R2A20134SP

Application Note

R03AN0004EJ0200
Rev.2.00
Feb 14, 2012

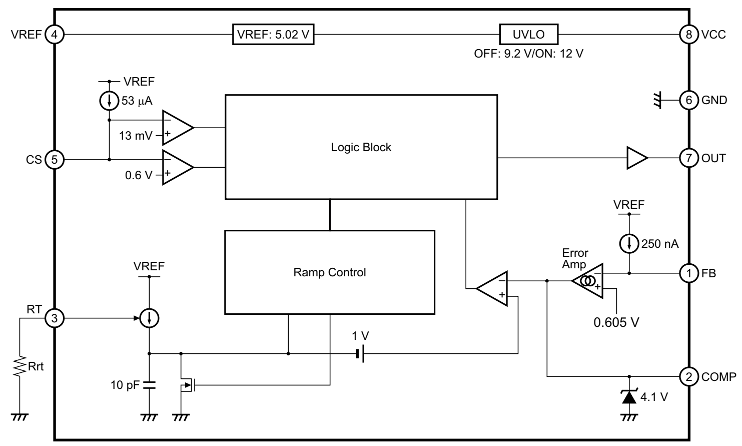
1. General Description

R2A20134SP is a control IC for LED lighting. It has two operation modes, Critical Conduction mode (CRM) and fixed switching frequency mode. User can choose one suitable mode for their purpose.
At Critical Conduction mode (CRM), this IC can control LED current precisely and correct power factor and achieve high efficiency by zero-current switching. At Fixed-Frequency mode, user can reduce the external components dramatically. AT Peak Current Control mode applying Fixed Switching Frequency Mode realized the minimum numbers of external components, smallest packaging and low BOM cost. Also this allows the isolated flyback operation.
Please refer to the 5.1 The list of Evaluation boards.

2. Block Diagram

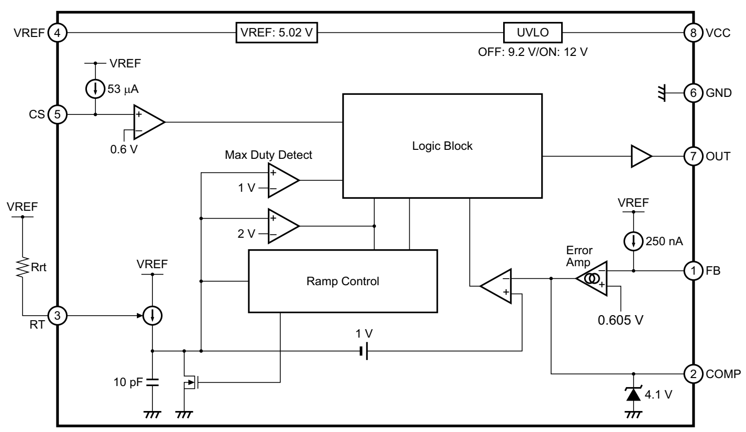
2.1 Critical Conduction Mode (Rrt is connected to GND)

When you connects external resistor Rrt between "RT" pin and GND, R2A20134SP works in Critical Conduction mode with Zero Current switching. At this mode, this IC turns the external MOSFET on at the timing when the inductor current becomes zero.



2.2 Fixed Switching Frequency Mode (Rrt is connected to Vref)

When you connect Rrt between "RT" pin and "VREF" pin, RE2A20134 works in Fixed Switching frequency mode. At this mode, this IC turns the external MOSFET on at the timing of internal oscillation signal. You can adjust the oscillation frequency by the value of Rrt.



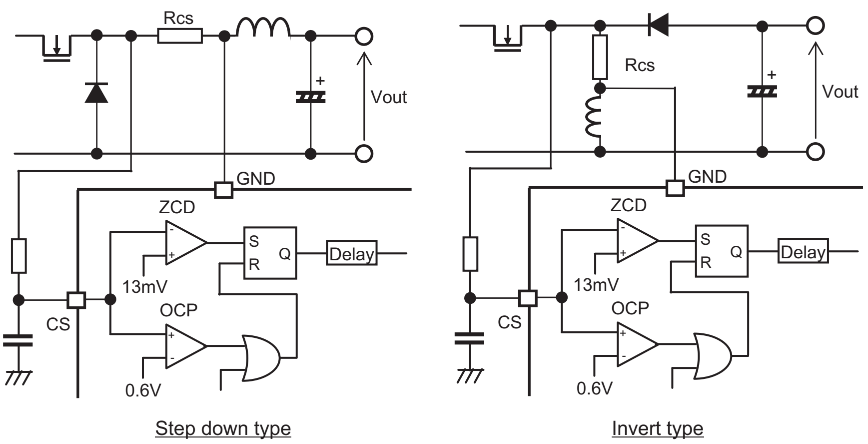
3. Explanation of Each Circuit Block

3.1 Zero Current Detection

R2A20134SP detects zero current point, checking the terminal voltage of Rrt which is connected in series with inductor. At critical Conduction Mode (CRM), this IC turns the external MOSFET on at this zero current point.
The threshold level of zero current detect is set to 13 mV typ. And delay time from zero current detection to drain voltage lay down of MOSFET is added. This delay time is fixed to 0.8 µs.

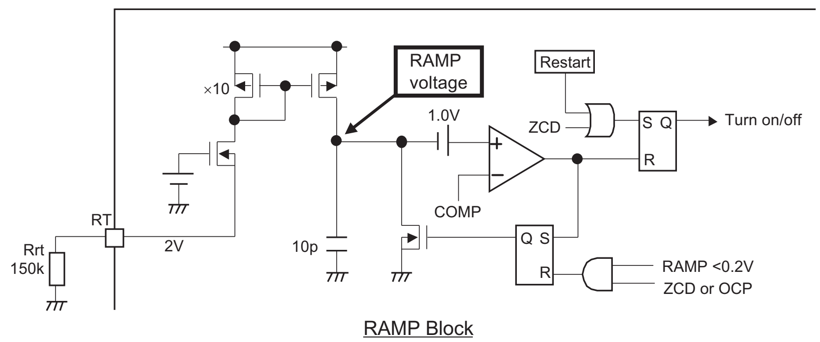
3.2 Over-Current Protection

Over-current protection circuit turns the MOSFET off, if the terminal voltage of current sensing resistor Rrt is over 0.6 V.



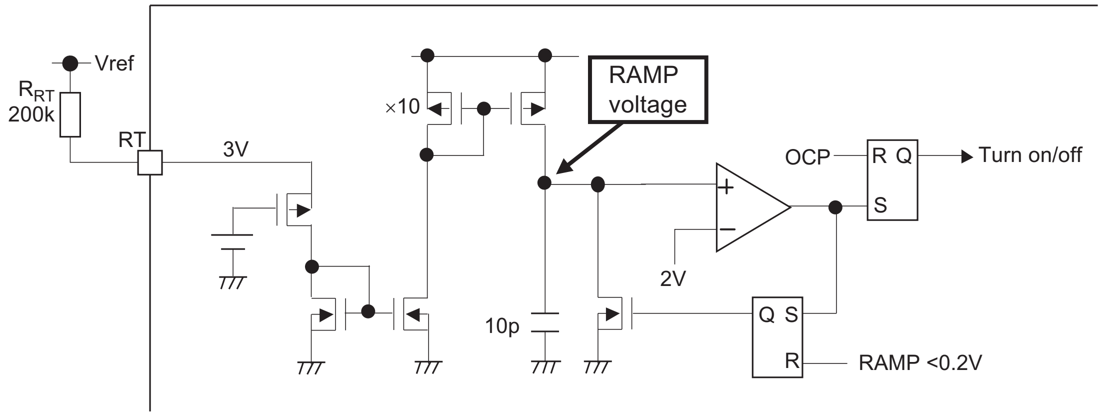
3.3 RAMP Slope

The built-in RAMP slope is defined by external Rrt (between "RT" pin and GND) and built-in Capacitor (10 pF). The charge current to 10 pF is defined as 1/10 of "RT" pin current.
The maximum ON time (ton_max) is limited when output voltage of error amplifier is 4 V.
The RAMP circuit starts to charge RAMP capacitor (10 pF) at the condition that ZCD detection circuit detects "zero current of inductor" and the RAMP voltage is lower than 0.2 V. When RAMP slope is equal to error amplifier output voltage, or over-current protection is detected, RAMP capacitor is discharged. If "COMP" voltage is less than 1 V, On time should be zero second, because of built-in level shifter of 1 V typ.



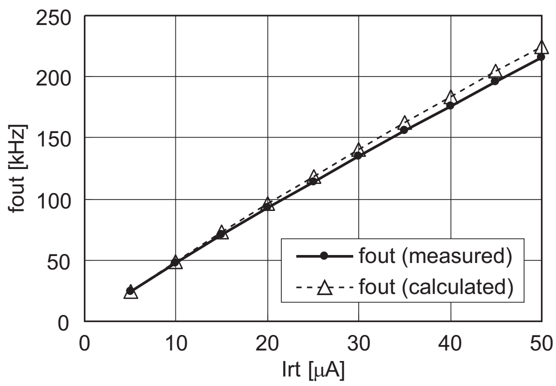
3.4 Built-in Oscillator

The oscillation frequency of built-in oscillator is defined by external Rrt (between "RT" pin and GND) and built-in capacitor (10 pF). The charge current to 10 pF is defined as 1/10 of "RT" pin current.
And the maximum ON duty is limited to 50% at switching frequency of 48 kHz. This oscillator starts to discharge the capacitor when the voltage of built-in capacitor is 2 V, and starts to charge when is less than 0.2 V.



The right graph indicates the relation between Irt (flowing-out current from "RT"pin) and the fout (oscillation frequency). Oscillation frequency can be calculated by the following formula.

$$fout\ [\text{kHz}] = \frac{1}{(100 \times 10^{-9} \times Rrt) + (450 \times 10^{-6})}$$

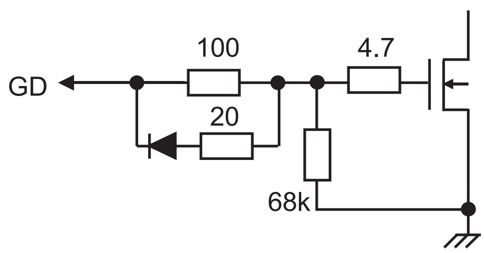


3.5 Error Amplifier

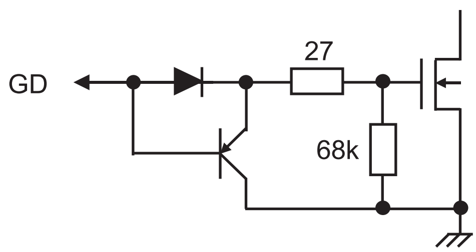
Trans-conduction amplifier is used as error amplifier inside. Its output current is defined by voltage difference between internal reference voltage and the voltage of "FB" pin.

3.6 Output Pin to Drive External MOSFET

Totem pole output circuit is built in at "OUT" pin.
The Maximum drive current is 900 mA (peak).
Basically it cab drive MOSFET directly, but adjustment of suitable driver circuit for each MOSFET is recommended.



Driver circuit example 1

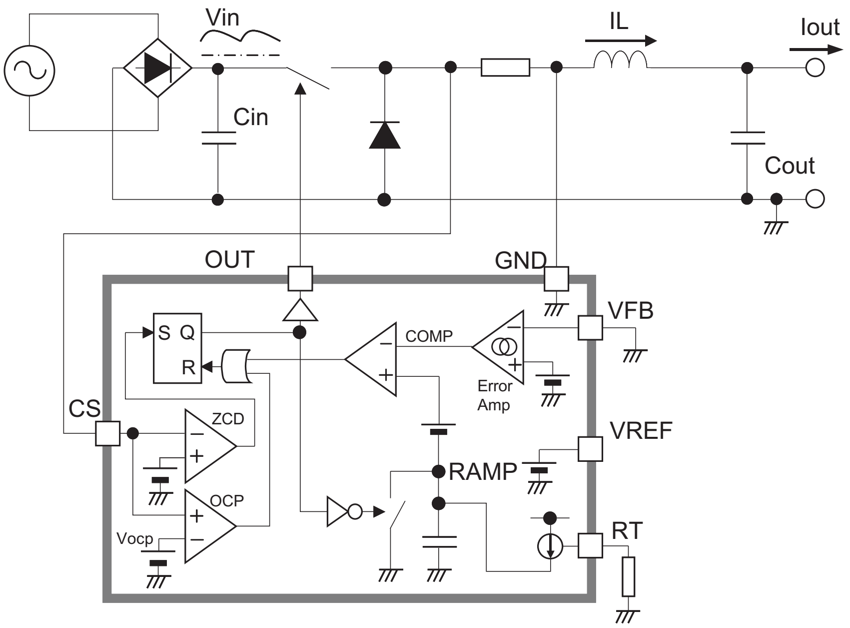


Driver circuit example 2

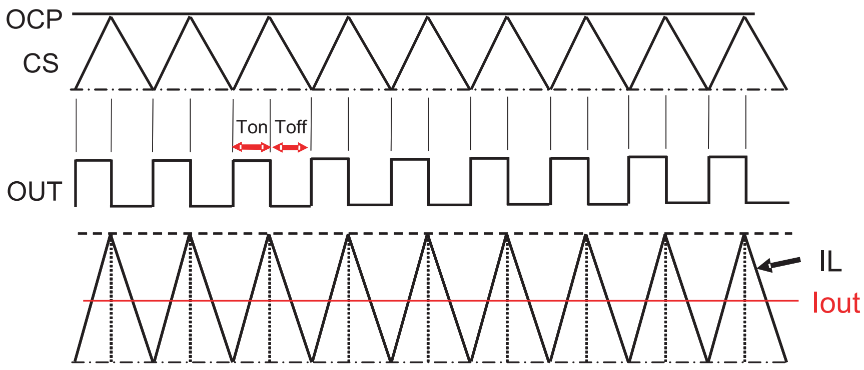
4. Application Circuit

4.1 Peak Current Control Circuit

The following is block diagram of peak current controlled step down driver circuit.
This circuit keeps peak current (=output current) constant, using over current protection function by detecting inductor current though "CS" pin.

