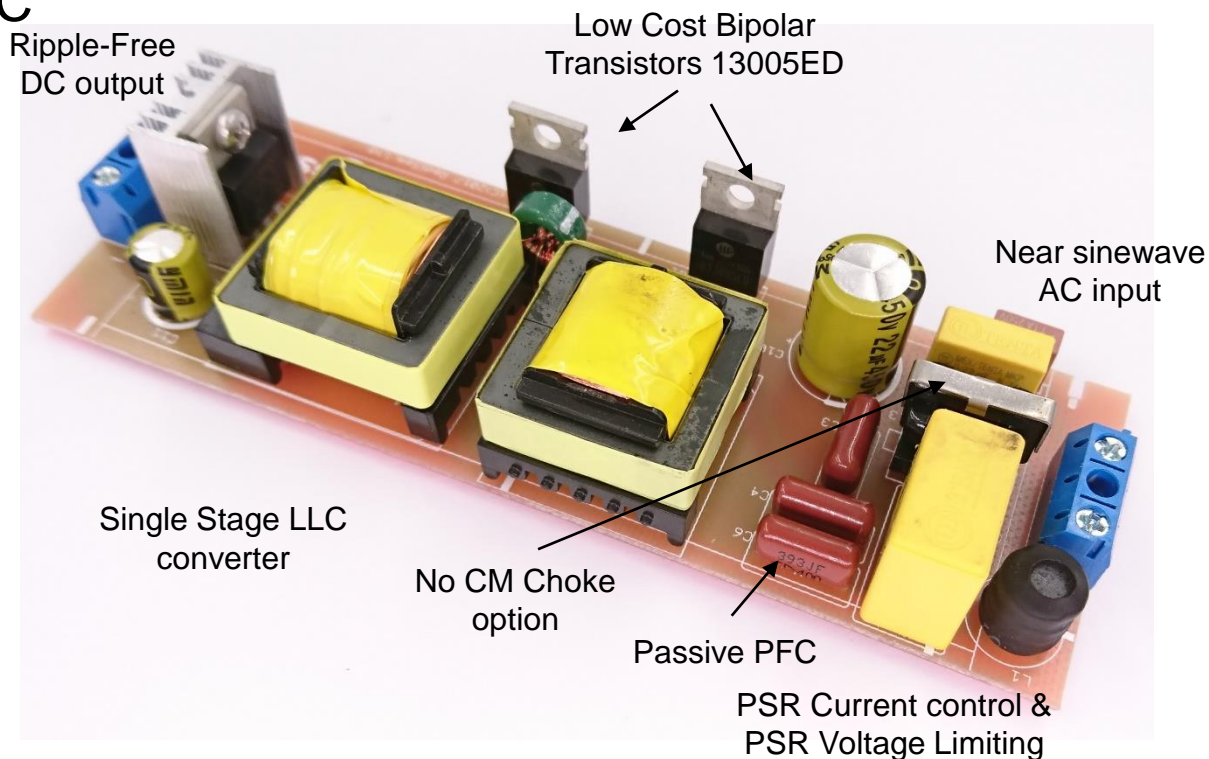
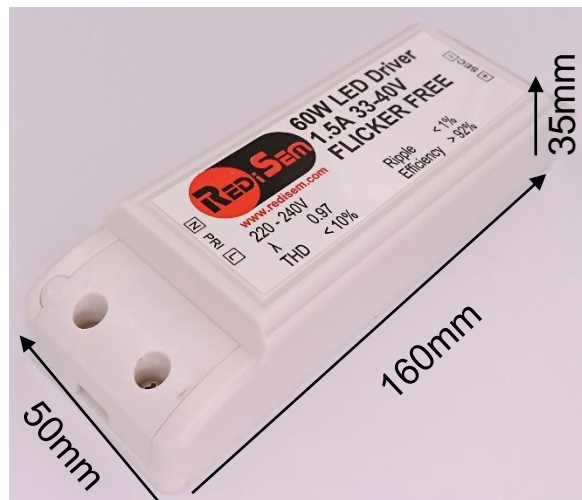




RED2521

60W 1500mA LED Driver Design Report

- Low-cost Flicker-free CC LED driver
- RED2521 SO8 controller IC
- Efficiency 92%
- High Power Factor >0.95
- 1.5A 33-40V output
- Low EMI

