R2A20135EVB-ND1

R2A20135 Evaluation Board

R19AN0012EJ0200
Rev.2.00
Jul 31, 2013

1. General Description

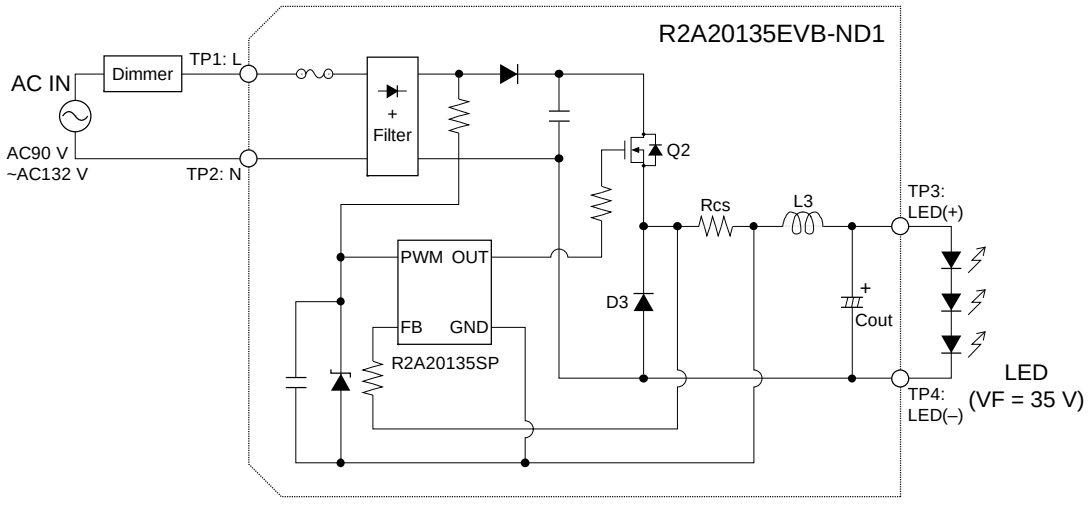
R2A20135EVB-ND1 is an evaluation tool for evaluating LED control IC R2A20135. As all of the parts and the peripheral circuit which are necessary for LED lighting control are built on this evaluation board, R2A20135 can be evaluated with just only supplying AC power source and connecting LED load.

Since this evaluation board is composed as Step-down/High-side (non-isolated), it achieves high efficiency, high power factor, low THD (total harmonic distortion) and low output current ripple. Furthermore, phase cut dimming is supported with dimmable function built in R2A20135. For using this board, please also refer the R2A20135SP datasheet and application note.

2. Specifications

No.	Item	Specification
1	Input voltage range	AC90 to 132 V (single phase 47 to 63 Hz)
2	Input power	9.1 W (typ.)
3	Output voltage (VF)	DC35 V
4	Output current	220 mA (typ.)
5	Efficiency	85% < (@Vin = AC100 V)
6	Power factor	0.9 < (@Vin = AC90 V to 132 V)
7	Switching frequency	62 kHz
8	Operational mode	Current discontinuity (Fixed switching frequency)
9	PCB	Dual layers / Glass epoxy (FR4) / Dual-sided mount
10	Size (W × D × H)	36 mm × 36 mm × 20 mm (Top layer)

3. System Diagram & Connection



Connecting steps:

(1) LED load (VF = 35 V, not less than 220 mA of current ratings) is connected to TP3 and TP4.
(2) AC power supply is connected to TP1 and TP2. When connecting, it is cautious of the polarity of LED.

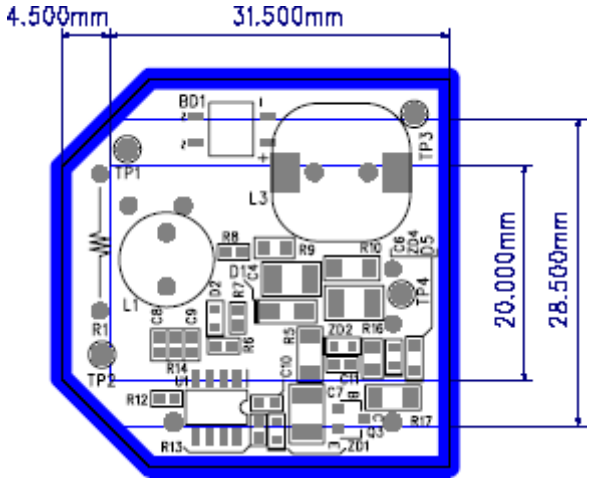
Note: When you use this evaluation board, please use connecting LED load to an output terminal (TP3, TP4). It is no-load, and output voltage will not be stabilized if it is made to operate. Parts may be damaged when the worst.

⚠ High voltages are produced in parts of the board. Take care of this point when using the board.