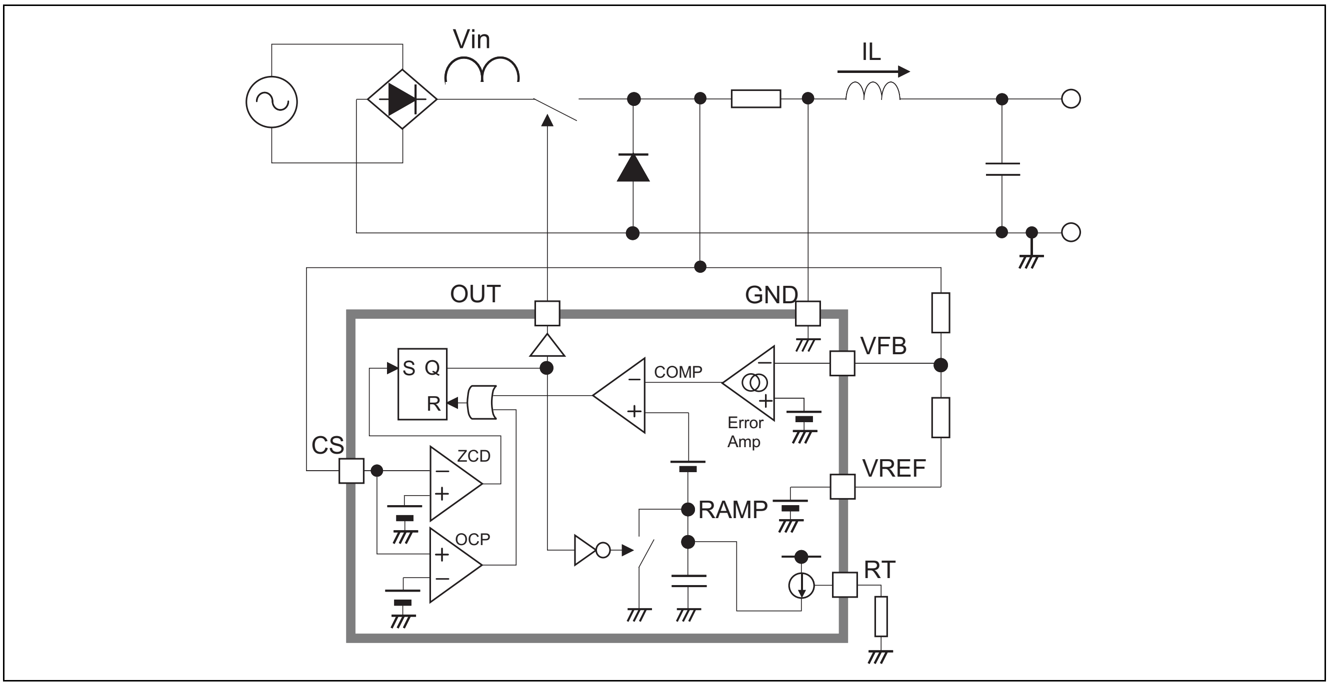


The peak current though inductor is kept constant in the range of Vin > Vout.
If Cin is big enough to keep always Vin > Vout, peak current though inductor is kept constant.
This means ripple on output current is reduced efficiently. And built-in error amplifier is not used in this example, less external components is used.



4.2 Constant ON Time Control (Power factor correction)

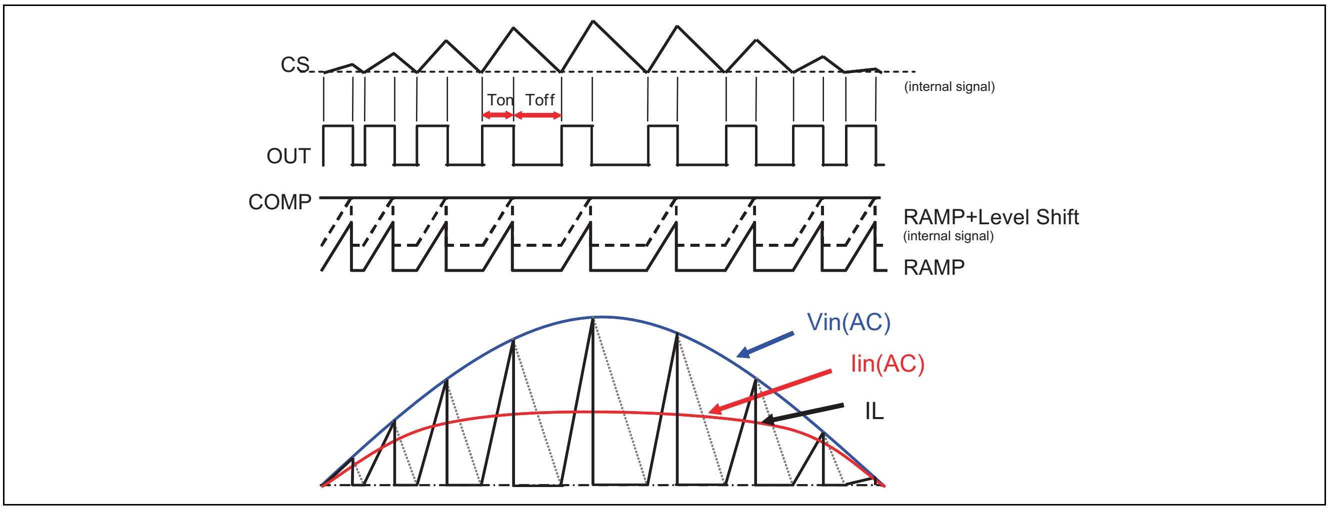
The following is the example circuit using error amplifier.
If inductor current is detected though "FB" pin, feed back loop using error amplifier controls the inductor current (=output current) constant.



In error amplifier controlled operation, ON time is fixed to constant during nominal operation. If On time is fixed to constant, peak inductor current is changed in proportion to input voltage. This operation corrects power factor.

$$di(t) = \frac{v(t)}{L}\,dt$$

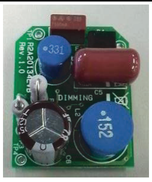
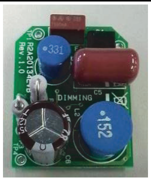
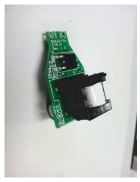
· · · Peak inductor current is changed in proportion to input voltage during ON time is constant.



5. Evaluation Boards (R2A20134 EVB-xx)

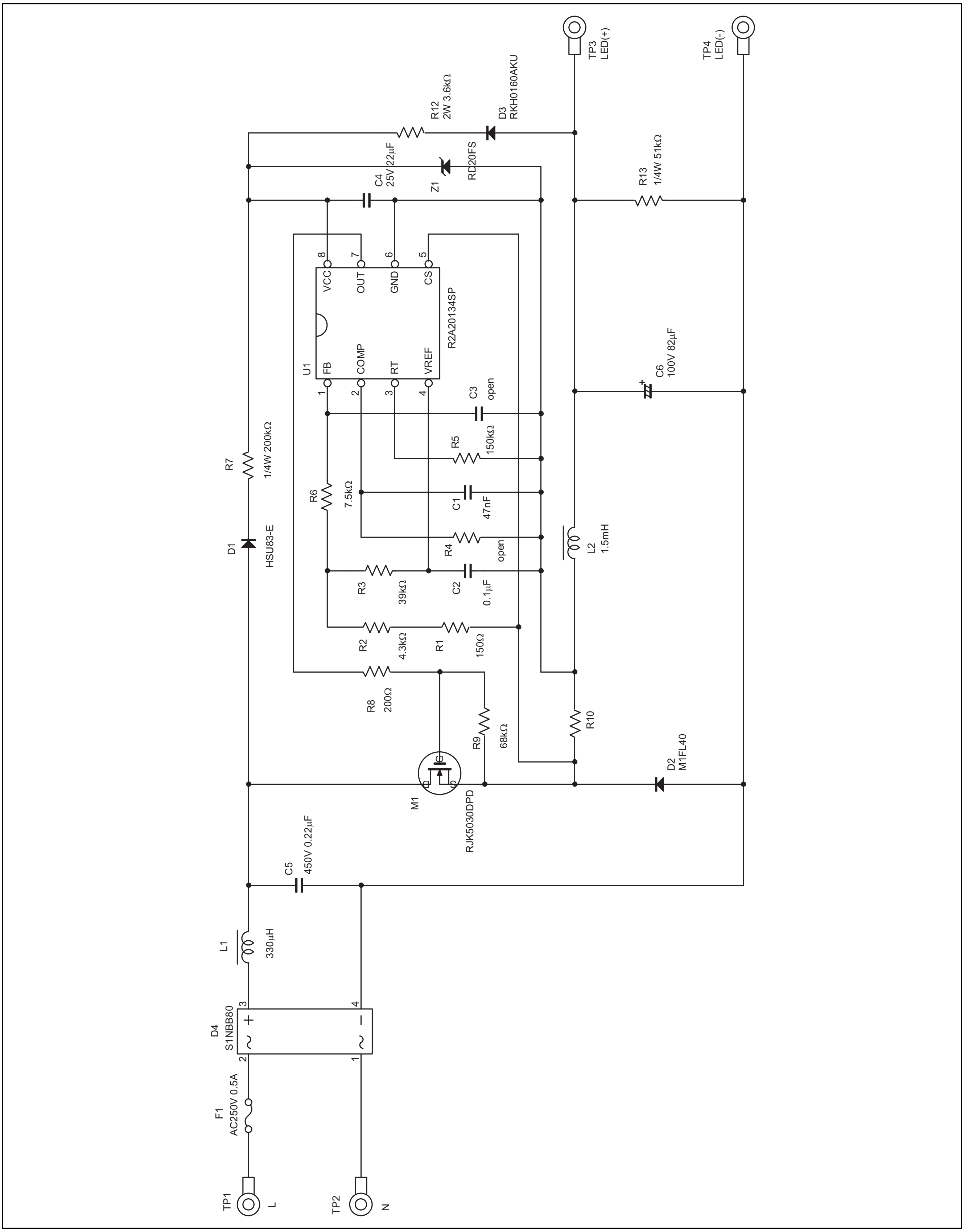
R2A20134 EVB-xx are the evaluation boards for LED driver IC R2A20134SP. There are six variations for each circuit structure. Customer can choose suitable one for each LED lighting products. Each evaluation board includes all necessary circuit. So, customer needs to prepare only AC power and LED load to evaluate R2A20134SP.

5.1 Summary of Each Evaluation Boards

Type Name		**R2A20134 EVB-NN1E**	**R2A20134 EVB-NN1P**	**R2A20134 EVB-NN2**	**R2A20134 EVB-ND**	**R2A20134 EVB-IN**	**R2A20134 EVB-ID**
Summary	Isolation	Non-isolation				Isolation	
	Mode	CRM		Fixed switching frequency			
	Topology	Step down/High-side SW		Buck boost/Low-side SW		Fly back	
	Control	Average current	Peak current				
	TRIAC dimming			Quasi at 100 V only	○		○
Original setting	AC input (V)	100	100	100	100	100	100
	Output Vf (V)	65/35	65/35	30	30	30	30
	LED current (mA)	100	100/120	120	240	120	250
Target bulb size		E26	E26	E17	E26	E17	E26
PCB size (mm)		33.5×36 max	33.5×36 max	20×35 max	33.5×36 max	20×35 max	33.5×36 max
Picture							
Typical perfor-mance	Eff.	92%/87%	89%/87%	84%	75%	82%	
	PF	0.93/0.94	0.6/0.53	0.7	0.91	0.73	
Characteristic		High Eff.&PF	Less components		TRIAC dimmable	Isolated	Isolated TRIAC dimmable
Note					Built-in valley-fill		Developing

5.2 R2A20134EVB-NN1E (non-isolation, without dimming function, one-converter PFC)

5.2.1 R2A20134EVB-NN1E Circuit Diagram (error amplifier controlled)



5.2.2 R2A20134EVB-NN1E (error amplifier controlled) BOM List

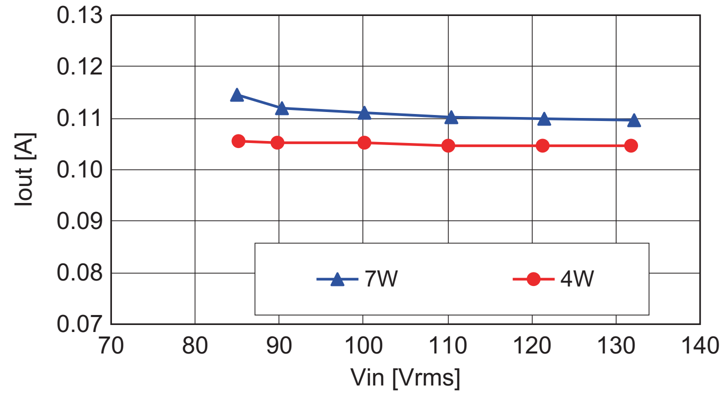
Vin = AC85 to 132 V, Vf = 65 V, ILED = 100 mA