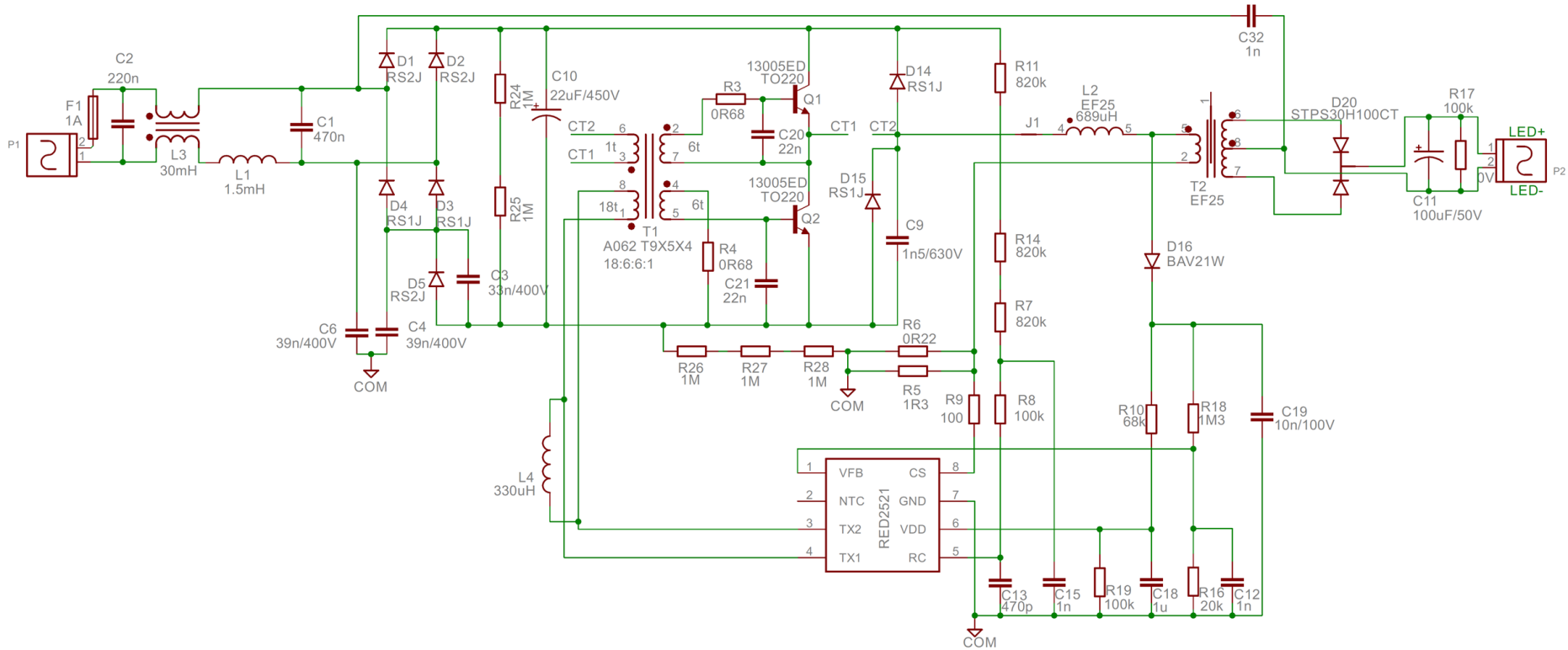


Specifications



Specification	Value	Test condition
Input voltage 50Hz	198 - 264VAC	Functional specifications
Input functional range	170 - 320VAC	5 minute survival
Output voltage	33 - 40V	198 - 264VAC
Output current	1.5A \pm 5%	198 - 264VAC
LF Ripple (Flicker)	<1%	230VAC, 40VDC
Harmonic compliance	220 - 240VAC	33-40V DC
Total Ripple	< 1%	230VAC, 40VDC
Time to light	< 30ms	230VAC, 40VDC
Efficiency	> 92%	230VAC, 40VDC
Power factor	> 0.97	230VAC, 40VDC
THD	< 10%	230VAC, 40VDC
No-load voltage	< 50V	264VAC
Protection	Overtemperature, short circuit, open circuit	
EMI test	7dB Margin	LED earthed, Driver floating
Surge	1kV DM, 2kV CM	
Ambient Temperature	-20 to 50°C	

Schematic



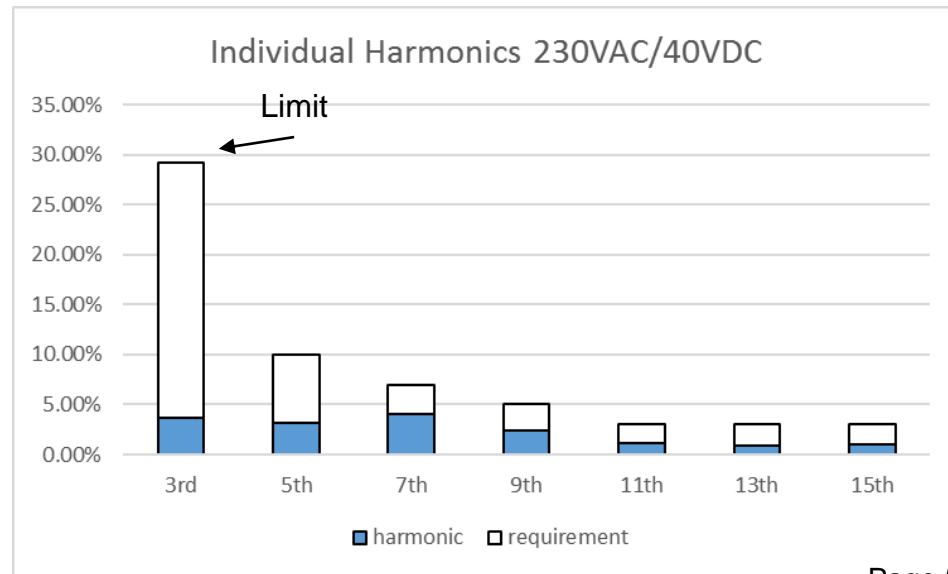
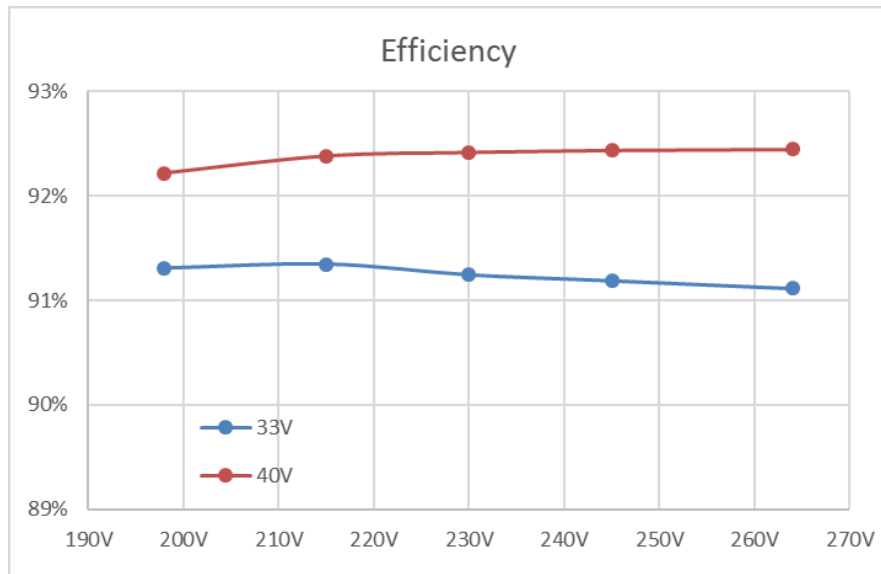
Code	Value	Description	Qty	Supplier
C1	470n	X2 MKP 20% 275VAC	1	Tenta
C2	220n	X2 MKP 20% 275VAC	1	Tenta
C3	33n	MKP 5% 400VDC	1	Fara
C4	39n	MKP 5% 400VDC	1	Fara
C6	39n	MKP 5% 400VDC	1	Fara
C10	22u	ELEC 20% 450VDC	1	Aishi
C11	100u	ELEC 20% 50VDC	1	Aishi
C9	1n5	1206 NPO 5% 1000VDC	1	Murata
C12,15	1n	0805 X7R 10% 50VDC	2	Samsung
C13	470p	0805 COG 5% 50VDC	1	Samsung
C19	10n	0805 X7R 10% 100VDC	1	Samsung
C18	1u	0805 X7R 10% 16VDC	1	Samsung
C20,21	22n	0805 X7R 10% 50VDC	2	Samsung
C32	1n	Y-CAP	1	
D3,4,14,15	RS1J	SMA Fast Diode 600VDC 1A	4	TSC/Mishay
D1,2,5	RS2J	SMB Fast Diode 600VDC 2A	3	TSC/Mishay
D16	BAV21W	MiniMELF	1	
D20	STPS30H100CT	schottky diode 100VDC 30A	1	ST
F1	1A	Fuse	1	
L1	1m5H	8x10 Drum Core	1	Ningbo Eilux Electric
L2	689uH	EF25 Main Inductor	1	Ningbo Eilux Electric
L3	30mH	UU9.8 Common mode	1	Ningbo Eilux Electric
L4	330uH	0410 0.25W Axial	1	
R3,4	0R68	0805 0.06W 1.0%	2	
R5	1R3	1206 0.25W 1.0%	1	
R6	0R22	1206 0.25W 1.0%	1	
R7,11,14	820k	0805 0.125W 1.0%	3	
R8,19	100k	0805 0.06W 1.0%	2	
R9	100R	0805 0.06W 1.0%	1	
R10	68k	0805 0.06W 1.0%	1	
R16	20k	0805 0.06W 1.0%	1	
R17	100k	1206 0.25W 1.0%	1	
R24,25	1M	1206 0.25W 1.0%	2	
R18	1M3	0805 0.06W 1.0%	1	
R26,27,28	1M	0805 0.125W 1.0%	3	
P1,P2		Terminal 2 Pin	2	
Q1,Q2	13005ED	TO220 4A NPN Transistor (Ts=2-2.5us)	2	Jilin Sino
T1	A062 T9x5x4, 18:6:6:1 turns	Base Drive	1	ACME
T2	EF25	Output Transformer	1	Ningbo Eilux Electric
U1	RED2521	LLC LED controller IC	1	Redisem
TOTAL			56	

