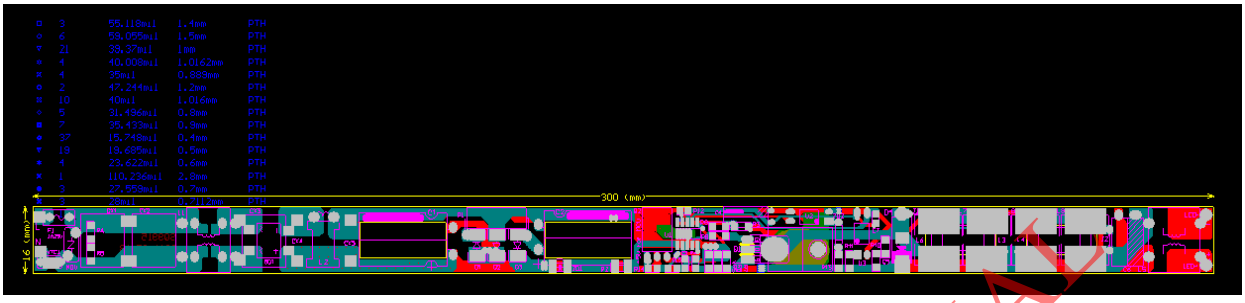

Figure 7. Picture of AC in Line / Neutral, Fuse, Bridge, Varistor, Choke L1

Figure 8. Picture of Valley-Fill PFC

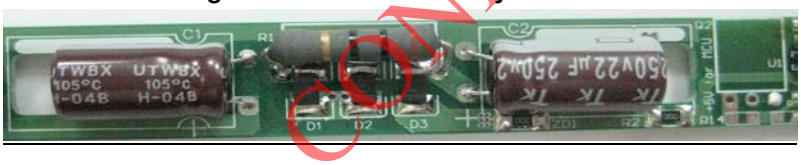

Figure 9. Picture of U1 (SQ9961), MOSFET, D4, Inductor L3 and L4, Choke L5 and DC Output LED+/- Connector