

R2A20135EVB-ND1 (Critical Conduction Mode) R19AN0023EJ0100 Rev.1.00

R2A20135 Evaluation Board for Dimmable LED Lighting Application Sep 27, 2013

1. Overview

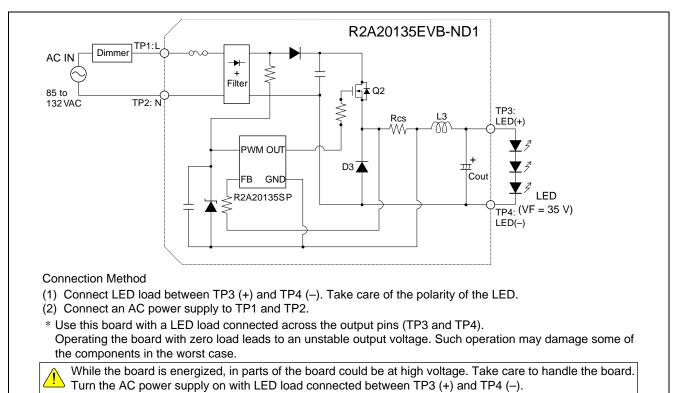
The R2A20135EVB-ND1 is an evaluation board for LED driver IC, having capability of dimming control. All the components to control LED lighting system are onboard, it is easy to start evaluation by supplying power and connecting dimmer and LED load.

The board has a step-down and non-isolated high-side driving circuit, controls dimming, and features high efficiency, high power factor, low total harmonic distortion (THD), and low ripple voltage. For evaluating this board, please refer to the R2A20135SP data sheet as well.

2. Specification

No.	Item	Specification			
1	Input voltage range	85 to 132 VAC (single phase: 47 to 63 Hz)			
2	Input power	9.5 W (typ.)			
3	Output voltage (VF)	35 V			
4	Output current	220 mA (typ.)			
5	Efficiency	85% or more (when Vin = 100 VAC)			
6	Power factor	0.9 or more (when Vin = 100 to 120 VAC)			
7	Switching frequency	35 kHz (min.)			
8	Operation mode	Critical Conduction Mode			
9	Board	Two layers / glass epoxy (FR4) / dual-sided mount			
10	Size (W ´ D ´ H)	36 mm ´ 41 mm ´ 20 mm (component side)			

3. System Diagram and Connection



RENESAS

• Soldering side

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(as viewed from the component side)

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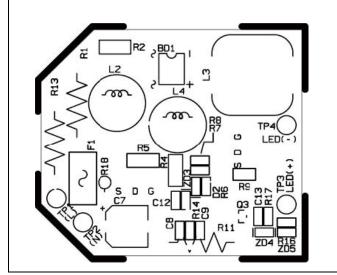
R2A20135EVB-ND2

BIS

4. PCB Layout

4.1 PCB Layout

• Component side



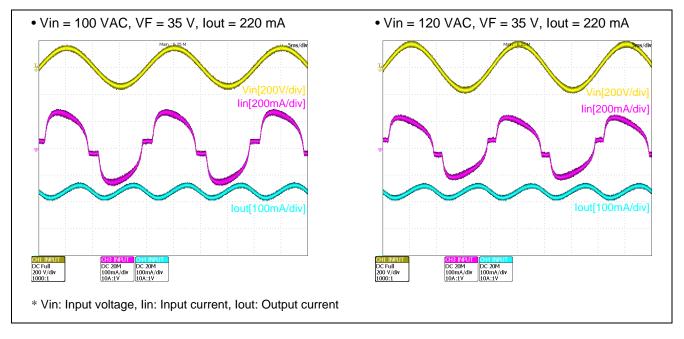
4.2 Circuit Patterns

Component side
Soldering side (as viewed from the component side)