Test Results



Output Voltage	33V					40V				
Input voltage	198V	215V	230V	245V	264V	198V	215V	230V	245V	264V
Output current	1493mA	1495mA	1495mA	1496mA	1497mA	1496mA	1498mA	1499mA	1500mA	1502mA
Input Power	53.96	54.01	54.07	54.14	54.22	64.89	64.86	64.88	64.91	64.99
Output Power	49.27	49.34	49.34	49.37	49.40	59.84	59.92	59.96	60.00	60.08
Efficiency	91.3%	91.3%	91.2%	91.2%	91.1%	92.2%	92.4%	92.4%	92.4%	92.4%
Power Factor	0.976	0.974	0.968	0.958	0.941	0.970	0.975	0.975	0.970	0.959
THD	11.1%	7.4%	7.7%	11.4%	16.9%	17.6%	11.5%	7.6%	6.8%	11.6%
Ripple (Flicker) @36V	0.90%	0.88%	0.83%	0.76%	0.71%					

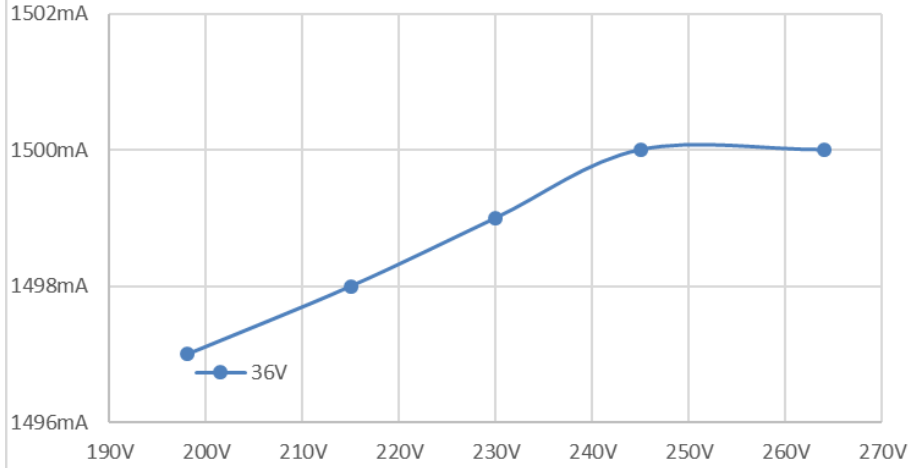
Test	Result	Condition
Peak no-load Voltage	50V	230VAC
Time To light	30ms	230VAC



