Design Example

Title	20W Non-isolated LED Driver Using PT4207
Specification	175-265VAC Input; 76V(24 LEDs in Series), 240mA Output
Application	T8/T10 Tube LED Driver
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Revision	1.0

FEATURES

- **AC Input Range 175-265VAC; 24 LEDs in Series Output, 240mA**
- **Over 92% Efficiency, More than 0.89 Power Factor**
- **±5% Output Current Accuracy including Line, Load(-90%Vo to +10%Vo), Temperature, and Component Tolerance**
- **Meet CISPR22B/EN55022B EMI(>6dB margin)**
- **Soft-Start/Output Short Protection**

1. Introduction

This design example describes the design and specification of a 175-265VAC input, 76V(24LEDs in series) 240mA output LED driver, using the PT4207 from Powtech's LED driver ICs family.

2. Prototype Photo

Figure 1 – Top View

3. Power Supply Specification

Output: 24 LEDs in series (See Note 1.).

DESCRIPTION	CONDITION	MIN	TYP	MAX	UNITS
INPUT CHARATERISTIC					
Input Voltage		175		265	VAC
Frequency		47	50	63	Hz
Power Factor	Vin=175~265Vac	0.89			
Efficiency	Vin=175~265Vac	92			%
OUTPUT CHARATERISTIC					
Rated Output Voltage	24 LEDs in series		76		V
Rated Output Current		228	240	252	mA
Ripple Output Voltage	Vin=230Vac		2000		mVpp
Ripple Output Current	Vin=230Vac		50	160	mA
Output Open Voltage	Vin=230Vac, No-Load (See Note 1.)		320		V
TIME SEQUENCE					
Turn-on Time	Vin=230Vac			300	mS
Turn-off Time	Vin=230Vac			100	mS
PROTECTION					
Output Short Circuit Protection	Vin=230Vac		PASS		
Power on-off	Vin=230Vac, No Load, Ton=Toff=2s, 3000times		PASS		
	Vin=230Vac 24LEDs in Series Ton=Toff=2s, 3000times		PASS		
ENVIRONMENTAL					
EMI		Meets CISPR22B / EN55022B			
Ambient Temperature	Free convection	-20		80	℃

Note 1. Make sure that connect the LED strings before power-on. If not, the high output voltage will destroy the LEDs. Figure 11 shows the solution for this issue.

