R2A20135EVB-ND2

R2A20135 Evaluation Board

R19AN0024EJ0100
Rev.1.00
Jul 30, 2013

1. General Description

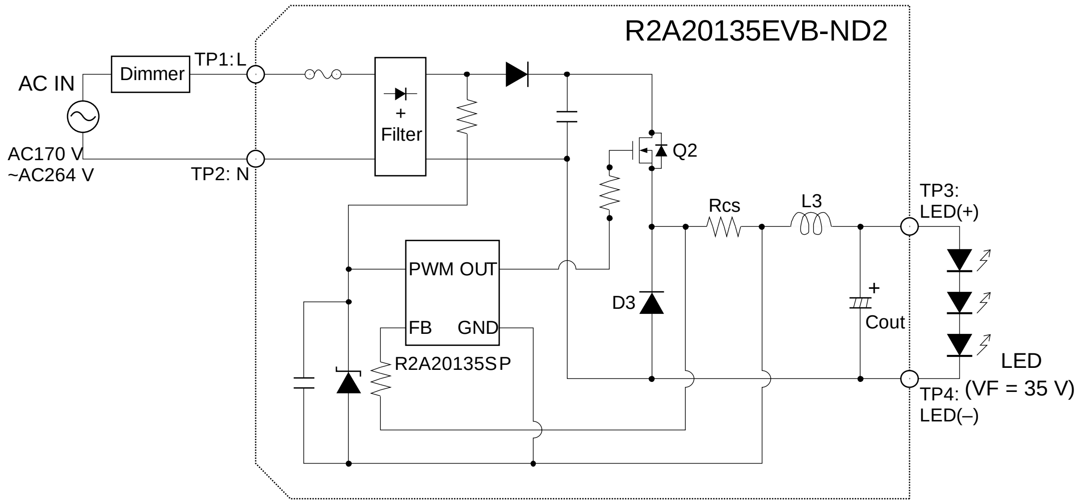
R2A20135EVB-ND2 is an evaluation tool for evaluating LED control IC R2A20135. As all of the parts and the peripheral circuit which are necessary for LED lighting control are built on this evaluation board, R2A20135 can be evaluated with just only supplying AC power source and connecting LED load.

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.	Items	Specifications
1	Input voltage range	AC170 to 264 V (single phase 47 to 63 Hz)
2	Input power	9.5 W (typ.)
3	Output voltage (VF)	DC35 V
4	Output current	220 mA (typ.)
5	Efficiency	80% < (@Vin = AC220 V)
6	Power factor	0.9 < (@Vin = AC220 V to 240 V)
7	Switching frequency	35 kHz (min.)
8	Operation mode	Critical Conduction Mode
9	PCB	Dual layers / Glass epoxy (FR4) / Dual-sided mount
10	Size (W ´ D ´ H)	36 mm ´ 41 mm ´ 20 mm (Top layer)

3. System Diagram & Connection



Connecting steps:

(1) Connect LED load (VF = 35 V, current rating over 220 mA) to TP3 and TP4 with caring LED polarity.

(2) Connect AC mains to TP1 and TP2.

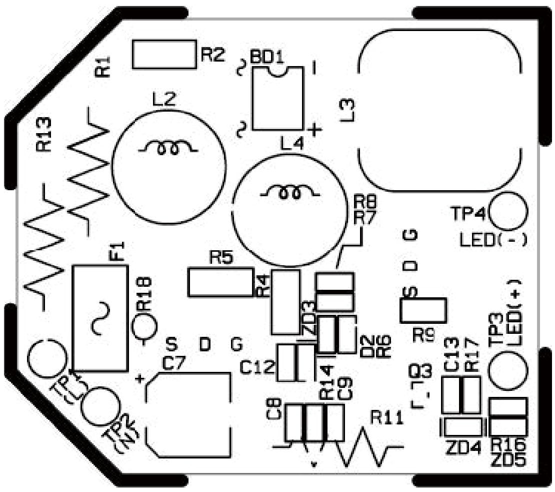
Note: Operating this evaluation board, LED load MUST be connected to TP3 & TP4. Without LED load, output voltage will be unstable and parts on the board may be damaged in the worst case.