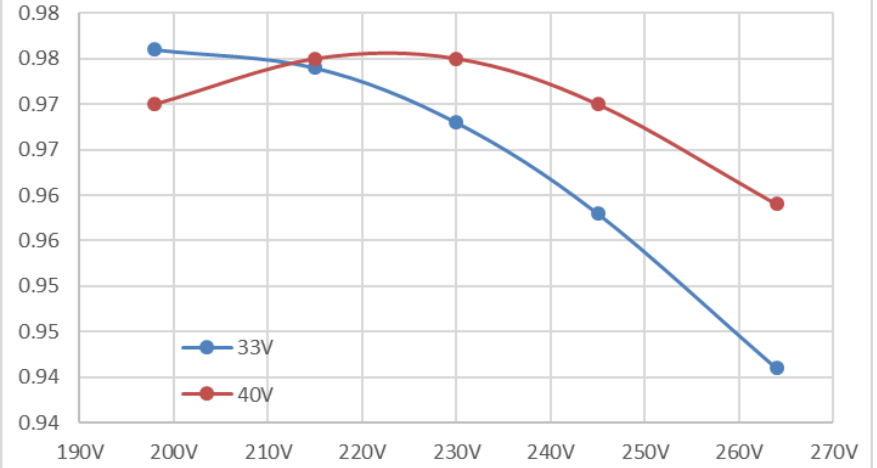
Test Results



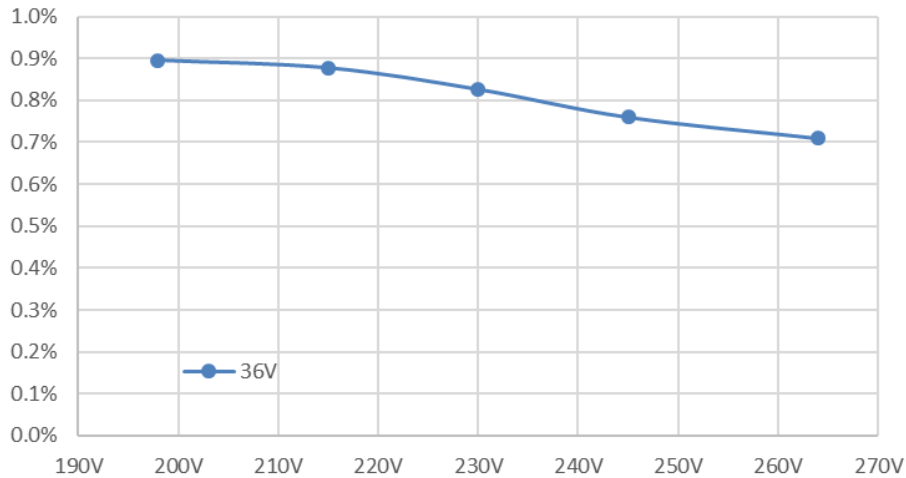
Current Regulation



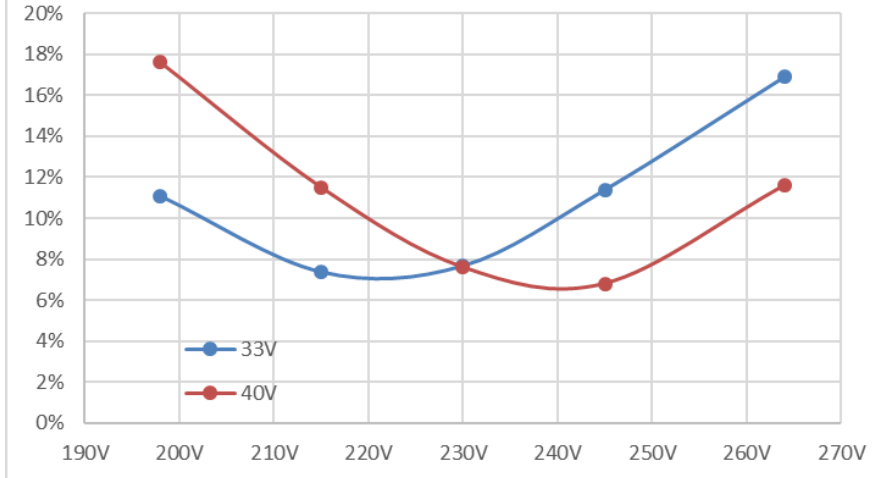
PF



Flicker



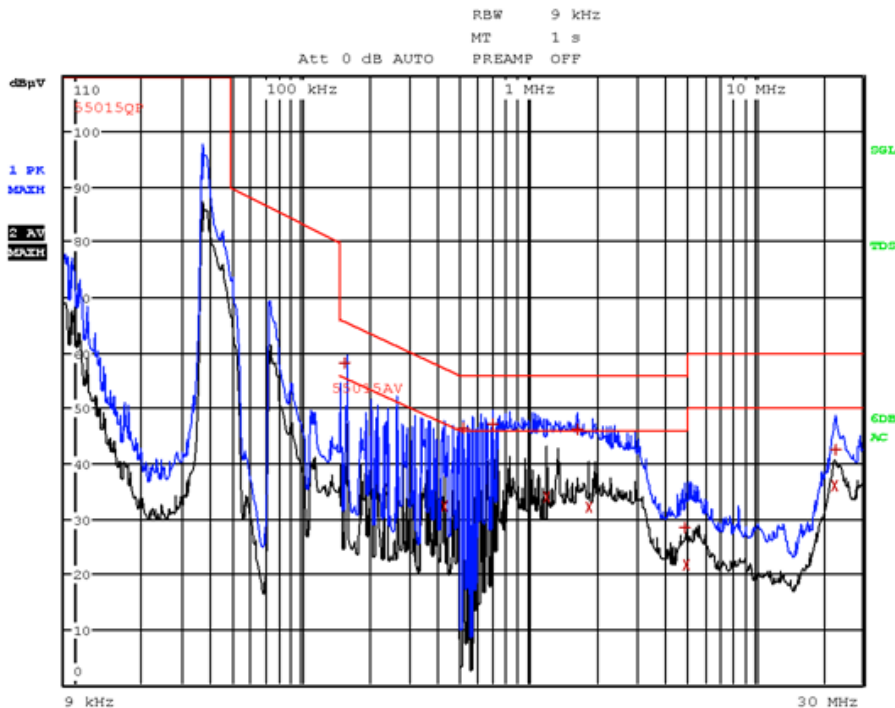
THD



Test Results – EMI & Surge

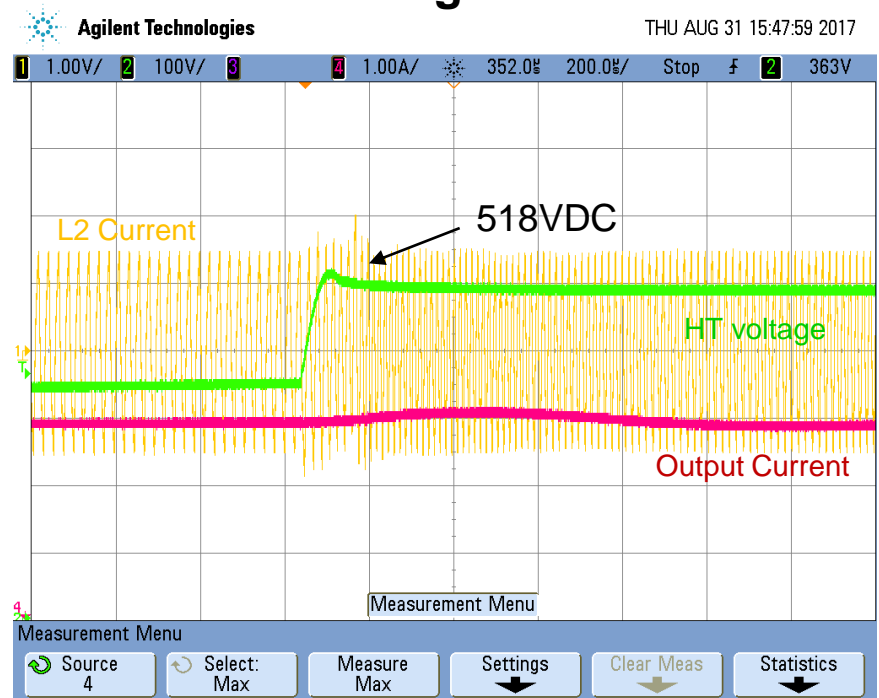


>7dB Margin Pass



Conducted EMI 9k~30MHz
Driver and LED on earthed ground plane

1kV surge pass with margin