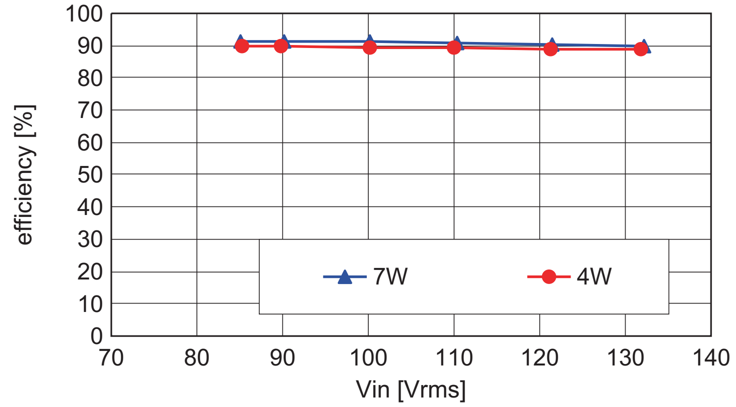
Symbol	Parts Name	Catalog No.	Q	Rating		Manufacture	Note
	P.C.B	R2A20134EVB	1				
U1	IC	R2A20134SP	1			Renesas	
M1	MOSFET	RJK5030DPD	1	500V	1.6Ω	Renesas	
D1	Switching diode	HSU83-E	1	250V	100mA	Renesas	
D2	FRD	M1FL40	1	400V	1.5A	Shindengen	
D3	FRD	RKS160AKU	1	600V	100mA	Renesas	
D4	Diode bridge	S1NBB80	1	800V	1A	Shindengen	
ZD1	Zener diode	RD20FS	1	20V	1W	Renesas	
L1	Choke coil	#8RDB-331K	1	330μH	200mA	Toko	
L2	Choke coil	13RHBP A7502HY-152M	1	1.5mH	400mA	Toko	
C1	Ceramic capacitor	GRM188B31H473K	1	47nF	50V	Murata	
C2	Ceramic capacitor	GRM188B31H104K	1	0.1μF	50V	Murata	
C3	open		0				
C4	Ceramic capacitor	GRM32EB31E226KE15B	1	22μF	25V	Murata	
C5	Film capacitor	ECQE2W224JH	1	0.22μF	450V	Panasonic	
C6	Chemical capacitor	EKY-101ELL820MJ20S	1	82μF	100V	Chemicon	
F1	Fuse	HTS 500mA	1	250V	500mA	Skygate	
R1	Resistor	150Ω	1	150Ω	1/16W		1%
R2	Resistor	4.3kΩ	1	4.3kΩ	1/16W		1%
R3	Resistor	39kΩ	1	39kΩ	1/16W		1%
R4	Resistor	open					
R5	Resistor	150kΩ	1	150kΩ	1/16W		
R6	Resistor	7.5kΩ	1	7.5kΩ	1/16W		
R7	Resistor	200kΩ	1	200kΩ	1/4W		400V
R8	Resistor	200Ω	1	200Ω	1/16W		
R9	Resistor	68kΩ	1	68kΩ	1/16W		
R10	Resistor	1.0Ω	1	1.0Ω	1/8W		1%
R11	None						
R12	Resistor	3.6kΩ	1	3.6kΩ	2W		
R13	Resistor	51kΩ	1	51kΩ	1/4W		
TP1							L
TP2							N
TP3							LED(+)
TP4							LED(–)

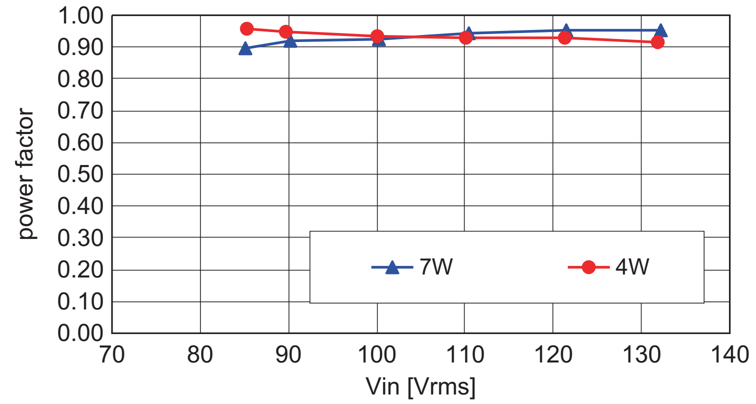
For reference: changed components for AC220 V input, VF = 35 V, ILED = 400 mA

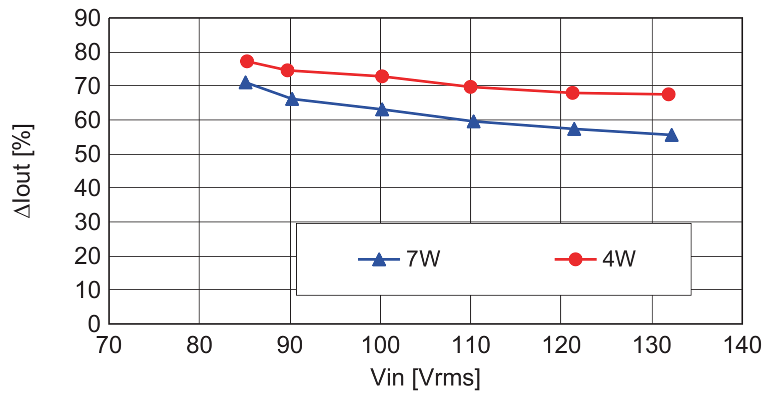
Symbol	Parts Name	Catalog No.	Q	Rating		Manufacture	Note
M1	MOSFET	RJK6002DPD	1	600V	5.7Ω	Renesas	
D2	FRD	CRF03	1	600V	1.5A	Toshiba	
L1	Choke coil	LHL08TB102J		1mH	800mA	Taiyo Yuden	
C3	Ceramic capacitor	GRM188R11E473KA01D	1	0.047μF	50V	Murata	
C5	Film capacitor	ECQE2W104JH		0.1μF	450V	Panasonic	
C6	Chemical capacitor	EKY-500ELL331MJ25S		330μF	50V	Chemicon	
R1	Resistor	3.3kΩ	1	3.3kΩ	1/16W		1%
R2	Resistor	820Ω	1	820Ω	1/16W		1%
R7	Resistor	RK73B 2B T TD 434 J		430kΩ	1/4W	KOA	400V
R10	Resistor	RL1220S-R33-F		0.33Ω	1/4W	Susumu	1%

5.2.3 R2A20134EVB-NN1E Board Evaluation Data (7W: Vf = 65 V, 4W: Vf = 35 V)

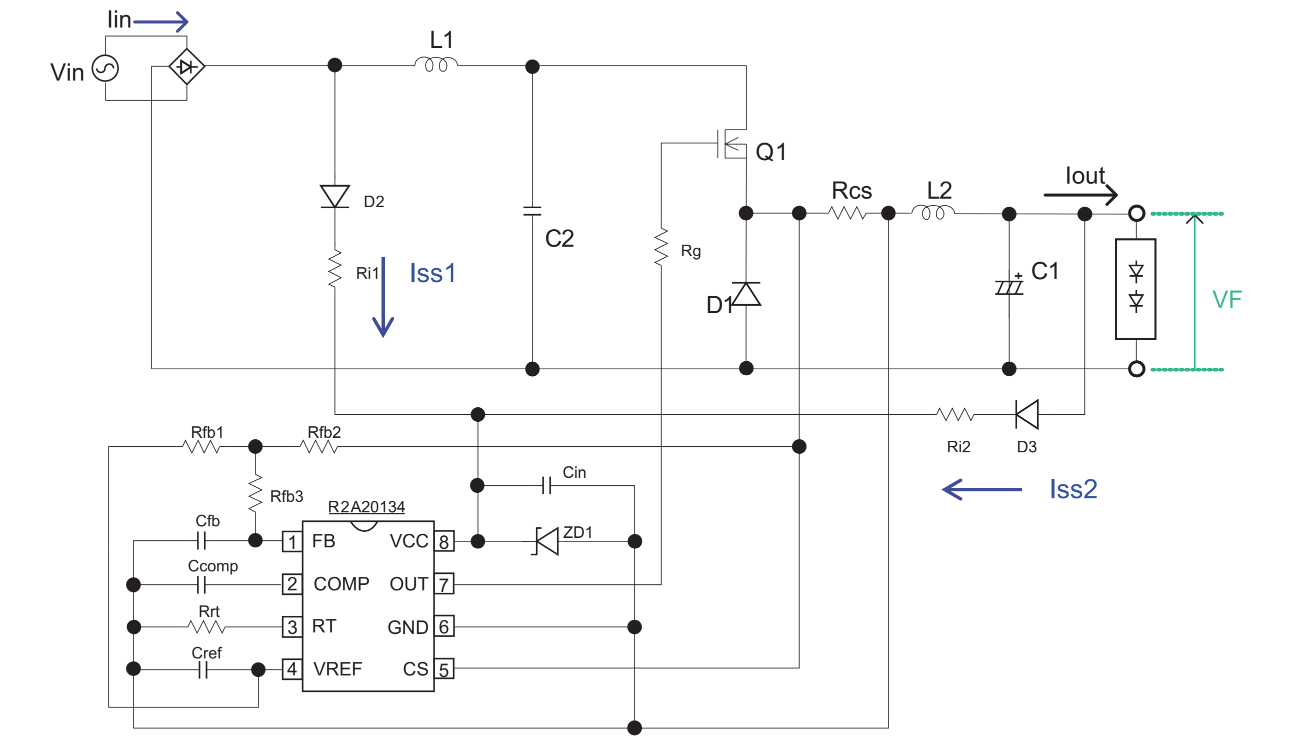








5.2.4 R2A20134EVB-NN1E: Basic Operation and Calculation of Major Components



[Preconditions of Design]
Vin = 80Vac to 120Vac, Iout = 0.1A, Vf = 65V, C1 = 82µF, Ri2 = 3.6kΩ, Ri1 = 200kΩ

1. Start-up operation and calculation of Cin

(a) Stand-by state

When Vcc is below 12 V, R2A20134SP is in stand-by state, and consumes about 130 µA as stand-by current. At this condition, Cin is charged by (Iss-130 µA).

(b) Active state

When Vcc rises over 12 V of UVL voltage, R2A20134SP is in active state, and it consumes about 2.2 mA.
R2A20134SP has the hysteresis range of 2.8 V in UVL operation and it keeps active state over Vcc = 9.2 V.
After activated, Vout is almost 0 V and Iss1 = (Vin–Vcc)/Ri1 = $(100\sqrt{2}-12)/200$ kΩ = 647 µA is supplied to R2A20134SP. At this time, Vcc is reduced gradually, because Icc(= 2.2 mA) > Iss1(= 647 µA).
If Vout rises to supply Icc < Iss1 + Iss2 before Vcc sinks less than 9.2 V, R2A20134SP succeeds to start up.
So, Cin have to keep over 9.2 V until Vout1 rises to supply enough current of Iss2.

<Calculation of Cin at Vcc>

Cin have to keep Vcc > 9.2V, until Vout becomes "Vhysteresis" supplying Iss2 > 2.2 mA–Iss1 = 1.55 mA.
To satisfy this, Vout1 is calculated as Vout = 3.6 kΩ × 1.55 mA + 12 V + VF(1 V) = about 19 V, because Iss1 + Iss2 = 2.2 mA and Ri2 = 3.6 kΩ.
If we define the voltage held by Cin as Vhys, the hold time by Cin "th" is calculated as th = Vhys × Cin/(Icc–Iss1) simply.
But at the same time, Iout is increasing to nominal Iout though LEDs. So it is not easy to be calculated. So, you need to define Cin by doing "Cut and Try" finally.
One simple calculating example is to define Iout = nominal Iout/2.

Please notice that Iss1becomes lower, AC input voltage is lower. So, please try at the minimum AC input voltage.

* Calculation example of Cin at the minimum AC input voltage Vin = 85 Vac

1) Vout to supply enough Iss2 to R2A20134SP
   Vout1 = Ri2 × (2.2 mA – (Vin / Ri1)) + UVL_Hi + Vf
   = 3.6 k × (2.2 mA – (80 $\sqrt{2}$ / 200 k)) + 12 + 1 = 18.9 V
   So, If Vout > 18.9 V, Iss1 + Iss2 > Icc (= 2.2 mA)

2) Necessary time to rise upto Vout1
   t1 = C1 × Vout1 / Iout1
   = 82 μ × 18.9 / 0.05 = 31 ms

3) Calculation of Cin
   Vhys (voltage reduction of Vcc) have to be less than 2.8 V typ.
   So we set it 2.5 V now.
   Cin = t1 × (2.2 mA – (Vin / R7)) / Vhys
   = 31 ms × (2.2 mA – (80 $\sqrt{2}$ / 200 k)) / 2.5 = 20.27 μF

4) Adjustment at the minimum AC input voltage
   Please check the actual board at minimum AC input voltage of 80 V.
   If you find this boards wakes up without any problem, please fix it 22 μF.

2. Current detection resistance Rcs and inductor L2

   Under the condition mentioned above, the external constants are calculated as follows;

   <Rcs>

   Buck converter can not operate in the range that input voltage is lower than output voltage, therefore the ratio of the time when the input current is supplied actually results in 1–2 × Arcsine (30 V/140 V × 1.414)/π = about 90%, and average supplied current results in 400 mA/0.9 = 444 mA.

   At this moment, peak current that flows to Rcs is the peak current of triangle waveform in critical conduction mode operation, it is two times of average current, that is 888 mA. Maximum value is about 1.4 times and it results in 888 mA × 1.4 = 1.24 A, because this is current waveform of power factor correction.