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

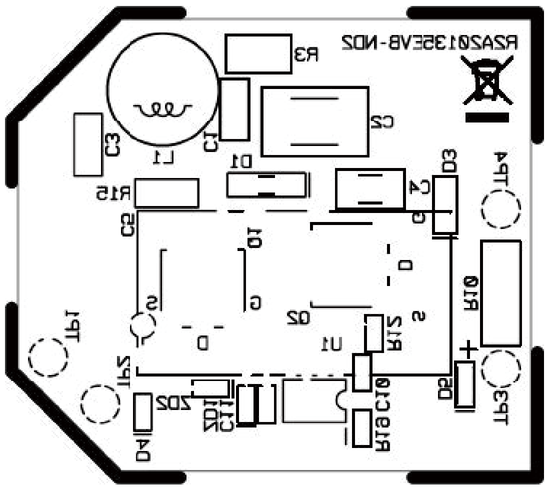
4. PCB Layout

4.1 Parts Layout

• Mounting side

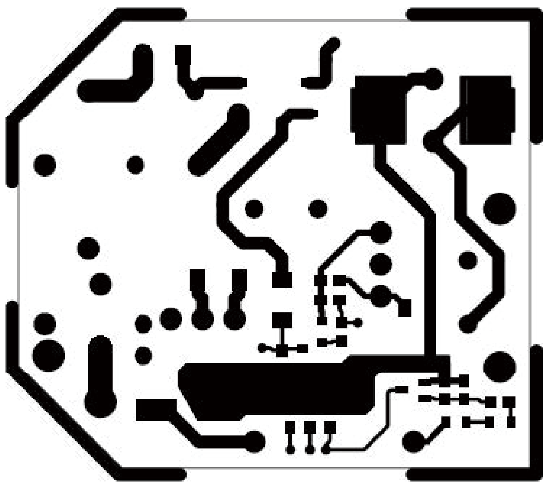


• Soldering side

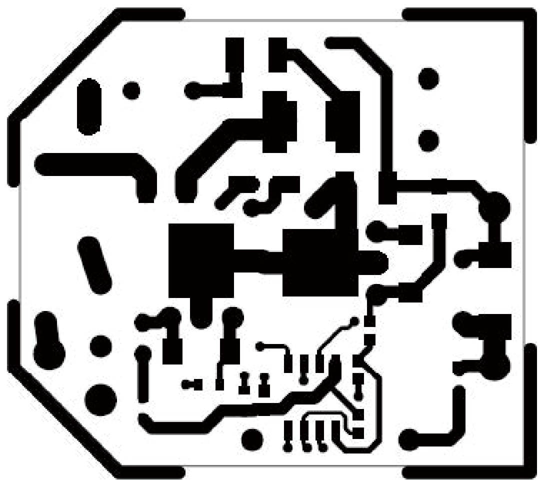


4.2 PCB Layout

• Mounting side



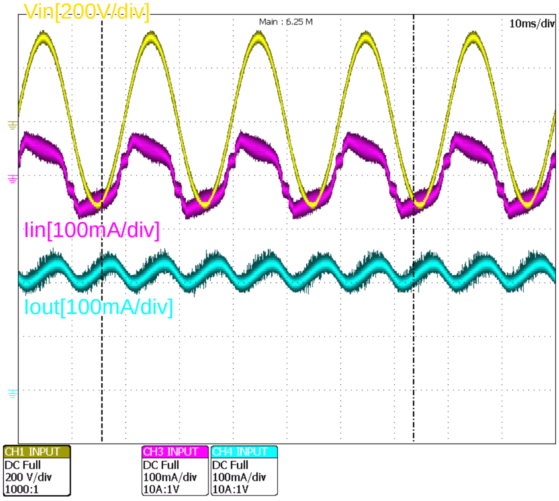
• Soldering side



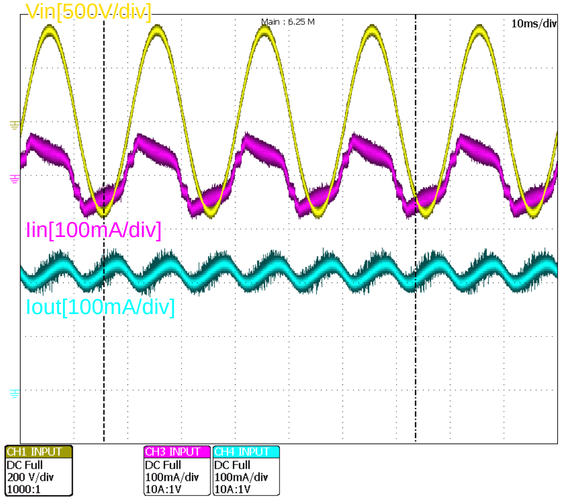
5. Performance Characteristics

5.1 Waveforms