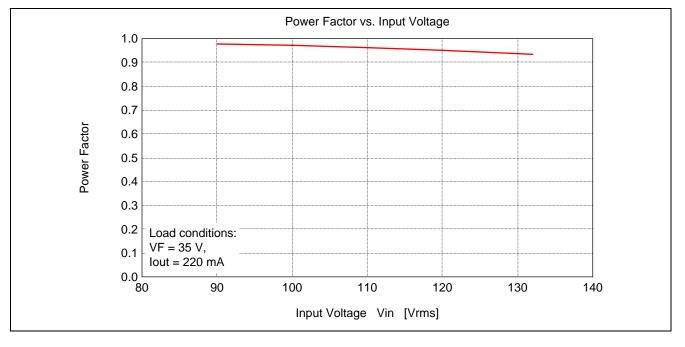


5. Performance Data

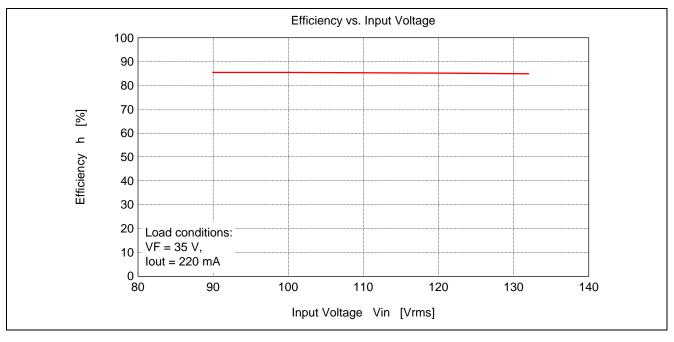
5.1 Operation Waveform



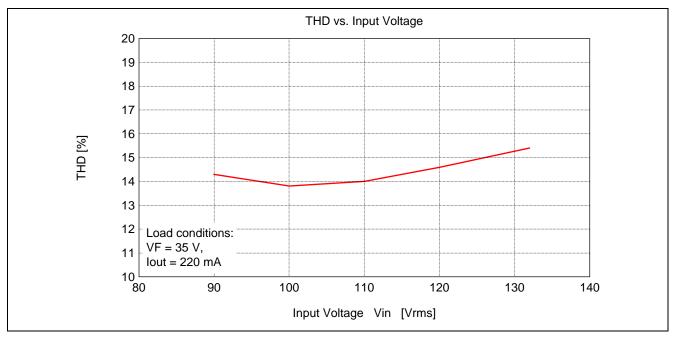
5.2 Power Factor



5.3 Efficiency

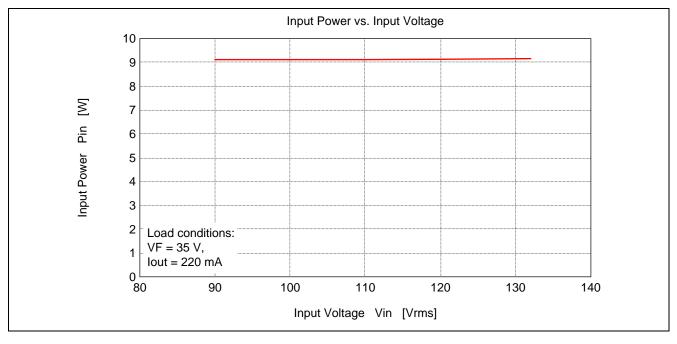


5.4 THD (Total Harmonic Distortion)

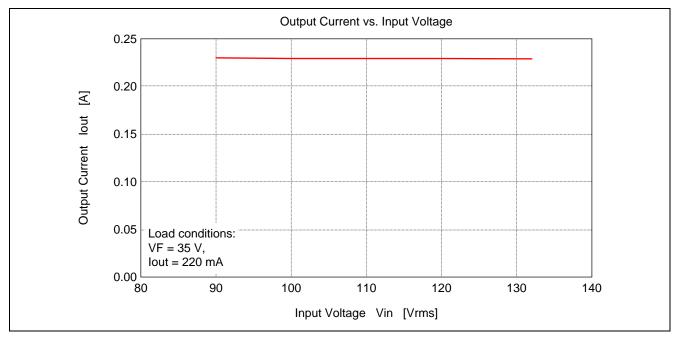




5.5 Input Power

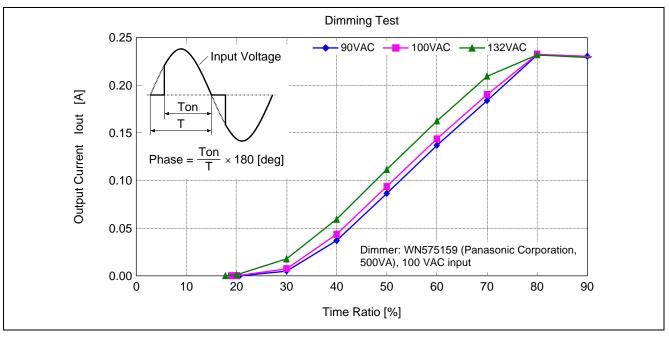


5.6 Output Current



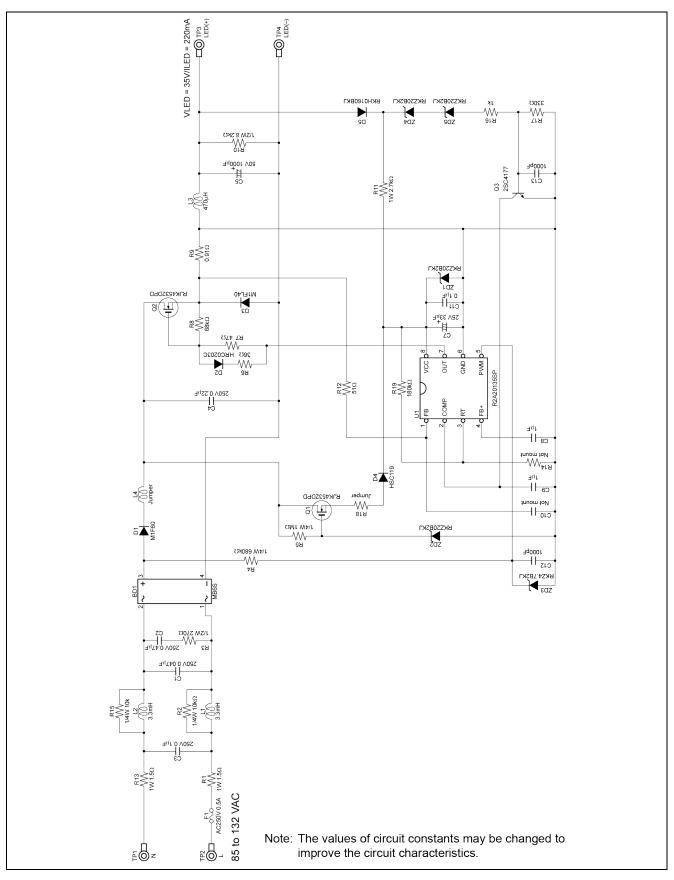


5.7 Dimming Characteristics





6. Schematic





7. Bill of Materials

Symbol	Parts Name	Catalog No.	Q	Rating		Manufacturer	Note	
PWB	Printed-wiring board	R2A20135EVB-ND1	1	Rating		Renesas Electronics	Note	
	i inter intig beard							
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	Transistor	2SC4177	1	60V	0.1A	Renesas Electronics	3pin SSM	
BD1	Bridge diode	MB6S	1	600V	0.5A	VISHAY	TO-269AA (MBS)	
54	D'a la	141500		0001/	4.4			
D1	Diode SBD	M1F60	1	600V 30V	1A	Shindengen	M1F	
D2 D3	FRD	HRC0203C-E M1FL40	1	400V	0.2A 1.5A	Renesas Electronics Shindengen	UFP M1F	
D3 D4	Diode	HSC119	1	400V 80V	1.5A 100mA	Renesas Electronics	UFP	
D4 D5	Diode	RKH0160BKJ	1	600V	100mA	Renesas Electronics	URP	
20				0001	10011/1			