   Rcs value needs to be set below 0.6/1.24 = 0.48 Ω because OCP detection voltage of CS terminal is 0.6 V.

   Here, Rcs is set to 0.33 Ω so that OCP detection level is defined below 150% of normal operation.

   <Rfb1, Rfb2>

   Partial voltage ratio of Rfb1/Rfb2 supplied to FB terminal needs to be set to Vfb = Vref – Vcs/(Rfb1 + Rfb2) × Rfb2 +Vcs = 0.6 V.

   Average voltage of Rcs selected in the preceding clause is Vcs = 0.33 × 400 mA = 0.132 V.

   (0.6V – 0.132V)/(5.0V – 0.132V) = Rfb2/(Rfb1 + Rfb2)

   When Rfb1 is set to 39 kΩ, Rfb2 results in, Rfb2 = 4.12 kΩ = 3.3 kΩ + 0.82 kΩ under the condition that Rfb1 + Rfb2 should be around 50 kΩ.

   <L2>

   Firstly, it needs to decide minimum oscillation frequency. Here It is set to 50 kHz.

   In critical conduction mode operation, the frequency would be minimum when the current is maximum and when the difference between input voltage and output voltage.

   On-duty of FET at this moment is 30 V/(140 × 1.414) = 0.15. So, Ton results in Ton = 0.15/50 kHz = 3 μs.

   On the other hand, ΔI of inductor is equal to the peak current of Rcs mentioned above.

   L = (Vin – Vout) × ΔT/ΔI = (197 V – 30 V) × 3 μs/1.24 A = 404 μH

   Finally the inductance value is set to 390 μH, considering the available line-ups of the parts.

3. Loop filter of feedback amplifier

   Frequency characteristics of R2A20134EVB-NN1E are shown in Figure 5.2.

   The control of this IC is Current mode (time-lag of first order), and it can operate stably. But to improve the power factor, it is recommended that the loop gain is 0 dB under 100 – 200 Hz which is twice as high as the AC input fLINE (50 – 60 Hz)

   And the output current can be kept constant in a wide input voltage range by inserting CR filter (Cf1, Rf1) to the terminal FB, and setting pole p0 of the CR filter to be the lowest switching frequency fMIN or less.

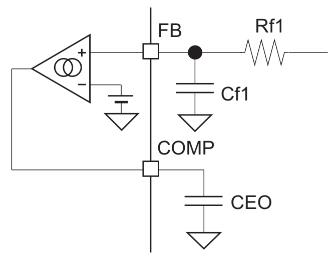


Figure 5.1 FB, COMP External Parts

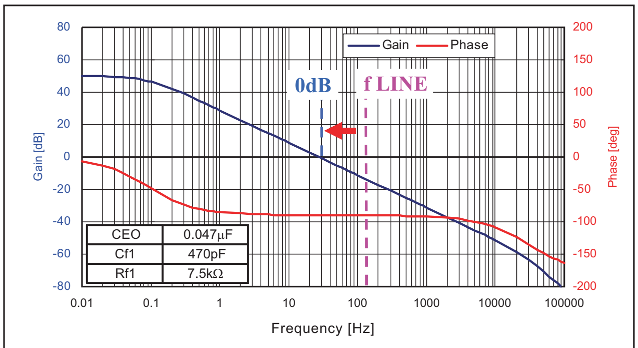


Figure 5.2 Frequency Characteristics of R2A20134EVB-NN1E

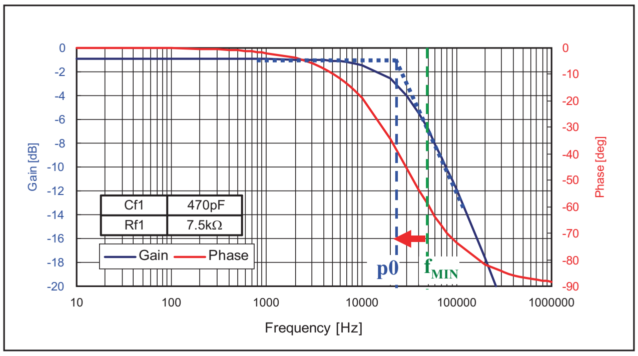
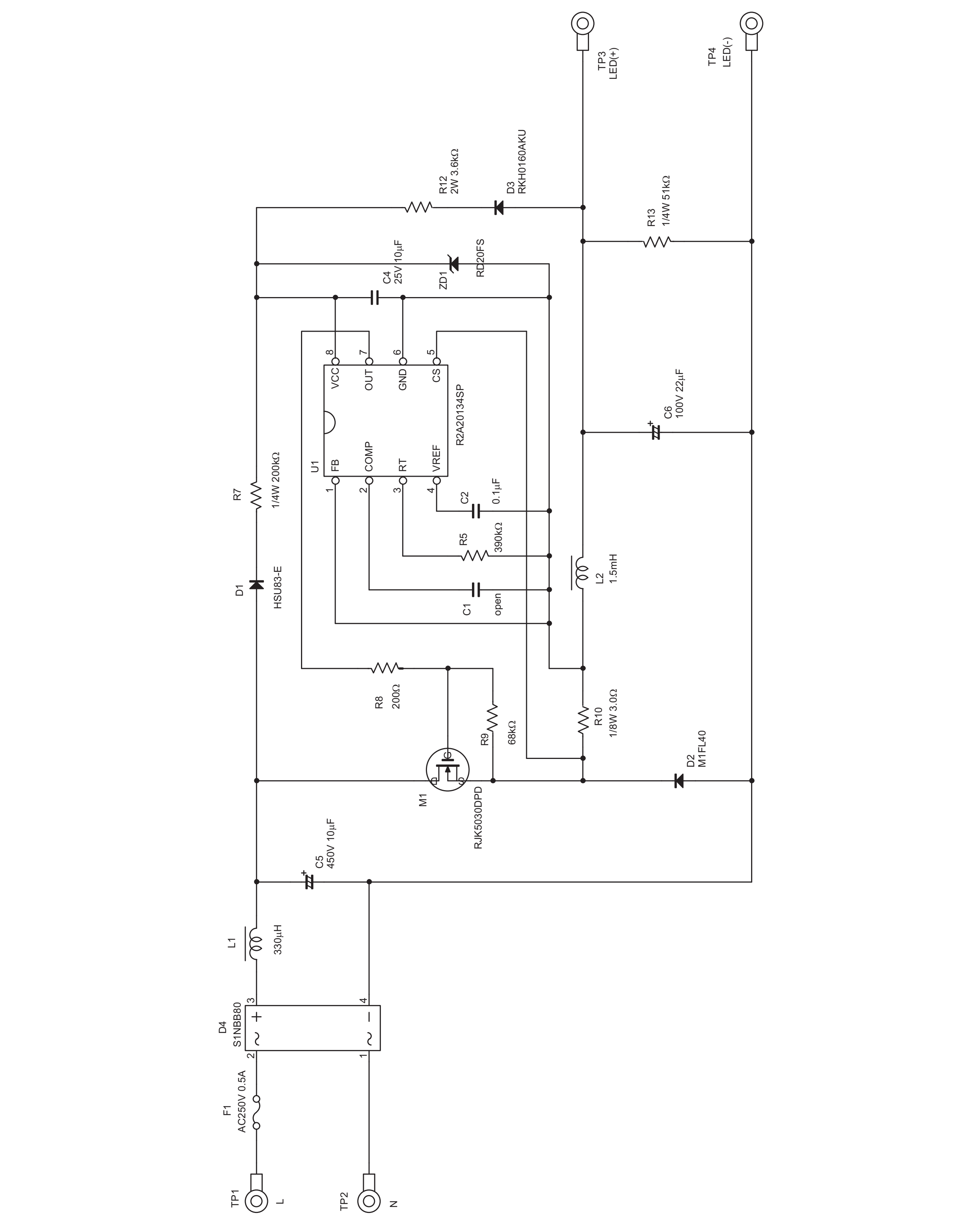


Figure 5.3 Frequency Characteristics of CR Filter of FB Terminal

5.3 R2A20134EVB-NN1P (non-isolation, non-dimming, peak current controlled, step down)

5.3.1 R2A20134EVB-NN1P Circuit Diagram

Note: This evaluation board is made by the change of external components using same PCB as R2A20134EVB-NN1.



5.3.2 R2A20134EVB-NN1P BOM List

Note: This evaluation board is made by the change of external components using same PCB as R2A20134EVB-NN1.

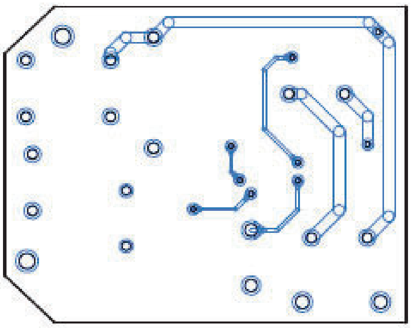
Symbol	Parts Name	Catalog No.	Q	Rating		Manufacture	Note
	P.C.B	R2A20134EVB	1				NN1E appropriation
U1	IC	R2A20134SP	1			Renesas	
M1	MOSFET	RJK5030DPD	1	500V	1.6Ω	Renesas	
D1	Switching diode	HSU83-E	1	250V	100mA	Renesas	
D2	FRD	M1FL40	1	400V	1.5A	Shindengen	
D3	FRD	RKS160AKU	1	600V	100mA	Renesas	
D4	Diode bridge	S1NBB80	1	800V	1A	Shindengen	
ZD1	Zener diode	RD20FS	1	20V	1W	Renesas	
L1	Choke coil	#8RDB-331K	1	330μH	200mA	Toko	
L2	Choke coil	13RHBP A7502HY-152M	1	1.5mH	400mA	Toko	
C1	Ceramic capacitor	open					
C2	Ceramic capacitor	GRM188B31H104K	1	0.1μF	50V	Murata	
C3	short		1				
C4	Ceramic capacitor	GRM32EB31E226KE15B	1	10μF	25V	Murata	
C5	Chemical capacitor	450BXF10M10×16	1	10μF	450V	Rubycon	
C6	Chemical capacitor	100YXJ22M6.3×11	1	22μF	100V	Rubycon	
F1	Fuse	HTS 500mA	1	250V	500mA	Skygate	
R1	open						
R2	open						
R3	open						
R4	open						
R5	Resistor	390kΩ	1	390kΩ	1/16W		
R6	open						
R7	Resistor	200kΩ	1	200kΩ	1/4W		400V
R8	Resistor	200Ω	1	200Ω	1/16W		
R9	Resistor	68kΩ	1	68kΩ	1/16W		
R10	Resistor	3.0Ω	1	3.0Ω	1/8W		1%
R11	None						
R12	Resistor	3.6kΩ	1	3.6kΩ	2W		
R13	Resistor	51kΩ	1	51kΩ	1/4W		
TP1							L
TP2							N
TP3							LED(+)
TP4							LED(–)

Appendix: Modification for Vin = AC140 to 220 V, Vf = 30 V, ILED = 400 mA

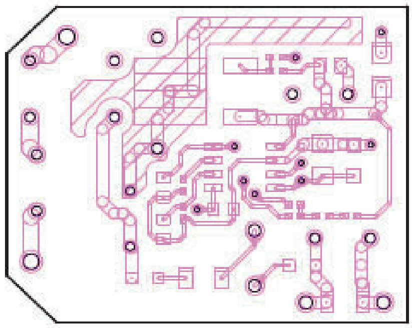
Symbol	Parts Name	Catalog No.	Q	Rating		Manufacture	Note
M1	MOSFET	RJK6002DPD	1	600V	5.7Ω	Renesas	
D2	FRD	CRF03	1	600V	700mA	Toshiba	
L1	Choke coil	RFS1317-394L		680μH	800mA	Coil Craft	
C5	Chemical capacitor	450BXC4R7M10×16		4.7μF	450V	Rubycon	
C6	Chemical capacitor	050YXJ4R7M5×11		4.7μF	50V	Rubycon	
R7	Resistor	RK73B 2B T TD 404 J		400kΩ	1/4W	KOA	400V
R8	Resistor	MCR01MZPJ220		22Ω	1/16W	ROHM	
R10	Resistor	RL1220S-R75-F		0.75Ω	1/4W	Susumu	1%

Note: You have to change D2 M1FL40 into 500V diode in the case of AC240V input

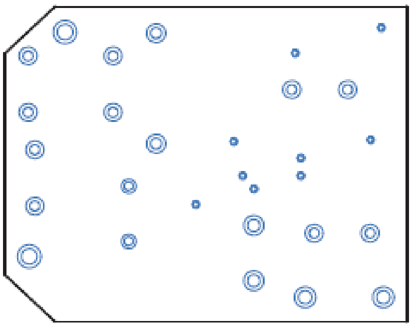
5.3.3 R2A20134EVB-NN1E, NN1P Common Board Pattern