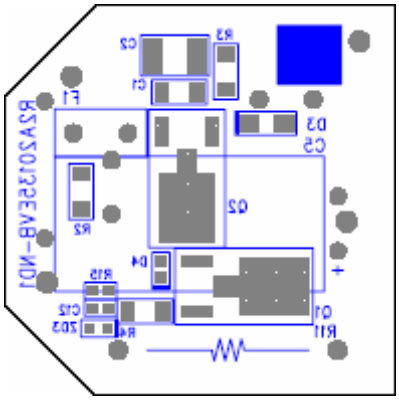
4. PCB Layout

4.1 Parts Layout

• Mounting layer

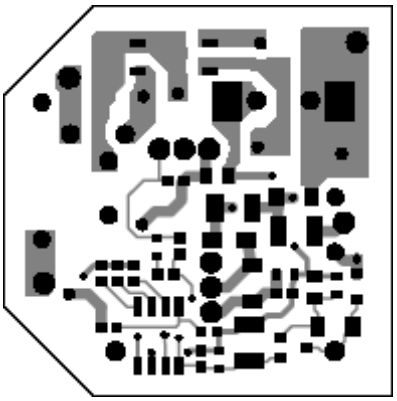


• Soldering layer

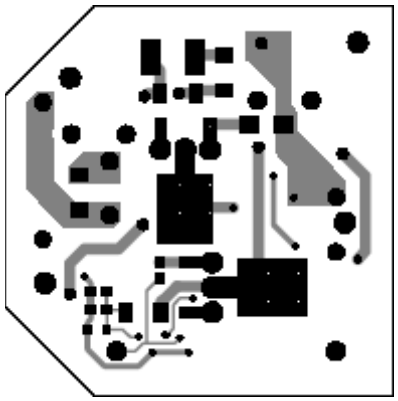


4.2 PCB Layout

• Mounting layer



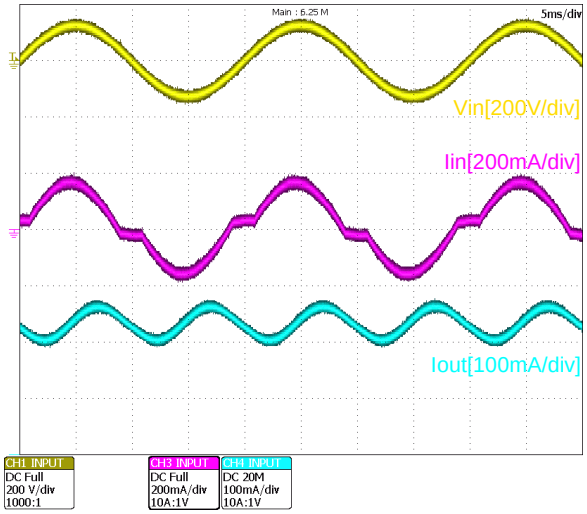
• Soldering layer



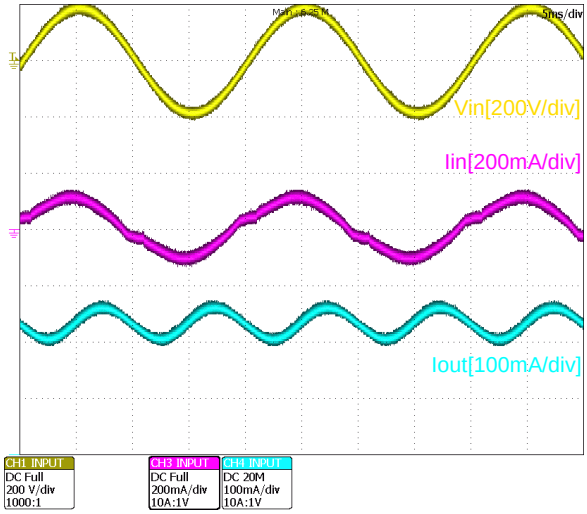
5. Performance Characteristics

5.1 Waveforms

• Vin = AC90 V, VF = 35 V, Iout = 220 mA