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	RKZ20B2KJ	1	20V	5mA	Renesas Electronics	UFP	
ZD5	Zener diode	RKZ20B2KJ	1	20V	5mA	Renesas Electronics	UFP	
-								
R1	Resistor		1	1W	1.5		Leaded	
R2	Chip resistor		1	1/4W	10k		3216	
R3	Chip resistor		1	1/2W	270		3225, Withstand pulse (SG73P by KOA, etc.)	
R4	Chip resistor		1	1/4W	680k		3216, Withstand voltage of 400 V or more (HV73 by KOA, etc.)	
R5	Chip resistor		1	1/4W	1M		3216, Withstand voltage of 400 V or more (HV73 by KOA, etc.)	
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 (1 percent or better)	
R10	Chip resistor		1	1/2W	8.2k		5025	
R11	Resistor			1W	2.7k		Leaded	
R12	Chip resistor		1	1/10W	51		1608	
R13	Resistor		1	1W	1.5		Leaded	
R14	Chip resistor		1	1/10W	150k		1608	
R15	Chip resistor			1/4W	10k		3216	
R16	Chip resistor		1	1/10W	1k		1608	
R17	Chip resistor		1	1/10W	330		1608	
R18	Chip resistor	No mount	1				Leaded	
R19	Chip resistor	Nomount					1608	
C1	Ceramic capacitor	GRM31	1	250V	0.047mF	Murata Manufacturing	3216	
C2	Ceramic capacitor	GRM43	1	250V	0.047mF	Murata Manufacturing	4532	
C3	Ceramic capacitor	GRJ31CR72E104KWJ3L	1	250Vdc	0.1mF			
C4	Ceramic capacitor	GRJ32DR72E224KWJ1L	1	250Vdc	0.22mF	Murata Manufacturing	3225	