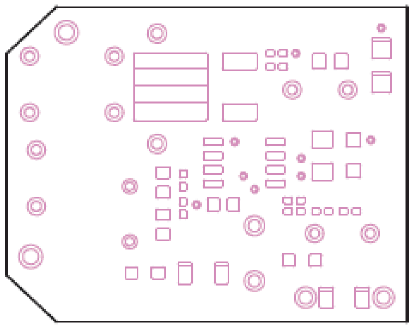
Top Layer: Circuit Pattern



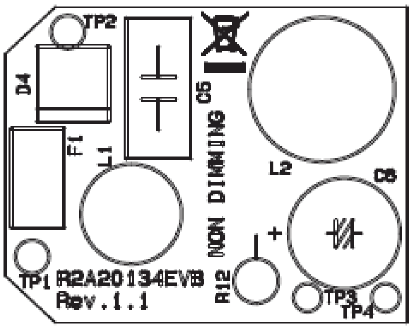
Bottom Layer: Circuit Pattern



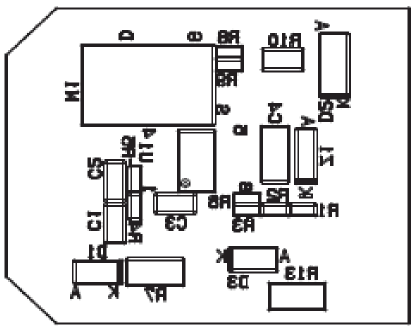
Top Layer: Solder Resist



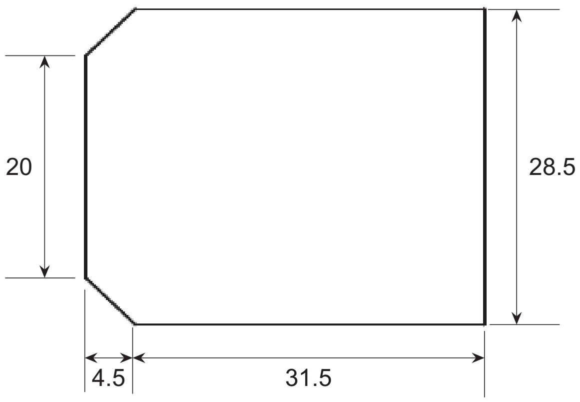
Bottom Layer: Solder Resist



Top Layer: Silk Screen

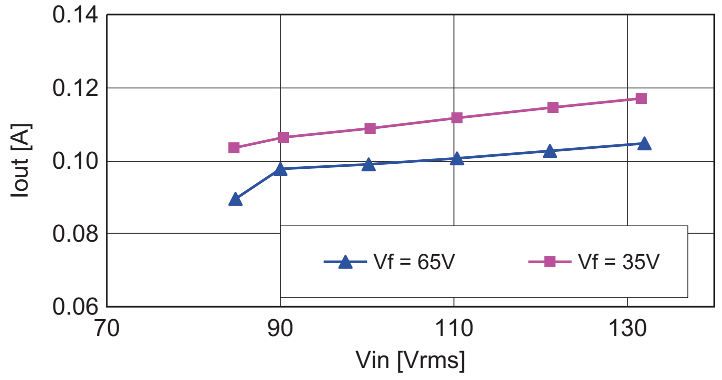


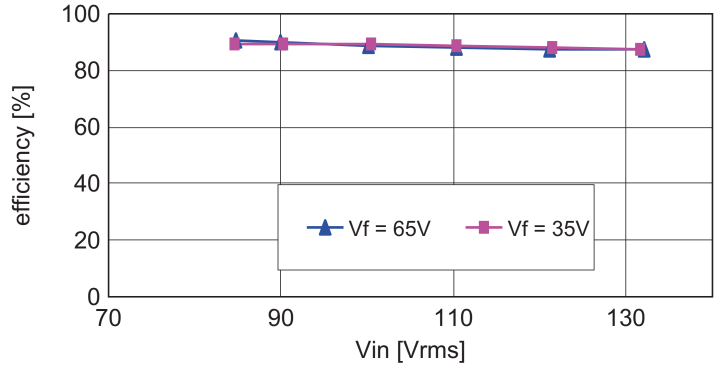
Bottom Layer: Silk Screen

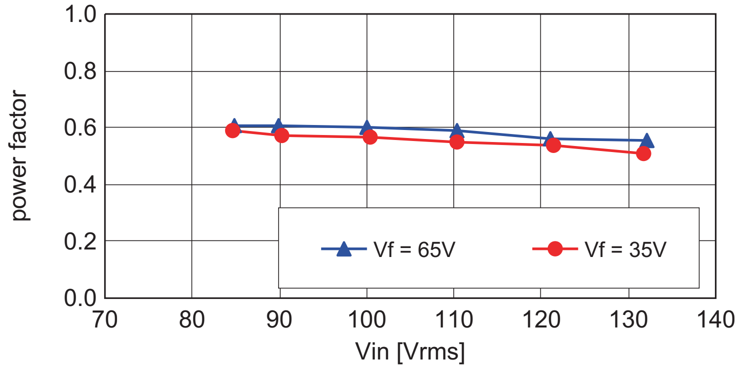


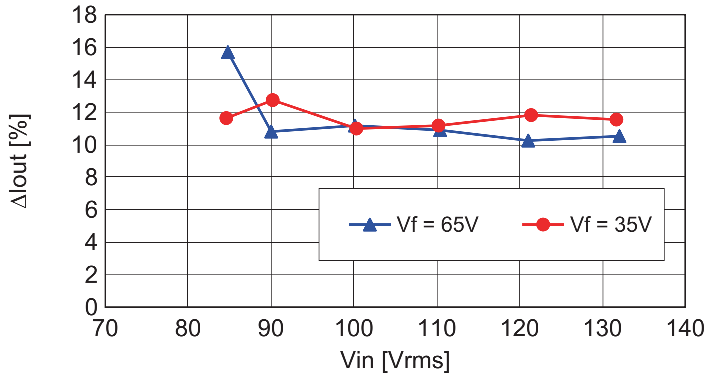
Outside view of the EVB

5.3.4 R2A20134EVB-NN1P Evaluation Data



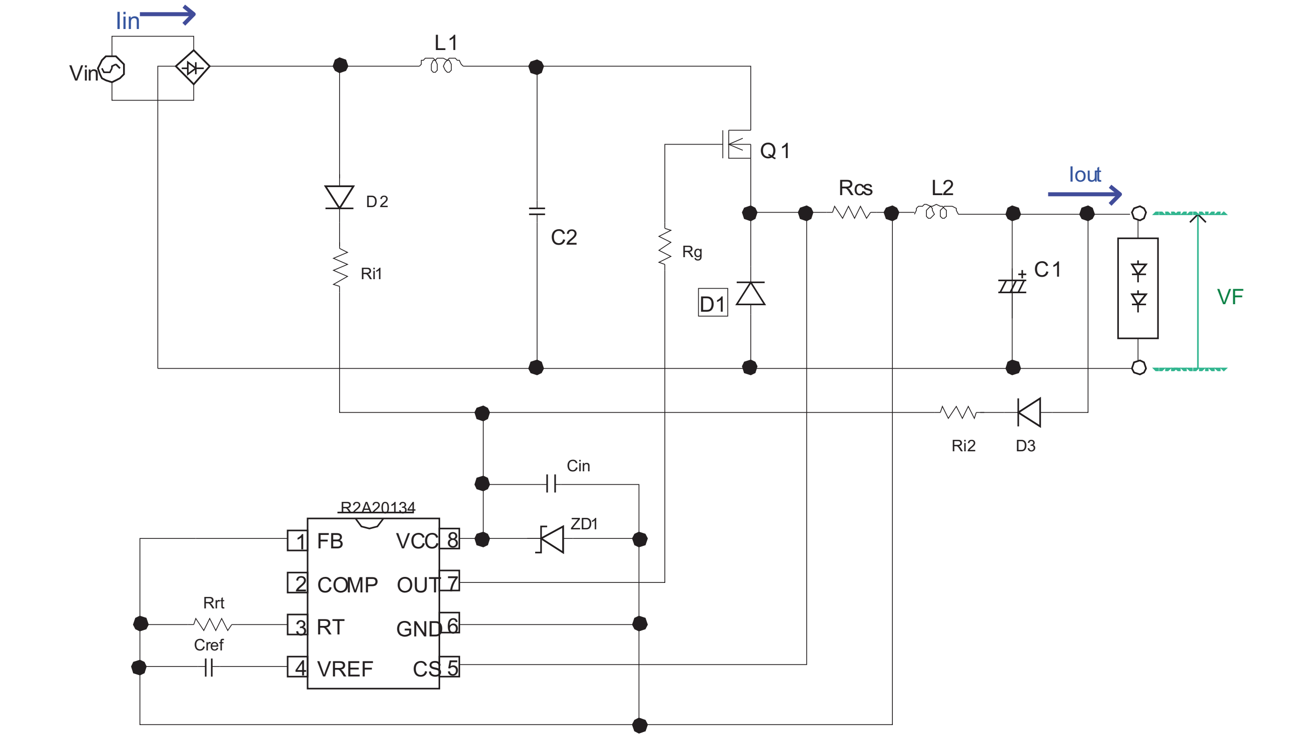






5.3.5 R2A20134EVB-NN1P: Basic operation and calculation of major components

Note: PCB of this board is the same as R2A20134EVB-NN, and changed the components and wire connection.



[Preconditions of Design]
Vin = 85Vac to 110Vac, Vout = 65Vdc, Iout = 0.1A, Minimum switching frequency 50kHz

1. Calculation of inductor with Constant ON time and Peak current control

<Setting of minimum switching frequency>

Minimum switching frequency is set to 50 kHz to avoid the audio frequency band. In this case, the cycle is T = Ton + Toff = 20 μs.

<Calculation of Inductor>

Amount of current change is ΔI = 2 × Iout = 200 mA at the condition of Vout = 65 V, Iout = 100 mA.
Switching frequency becomes minimum when the difference of the input and the output voltage is least, because of the Constant ON time control operation. The difference between input and output voltage should be set to 20 V in IC operable voltage range, T is calculated with following equations.
Ton = L × ΔI/(Vin – Vout) or Toff = L × ΔI/Vout and T = L × ΔI × Vin/(Vout × (Vin – Vout))
Therefore, L = T/ΔI/Vin × Vout × (Vin – Vout) = 20 μs/200 mA/85 V × 65 V × 20 V = 1.53 mH
Selected inductor value is 1.5 mH which has 200 mA current capability and necessary margin considering temperature rise and magnetic saturation.

2. Calculation of Rcs in Constant ON time and Peak current Control
The peak current becomes ΔI = 2 × Iout = 200 mA under Preconditions of Design of Iout = 100 mA.
And the reference voltage of comparator Vcs is 0.6 V.
Therefore, the resistor of the current detection Rcs is calculated as 0.6 V/200 mA = 3 Ω.

3. Calculation of the input capacitor C2

<Estimation of input power>

The period in which rectified input voltage is lower than output voltage Vout can be calculated as
$0.182 \times 2 \times 10$ ms = 3.64 ms

Considering arcsin (Vout/($\sqrt{2}$ × Vac))/π = arcsin (65/(1.414 × 85))/3.14 ≈ 0.182.

Input power is estimated around 6.5/0.9 = 7.33 W when the output voltage is 65 V × 100 mA = 6.5 W and 90% efficiency.

<Calculation of the input capacitor C2>

The average voltage of C2 is 103 V. It is calculated as the middle point of the peak voltage (85Vac × $\sqrt{2}$ = around 120 V and the minimum voltage (65 V + 20 V = 85 V). So, the charge amount Q2 is calculated as
Q2 = 7.33 W/103 V × 3.64 ms = 0.26 mC.

The C2 value must be bigger than 0.26 mC/35 V = 7.4 μF calculated as C = Q/V and the voltage drop have to be kept to be less than 120 – 85 = 35 V.

As the result, the C2 is selected 10 μF in consideration of allowable margin.

4. Calculation of the Rrt setting the minimum RAMP switching frequency

<Estimation of MOSFET on time>

In case of "Constant On time and Peak current control" operation,

ΔI = (Vin – Vout)/L × Ton because V = L • di/dt

Ton becomes Ton = 200 mA × 1.5 mH/65 V ≈ 4.6 μs with ΔI = 2 × Iout = 200 mA in this design condition.

<Calculation of Rrt to set the switching frequency>

To keep longer than 4.6 μs of Ton time, the RAMP charge current is calculated by the following equation.

V = Q/C = Ton × Irt/C, Irt = V × C/Ton

In a case of "Peak current control" operation, the COMP voltage is cramped at 4 V, and the Ramp voltage has 1 V voltage shift. Therefore, the voltage V is 3 V.