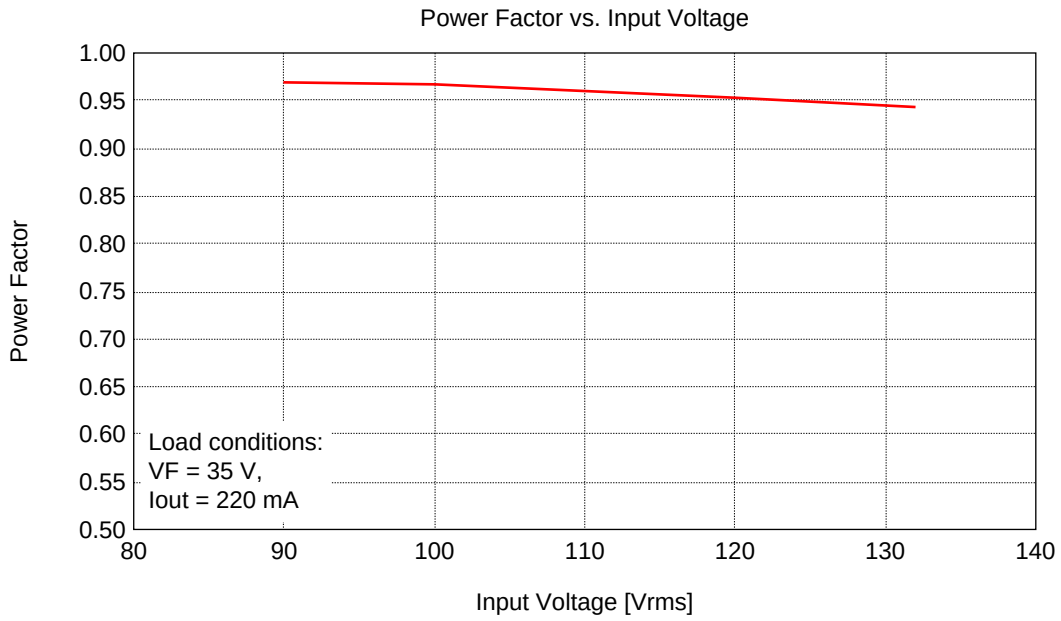


• Vin = AC132 V, VF = 35 V, Iout = 220 mA

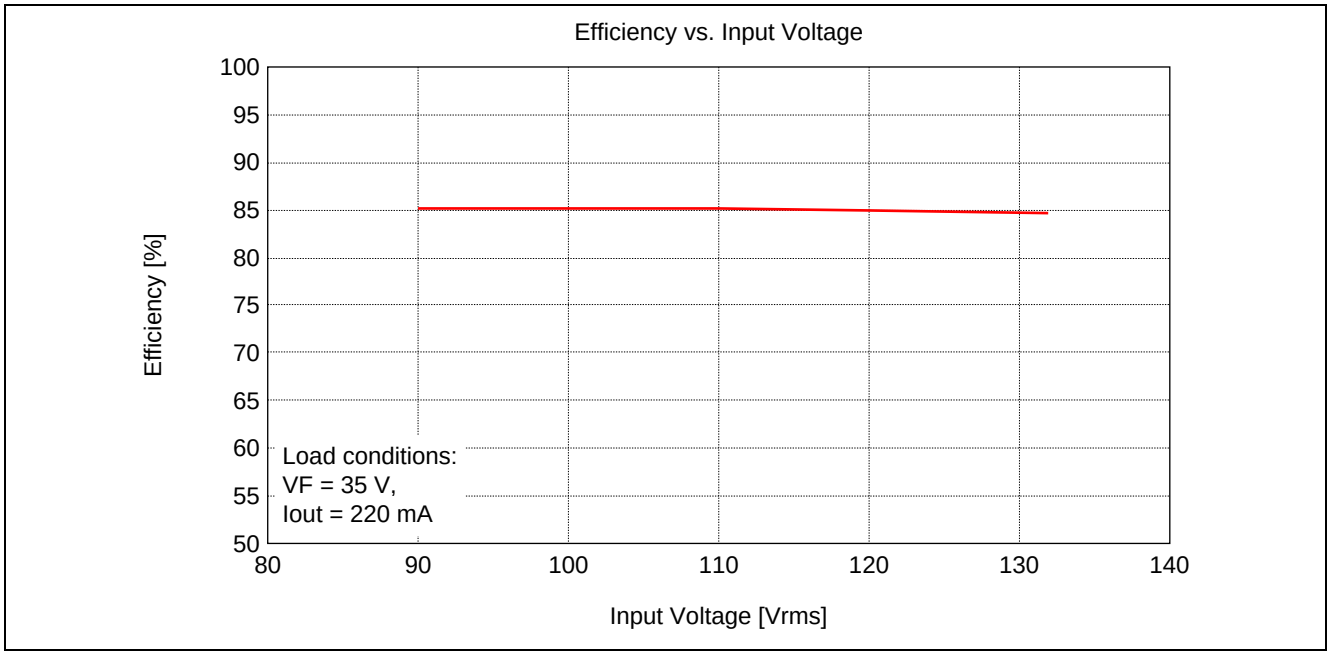


* Vin: Input voltage, Iin: Input current, Iout: Output current

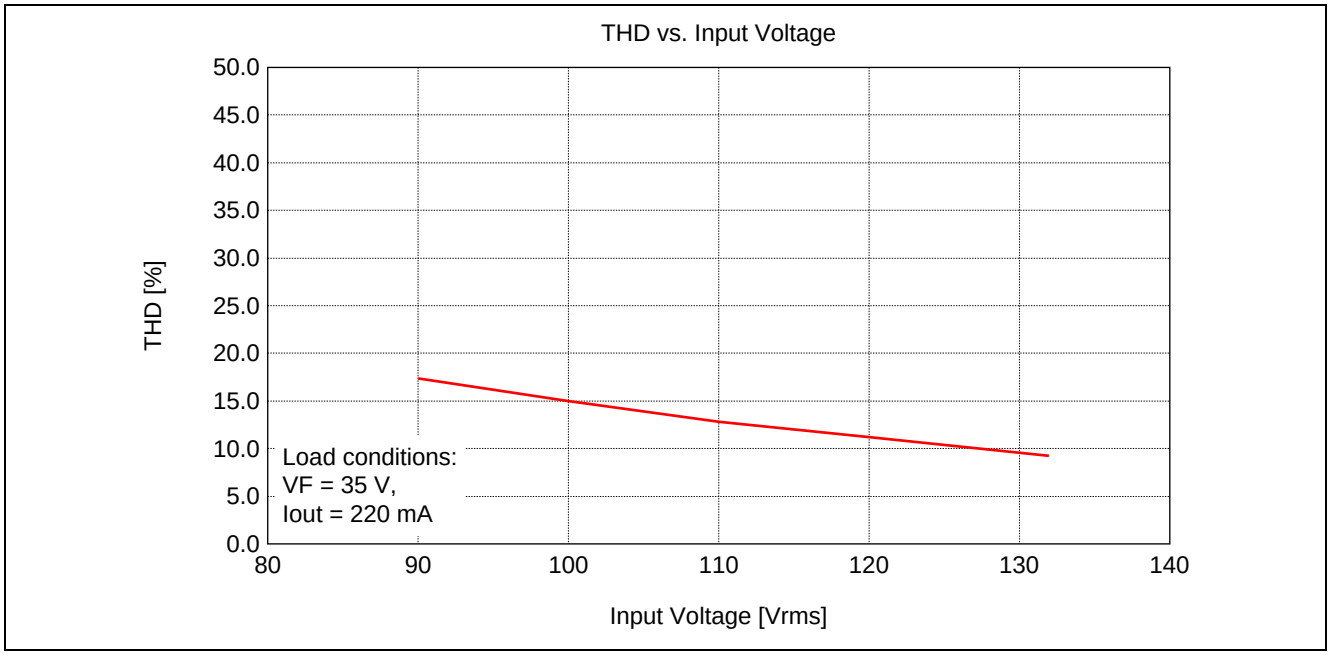
5.2 Power Factor



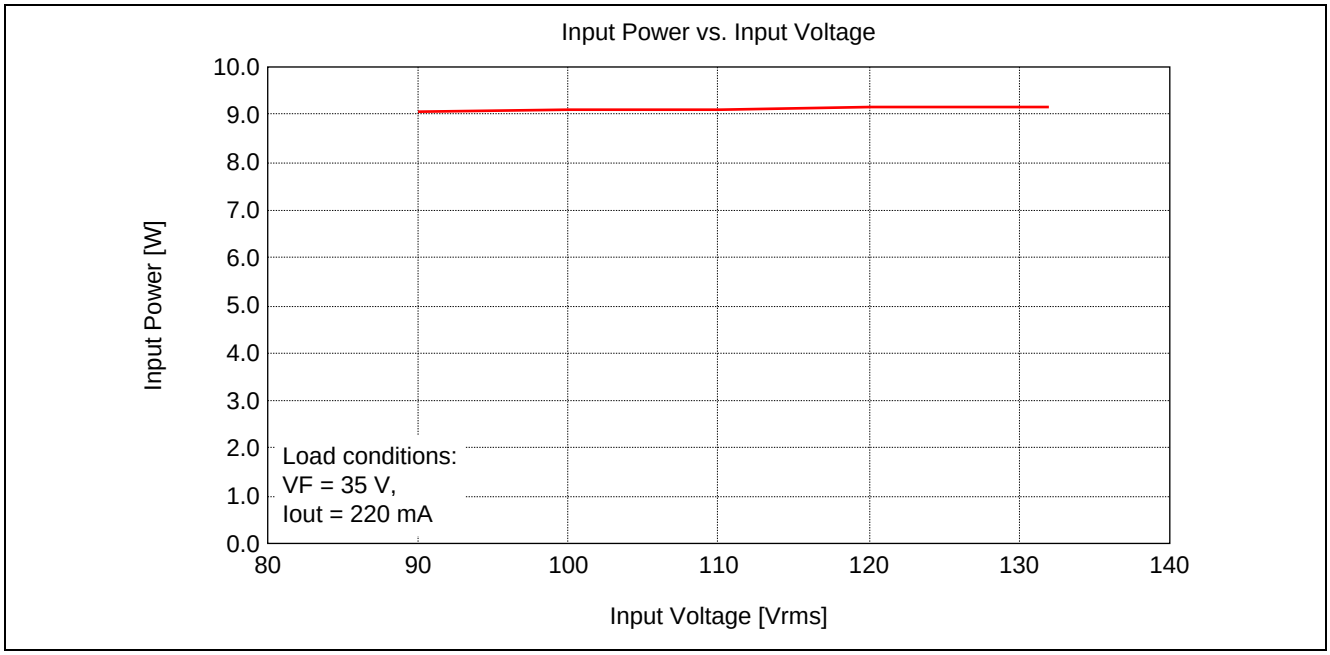
5.3 Efficiency



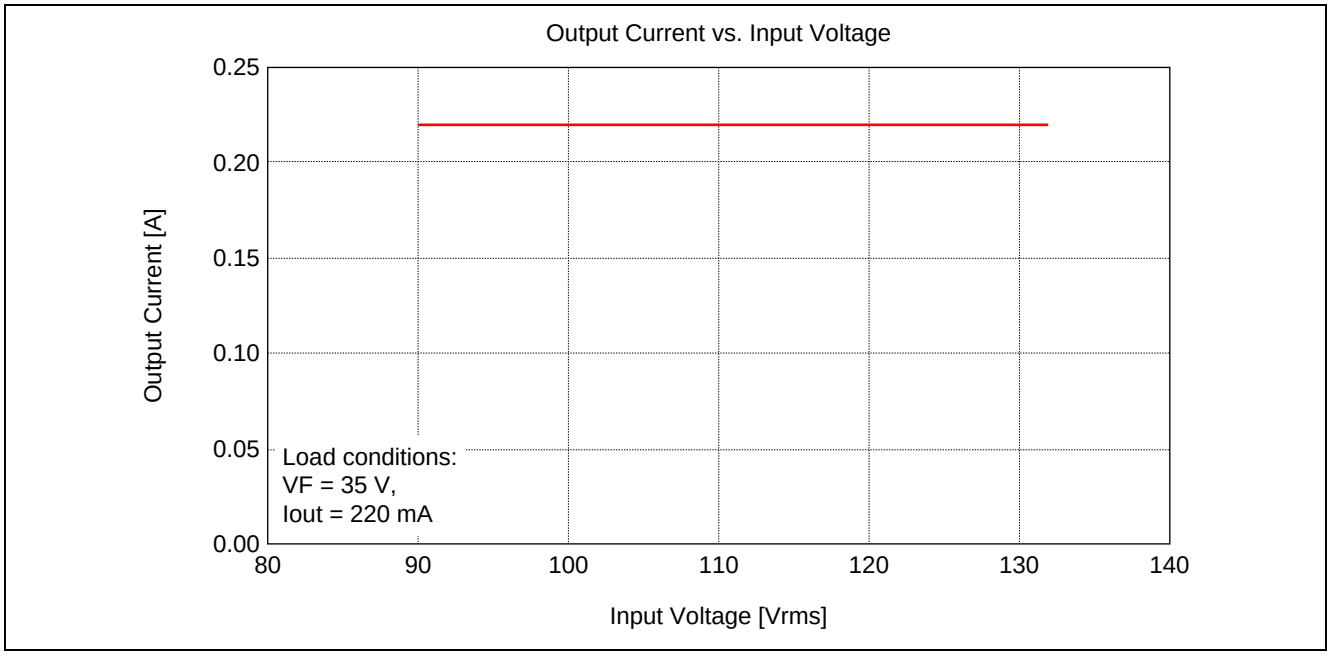
5.4 THD (Total Harmonic Distortion)