C5	Electrochemical capacitor	ECA1HHG102	1	50V	1000mF	Panasonic	f : (12.5' 25) or less, rated for 105°C	
C7	Electrochemical capacitor	EMVL250ADA330MF60G	1	25V	33mF	Nippon Chemi-Con	f: (6.3´8) or less, rated for 105°C	
C8	Ceramic capacitor	GRM188	1	25V	1mF	Murata Manufacturing	1608	
C9	Ceramic capacitor	GRM188	1	25V	1mF	Murata Manufacturing	1608	
C10	Ceramic capacitor	GRM188	1	25V	0.1mF	Murata Manufacturing	1608	
C11	Ceramic capacitor	GRM188	1	25V	0.1mF	Murata Manufacturing	1608	
C12	Ceramic capacitor	GRM188	1	25V	1000pF	Murata Manufacturing	1608	
C13	Ceramic capacitor	GRM188	1	25V	1000pF	Murata Manufacturing	1608	
11	Inductor		1	0.144	3 2mL	TDK		
L1 L2	Inductor Inductor	TSL0808S-332KR14-PF TSL0808S-332KR14-PF	1	0.14A 0.14A	3.3mH 3.3mH	TDK		
L2 L3	Inductor	#B953AS-221M	1	1A	220mH	ТОКО		
L3 L4			+ -		220111			
			1	1	1		1	
F1	Fuse	HTS 500mA	1	AC250V	0.5A	Skygate		
			L					
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 components may be changed to improve the circuit characteristics.



8. Design Guide

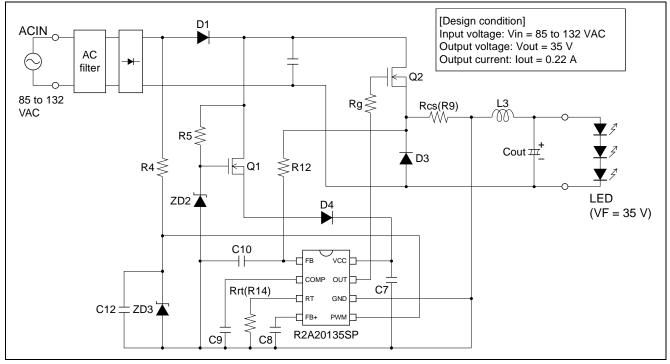


Figure 8.1 R2A20135EVB-ND1 Circuit

In current critical mode, the current which flows into the coil has a peak proportional to the voltage across the coil. Figure 8.2 shows the current waveform.