• Vin = AC220 V, VF = 35 V, Iout = 220 mA

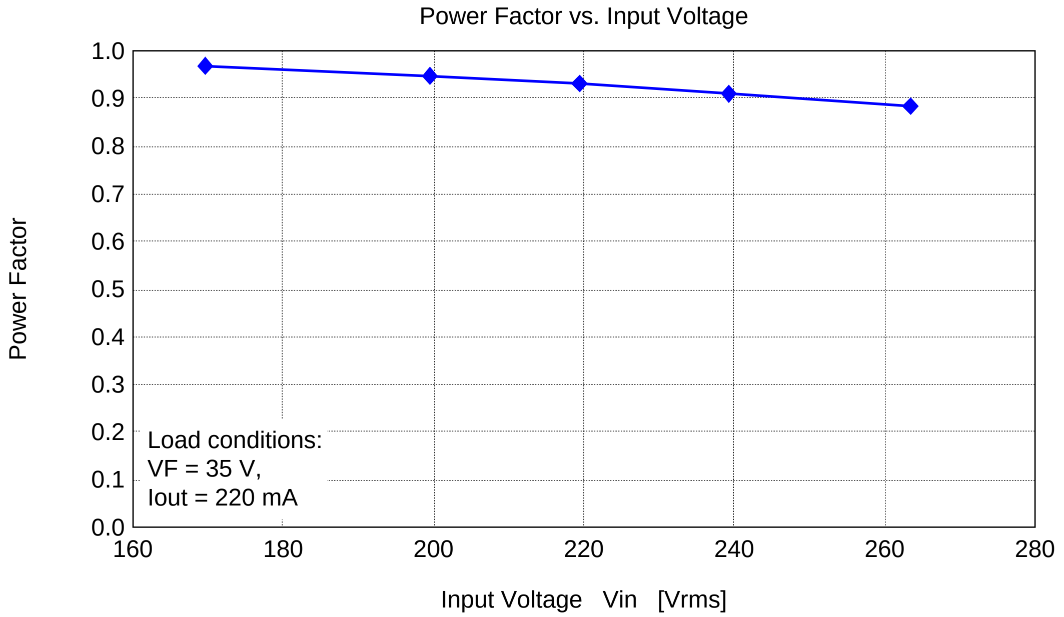


• Vin = AC240 V, VF = 35 V, Iout = 220 mA

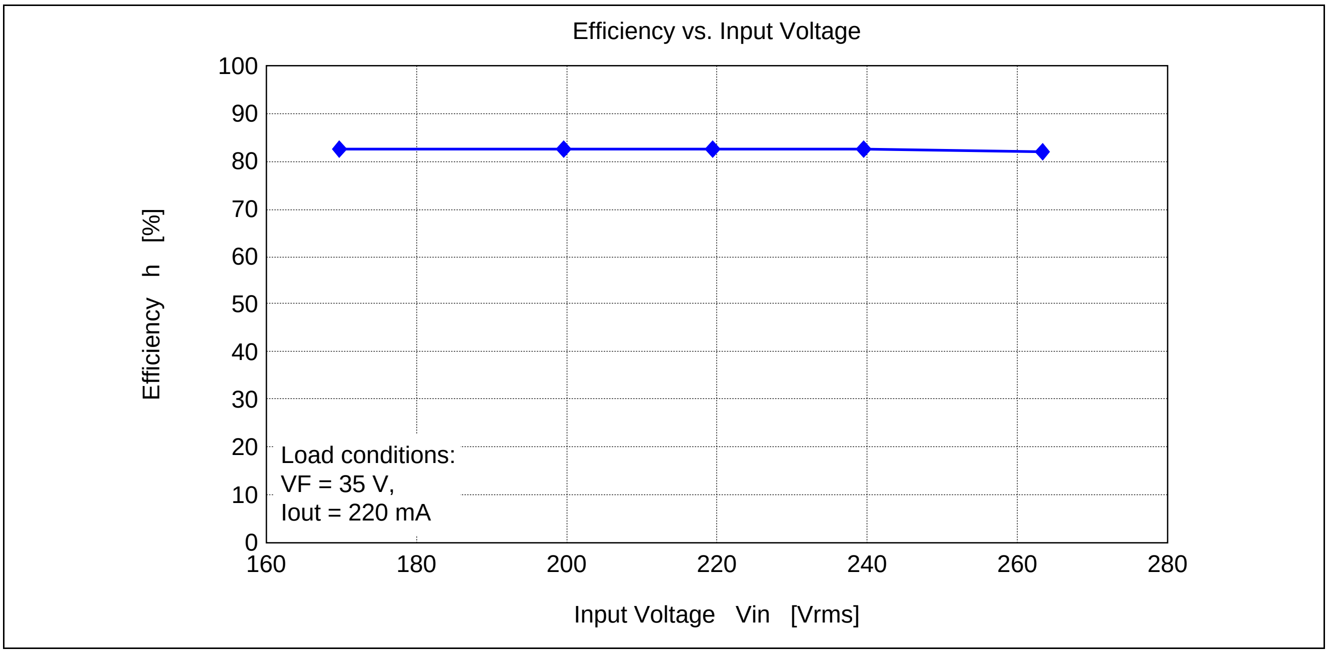


* Vin: Input voltage, Iin: Input current, Iout: Output current

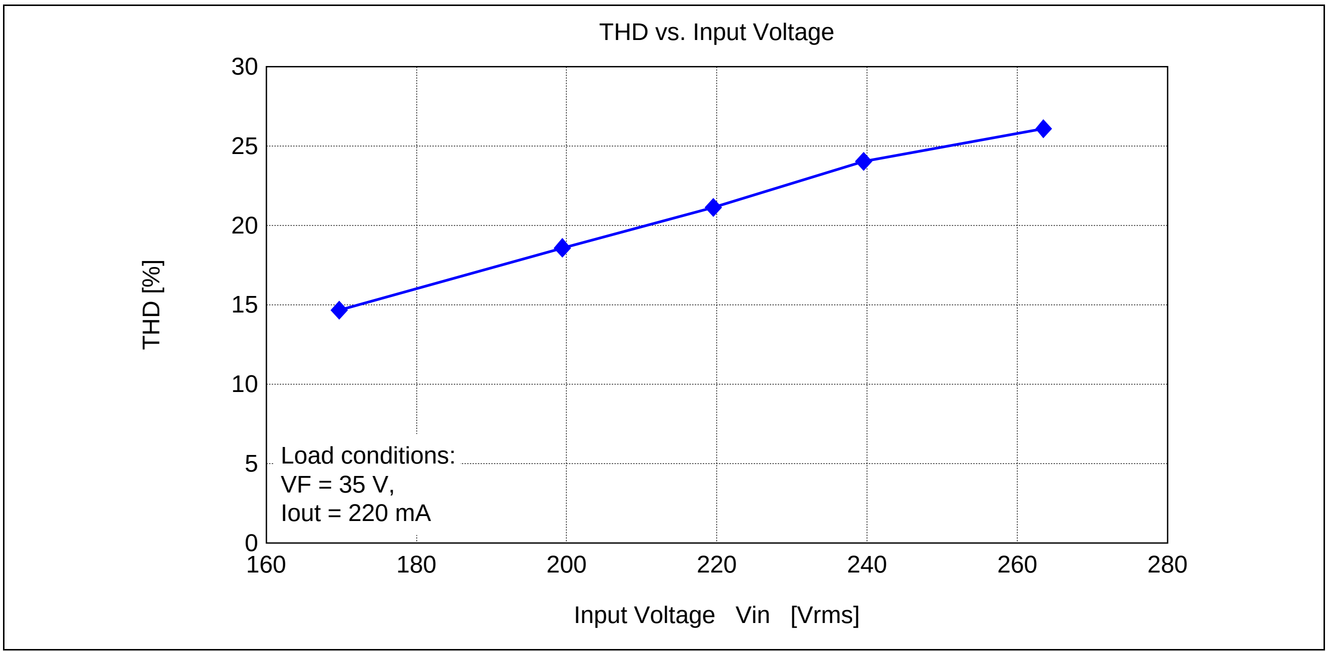
5.2 Power Factor



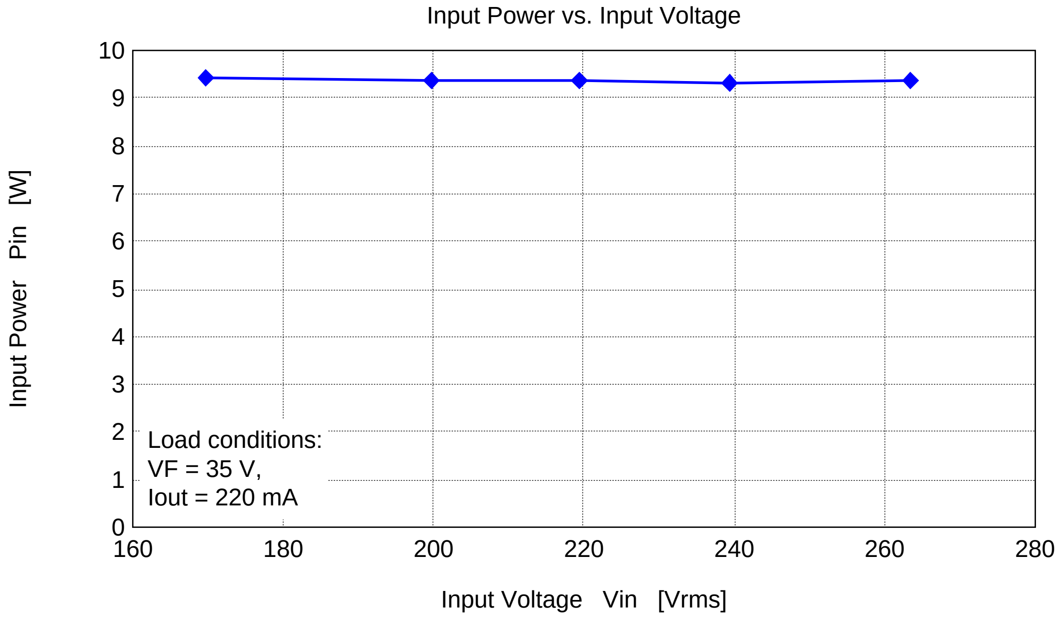
5.3 Efficiency



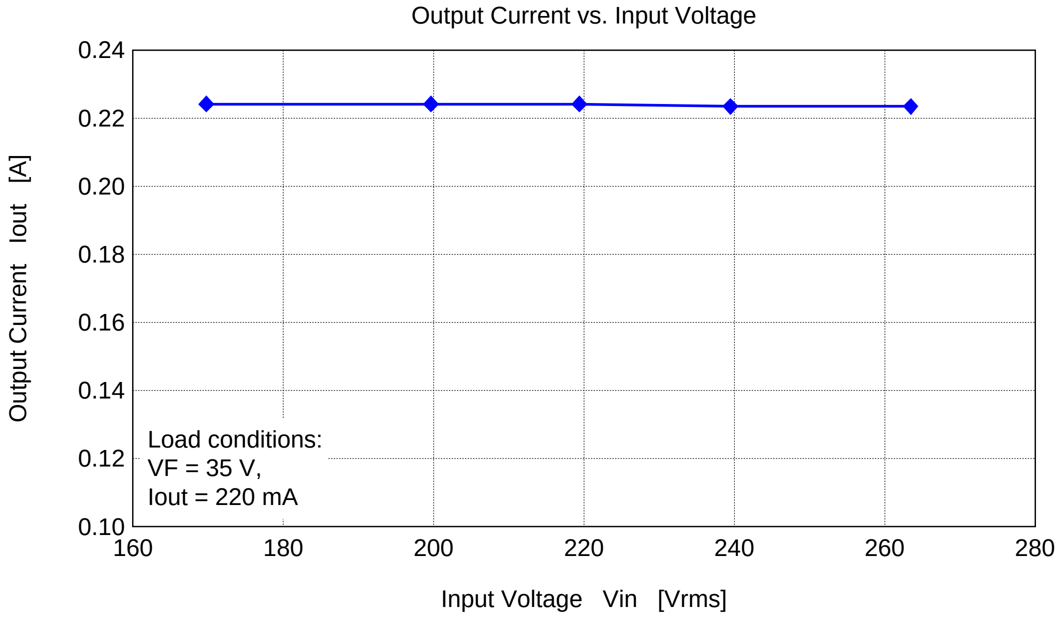
5.4 THD (Total Harmonic Distortion)