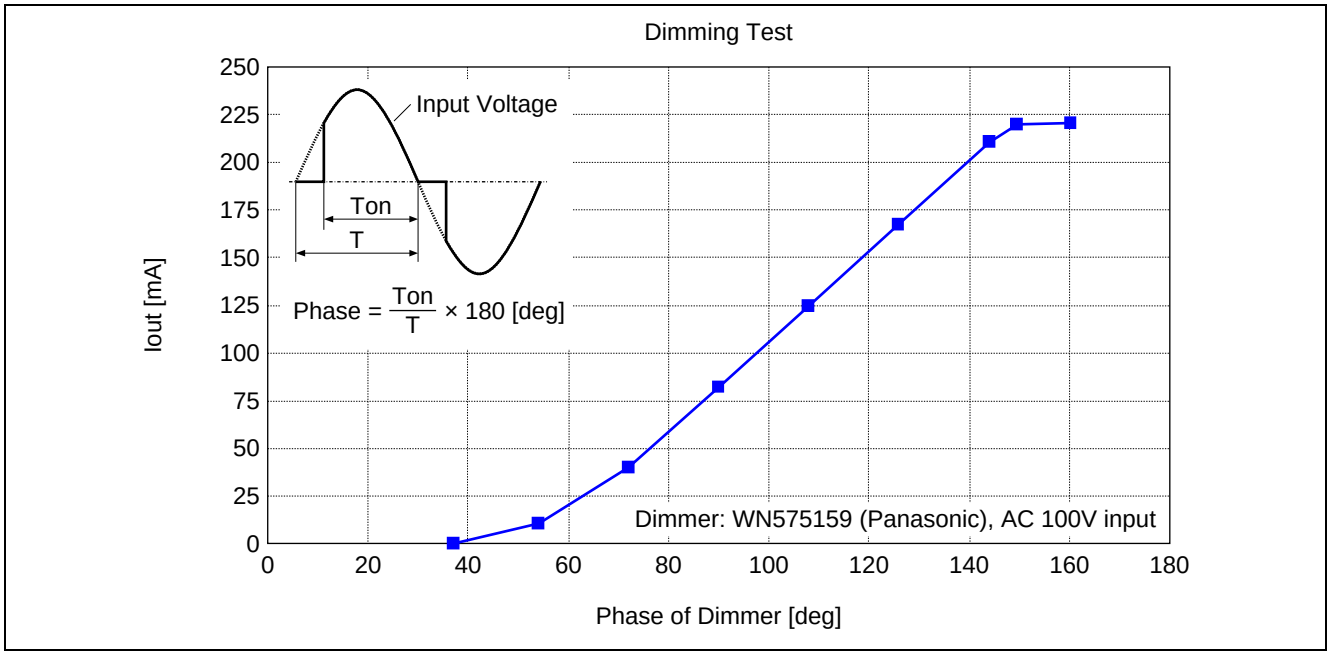
5.5 Input Power



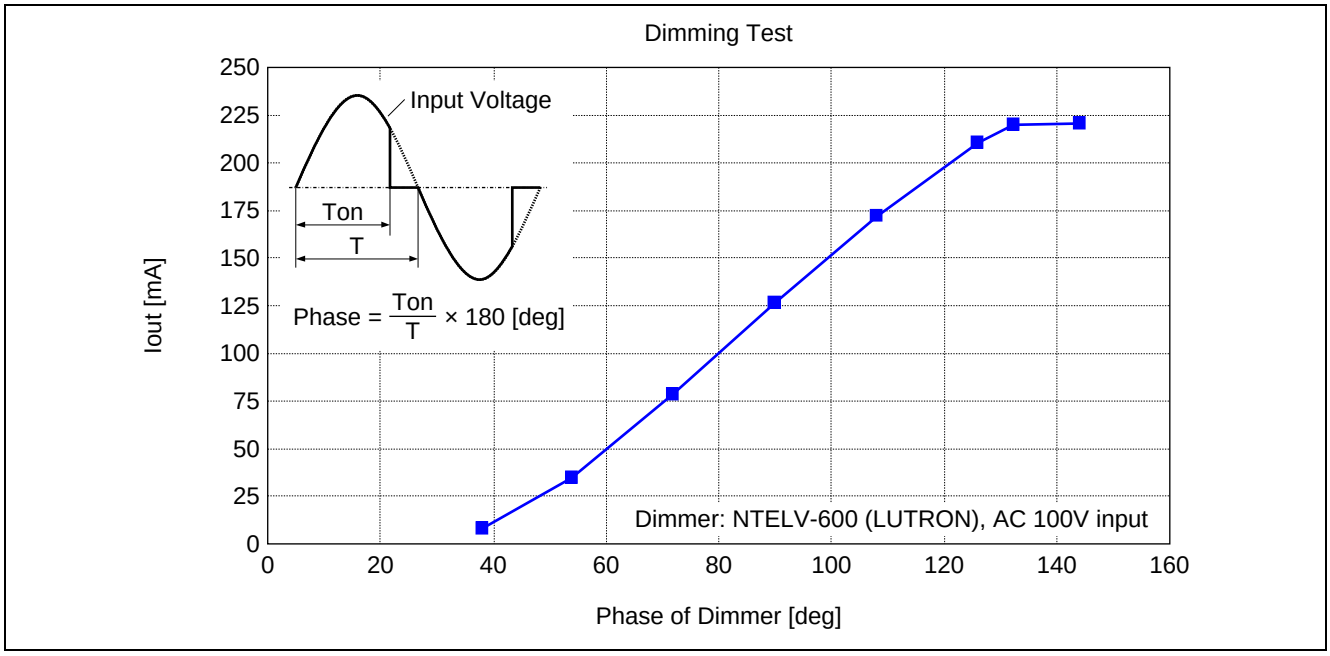
5.6 Output Current



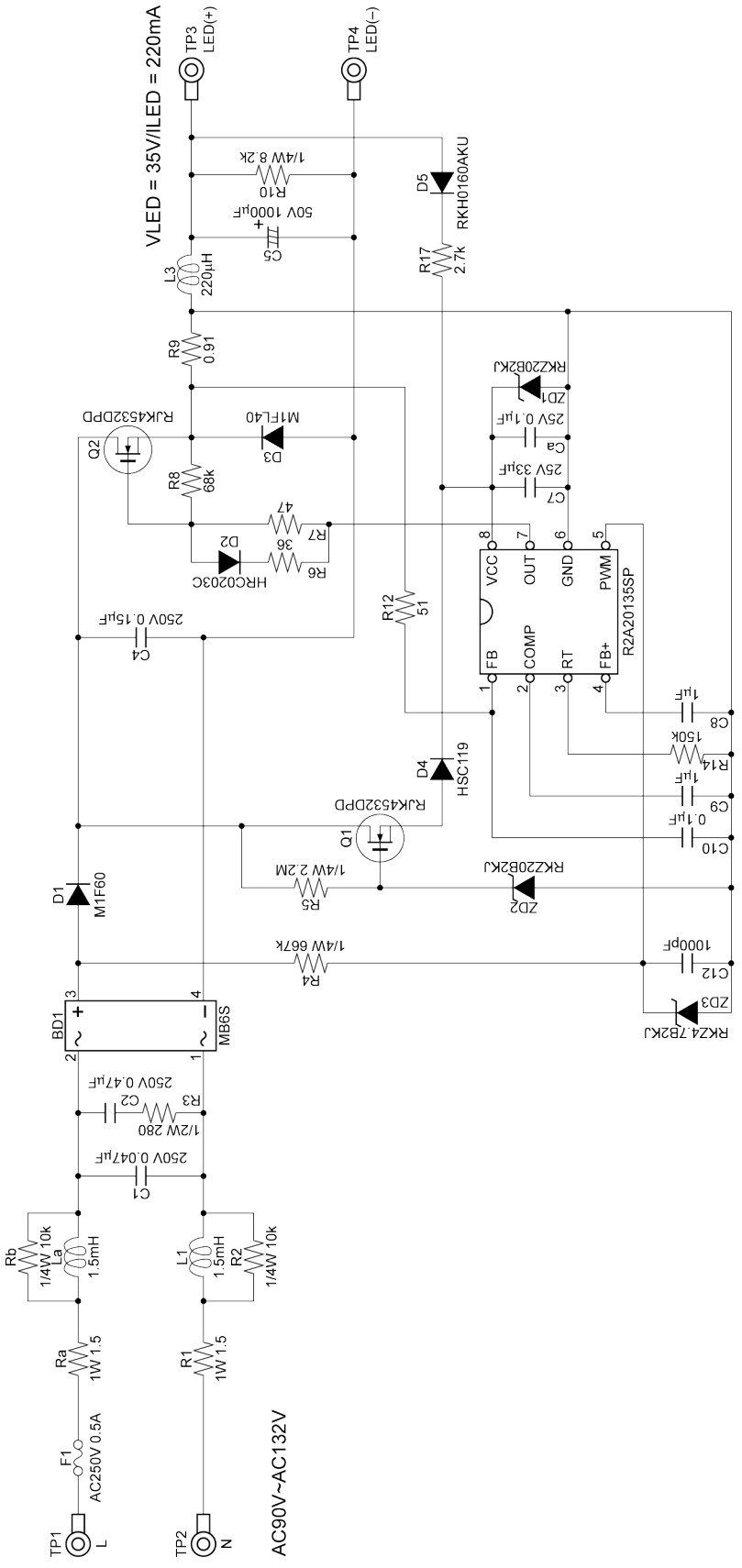
5.7 Dimming Characteristic (Leading edge dimmer)



5.8 Dimming Characteristic (Trailing edge dimmer)



6. R2A20135EVB-ND2 Schematic



Note: The circuit conditions might be possibly changed for improving the performance.