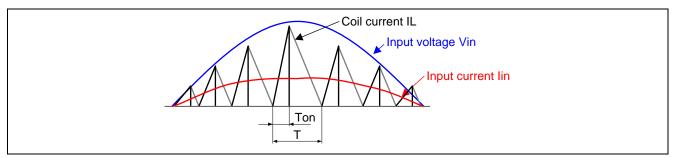


Figure 8.2 Input Current and Coil Current

8.1 Setting of Operation in Critical Conduction Mode

When the evaluation board operates in critical conduction mode, the RT pin should be pulled up to Vcc by a resistor with a value of several hundred kW.

Note: The current flowing into the RT pin should be no greater than 100 mA.

8.2 Selection of Minimum Switching Frequency

The switching frequency varies with the input voltage in current critical mode. This frequency is generally 100 kHz or less, both in consideration of efficiency and so that it is not in the range of audible frequencies. The minimum switching frequency is set to 40 kHz on this evaluation board.

8.3 Selection of Current Detection Resistance Rcs

The relationship between output current Iout and Rcs is as follows: Rcs = 0.2 / IoutIf Iout is 0.22 A in accordance with the design conditions, Rcs is calculated as follows: Rcs = 0.2 / 0.22 = 0.91 [W]



8.4 Selection of Inductor L

Calculate the inductance for the lowest switching frequency. When the minimum Vin is 85 VAC and Vout is 80 V, duty cycle DON is calculated as follows:

$$D_{ON} = Vout/(Vin) = 35/(85 \text{ '} \overrightarrow{O2}) = 0.291$$

Because the frequency is 40 kHz, ON time Ton is calculated as follows:

 $Ton = D_{ON}/fout = 0.291/40kHz = 7.28ms$

When input voltage Vin is 85 VAC, output power Pout is 7.7 W (0.22 ' 35), and conduction angle is 90%, average input current Iin (ave) is calculated as follows:

lin(ave) = Pout/h/Vin = 7.7/0.90/85 = 101mA

The peak value of the coil current is calculated as follows:

IL(peak) = lin(ave) 2/D_{ON} = 0.101 2/0.291 = 2.049A

Then, the value of inductor L is calculated as follows:

L = (Vin – Vout) 'Ton/lin(peak) = $(85 ' \ddot{\Omega} - 35)$ ' 3.64ms/0.687 = 1090mH

An inductor with a value of 1 mH is selected from the lineup of available standard inductors in consideration of allowable tolerance and size.

Note: *1 For the conduction angle, refer to the separate material (section headed "Selection of L" in the R2A20135SP application note).

External Circuit for FB and COMP Pins 8.5

Figure 8.4 shows the frequency characteristics of the R2A20135EVB-ND1.

This circuit is for stable operation in current mode (first-order lag). To improve the power factor, it is recommended to set the COMP pin in Figure 8.3 so that the loop gain is 0 dB at a frequency less than twice as the range of AC frequencies 50 to 60 Hz (100 to 120 Hz). Ccomp is 1 uF on the evaluation board.

In the case that a CR filter for the FB pin is inserted to reduce noise influence, select Rf1 so that the FB pin voltage is equal to or less than the zero-crossing detection threshold voltage in consideration of the current flowing into the FB pin. Rf1 on the board is 51 W.

Cf1 should have a value which produces a time constant much smaller than the switching frequency. It is left open circuit on the board.

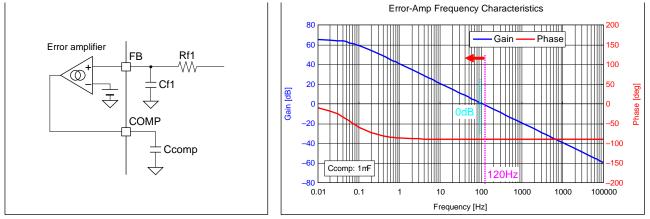


Figure 8.3 External Circuit for FB and COMP Pins Figure 8.4 R2A20135EVB-ND1 Frequency Characteristics

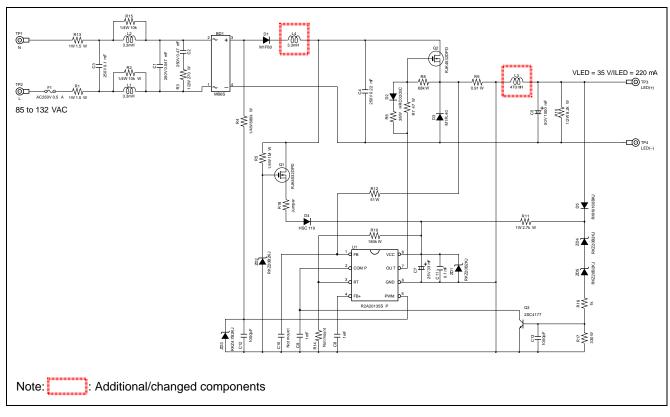
9. Conducted EMI

9.1 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.