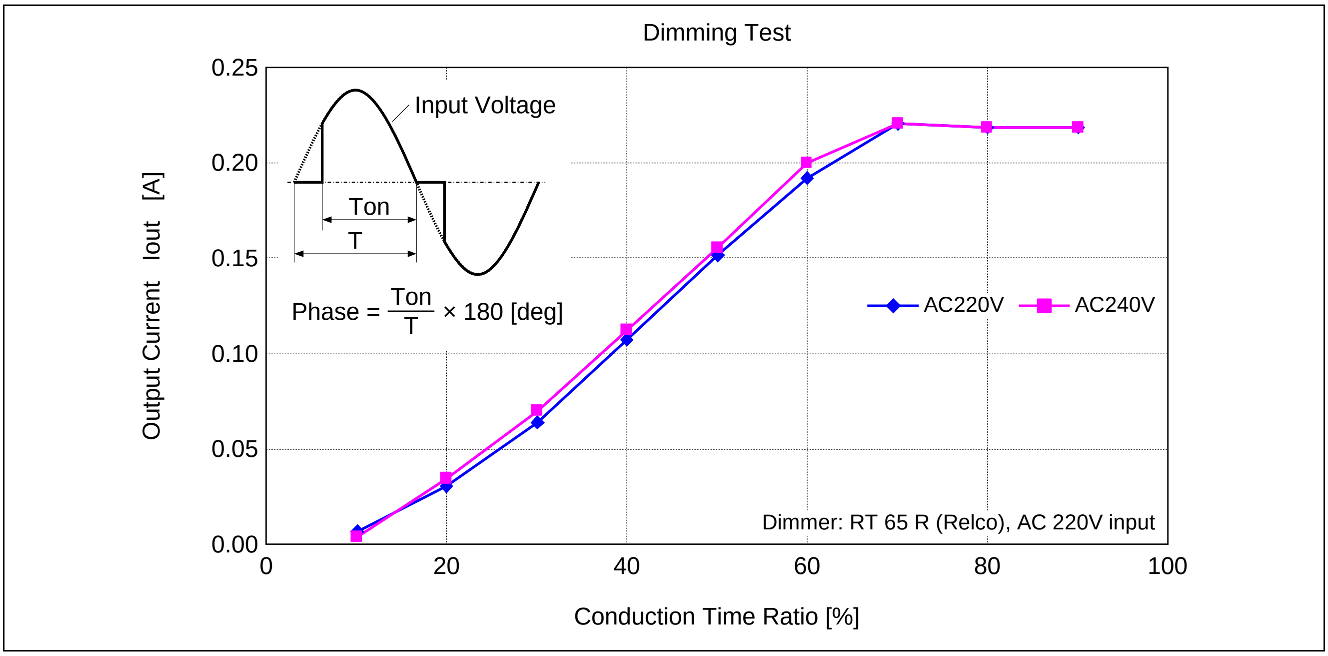
5.5 Input Power



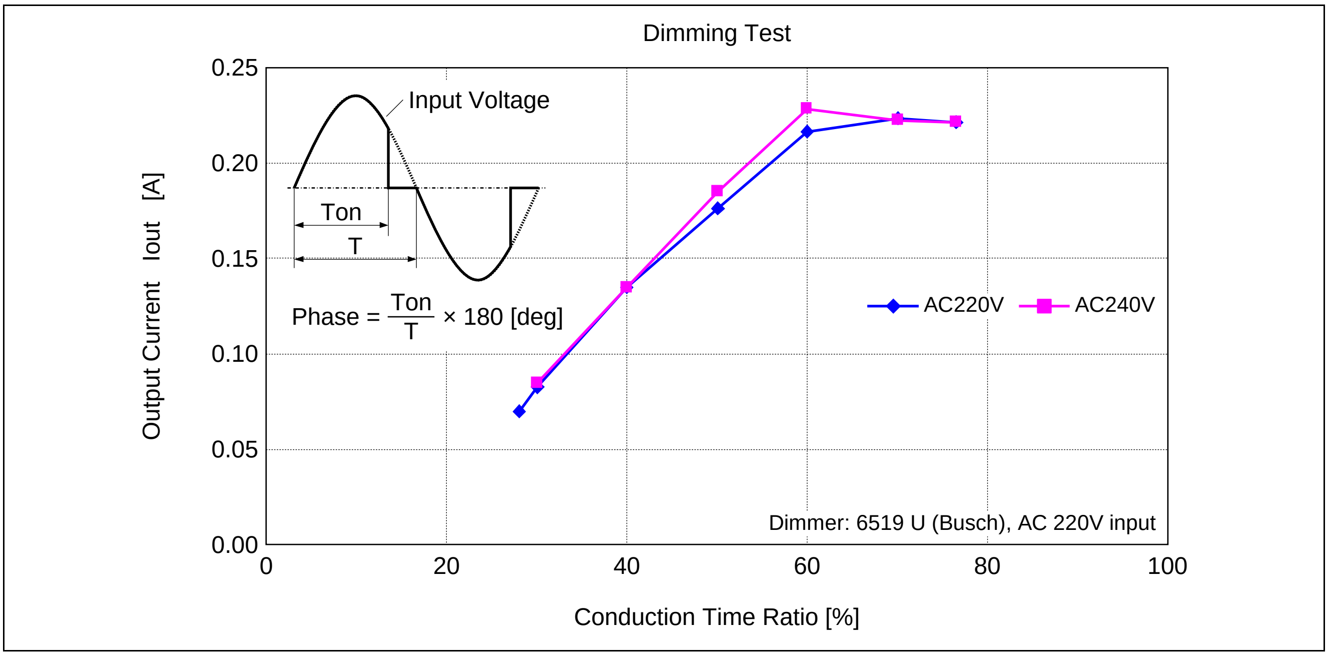
5.6 Output Current



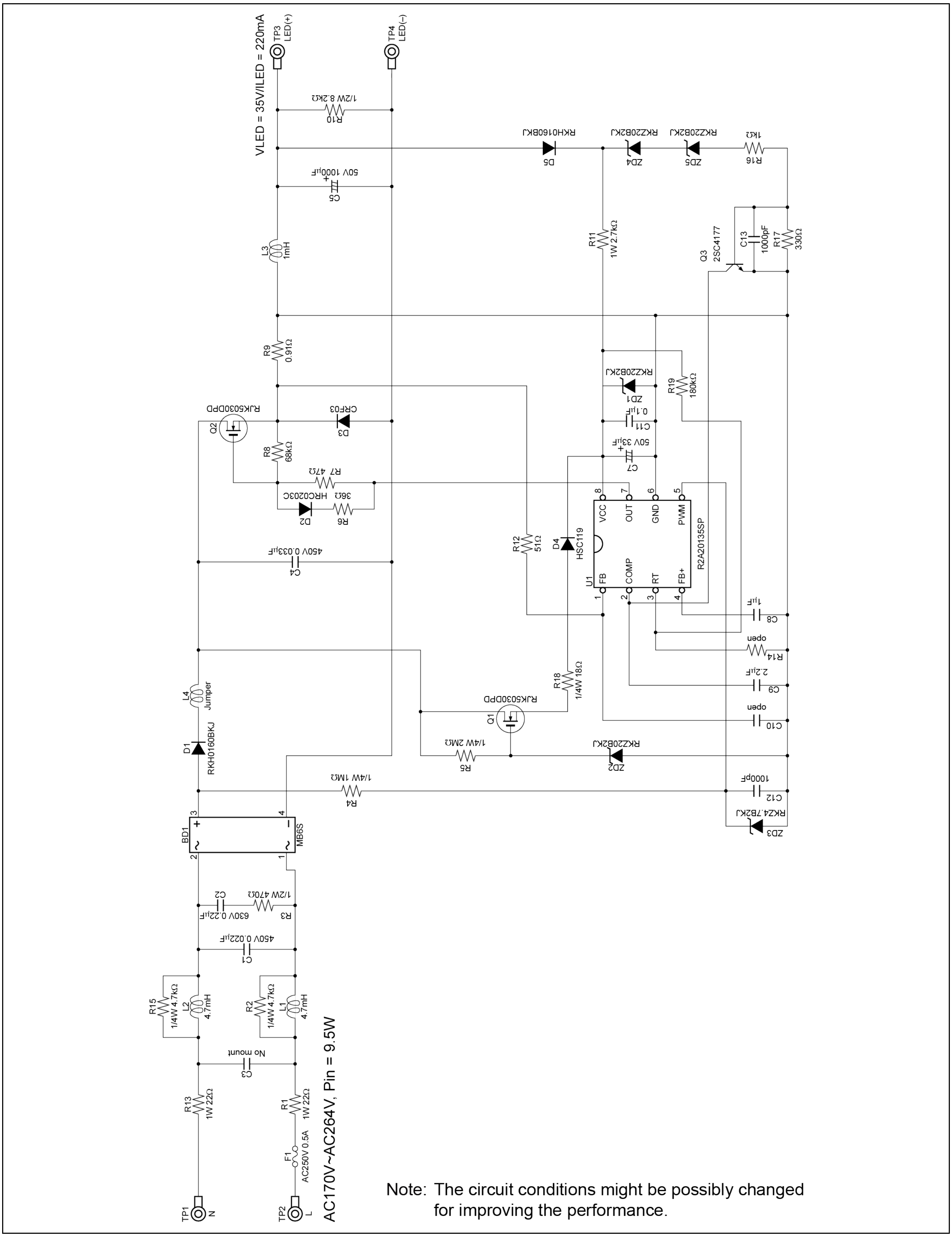
5.7 Dimming Characteristic (Leading edge dimmer)