7. Design Guide

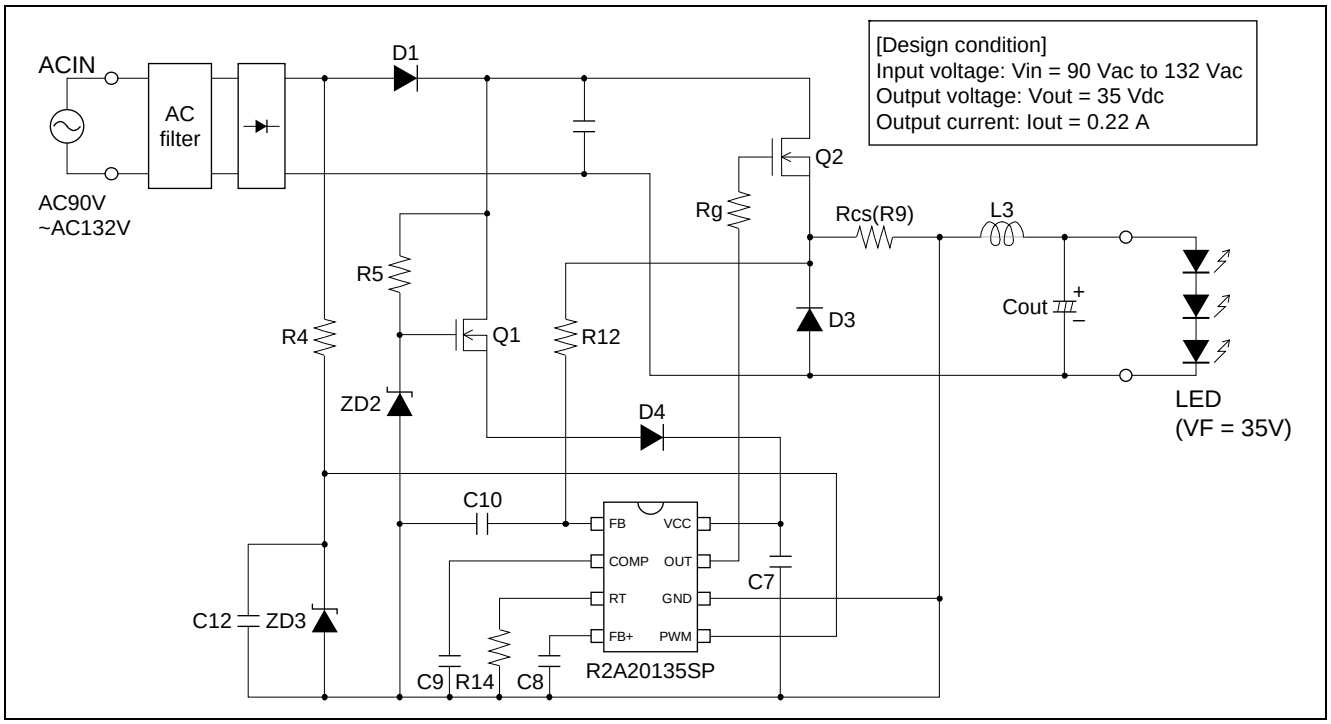


Figure 7.1 R2A20135EVB-ND1 Schematic

In frequency fixation and average current control, it becomes a control system which makes input electric power regularity.
In this case, the current which flows into the inductor L3 becomes discontinuous, as shown in the following figure.

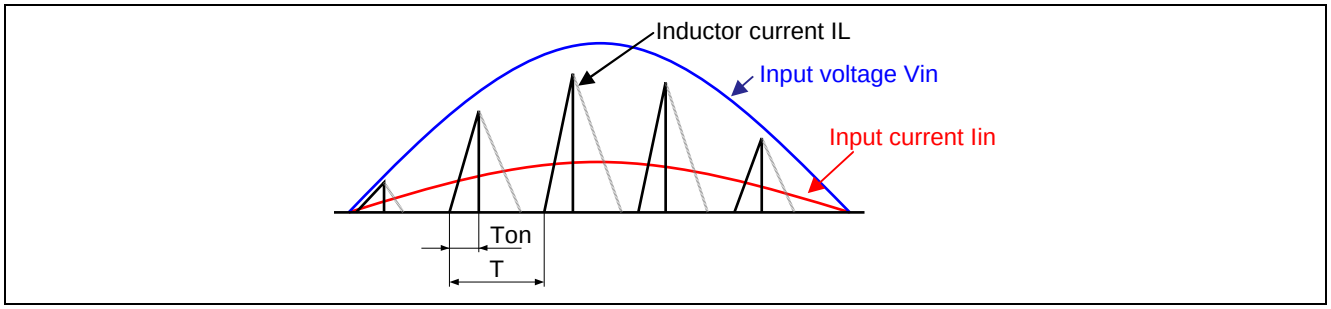


Figure 7.2 Input Current & Inductor Current

7.1 The Choice of Fixed-Frequency

To avoid the listenable frequency range, and in consideration of efficiency, it designs or less than 100 kHz. We choose 60 kHz as an example. (20 kHz or more)

7.2 Calculation of the Resistance Rrt for Setting the Frequency

It is calculated with 157 kW from the following formula, and 150 kW is selected.
The frequency at this time is set to 62 kHz.

$$Rrt[kW] = \frac{(1/fout[kHz]) - (200 \times 10^{-6})}{105 \times 10^{-9}}$$

7.3 Setting Rcs

The relation between output current Iout and Rcs is in following formula;

Rcs = 0.204/Iout

when the design condition is Iout = 0.22 A, Rcs will be;

Rcs = 0.204/0.22 = 0.93 W

7.4 Selecting Inductor L

In order to compute the maximum on-duty.
Critical conditions are searched for first.
As severest conditions, if the minimum value of Vin shall be 90 Vac and Vout is set to 35 V, it is the on-duty D_{ON}.

D_{ON} = Vout/(Vin) = 35/(90 ´ 1.414) = 0.275

Note: *1 When D_{ON} exceeds 0.5 on condition of the Vin minimum and the Vout minimum, it calculates as D_{ON} = 0.5.

When frequency is 62 kHz, it is the ON time Ton,

Ton = D_{ON}/fout = 0.275/62 kHz = 4.44 ms

If it is input voltage Vin = 90 V, output electric power Pout = 0.22 ´ 35 = 7.7 W, and 82% of conduction angle (*2), it is the average input current Iin (ave),

Iin(ave) = Pout/h/Vin = 7.7/0.82/90 = 104 mA

The peak value of coil current,

IL(peak) = Iin(ave) ´ 2/D_{ON} = 0.104 ´ 2/0.275 = 0.756 A

From this result,

L = (Vin – Vout) ´ Ton/Iin(peak) = (90 ´ 1.414 – 35) ´ 4.44 ms/0.756 = 542 mH

Since it will become discontinuous operation if it is the inductance below this value, 220 mH is chosen from the lineup of standard inductance in consideration of a permissible error, size, etc.