4. Schematic

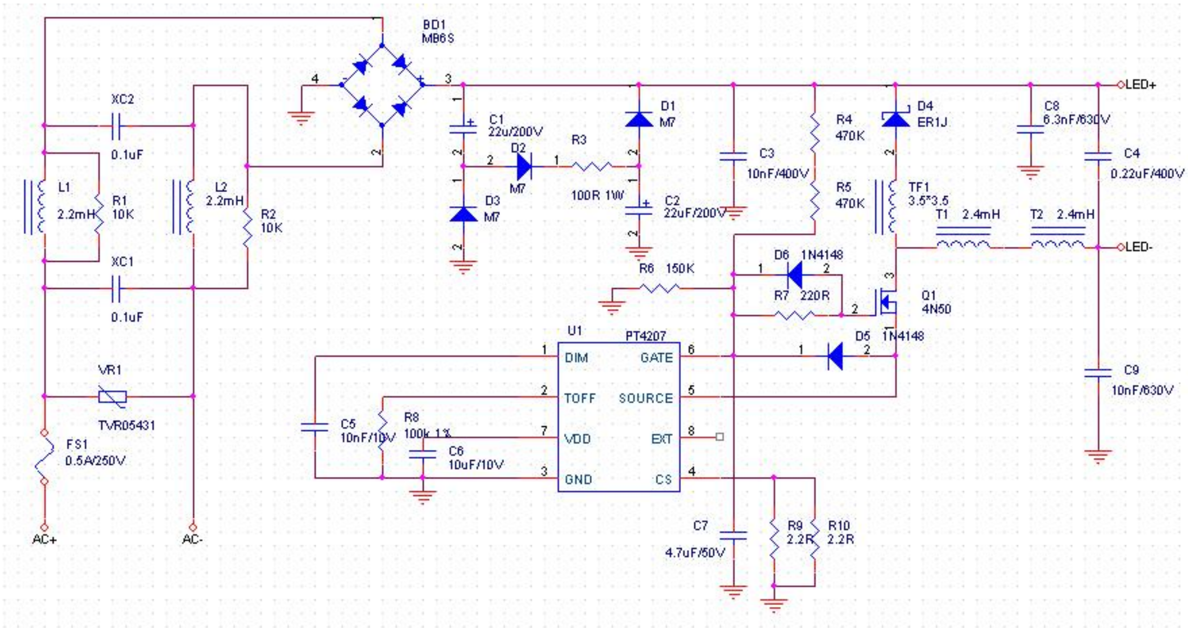

Figure 2 – Schematic

5. PCB Layout

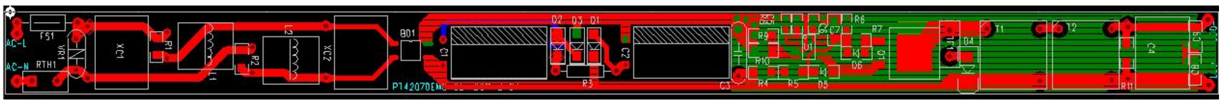

Figure 3 – PCB Layout (240mm*16mm)

6. Bill of Materials

Item	Reference	Description	QTY	Manufacturer
1	C1,C2	Electrolytic, 22uF/200V, RD series, Φ 10mm*16mm	2	SAMWHA
2	C3	CBB Cap, 10nF/400V, P=7.5mm	1	Panasonic
3	C4	CBB Cap, 0.22uF/400V, P=10mm	1	Panasonic
4	C5	Ceramic, 0.01uF/10V, X7R, 0805	1	FENGHUA
5	C6	Ceramic, 10uF/10V, X7R, 0805	1	FENGHUA
6	C7	Ceramic, 4.7uF/50V, X7R, 1206	1	FENGHUA
7	C8,C9	Ceramic, 0.01uF/630V, X7R, 1206	2	FENGHUA
8	XC1,XC2	X2 Cap, 0.1uF/275VAC, P=10mm	2	VISHAY
9	R1,R2	Chip Resistor, 10K, ±5%, 1206	2	FENGHUA
10	R3	MetalFilm Resistor, 100R/1W	1	YAGEO
11	R4,R5	Chip Resistor, 470K, ±5%, 1206	2	FENGHUA
12	R6	Chip Resistor, 150K, ±5%, 0805	1	FENGHUA
13	R7	Chip Resistor, 220R, ±5%, 1206	1	FENGHUA
14	R8	Chip Resistor, 100K, ±1%, 0805	1	FENGHUA
15	R9,R10	Chip Resistor, 2.2R, ±1%, 1206	2	FENGHUA
16	D1,D2,D3	Diode, General Rectifier, 1A/1kV, SMA	3	SIYU
17	D4	Diode, Ultra fast, ER1J, 1A/600V, SMB	1	DIODES
18	D5,D6	Diode, Fast recover, 1N4148, 0.1A/75V, SOD123	2	VISHAY
19	BD1	Bridge Rectifier, MB6S, 0.5A/600V, TO269AA	1	GENERAL SEMI
20	FS1	Fuse, 0.5A/250V	1	TY-OHM
21	T1,T2	Transformer Bobbin, E1312, Horizontal, 10pins	2	KANGSHUN
22	L1,L2	Power Inductor, SL1012-222	2	YAGEO
23	TF1	Ferrite Bead Inductor, Axial Φ 3.5mm*5mm	1	TDK
24	Q1	MOSFET, N-Channel, 4N50, TO252	1	UTC
25	VR1	Varistor, TVR05431	1	THINKING
26	U1	IC, PT4207, SOP8	1	POWTECH