9.1.1 Schematic with Conducted Emission Filter



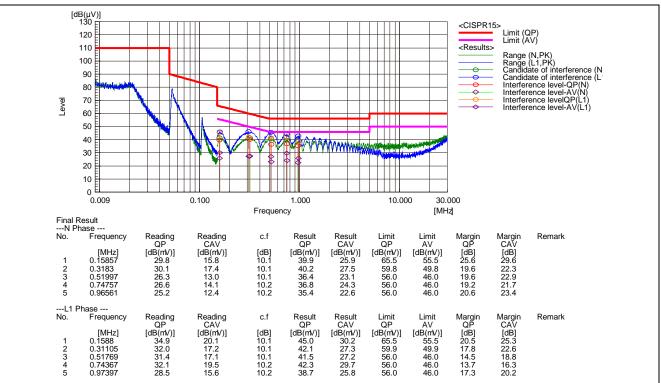
9.1.2 Additional/Changed Parts to Meet Conducted Emission Standard

Symbol	Parts Name	Catalog No.	Q	Rating		Manufacturer
L3	Inductor	RCP1317NP-471L	1	1.35A	470mH	Sumida
L4	Inductor	TSL0808S-332KR14-PF	1	0.14A	3.3mH	Taiyo Yuden

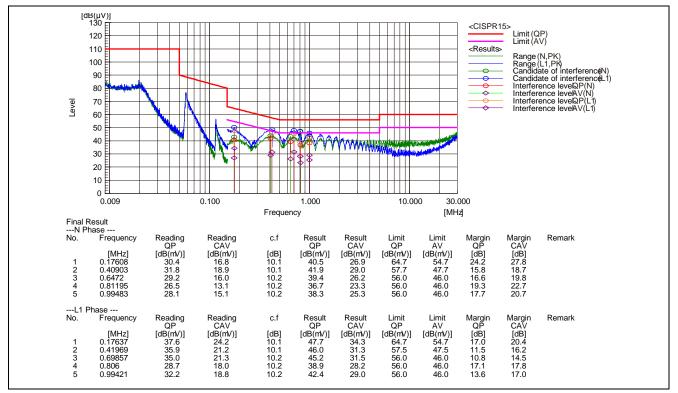


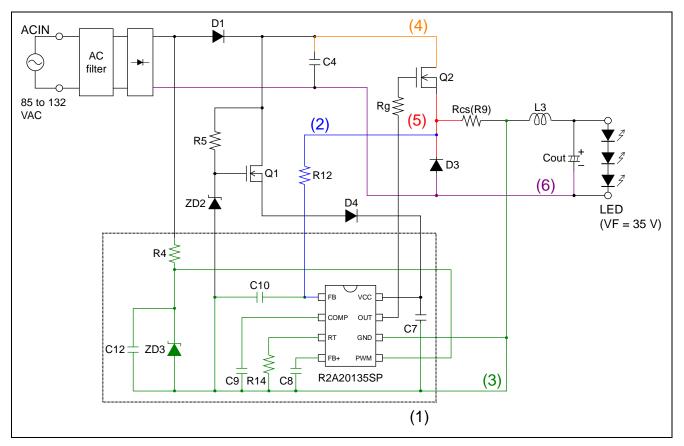
9.2 Conducted EMI Performance Data (CISPR15)