Note: *2 Please refer to another data (R2A20135SP Application Note, Selection of the inductance L) for a conduction angle.

7.5 FB, COMP External Circuitry

The frequency characteristic of R2A20135EVB-ND1 is shown in the following figure.
Since this is the composition in current mode (single capacity lag system), it operates stably, but in order to improve power factor, please set up the value of Ccomp so that a loop gain is set to 0 dB below by AC frequency: 50 to 60 Hz twice (100 to 120 Hz). The value of Ccomp is set to 1 mF with the evaluation board.
Moreover, when operation is affected by a switching noise etc., it is CR filter (Cf1, Rf1) to FB pin. Please insert. 51 W and 0.1 mF are beforehand mounted in EVB.

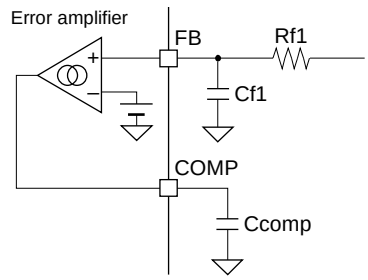


Figure 7.3 External Circuit for FB & COMP Terminals

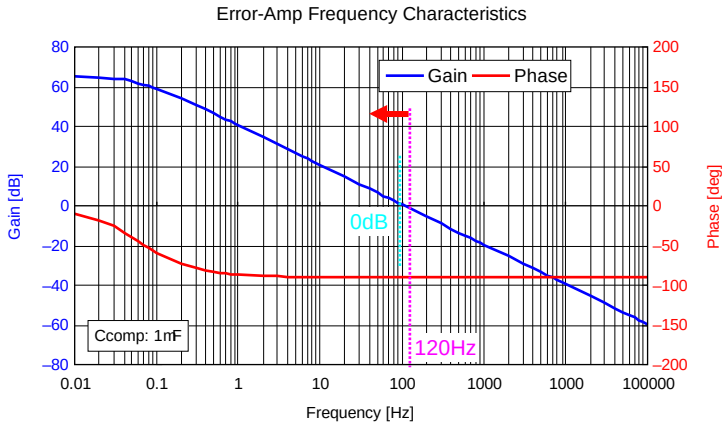
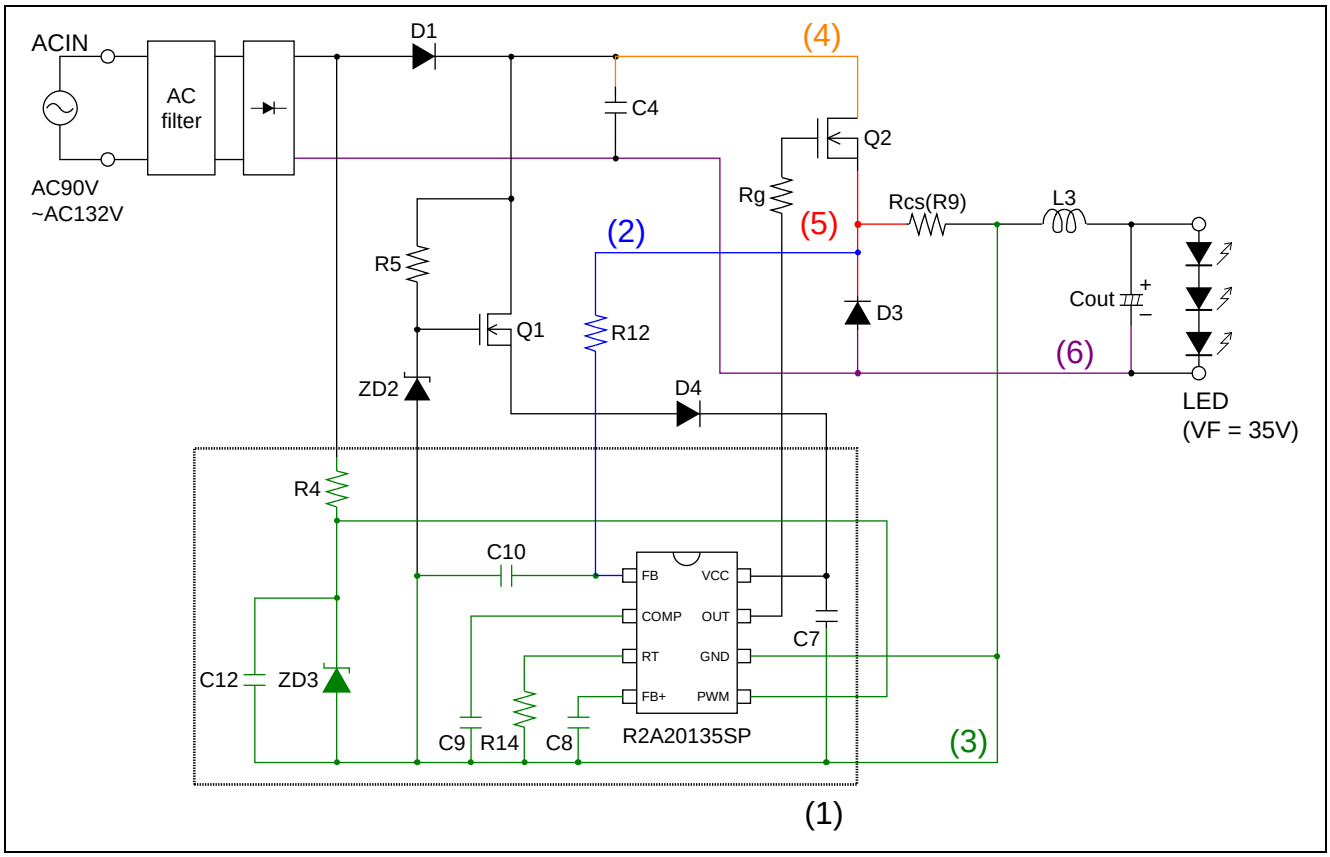


Figure 7.4 R2A20135EVB-ND1 Frequency Characteristics

8. PCB Layout Guide



(1) It is subject to the influence of a switching noise. Wiring of the circumference of IC is made into the minimum length.
(2) CS line wires short by connecting with the Rcs latest.
(3) Wire the GND line of the IC with a single thick pattern to the Rcs Resistor (Output side). Also place the bypass capacitors (C7) for VCC and resistor of RT, FB (R14, R12) as close to the IC as possible.
(4) Wiring between Q2 (Drain) and C2 (+) is shortened thickly.
(5) Wiring between Q2 (Source) and D3 (Cathode) is shortened thickly.
(6) Since switching current flows, it shortens thickly.