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

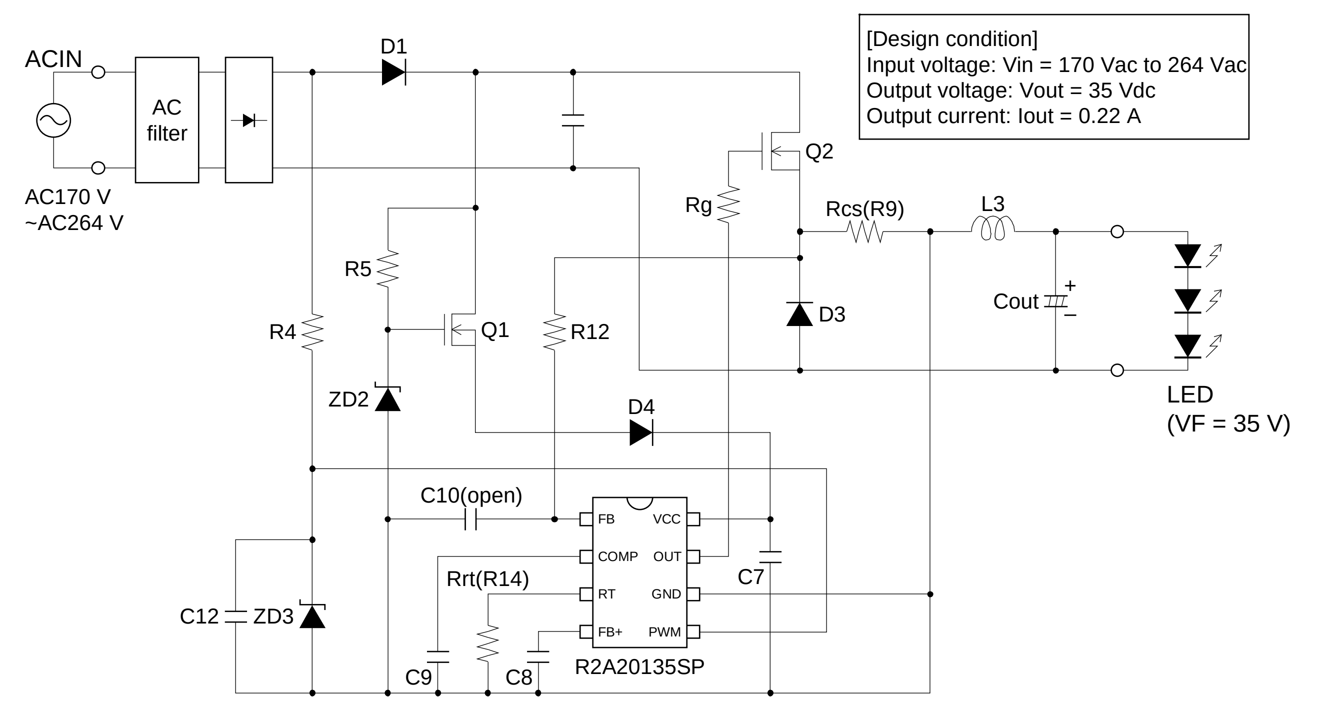


Figure 7.1 R2A20135EVB-ND2 Schematic

In critical conduction mode operation, current flow through the inductor is proportional to a voltage across the inductor and its waveform is shown in Figure 7.2.

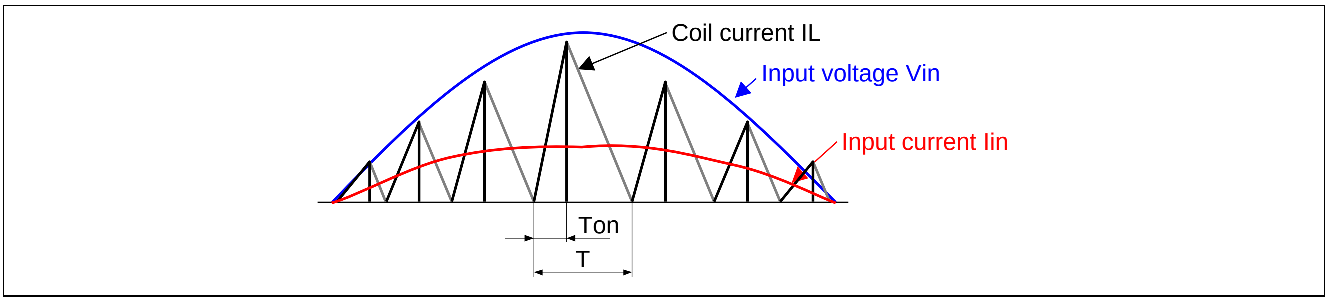


Figure 7.2 Input Current & Inductor Current

7.1 Setting Critical Conduction Mode Control Operation

To set critical conduction mode operation, RT terminal is necessary to be connected as 'open'.

* In case malfunction is caused by noise or other effect, RT terminal should be pulled up to Vcc level.

Also, it is necessary that R12 is set to below 100 Wand C10 is connected to open so as to set FB terminal voltage below 13 mV in zero current detection.

7.2 Setting Switching Frequency

In critical conduction mode operation, switching frequency changes according to input voltage. To avoid audio frequency band and reduce switching loss, the switching frequency should be set from 20 kHz to 100 kHz. Now, the switching frequency is set to 40 kHz with considering above.

7.3 Setting Rcs

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

$$Rcs = 0.2/Iout$$

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

$$Rcs = 0.2/0.22 = 0.91\ \Omega$$

7.4 Selecting Inductor L

Firstly, the inductance is calculated in the condition of the minimum switching frequency.

When the condition that the minimum Vin is 170 Vac and Vout is 35 V is given, on duty Don will be;

$$D_{ON} = Vout/(Vin) = 35/(170 \times \sqrt{2}) = 0.146$$

as the switching frequency is 40 kHz, on period Ton will be calculated;

$$Ton = D_{ON}/fout = 0.146/40\ kHz = 3.64\ \mu s$$

when the condition is given as input voltage; Vin = 170 V, output power Pout; 0.22 × 35 = 7.7 W, conduction angle (*1) is 90%, average input current Iin (ave) will be;

$$Iin(ave) = Pout/\eta/Vin = 7.7/0.90/170 = 50\ mA$$

and inductor current peak will be;

$$IL(peak) = Iin(ave) \times 2/D_{ON} = 0.50 \times 2/0.146 = 0.687\ A$$

thus,

$$L = (Vin - Vout) \times Ton/Iin(peak) = (170 \times \sqrt{2} - 35) \times 3.64\ \mu s/0.687 = 1090\ \mu H$$

1 mH inductor will be selected from standard parts line-up with considering tolerance rating and size.

Note: *1 Please also see refer setting L in R2A20135SP application note conduction angle.

7.5 Loop Filter of Feedback Amplifier (external circuit for FB & COMP terminal)

Frequency characteristics of R2A20135EVB-ND2 is shown in Figure 7.4. Although this system is controlled as current mode (first-order lag system) and can operate stably, it is recommended that Ccomp (shown in Figure 7.3.) is set to make loop gain as 0 dB under 100 – 200 Hz which is double frequency of the AC mains; 50 – 60 Hz. On the evaluation board, Ccomp has been set to 1 μF.

In the case that CR filter, which is composed of Cf1 and Rf1, is added to FB terminal to reduce noise influence, please consider output current of FB terminal and select Rf1 condition which sets lower FB terminal voltage than ZCD threshold voltage. On this evaluation board, Rf1 condition is 51 Ω. Also, please select the capacitor Cf1 which is enough small time constant condition against the switching frequency. Cf1 is ‘open’ on this evaluation board.