Plot of HT bus voltage and L2
(resonant) current during 1kV surge
with fuse resistor 230VAC/36VDC

Test Results - Thermals



Test condition:

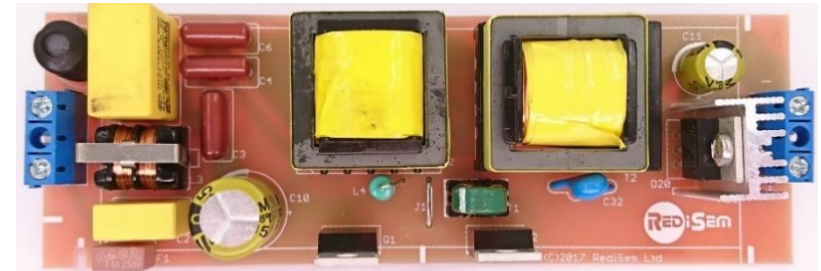
In a box in a heated oven

Ta = 50C

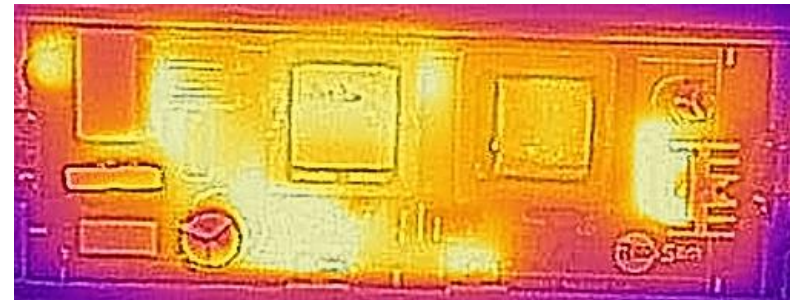
Thermal Results (cased)	198V 40V	264V 32V
Ta	50C	53C
Q1	102C	111C
Q2	97C	109C
L2 core	103C	114C
L2 winding	102C	97C
T2 core	99C	101C
T2 winding	98C	103C



Test condition:



Open on the bench



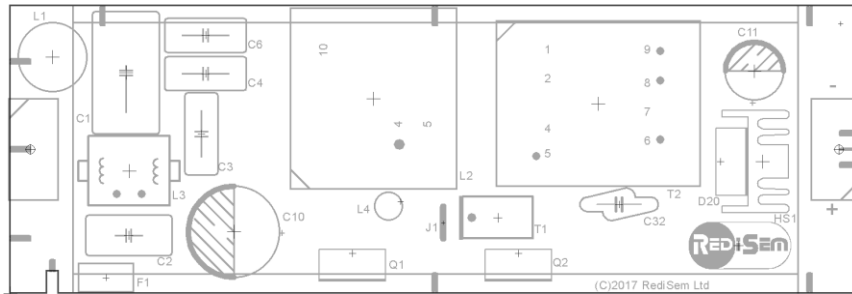
Top side Thermal



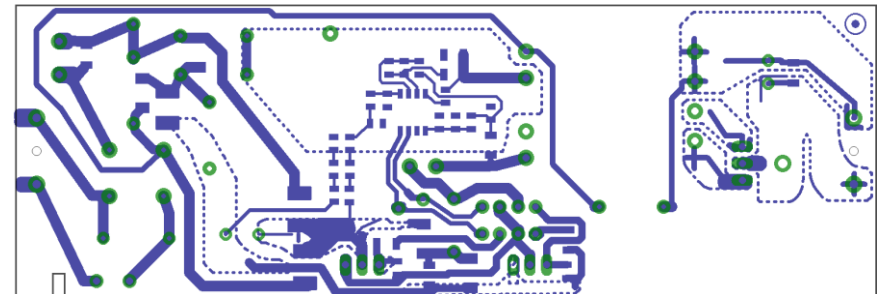
Bottom side Thermal

PCB layout

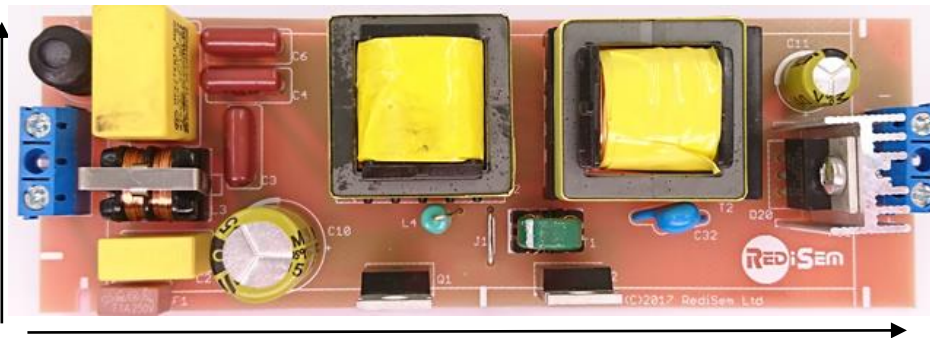
Top Side



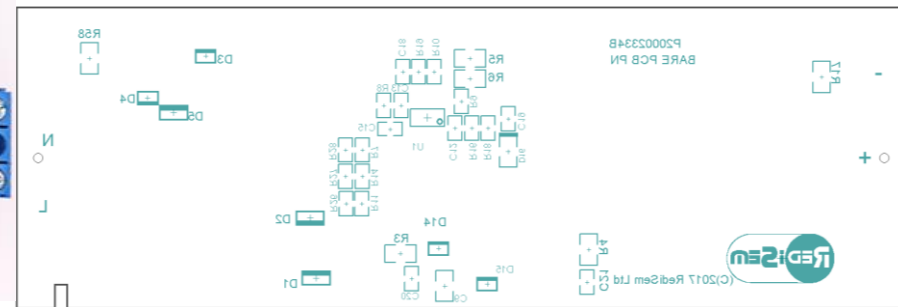
Bottom Side



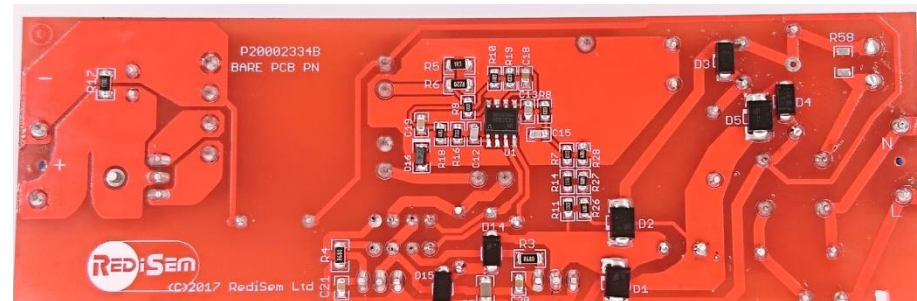
44mm



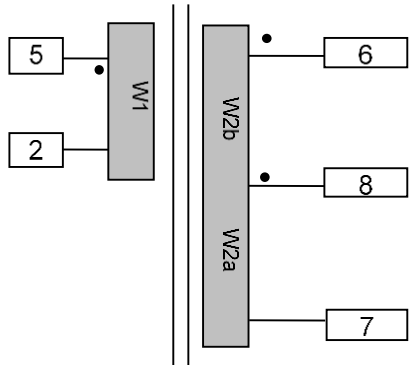
130mm



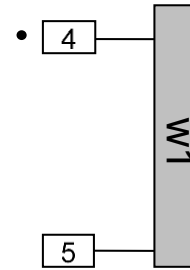
- Single sided PCB
- 1mm thick
- 1 Oz copper



Wound components



Transformer	
Core type	EF25
Material	P45



Inductor	
Core type	EF25
Material	P45
Value	690uH

Winding	Turns	Start Pin	End Pin	Wire	Layers	Type	Purpose
W1a	20	5	4	0.33mm x 2strands	1	ECW	Primary
Tape	1						
W2a	22	6	8	0.6mm	1.25	TEXE	Secondary
W2b	22	8	7	0.6mm	1.25	TEXE	Secondary
Tape	1						
W1b	19	4	2	0.33mm x 2strands	0.9	ECW	Primary
Tape	1						