9. Bill of Materials

Symbol	Parts Name	Catalog No.	Q	Rating		Manufacturer	Note
PWB	Printed-wiring board	R2A20135EVB-ND1	1			Renesas Electronics	
U1	IC	R2A20135SP	1	24V		Renesas Electronics	SOP-8
Q1	FET	RJK4532DPD	1	450V	4A	Renesas Electronics	TO-252 (DPAK)
Q2	FET	RJK4532DPD	1	450V	4A	Renesas Electronics	TO-252 (DPAK)
Q3	TRS	No mount					
BD1	Bridge diode	MB6S	1	600V	0.5A	VISHAY	TO-269AA (MBS)
D1	Diode	M1F60	1	600V	1A	Shindengen	M1F
D2	SBD	HRC0203C-E	1	30V	0.2A	Renesas Electronics	UFP
D3	FRD	M1FL40	1	400V	1.5A	Shindengen	M1F
D4	Diode	HSC119	1	80V	100mA	Renesas Electronics	UFP
D5	Diode	RKH0160AKU	1			Renesas Electronics	
ZD1	Zener diode	RKZ20B2KJ	1	20V	5mA	Renesas Electronics	UFP
ZD2	Zener diode	RKZ20B2KJ	1	20V	5mA	Renesas Electronics	UFP
ZD3	Zener diode	RKZ4.7B2KJ	1	4.7V	5mA	Renesas Electronics	UFP
ZD4	Zener diode	No mount					UFP
Ra	Resistor	MOSX1CT52A1R5J	1	1W	1.5	KOA	Leaded
R1	Resistor	MOSX1CT52A1R5J	1	1W	1.5	KOA	Leaded
Rb	Chip resistor	KTR18EZPJ103	1	1/4W	10k	Rohm	3216
R2	Chip resistor	KTR18EZPJ103	1	1/4W	10k	Rohm	3216
R3-1	Chip resistor	KTR18EZPJ561	1	1/4W	560	Rohm	3216, paralleling
R3-2	Chip resistor	KTR18EZPJ561	1	1/4W	560	Rohm	3216, paralleling
R4-1	Chip resistor	KTR18EZPJ105	1	1/4W	1M	Rohm	3216, paralleling
R4-2	Chip resistor	KTR18EZPJ205	1	1/4W	2M	Rohm	3216, paralleling
R5	Chip resistor	KTR18EZPJ225	1	1/4W	2.2M	Rohm	3216
R6	Chip resistor	MCR03EZPFX36R0	1	1/10W	36	Rohm	1608
R7	Chip resistor	MCR03EZPFX47R0	1	1/10W	47	Rohm	1608
R8	Chip resistor	MCR03EZPFX6802	1	1/10W	68k	Rohm	1608
R9	Chip resistor	RL1220S-R91-F	1	1/4W	0.91	Rohm	2012
R10	Chip resistor	MCR18ERTJ822	1	1/4W	8.2k	Rohm	3216
R11	Resistor	No mount					Leaded
R12	Chip resistor	MCR03EZPFX51R0	1	1/10W	51	Rohm	1608
R13	Chip resistor	No mount					1608
R14	Chip resistor	MCR03EZPFX1503	1	1/10W	150k	Rohm	1608
R15	Chip resistor	No mount					1608
R16	Chip resistor	MCR25JZHJ000	1	1/2W	0	Rohm	3225
R17	Chip resistor	MCR18ERTJ272	1	1/4W	2.7k	Rohm	3216
Q3 B-E	Chip resistor	MCR03ERTJ000	1	1/10W	0	Rohm	1608
Ca	Ceramic capacitor	GRM188B11E104KA01	1	25V	0.1mF	murata	1608
C1	Ceramic capacitor	GR331BD72E473KW01L	1	250V	0.047mF	murata	3216
C2	Ceramic capacitor	GRJ43DR72E474KWJ1L	1	250V	0.47mF	murata	4532
C4	Ceramic capacitor	GR332DD72E154KW01L	1	250V	0.15mF	murata	3225
C5	Electrochemical capacitor	ECA1HHG102	1	50V	1000mF	Panasonic	f 12.5´ 25, 105°C
C6	Ceramic capacitor	No mount					2012
C7	Electrochemical capacitor	UPV1E330MFD	1	25V	33mF	nichicon	f 5´ 10, 105°C
C8	Ceramic capacitor	GRM188B31E105KA75B	1	25V	1mF	murata	1608
C9	Ceramic capacitor	GRM188B31E105KA75B	1	25V	1mF	murata	1608
C10	Ceramic capacitor	GRM188B11E104KA01	1	25V	0.1mF	murata	1608
C11	Ceramic capacitor	No mount					1608
C12	Ceramic capacitor	GRM1882C1E102JA01	1	25V	1000pF	murata	1608
L1	Inductor	TSL0808S-152KR21-PF	1	0.21A	1.5mH	TDK	
L2	Inductor	TSL0808S-152KR21-PF	1	0.21A	1.5mH	TDK	
L3	Inductor	#B953AS-221M	1	1A	220mH	TOKO	
F1	Fuse	HTS 500mA	1	AC250V	0.5A	Skygate	

Note: The parts might be possibly changed for improving the performance.

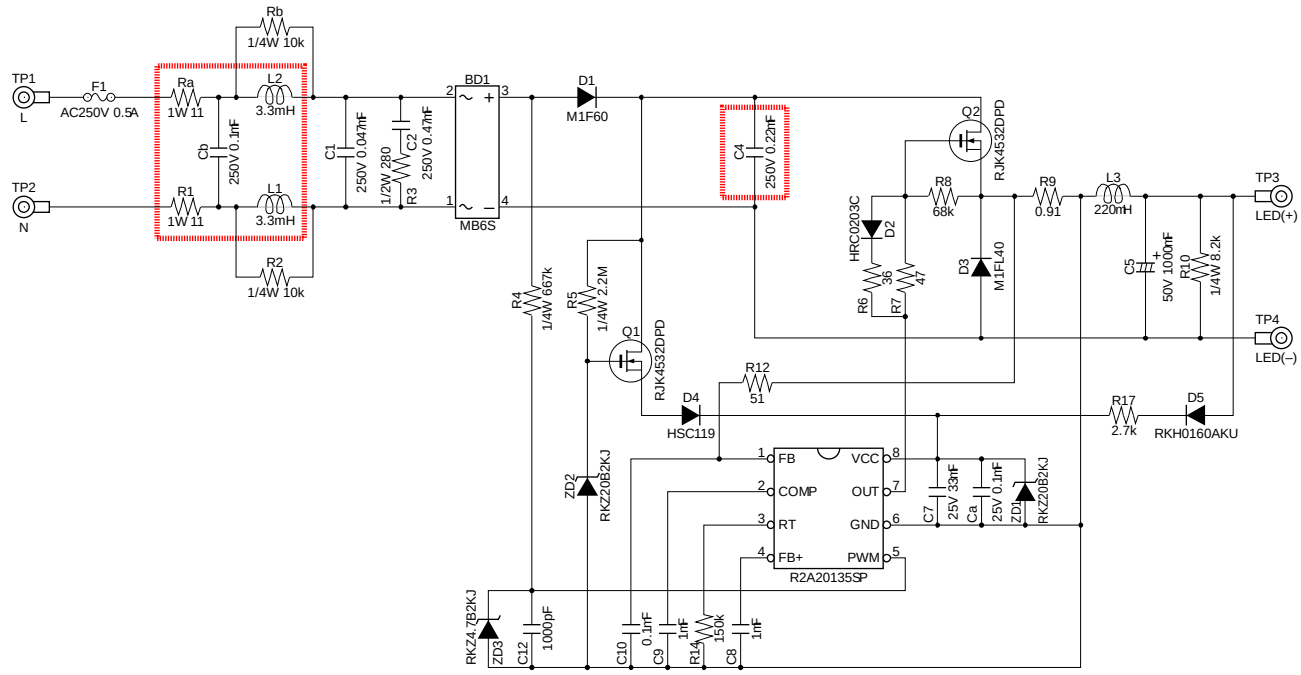
10. Conducted Emission

10.1 Conducted Emission Standard (CISPR15) Adaptation

This evaluation board is possible to meet the conducted emission standard (CISPR15) by changing or adding some components.

However, basic characteristics such as power efficiency or power factor are trade-off for conducted emission, please adjust each components' value according to required performance.