7. Transformer Specification

7.1. Physical Dimension

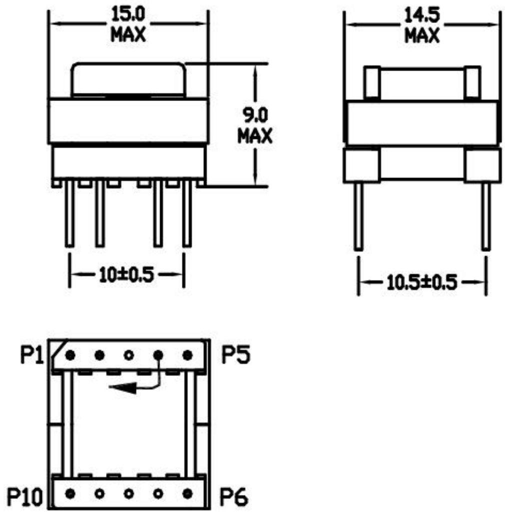

Figure 4 – Physical Dimension

7.2. Build-up Table

Winding	Terminal		Turns	Method	Wire			Insulation	
	Start	Finish			Type	Size*QTY	Layer	T/W	Layer
P1	1	10	180	Distribute Center	2UEW	0.23*1		0.025*8	2

7.3. Electrical Specifications

Item	Description	Condition	Limits
1	Inductance	Pin 1 to Pin10, measured at 40KHz, 1Vrms	2.4mH±5%

8. Demo Test Data

24 LEDs in series, 240mA output.

Vin (Vac)	Iin (mA)	Pin (W)	PF	Io (mA)	Vo (V)	Eff. (%)
175	121.3	19.611	0.925	239.0	75.97	92.58
200	106.2	19.527	0.915	238.2	75.91	92.60
230	93.46	19.495	0.903	238.6	75.85	92.83
265	82.43	19.46	0.891	238.0	75.80	92.71

9. Key Design Points

9.1. If lower average efficiency is acceptable (a 1% to 2% drop), change resisitor R3 from 100R to 300R make a average power factor 0.02 increase.

9.2. Capacitor C4 can be chosen as a low ESR, X7R type ceramic to lower the output current ripple.

9.3. Use 1% tolerance resistors R8/R9/R10 for better output current accuracy.

9.4. Use 105℃ type electrolytic capacitors C1/C2, and ferrite core that over 130℃ cure temperature to meet the lifetime requirement.

9.5. Place the BYPASS pin capacitors C5/C6/C7 and the off-time setting resistor R8 physically close to U1 on the PCB. Make sure that pin3 of U1, ground pad of C6 and C7 are connected at the same node on the PCB, away from the switching ground nodes.See Figure 6.