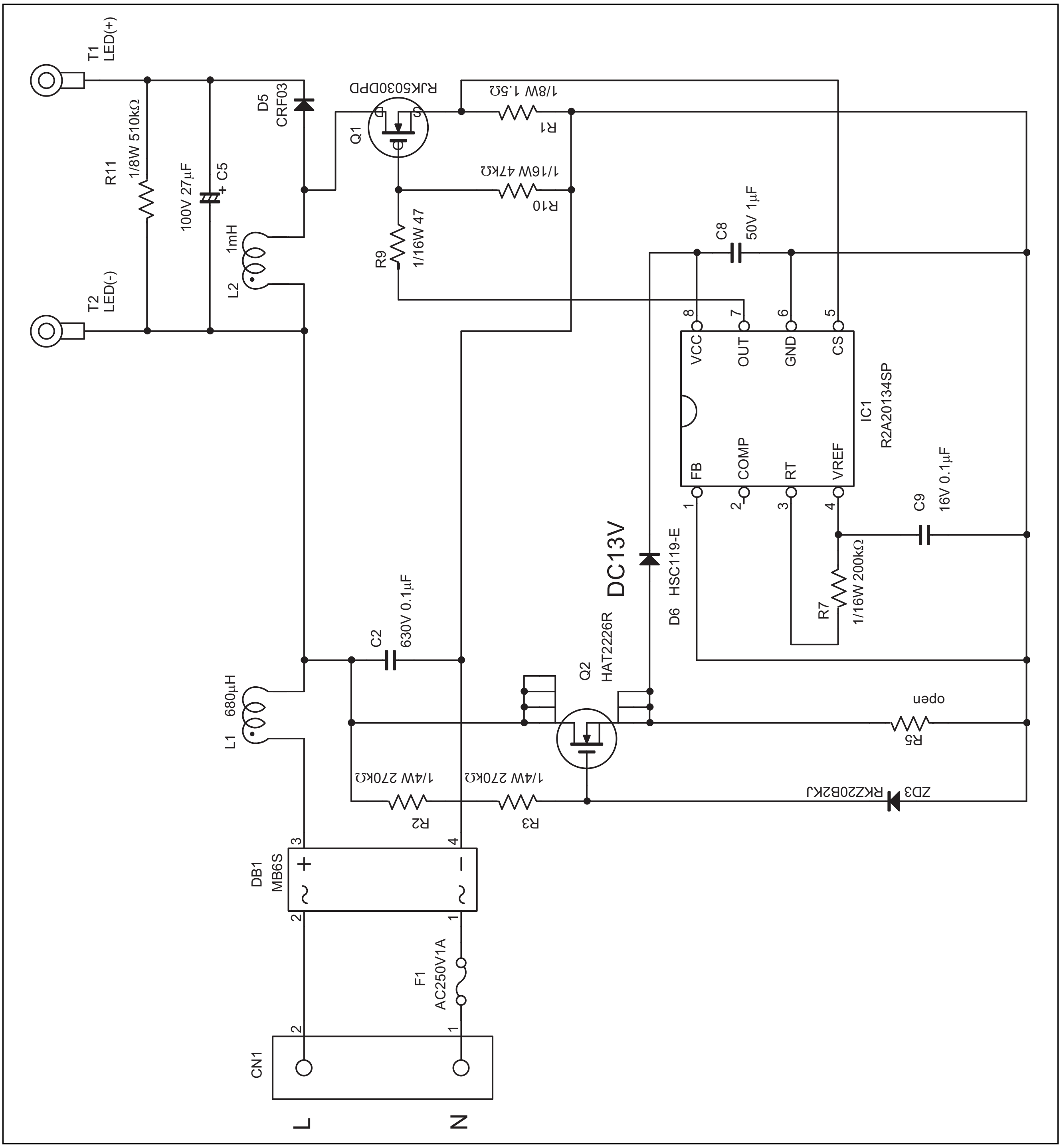
In addition, internal capacitor C is 10 pF, and the ratio of the current mirror circuit is 1/10. So, Irt is calculated as
Irt = 3 V × 10 pF/(4.6 μs × 10) = around 65 μA.

So, Rrt value should be bigger than 30.8 kΩ = Vrt/Irt = 2 V/0.65 μA.

5.4 R2A20134EVB-NN2 (non-isolation, non-dimming, peak current controlled, buck-boost)

5.4.1 R2A20134EVB-NN2 Circuit Diagram

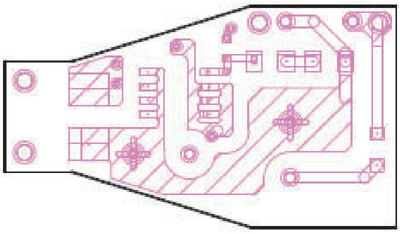
(Vin = 85-132 Vrms, Iout = 0.12 A, VF = 30 V)



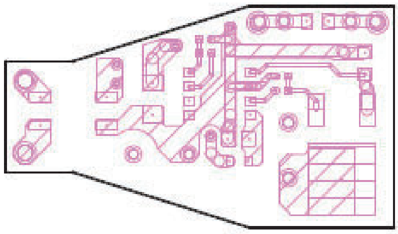
5.4.2 R2A20134EVB-NN2 BOM List

Symbol	Parts Name	Catalog No.	Q	Rating		Manufacture	Note
IC1	IC	R2A20134SP	1			Renesas	
Q1	MOSFET	RJK5030DPD	1	500V	1.6Ω max	Renesas	
Q2	MOSFET	HAT2226	1	600V	52Ω	Renesas	
DB1	Bridge diode	MB6S	1	420Vrms	0.5A		
D5	FRD	CRF03	1	600V	0.8A	Toshiba	
D6	Diode	HSC119-E	1			Renesas	
ZD3	Zener diode	RKZ20B2KJ	1	20V		Renesas	
C2	Ceramic capacitor	RDER72J104K8K1C11B	1	630V	0.1μF	Murata	
C5	Chemical capacitor	EKY-800ELL270MHB5D	1	100V	27μF	Nippon Chemical	φ8×11.5
C8	Ceramic capacitor	GRM21BR71H105KA12L	1	50V	1μF	Murata	2012 size
C9	Ceramic capacitor	GRM155R71C104KA88J	1	16V	0.1μF	Murata	1005 size
R1	Resistor	RK73H2ATTD1R5F	1	1/8W	1.5Ω	KOA	2012 size 1%
R2	Resistor	RK73B3ATTD274J	1	1/4W	270kΩ	KOA	3216 size
R3	Resistor	RK73B3ATTD274J	1	1/4W	270kΩ	KOA	3216 size
R7	Resistor	RK73B1ETTD204J	1	1/16W	200kΩ	KOA	1005 size
R9	Resistor	RK73B1ETTD470	1	1/16W	47Ω	KOA	1005 size
R10	Resistor	RK73B1ETTD473J	1	1/16W	47kΩ	KOA	1005 size
R11	Resistor	RK73B2ATTD514J	1	1/8W	510kΩ	KOA	2012 size
L1	Coil	LQH55DN681M03	1		680μH	Murata	
L2	Choke coil	RP1315B-102M	1		1mH	Sumida	
		A7503CY-102M	or			Toko	

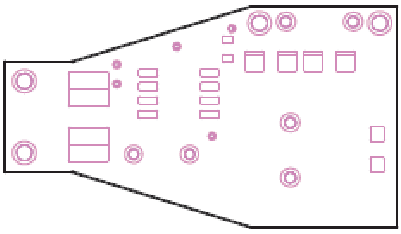
5.4.3 R2A20134EVB-NN2 Board Pattern



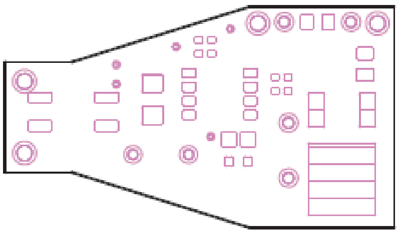
Top Layer: Circuit Pattern



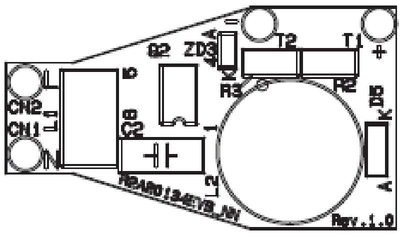
Bottom Layer: Circuit Pattern



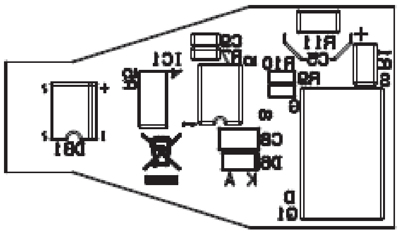
Top Layer: Solder Resist



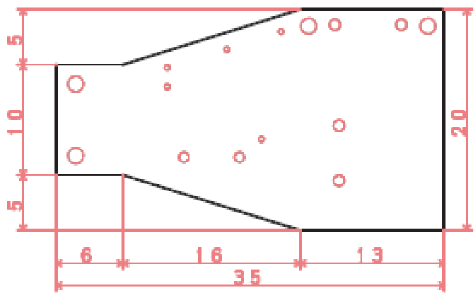
Bottom Layer: Solder Resist



Top Layer: Silk Screen

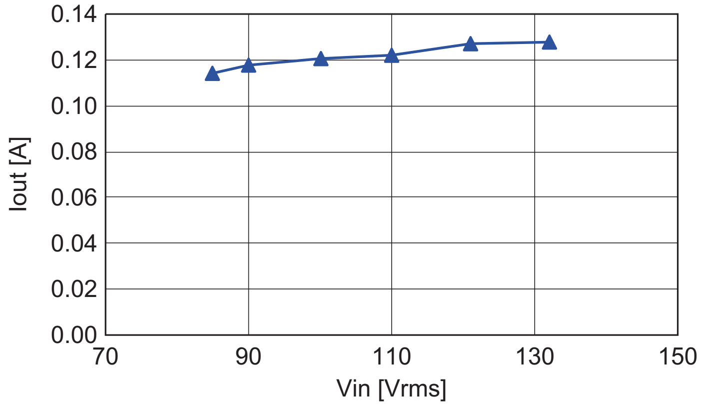


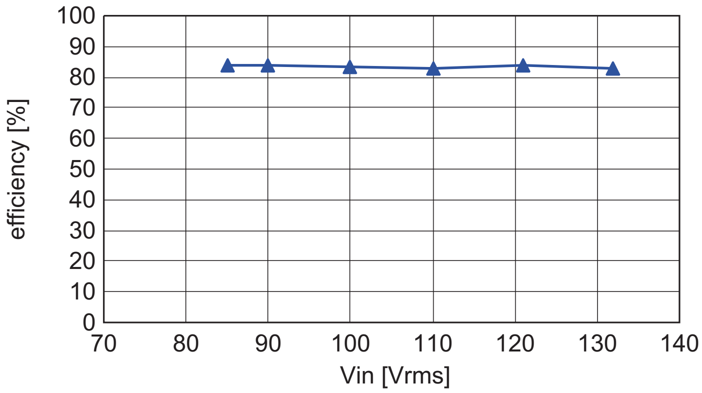
Bottom Layer: Silk Screen

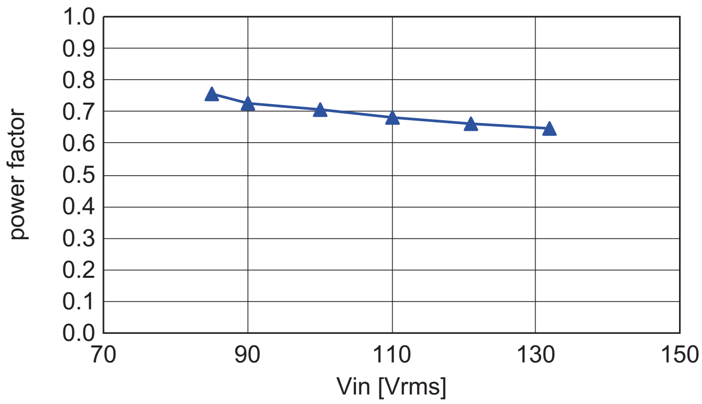


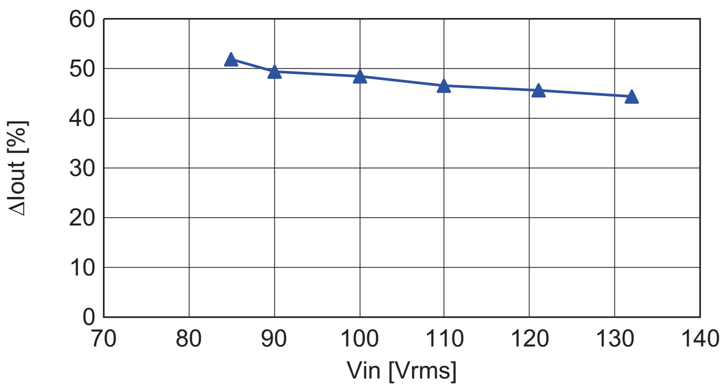
Outside view of the EVB

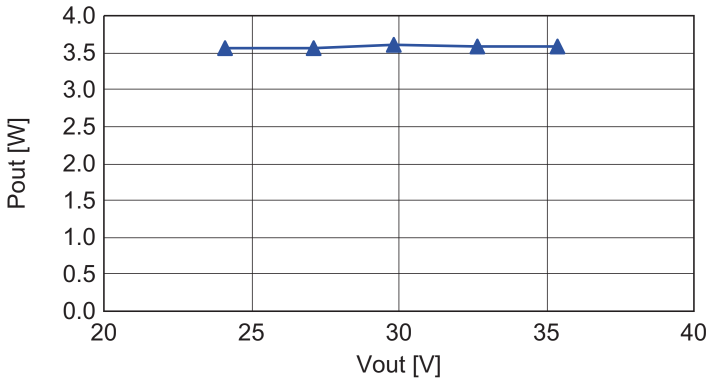
5.4.4 R2A20134EVB-NN2 Evaluation Data

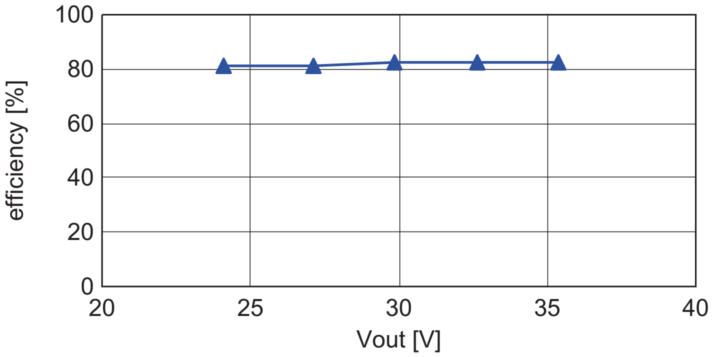


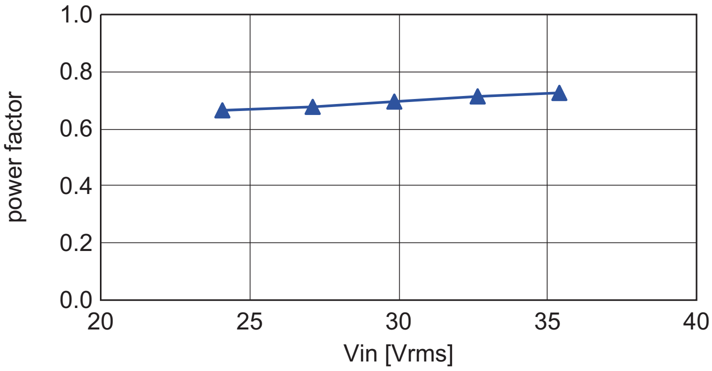


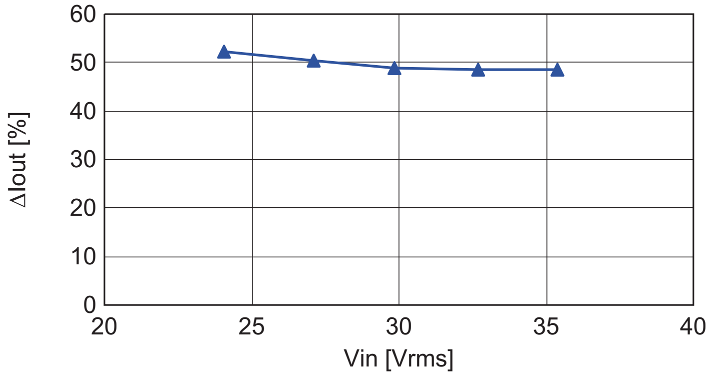





Pout [W]
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20
25
30
35
40
Vout [V]


efficiency [%]
100
80
60
40
20
0
20
25
30
35
40
Vout [V]


power factor
1.0
0.8
0.6
0.4
0.2
0.0
20
25
30
35
40
Vin [Vrms]