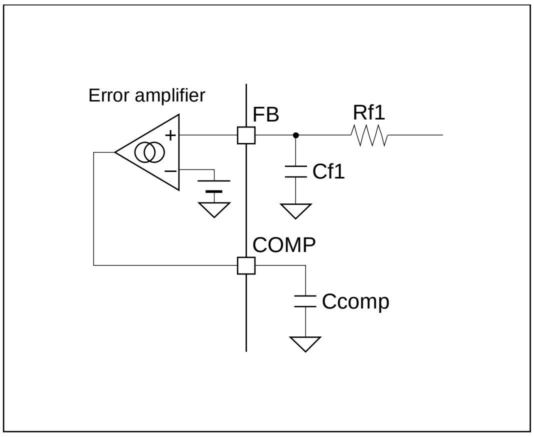


Figure 7.3 External Circuit for FB & COMP Terminals

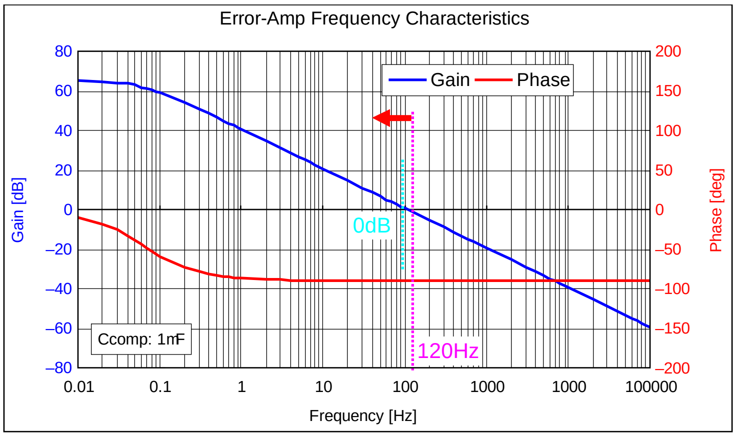
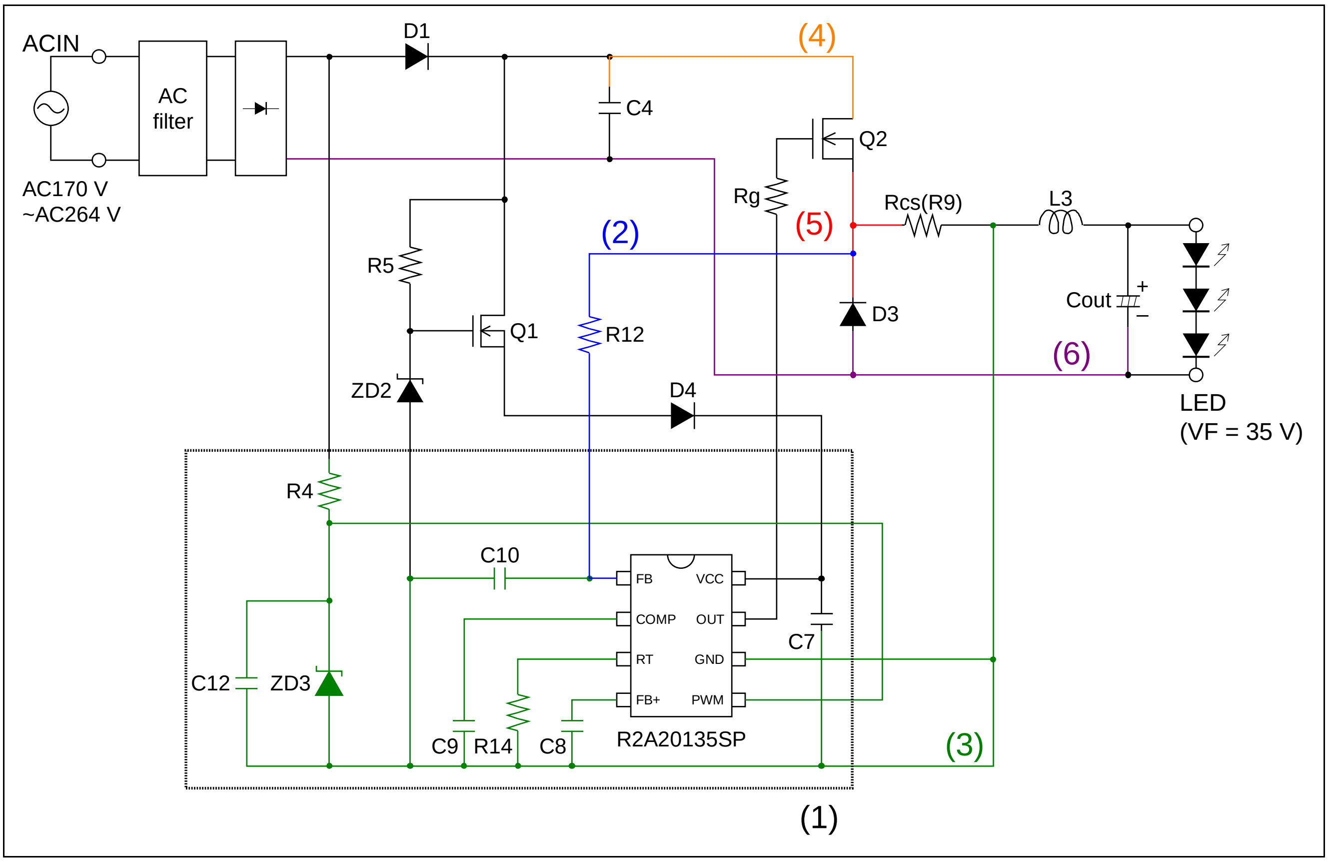