Winding	Turns	Wire	Inductance
W1	105T	0.1mm x 30strands	690uH +/- 3% ECW Grade 2

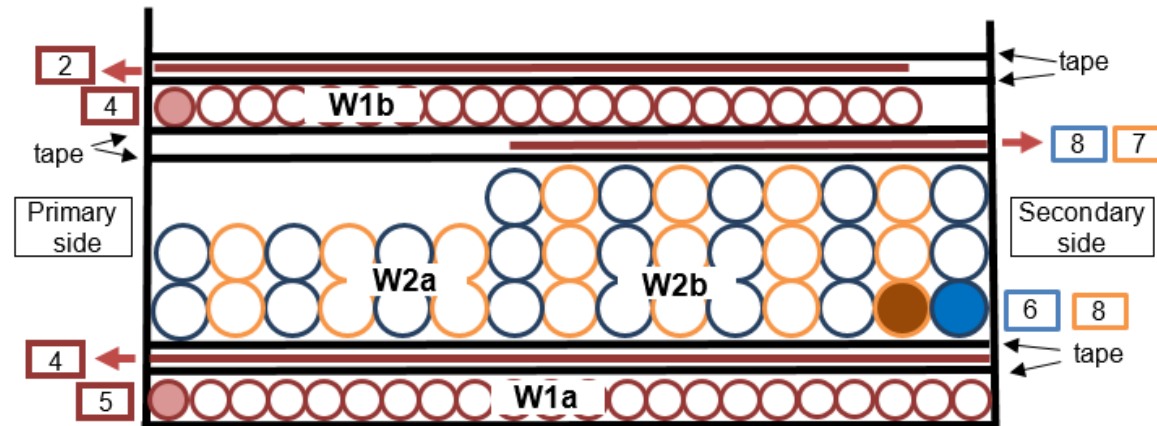
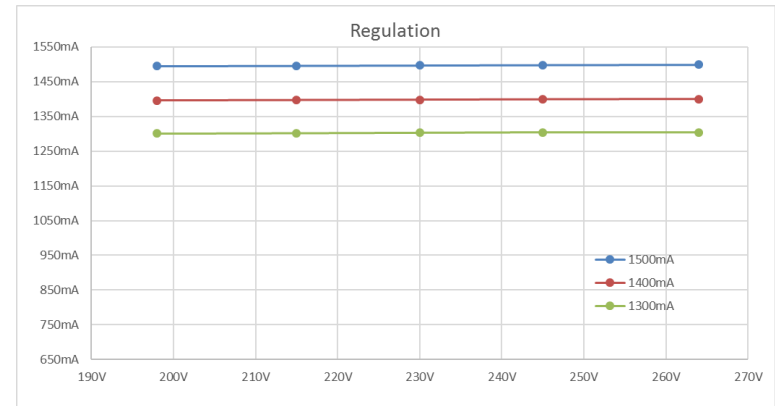
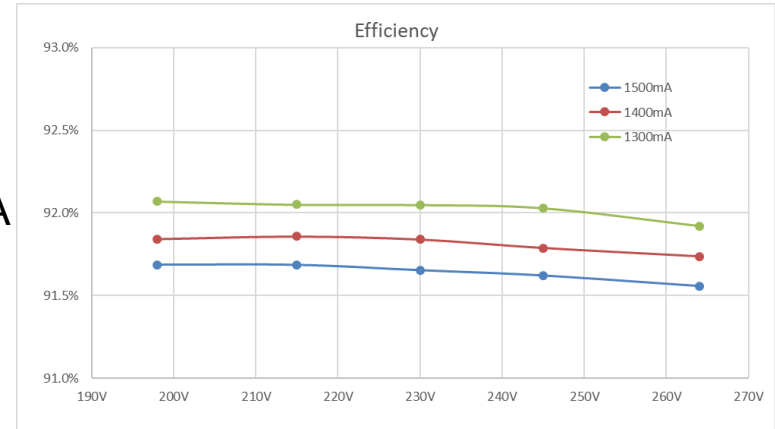
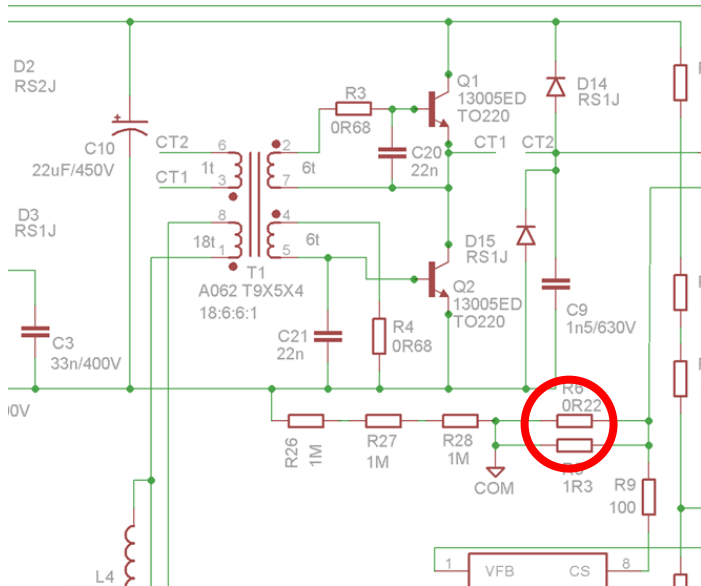


Figure 2: Transformer Winding Arrangement

Modify output current



Only need to change the CS resistor to control the output current from 1500mA to 1300mA

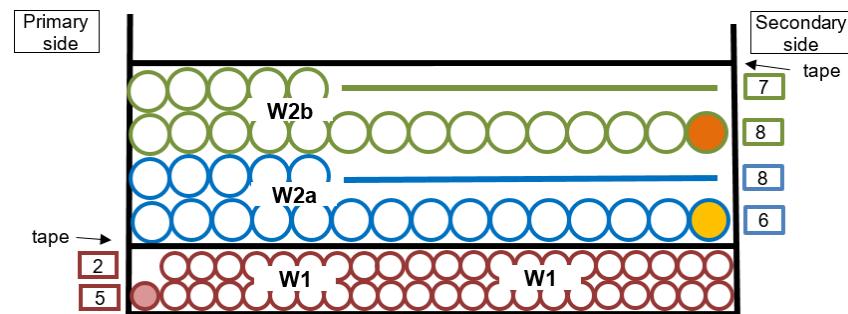
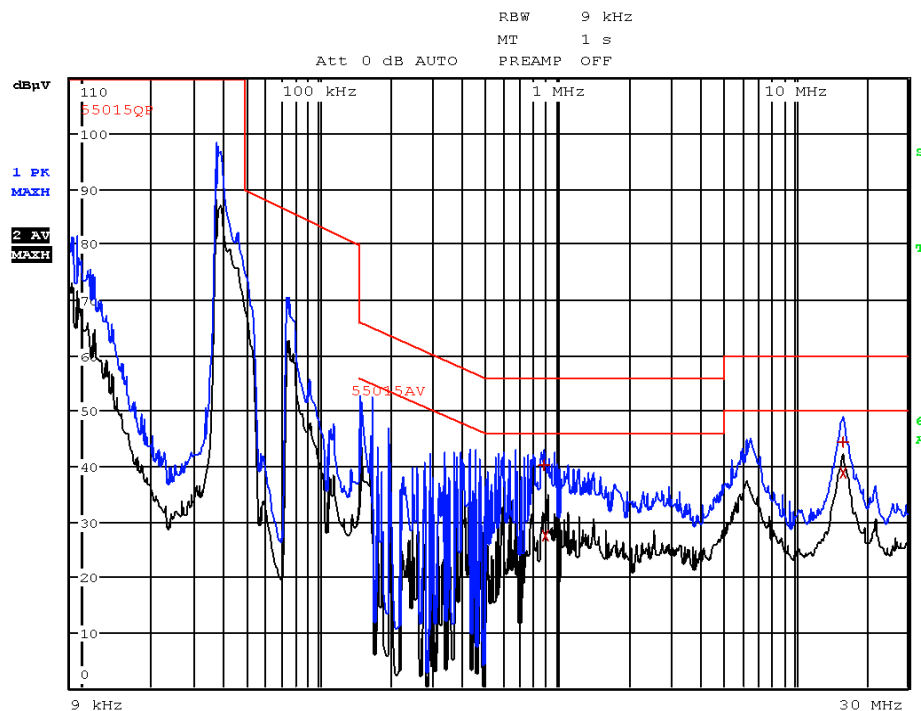