9.6. Minimize output loop areas(See Figure 5) to reduce EMI.

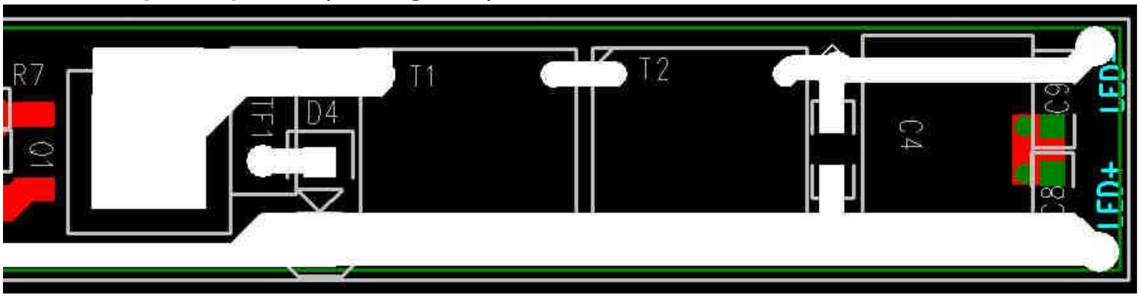

Figure 5 – Output Loop Areas

9.7. Space the U1 away from switching nodes and the large current paths to minimize noise coupling. See Figure 6.

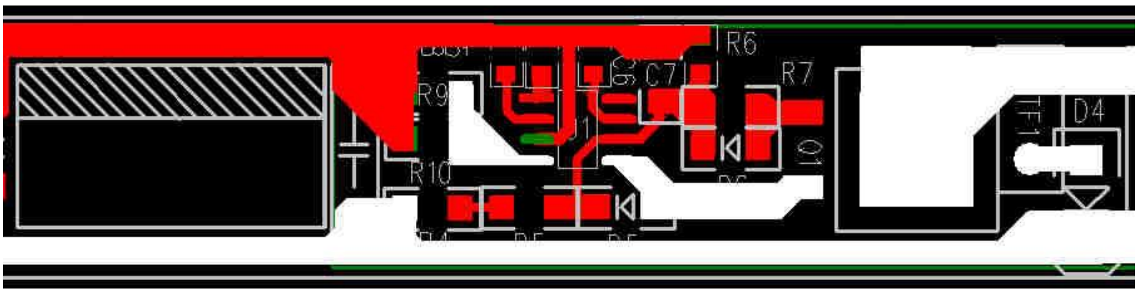

Figure 6 – U1 Placing

10. EMC Test

10.1. Conducted EMI

EMI TEST REPORT

parameter

Organization:	POWTECH	Operator:		EUT:	44207Demo05
Place:	LAB	Time:	2011/4/18/11:18		
Detector:	PK+AV	Test-time(ms):	10		
Limit:	EN55022B	Transductor:	10		
Remark:	L				

freq, step

Start(MHz)	End(MHz)	Step(MHz)
0.090	1.000	0.010
1.000	5.000	0.010
5.000	30.000	0.100

scan result

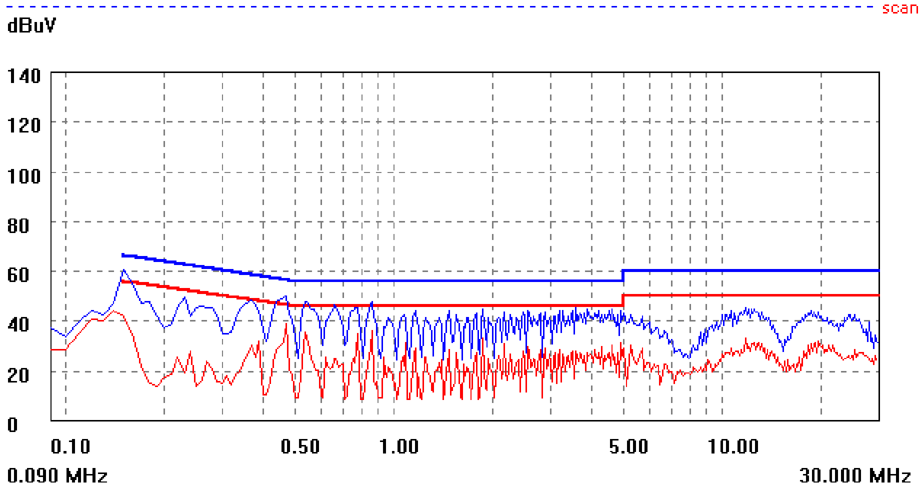

Figure 7 – EN55022B Limit, L-Line, Vin=230VAC, 24LEDs in series 240mA output

EMI TEST REPORT

parameter

Organization:	POWTECH	Operator:		EUT:	44207Demo05
Place:	LAB	Time:	2011/4/18/11:19		
Detector:	PK+AV	Test-time(ms):	10		
Limit:	EN55022B	Transducer:	10		
Remark:	N				

freq, step

Start(MHz)	End(MHz)	Step(MHz)
0.090	1.000	0.010
1.000	5.000	0.010
5.000	30.000	0.100