Figure 7.4 R2A20135EVB-ND2 Frequency Characteristics

8. PCB Layout Guide

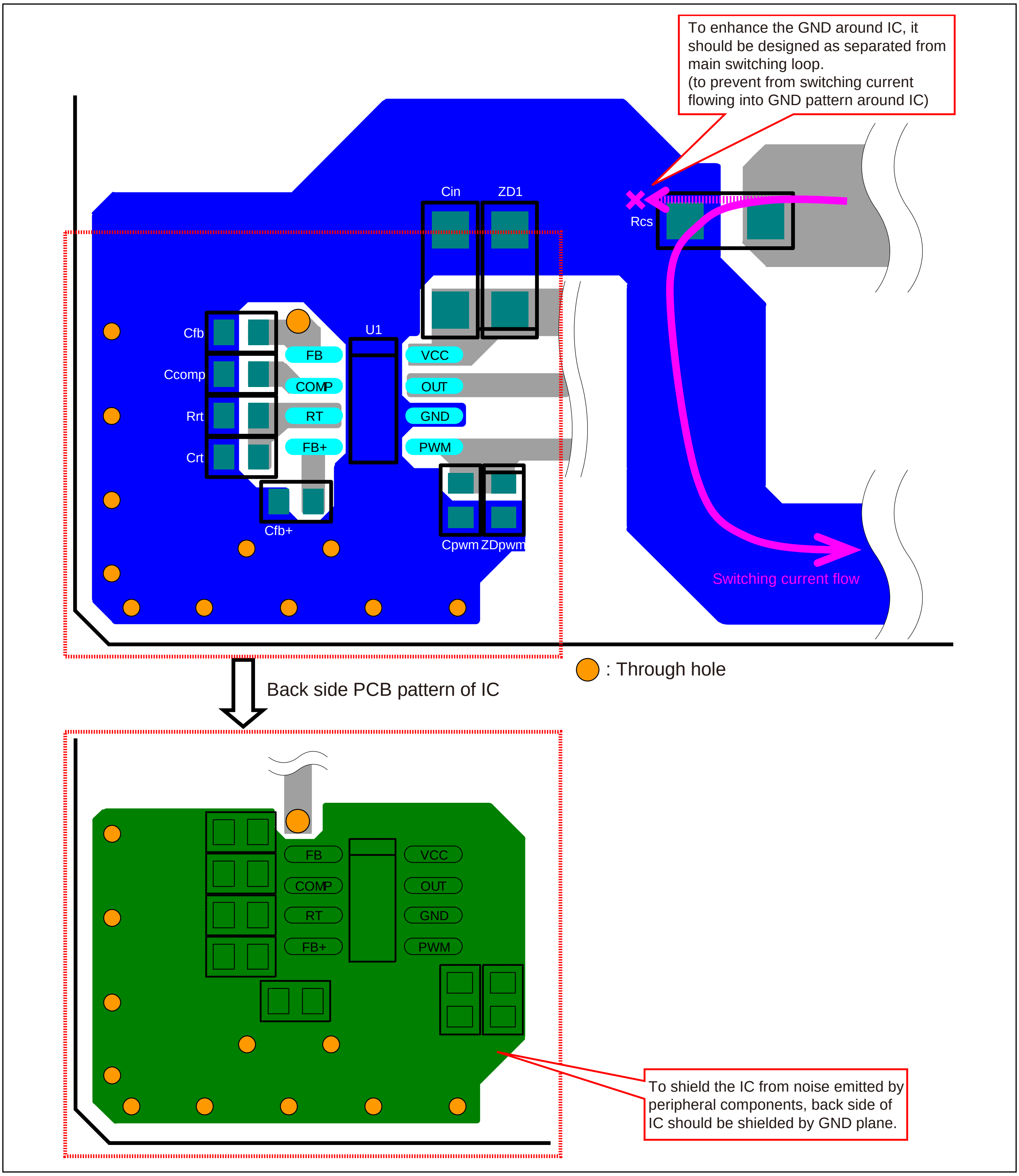


(1) Make the wring around the IC as short as possible in order to reduce the switching noise influence.
(2) Connect the CS line as close as possible to Rcs to shorten the wiring.
(3) Wire the independent wide GND pattern and connect it as close as possible to Rcs (output side). Also, please place bypass capacitors (C7) of Vcc and Vref, and the resistors of RT and FB (R14, R12) as close as possible to IC, as well as the wiring between GND of IC and the bypass capacitor (Cref) of Vref pin as short as possible.
(4) Make the wire between Q2 (Drain) and C4 (+) as short and as thick as possible.
(5) Make the track between Q2 (source) and D3 (cathode) as short and as thick as possible.
(6) As switching current flows, make this track as short and as thick as possible.

8.1 PCB Pattern Design

To prevent switching noise influence to the IC, PCB pattern should be designed based on following PCB design example.
* Components numbers correspond to the schematics shown in previous page.
* This IC peripheral PCB pattern guidelines should be followed regardless of any topology.
Note; this PCB pattern design is for reference and operation is not guaranteed. Please verify the operation sufficiently in actual PCB.

PCB Pattern Design Example (IC peripheral)



9. Bill of Materials

Symbol	Parts Name	Catalog No.	Q	Rating		Manufacturer	Note
PWB	Printed-wiring board	R2A20135EVB-ND2	1			Renesas Electronics	
U1	IC	R2A20135SP	1	24V		Renesas Electronics	SOP-8
Q1	FET	RJK5030DPD	1	500V	5A	Renesas Electronics	TO-252 (DPAK)
Q2	FET	RJK5030DPD	1	500V	5A	Renesas Electronics	TO-252 (DPAK)
Q3	Transistor	2SC1622A	1	60V	0.1A	Renesas Electronics	2SC1623
Q4	Transistor	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	CRF03	1	600V	0.7A	Toshiba	S-FLAT
D4	Diode	HSC119	1	80V	100mA	Renesas Electronics	UFP
D5	Diode	RKH0160AKU	1	600V	100mA	Renesas Electronics	URP
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					
ZD5 *	Zener diode	RD39SB1	1	39V	200mA	Renesas Electronics	UFP
R1	Resistor		1	1W	22		Leaded
R2	Chip resistor		1	1/6W	4.7k		Leaded
R3	Chip resistor		1	1/4W	470		Leaded
R4	Chip resistor		1	1/4W	1M		3216, High voltage
R5	Chip resistor		1	1/4W	2M		3216, High voltage
R6	Chip resistor		1	1/10W	36		1608
R7	Chip resistor		1	1/10W	47		1608
R8	Chip resistor		1	1/10W	68k		1608
R9	Chip resistor		1	1/4W	0.91		2012, High accuracy (over 1%)
R10-1	Chip resistor		1	1/4W	12k		3216
R10-2	Chip resistor			1/4W	24k		3216
R11	Resistor			1W	2.7k		Leaded
R12	Chip resistor		1	1/10W	51		1608
R13	Chip resistor	No mount					1608
R14	Chip resistor	No mount					1608
R15	Chip resistor	No mount					1608
R16	Chip resistor		1	1/2W	0		3225
R17	Chip resistor	No mount	1	1/10W	330		3216
R18 *	Resistor		1	1/6W	4.7k		Leaded
R19 *	Resistor		1	1W	22		Leaded
R20 *	Resistor		1	1/4W	18		Leaded
R21 *	Chip resistor		1	1/10W	10k		1608
R22 *	Chip resistor		1	1/10W	1k		1608
C1	Ceramic capacitor	GR331BD72W223KW01L	1	450V	0.022μF	murata	3216
C2	Ceramic capacitor	GRM55DR72J224KW01L	1	630V	0.22μF	murata	5750
C3	Ceramic capacitor	No mount					3216
C4	Ceramic capacitor	GR331BD72W333KW01L	1	450V	0.033μF	murata	3216
C5	Electrochemical capacitor	ECA1HHG102	1	50V	1000μF	Panasonic	smaller than φ12.5× 25, 105°C
C6	Ceramic capacitor	No mount					2012
C7	Electrochemical capacitor		1	25V	33μF		3225
C8	Ceramic capacitor	GRM188	1	25V	1μF	murata	1608
C9	Ceramic capacitor	GRM188	1	10V	2.2μF	murata	1608
C10	Ceramic capacitor	No mount					1608
C11	Ceramic capacitor	No mount					1608
C12	Ceramic capacitor	GRM188	1	25V	1000pF	murata	1608
C13 *	Ceramic capacitor	GRM188	1	25V	1000pF	murata	1608
L1	Inductor	LHLC08TB472J	1	0.16A	4.7mH	Yuden	
L2 *	Inductor	LHLC08TB472J	1	0.16A	4.7mH	Yuden	
L3	Inductor	MSS1278-105KLB	1	0.48Arms	1mH	Coilcraft	
L4 *	Inductor	short					
F1	Fuse	HTS 500mA	1	AC250V	0.5A	Skygate	
TP1	Test point	No mount	1				MAC8 ST-3-2 size
TP2	Test point	No mount	1				MAC8 ST-3-2 size
TP3	Test point	No mount	1				MAC8 ST-3-2 size
TP4	Test point	No mount	1				MAC8 ST-3-2 size