10.1.1 Schematic with Conducted Emission Filter



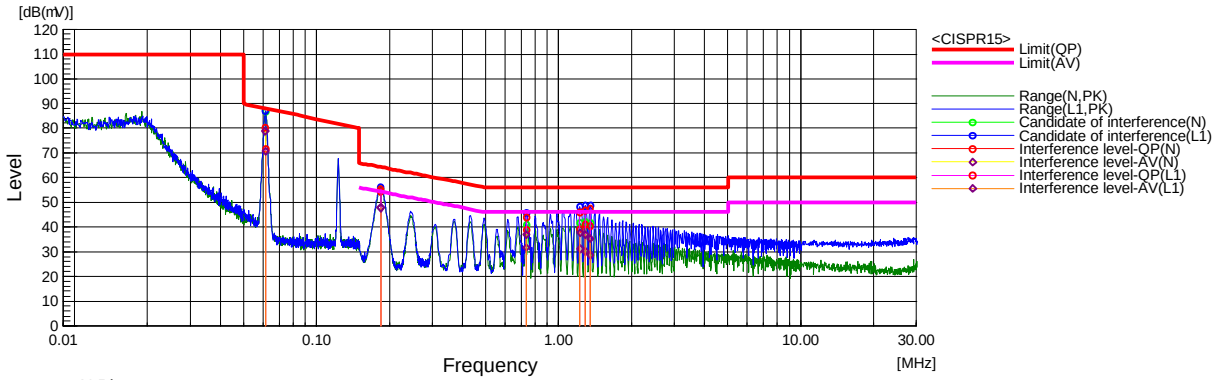
Note: : Additional/changed components

10.1.2 Additional/Changed Parts to Meet Conducted Emission Standard

Symbol	Parts Name	Catalog No.	Q	Rating		Manufacturer
Ra	Resistor	MOS1CT52A110J	1	1 W	11	KOA
R1	Resistor	MOS1CT52A110J	1	1 W	11	KOA
Cb	Ceramic capacitor	GRJ31CR72E104KWJ3L	1	250 Vdc	0.1 mF	murata
C4	Ceramic capacitor	GRJ32DR72E224KWJ1L	1	250 Vdc	0.22 mF	murata
L1	Inductor	TSL0808S-332KR14-PF	1	0.14 A	3.3 mH	TDK
L2	Inductor	TSL0808S-332KR14-PF	1	0.14 A	3.3 mH	TDK

10.2 Conducted Emission Test Results (CISPR15)

· Vin = AC100 V, 60 Hz, LED load (VF = 35 V), Iout = 220 mA



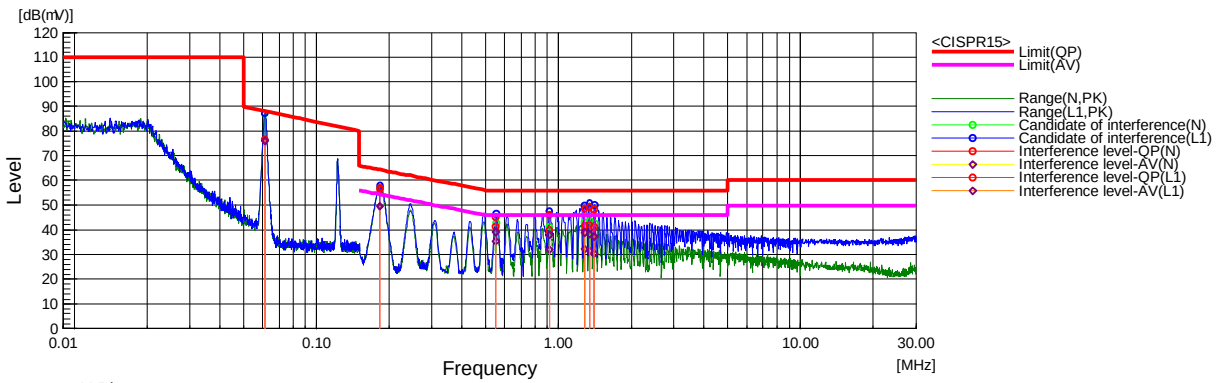
---N Phase ---

No.	Frequency [MHz]	Reading QP [dB(mV)]	Reading CAV [dB]	c.f [dB(mV)]	Result QP [dB(mV)]	Result CAV [dB(mV)]	Limit QP [dB(mV)]	Limit AV [dB(mV)]	Margin QP [dB]	Margin CAV [dB]
1	0.06129	70.2	68.7	10.0	80.2	78.7	88.1		7.9	
2	0.1838	44.3	37.8	10.1	54.4	47.9	64.3	54.3	9.9	6.4
3	0.73582	28.7	21.5	10.2	38.9	31.7	56.0	46.0	17.1	14.3
4	1.22699	29.1	21.0	10.2	39.3	31.2	56.0	46.0	16.7	14.8
5	1.28551	30.8	20.0	10.2	41.0	30.2	56.0	46.0	15.0	15.8
6	1.34795	30.3	18.5	10.2	40.5	28.7	56.0	46.0	15.5	17.3

---L1 Phase ---

No.	Frequency [MHz]	Reading QP [dB(mV)]	Reading CAV [dB]	c.f [dB(mV)]	Result QP [dB(mV)]	Result CAV [dB(mV)]	Limit QP [dB(mV)]	Limit AV [dB(mV)]	Margin QP [dB]	Margin CAV [dB]
1	0.0615	61.6	60.7	10.0	71.6	70.7	88.1		16.5	
2	0.18374	45.1	37.7	10.1	55.2	47.8	64.3	54.3	9.1	6.5
3	0.73587	33.9	26.6	10.2	44.1	36.8	56.0	46.0	11.9	9.2
4	1.22711	35.8	27.6	10.2	46.0	37.8	56.0	46.0	10.0	8.2
5	1.2878	36.6	26.6	10.2	46.8	36.8	56.0	46.0	9.2	9.2
6	1.34844	37.2	25.2	10.2	47.4	35.4	56.0	46.0	8.6	10.6

· Vin = AC120 V, 60 Hz, LED load (VF = 35 V), Iout = 220 mA



---N Phase ---

No.	Frequency [MHz]	Reading QP [dB(mV)]	Reading CAV [dB]	c.f [dB(mV)]	Result QP [dB(mV)]	Result CAV [dB(mV)]	Limit QP [dB(mV)]	Limit AV [dB(mV)]	Margin QP [dB]	Margin CAV [dB]
1	0.06115	66.6	66.1	10.0	76.6	76.1	88.2		11.6	
2	0.18283	46.3	39.5	10.1	56.4	49.6	64.4	54.4	8.0	4.8
3	0.55011	31.2	25.4	10.1	41.3	35.5	56.0	46.0	14.7	10.5
4	0.91653	29.7	21.7	10.2	39.9	31.9	56.0	46.0	16.1	14.1
5	1.2815	31.5	22.0	10.2	41.7	32.2	56.0	46.0	14.3	13.8
6	1.34343	32.0	21.3	10.2	42.2	31.5	56.0	46.0	13.8	14.5
7	1.40246	30.9	20.1	10.2	41.1	30.3	56.0	46.0	14.9	15.7

---L1 Phase ---

No.	Frequency [MHz]	Reading QP [dB(mV)]	Reading CAV [dB]	c.f [dB(mV)]	Result QP [dB(mV)]	Result CAV [dB(mV)]	Limit QP [dB(mV)]	Limit AV [dB(mV)]	Margin QP [dB]	Margin CAV [dB]
1	0.06115	66.7	66.1	10.0	76.7	76.1	88.2		11.5	
2	0.1833	46.9	39.4	10.1	57.0	49.5	64.3	54.3	7.3	4.8
3	0.55003	35.0	29.1	10.1	45.1	39.2	56.0	46.0	10.9	6.8
4	0.91568	36.0	27.9	10.2	46.2	38.1	56.0	46.0	9.8	7.9
5	1.28158	38.4	28.7	10.2	48.6	38.9	56.0	46.0	7.4	7.1
6	1.34146	39.1	27.9	10.2	49.3	38.1	56.0	46.0	6.7	7.9
7	1.40347	38.2	27.1	10.2	48.4	37.3	56.0	46.0	7.6	8.7

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Revision Record

		Description	
Rev.	**Date**	**Page**	**Summary**
Rev.1.00	May 24, 2012	—	First edition issued
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