scan result

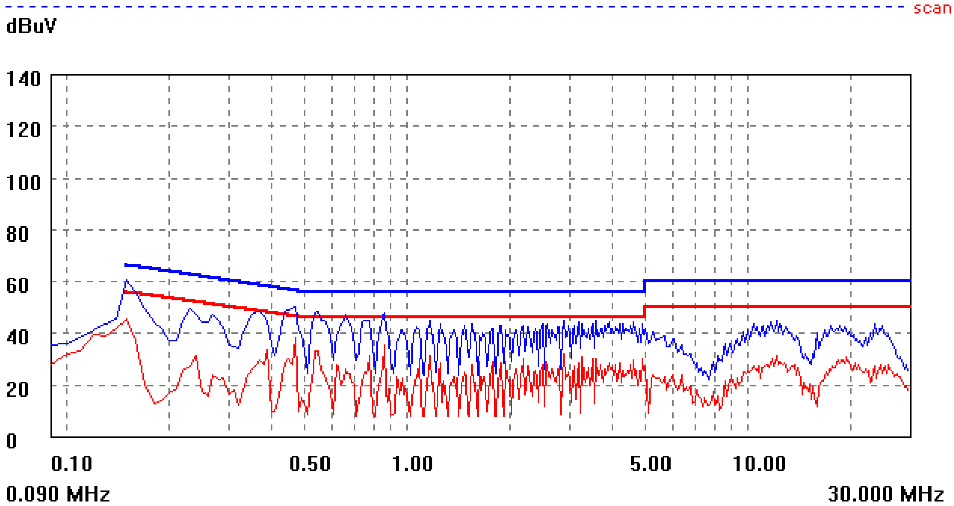

Figure 8 – EN55022B Limit, N-Line, Vin=230VAC, 24LEDs in series 240mA output

10.2. Radiated EMI

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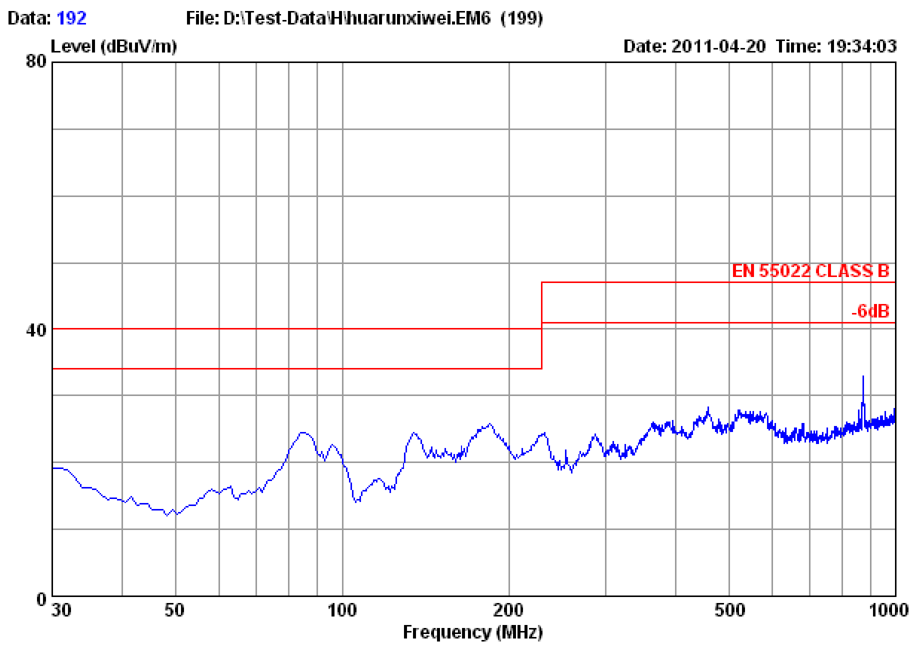


```
Site          : Audix(Shanghai) Chamber3
Condition     : EN 55022 CLASS B HORIZONTAL
Project No.   :
Applicant     :
EUT           :
M/N           : 4207-1
S/N           :
Power Supply  : 230V/50Hz
Ambient       : 25'C 55%
Test Mode     :
Test Engineer: Raven
Memo          :
```