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

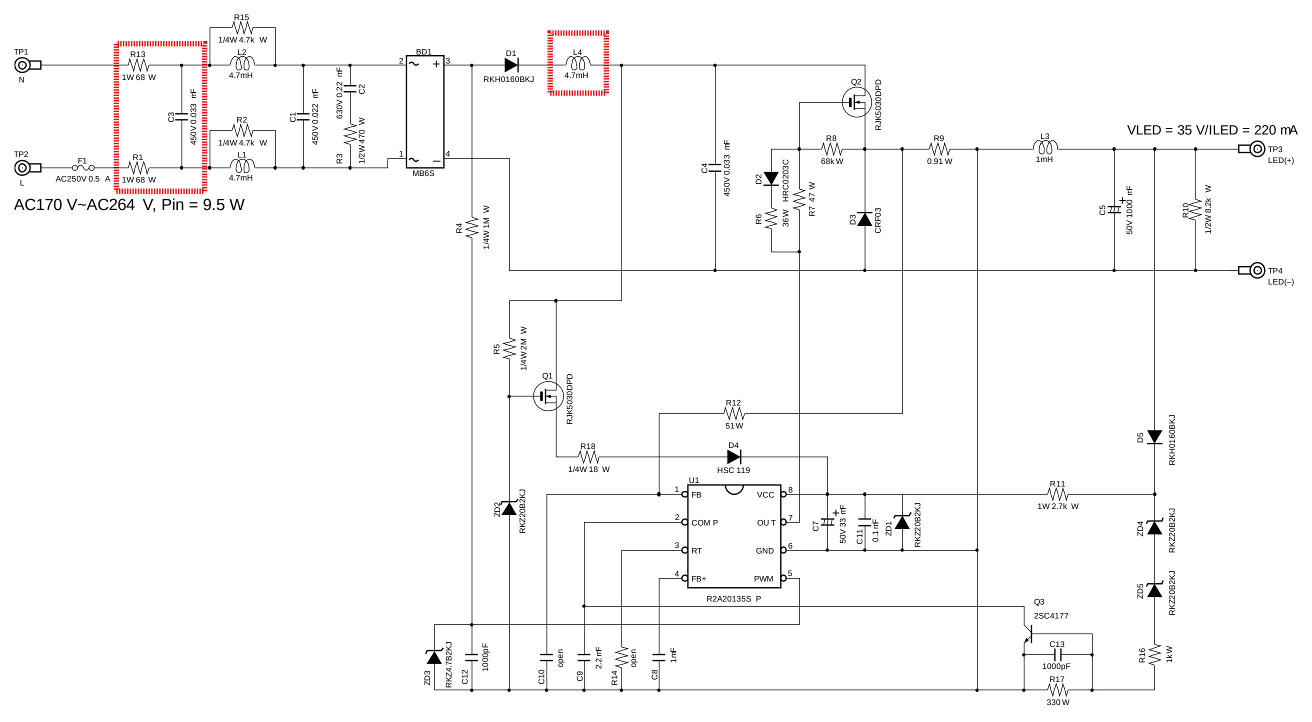
10. Conducted Emission

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



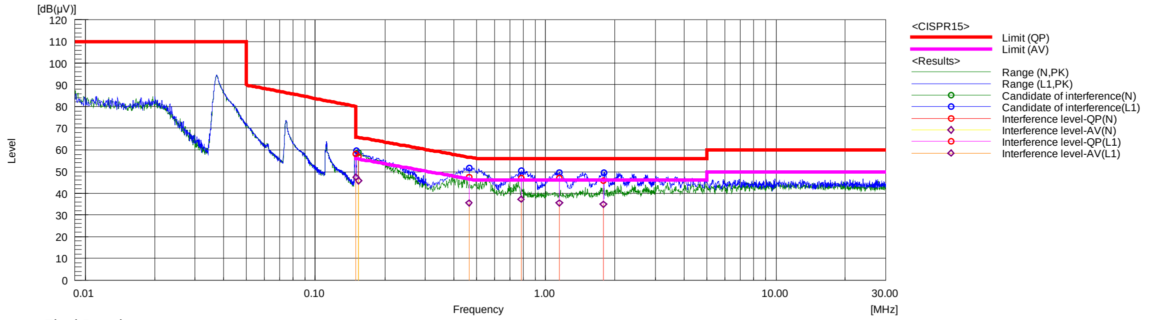
Note: [red box]: Additional/changed components

10.1.2 Additional/Changed Parts to Meet Conducted Emission Standard

Symbol	Parts Name	Catalog No.	Q	Rating		Manufacturer	Note
R1	Resistor		1	1W	68		Leaded
R19	Resistor		1	1W	68		Leaded
C3	Ceramic capacitor	GR331BD72W333KW01L	1	450V	0.033mF	murata	3216
L4	Inductor	LHLC08TB472J	1	0.16A	4.7mH	Yuden	

10.2 Conducted Emission Test Results (CISPR15)

- Vin = 220 Vac, 60 Hz, actual LED load (VF = 35 V), Iout = 220 mA



Final Result

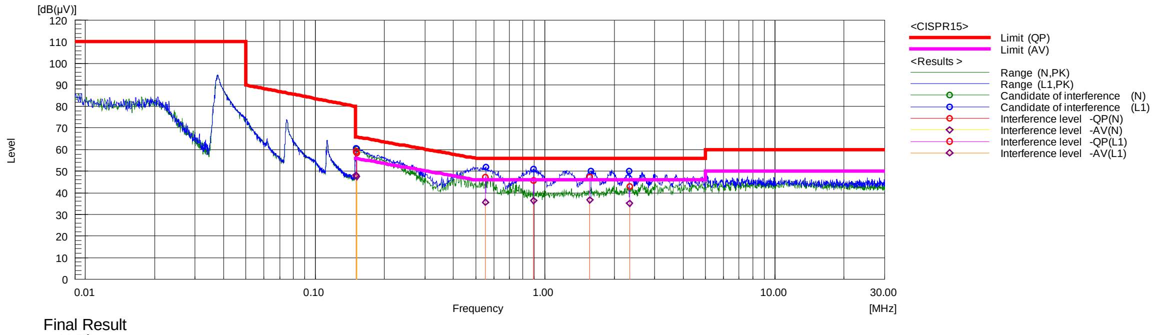
---N Phase ---

No.	Frequency [MHz]	Reading QP [dB(μV)]	Reading CAV [dB(μV)]	c.f [dB]	Result QP [dB(μV)]	Result CAV [dB(μV)]	Limit QP [dB(μV)]	Limit AV [dB(μV)]	Margin QP [dB]	Margin CAV [dB]	Remark
1	0.1537	46.8	35.6	10.1	56.9	45.7	65.8	55.8	8.9	10.1	

---L1 Phase ---

No.	Frequency [MHz]	Reading QP [dB(μV)]	Reading CAV [dB(μV)]	c.f [dB]	Result QP [dB(μV)]	Result CAV [dB(μV)]	Limit QP [dB(μV)]	Limit AV [dB(μV)]	Margin QP [dB]	Margin CAV [dB]	Remark
1	0.150	48.1	37.3	10.1	58.2	47.4	66.0	56.0	7.8	8.6	
2	0.46398	37.4	25.3	10.1	47.5	35.4	56.6	46.6	9.1	11.2	
3	0.78235	37.0	27.1	10.2	47.2	37.3	56.0	46.0	8.8	8.7	
4	1.14916	36.8	25.4	10.2	47.0	35.6	56.0	46.0	9.0	10.4	
5	1.78219	35.6	24.8	10.2	45.8	35.0	56.0	46.0	10.2	11.0	

- Vin = 240 Vac, 60 Hz, actual LED load (VF = 35 V), Iout = 220 mA



Final Result

---N Phase ---

No.	Frequency [MHz]	Reading QP [dB(μV)]	Reading CAV [dB(μV)]	c.f [dB]	Result QP [dB(μV)]	Result CAV [dB(μV)]	Limit QP [dB(μV)]	Limit AV [dB(μV)]	Margin QP [dB]	Margin CAV [dB]	Remark
1	0.15163	48.4	37.5	10.1	58.5	47.6	65.9	55.9	7.4	8.3	

---L1 Phase ---

No.	Frequency [MHz]	Reading QP [dB(μV)]	Reading CAV [dB(μV)]	c.f [dB]	Result QP [dB(μV)]	Result CAV [dB(μV)]	Limit QP [dB(μV)]	Limit AV [dB(μV)]	Margin QP [dB]	Margin CAV [dB]	Remark
1	0.15028	49.1	38.0	10.1	59.2	48.1	66.0	56.0	6.8	7.9	
2	0.55153	37.2	25.6	10.1	47.3	35.7	56.0	46.0	8.7	10.3	
3	0.89257	35.4	26.1	10.2	45.6	36.3	56.0	46.0	10.4	9.7	
4	1.5698	37.3	26.6	10.2	47.5	36.8	56.0	46.0	8.5	9.2	
5	2.33433	32.7	24.9	10.3	43.0	35.2	56.0	46.0	13.0	10.8	

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Rev.	Date	Description: Page	Description: Summary
Rev.1.00	Jul 30, 2013	—	First edition issued

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