ΔIout [%]
60
50
40
30
20
10
0
20
25
30
35
40
Vin [Vrms]

5.4.5 Basic Operation of R2A20134EVB-ND, and the Procedure to Calculate the External Constants

[Preconditions of Design] Vin = 85 Vac to 132 Vac, Vout = 30 Vdc, Iout = 0.12 A

In this board, input power is controlled at fixed value by the Fixed-Frequency operation and peak current controlled operation.

Note: At the constant input power control, the current flows though the inductor discontinuously.

1. Calculation of the resistance Rrt for setting the frequency and the inductance L, for the fixed-frequency mode

<The choice of Fixed-Frequency>

To avoid the listenable frequency range, we choose 50kHz as an example.

<Calculation of the resistance Rrt for setting the frequency>

By using the calculation formula at chapter 3.4, Rrt is calculated 195.5 kΩ.

If we choose 200 kΩ nearest to 195.6 kΩ, the frequency is recalculated as Rrt = 200 kΩ.

$$fout\ [\text{kHz}] = \frac{1}{(100 \times 10^{-9} \times Rrt) + (450 \times 10^{-6})}$$

<Calculation of the inductance L for the constant input power operation>

The current have to flow the inductor discontinuously at constant input power operation.

So, you should calculate the critical condition between continuous current mode and discontinuous current mode first.

As the most severe condition, if you define the minimum input voltage as Vin = 80 V, minimum output voltage as Vout = 30 V.

At this condition, the duty ratio is calculated as

Vout/(Vin + Vout) = 30/(80 + 30) = 0.273

Note: In case of that the calculated duty ratio is over 50%, please re-define the duty ratio = 50%, during the following calculation procedure.

Because the oscillation frequency is 48.9 kHz, Ton can be calculated as Ton = 0.273/48.9 kHz = 5.58 µs

If we define Vin = 80 V Pin = 4 W, Iin(ave) = 4/80 = 50 mA

Therefore Iin(peak) = Iin(ave) × 2/Duty = 367 mA

So, L=Vin × Ton/Iin(peak) = 1.2 mH (maximum)

To allow permitted tolerance of inductance, you should choose 1 mH.

<Calculation of the current sensing resistance Rcs>

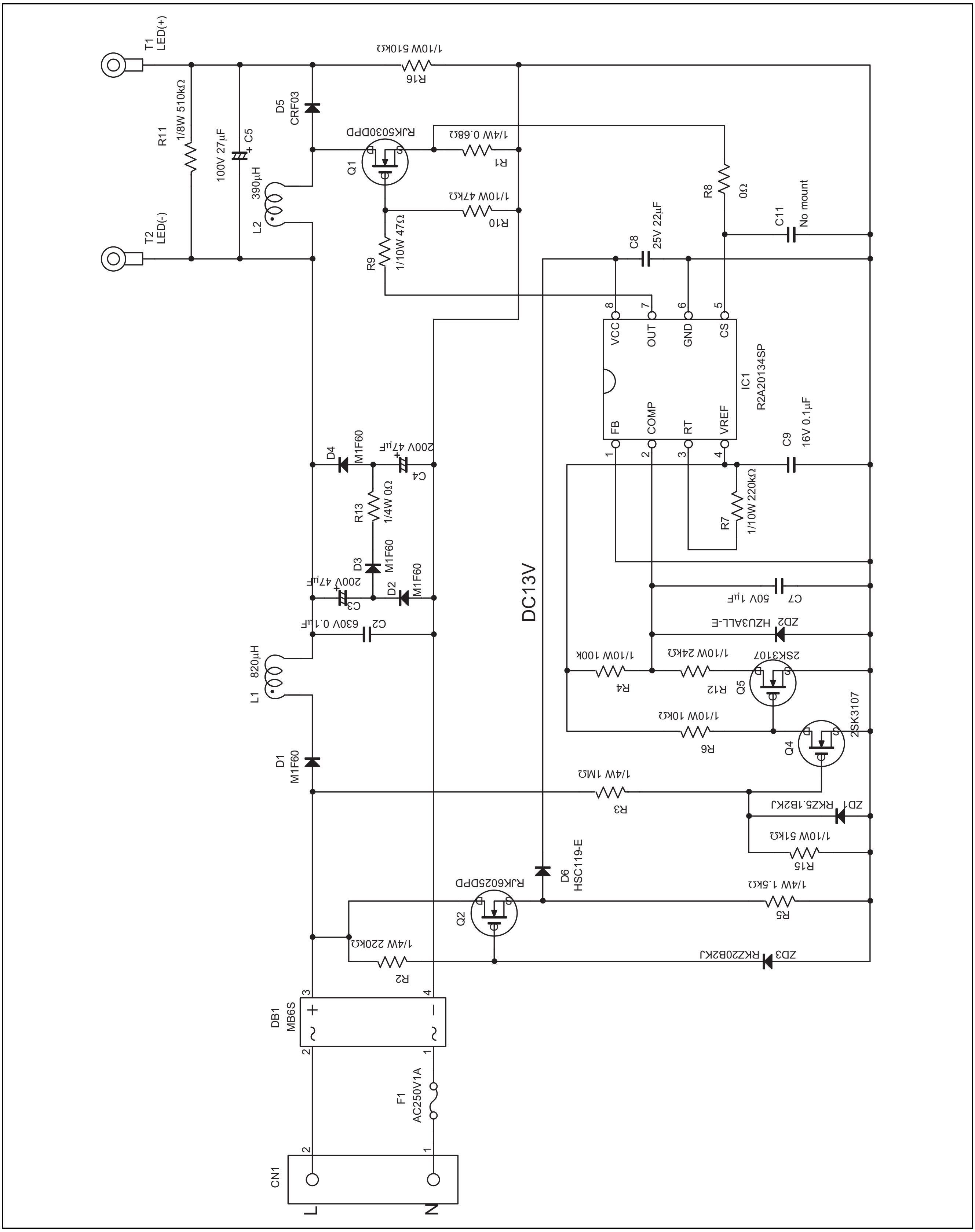
Iin(peak) = √(Pin × 2 × T/L) = √(4W × 2/48.9 kHz/1 mH) = 404 mA

Because Vcs = 0.6 V, you should choose Rcs = 1.5 Ω

5.5 R2A20134EVB-ND (non-isolation, with dimming function, peak current controlled, buck-boost)

5.5.1 R2A20134EVB-ND Circuit Diagram

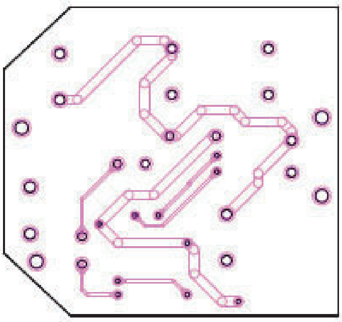
(Vin = 85-132 Vrms, Iout = 0.24 A, VF = 30 V, breeding current = 11 mA)



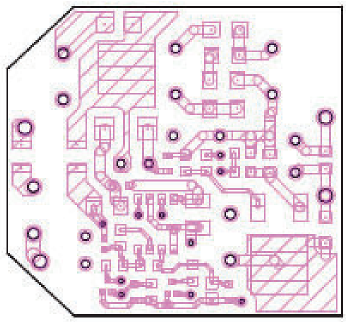
5.5.2 R2A20134EVB-ND BOM List

Symbol	Parts Name	Catalog No.	Q	Rating		Manufacture	Note
IC1	IC	R2A20134SP	1			Renesas	
Q1	MOSFET	RJK5030DPD	1	500V	1.6Ω max	Renesas	
Q2	MOSFET	RJK6025DPD	1	600V		Renesas	
Q4	MOSFET	2SK3107	1	30V	8Ω	Renesas	
Q5	MOSFET	2SK3107	1	30V	8Ω	Renesas	
DB1	Bridge diode	MB6S	1	420Vrms	0.5A		
D1	Diode	M1F60	1	600V	1A	Shindengen	
D2	Diode	M1F60	1	600V	1A	Shindengen	
D3	Diode	M1F60	1	600V	1A	Shindengen	
D4	Diode	M1F60	1	600V	1A	Shindengen	
D5	FRD	CRF03	1	600V	0.7A	Toshiba	
D6	Diode	HSC119-E	1	80V	100mA	Renesas	
ZD1	Zener diode	RKZ5.1B2KJ	1	5V		Renesas	
ZD2	Zener diode	HZU3ALL-E	1			Renesas	
ZD3	Zener diode	RKZ20B2KJ	1	20V		Renesas	
C2	Ceramic capacitor	RDER72J104K8K1C11B	1	630V	0.1µF	Murata	
C3	Chemical capacitor	UCY2D470MPD	1	200V	47µF	Nichicon	105°C, 10ϕ×20
C4	Chemical capacitor	UCY2D470MPD	1	200V	47µF	Nichicon	105°C, 10ϕ×20
C5	Chemical capacitor	100VYXJ27uF6.3×11	1	100V	27µF	Rubycon	105°C, 6.3ϕ×11
C7	Ceramic capacitor	GRM21BR71H105KA12L	1	50V	1µF	Murata	2012 size
C8	Ceramic capacitor	GRM32EC81E226KE15L	1	25V	22µF	Murata	3225 size
C9	Ceramic capacitor	GRM155R71C104KA88J	1	16V	0.1µF	Murata	1005 size
C11	Ceramic capacitor	—		—			No mount
R1	Resistor	SR732ATTDR68F	1	1/4W	0.68Ω	KOA	2012 size 1%
R2	Resistor	RCR25C224J	1	1/4W	220kΩ	KOA	High voltage
R3	Resistor	RCR25C105J	1	1/4W	1MΩ	KOA	High voltage
R4	Resistor	RK73B1JTTD104J	1	1/10W	100kΩ	KOA	1608 size
R5	Resistor	RK73B3ATTD152J	1	1/4W	1.5kΩ	KOA	3216 size
R6	Resistor	RK73B1JTTD103J	1	1/10W	10kΩ	KOA	1608 size
R7	Resistor	RK73B1JTTD204J	1	1/10W	200kΩ	KOA	1608 size
R8	Resistor	RK73Z1JTTD	1	1A	0Ω	KOA	1608 size
R9	Resistor	RK73B1JTTD470J	1	1/10W	47Ω	KOA	1608 size
R10	Resistor	RK73B1JTTD473J	1	1/10W	47kΩ	KOA	1608 size
R11	Resistor	RK73B2ATTD514J	1	1/8W	510kΩ	KOA	2112 size
R12	Resistor	RK73B1JTTD243J	1	1/10W	24kΩ	KOA	1608 size
R13	Resistor	jumper chip	1		0Ω	KOA	3216 size
R15	Resistor	RK73B1JTTD513J	1	1/10W	51kΩ	KOA	1608 size
R16	Resistor	RK73B1JTTD514J	1	1/10W	510kΩ	KOA	1608 size
L1	Coil	RCH875-821K	1		820µH	Sumida	
L2	Choke coil	RCP1317NP-391L	1		390µH	Sumida	
F1	Fuse	HTS1A	1	AC250V	1A	Skygate	