Design current	Changes		THD @ 230V & 36V	Efficiency @ 230V & 36V	Output range for good Harmonic	VHT @ 33V & 264VAC	Remarks
	C3	R5&6					
1500mA	33n	1R3 & 0R22	6.7%	91.7%	33 - 40V	416.7	Original driver
1400mA	33n	2R4 & 0R22	7.9%	91.8%	30 - 40V	407.8	Efficiency rises as power reduces
1300mA	33n	1R1 & 0R27	10.6%	92.0%	30 - 40V	400.7	

No CM choke option

No CM choke option can be accomplished by using a non-split primary transformer. The trade-off is worse EMI performance but cheaper BOM.

>10dB Margin Pass



Non-split Primary Transformer Winding

Conducted EMI 9k~30MHz
Driver located on LED panel

Basedrive Transformer



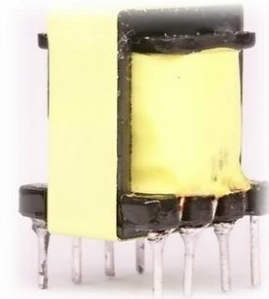
RediSem recommends ACME A062 T9x5x4

- Complete wound & varnished base-drive transformer
- Made to RediSem specs
- Qualified and tested turn-key solution



EE10 option for in-house manufacturing

- Base-drive transformer using EE10 core
- Contact RediSem for design information





RED2521

LED Controller for LLC converters

Features

- Advanced LED Controller IC for high efficiency low-cost LLC converters with bipolar transistors and integrated PFC
- Improved CC regulation for zero flicker
- PSR - +/-5% Primary Side Regulation of LED current and voltage with no Flicker
- 50% duty cycle, variable frequency control of resonant half-bridge
- Automatic dead-time control and capacitive mode protection
- Protection modes:
 - Overload
 - No-Load
 - Internal Over-temperature
 - External Over-temperature (NTC)
- Low output capacitance allows live LED connection
- Very low output current ripple – 0.5%
- Small SO8 IC package



SO8

Applications

- Single stage PFC LED drivers without flicker
- CC LED drivers up to 100W
- Pin compatible with RED2511

Order code

Part Number	Package	Packaging
RED2521AD-TR13	SO8	Tape and reel

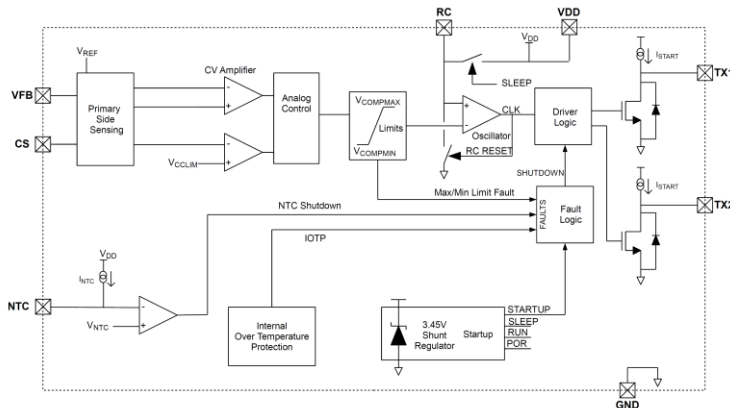


Figure 1: Block diagram



RED2521 LED LLC Controller

Device Pins

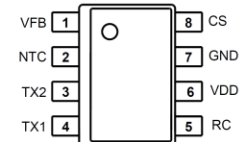
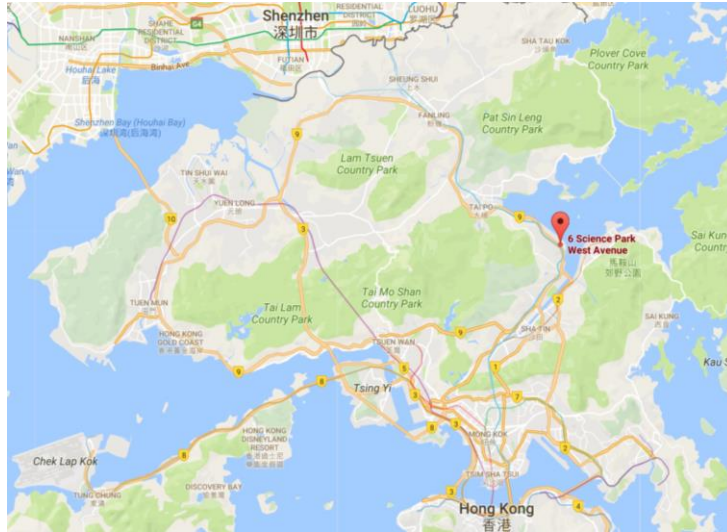


Figure 2: SO8 pin connections (top view)

Pin Functions

Pin #	Name	Function
1	VFB	PSR Feedback input for output voltage regulation. Connect to primary sense winding.
2	NTC	Shutdown pin that can be used for over-temperature protection with an external NTC resistor. A voltage of $<V_{NTC}$ will shut the IC down. Pin also includes a current source.
3	TX2	Output to control transformer.
4	TX1	Output to control transformer.
5	RC	External RC network sets the minimum [full power] switching frequency.
6	VDD	IC Power Supply pin – nominally 3.45V
7	GND	Chip ground.
8	CS	PSR Current Sense input provides output current regulation and cycle-by-cycle over-current protection. The CS pin is connected to the half-bridge current sense resistor

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