· Vin = 100 VAC, 60 Hz, LED load (VF = 35 V), Iout = 220 mA



• Vin = 120 VAC, 60 Hz, LED load (VF = 35 V), Iout = 220 mA





10. Guidelines for PCB Pattern Design and Placing/Mounting Components

10.1 Basic Notes

(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 thick GND pattern and connect it as close to the Rcs resistor (on the output side) as possible. Also, place the VCC bypass capacitor (C7) and the RT and FB resistors (R14 and R12, respectively) as close to the IC 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.

for design the circuit and PCB, following guidelines also should be cared;

- do NOT draw main switching pattern ((3)~(5) in previous schematics) under the IC nor back side of IC.
- M1, L2, D3 and main switching pattern should be kept enough distance from the IC as much as possible.
- mount the components NOT to contact to the IC.
- As FB pin and CS pin detect weak level signal, it is strongly recommended to insert low pass filter composed of resistor and capacitor, in front of FB pin.

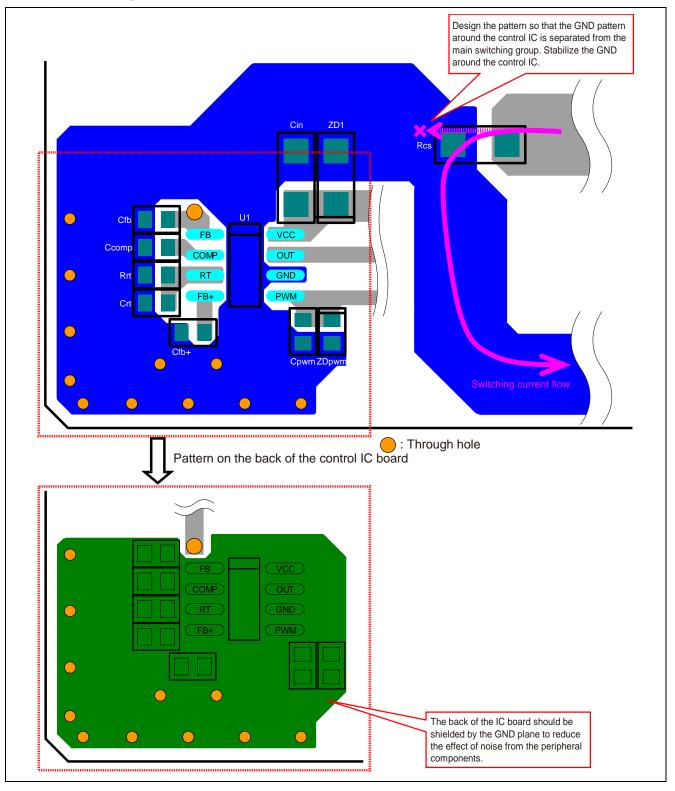


10.2 PCB Pattern Design

To reduce the effect of noise on the control IC, design the pattern by referring to the following example of design of the pattern around the control IC. The component numbers correspond to those of the circuits on the previous page and are common to both circuits.

These patterns are for reference and the operation of the circuit with components mounted is not guaranteed. The operation must be verified on an actual board.

Example of Design of Pattern around Control IC

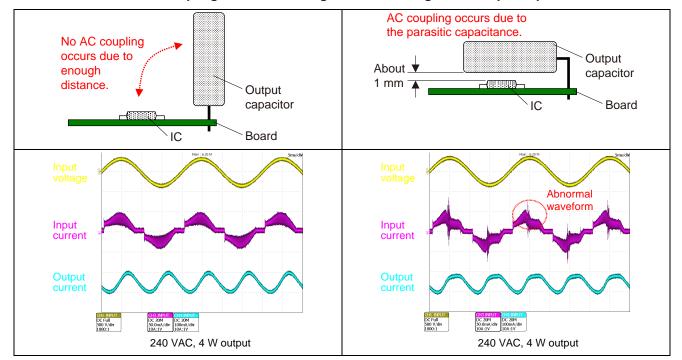




10.3 Notes on Mounting Components

The occurrence of AC coupling may vary even with the same board and circuit constants according to the mounting of the components.

Mount the components so that none of them makes contact with the control IC.



The occurrence of AC coupling varies according to the mounting of the output capacitor as follows.



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Revision Record

		Description	
Rev.	Date	Page	Summary
Rev.1.00	Sep 27, 2013	_	First edition issued

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