Figure 9 – EN55022B Limit, Horizontal, Vin=230VAC
24LEDs in series 240mA output

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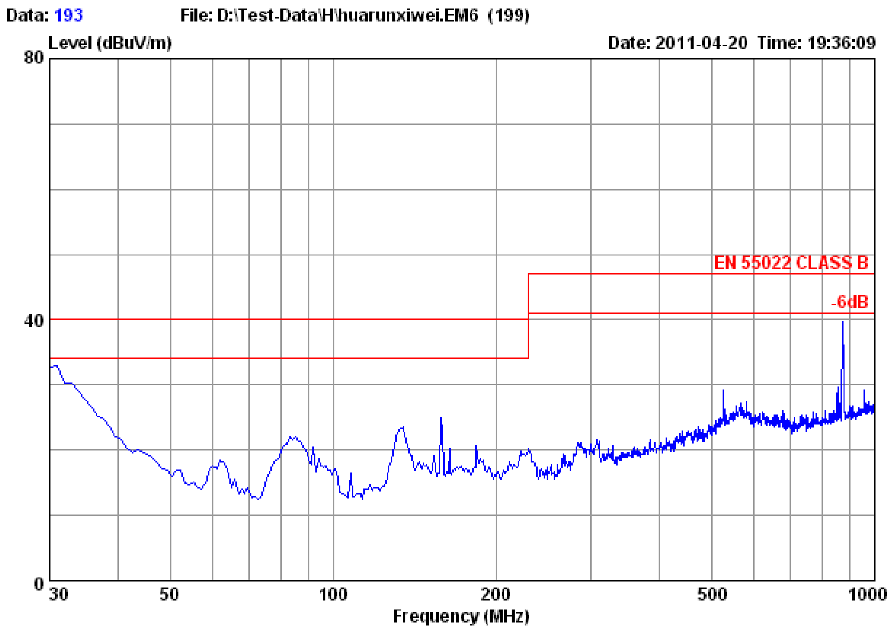

Site : Audix(Shanghai) Chamber3
Condition : EN 55022 CLASS B VERTICAL
Project No. :
Applicant :
EUT :
M/N : 4207-1
S/N :
Power Supply : 230V/50Hz
Ambient : 25'C 55%
Test Mode :
Test Engineer: Raven
Memo :

	Freq	Level	Read Level	Antenna Factor	Cable Loss	Limit Line	Over Limit	Remark
	MHz	dBuV/m	dBuV	dB/m	dB	dBuV/m	dB	
1	30.07	31.74	12.70	18.24	0.80	40.00	-8.26	QP

Figure 10 – EN55022B Limit, Vertical, Vin=230VAC, 24LEDs in series 240mA output

11. Improvements

11.1. Output Voltage Clamping

Figure 11 show the output voltage clamping circuit, using optocoupler. And output voltage can be clamped at 90VDC.

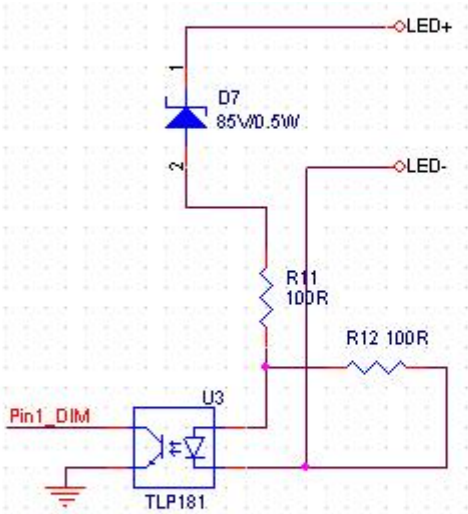

Figure 11 – Output Voltage Clamping Circuit