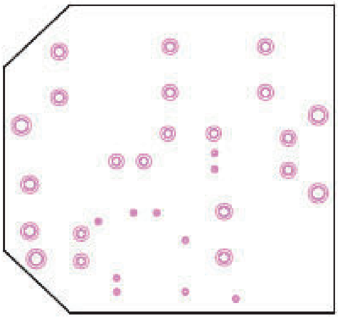
5.5.3 R2A20134EVB-NN2 Board Pattern



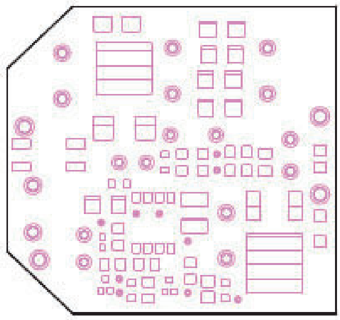
Top Layer: Circuit Pattern



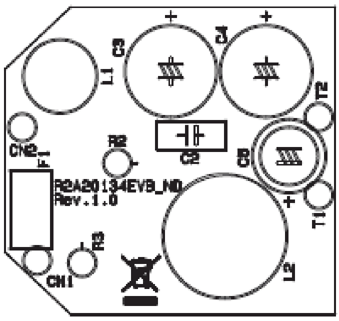
Bottom Layer: Circuit Pattern



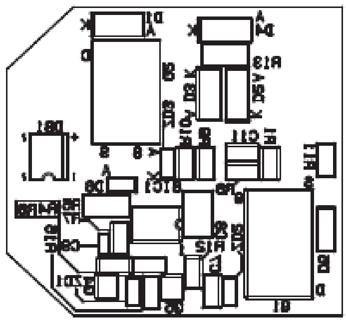
Top Layer: Solder Resist



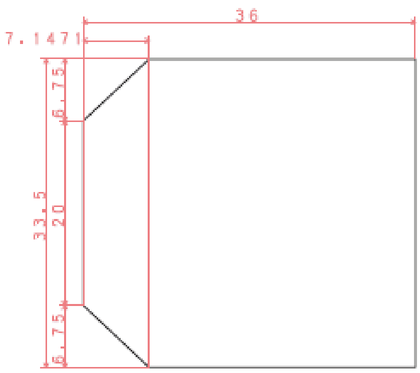
Bottom Layer: Solder Resist



Top Layer: Silk Screen

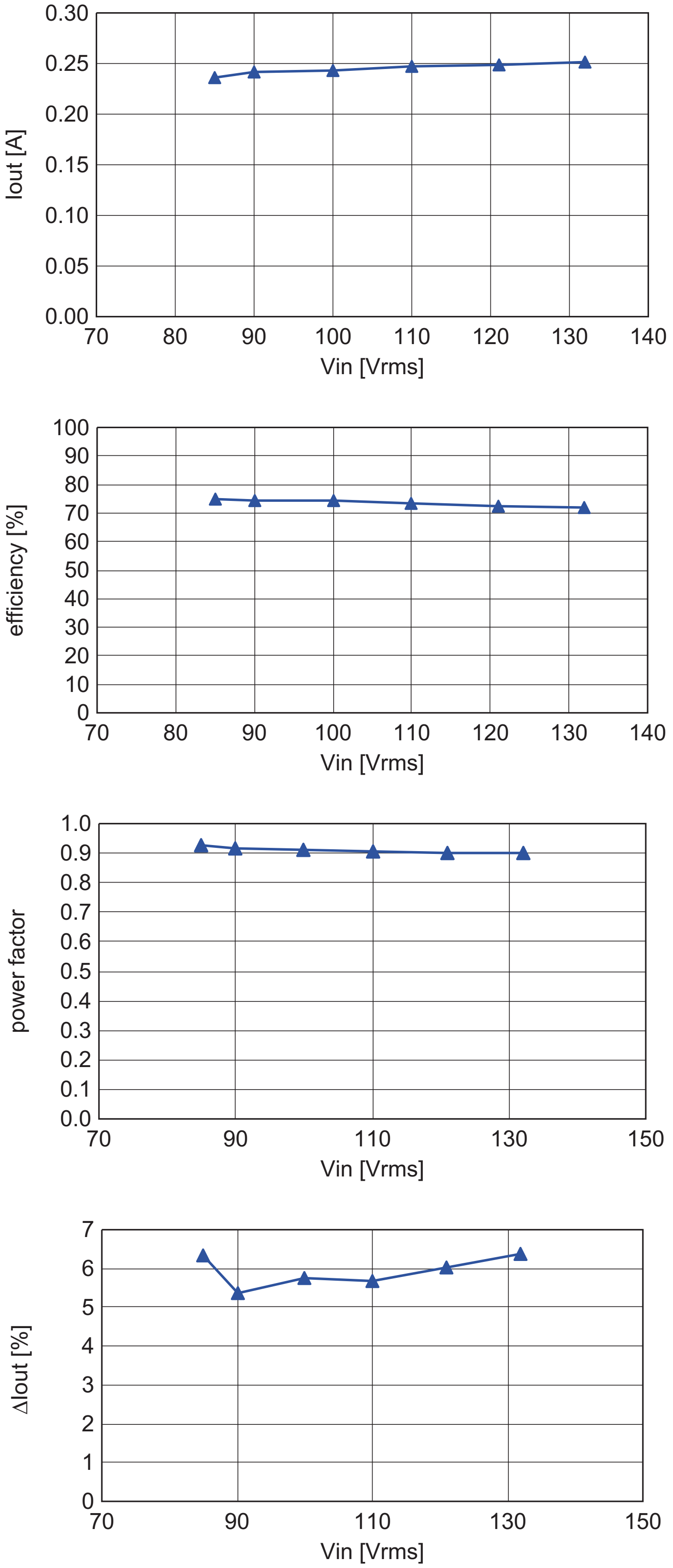


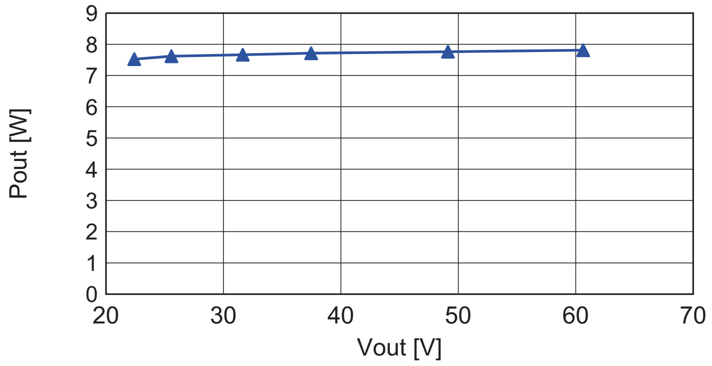
Bottom Layer: Silk Screen

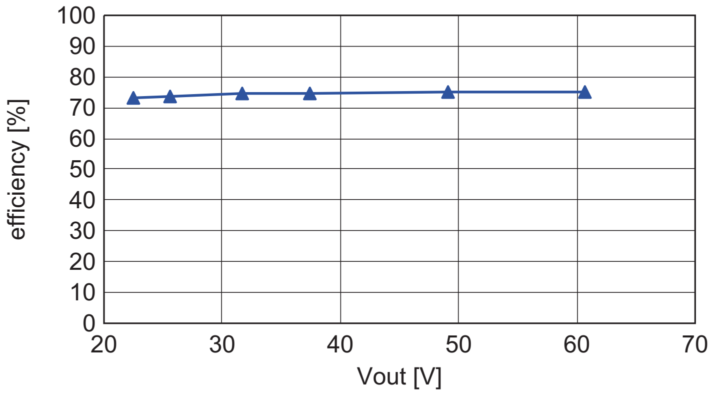


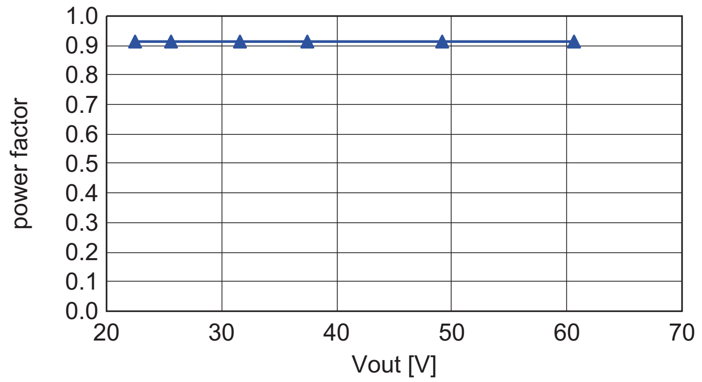
Outside view of the EVB

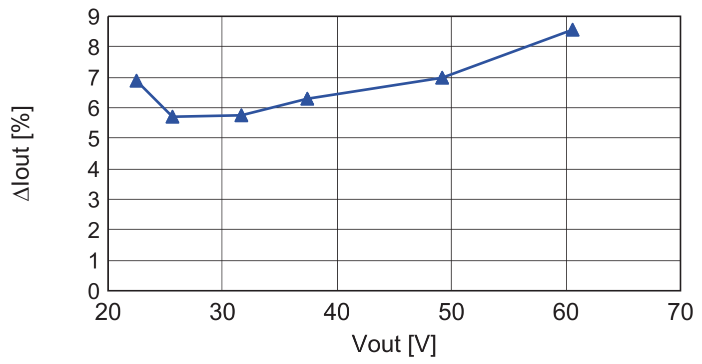
5.5.4 R2A20134EVB-ND Evaluation Data (breeding current = 11 mA)




Pout [W]
Vout [V]

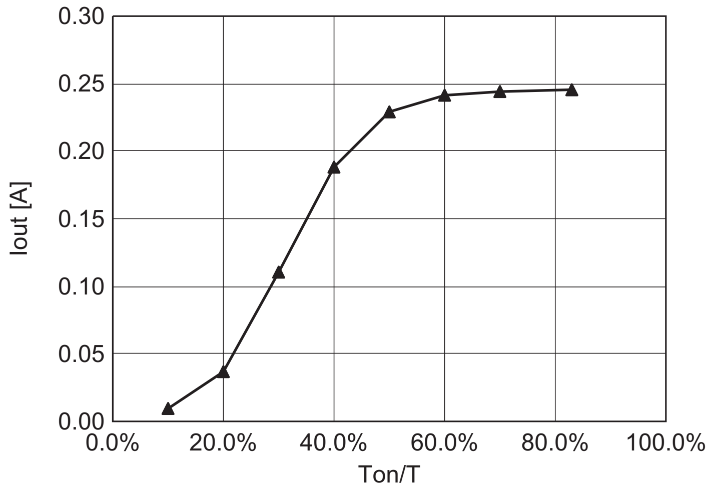

efficiency [%]
Vout [V]

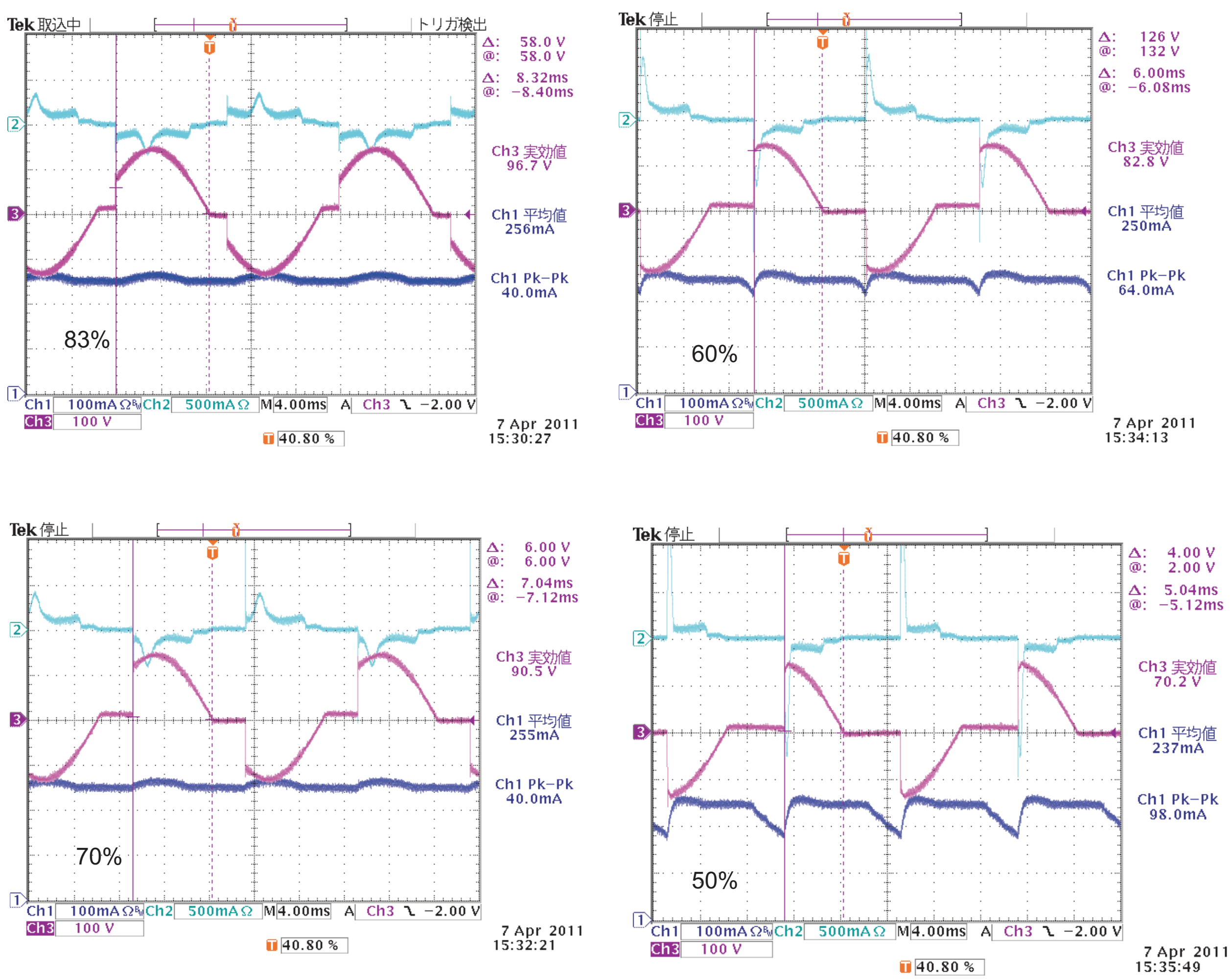

power factor
Vout [V]

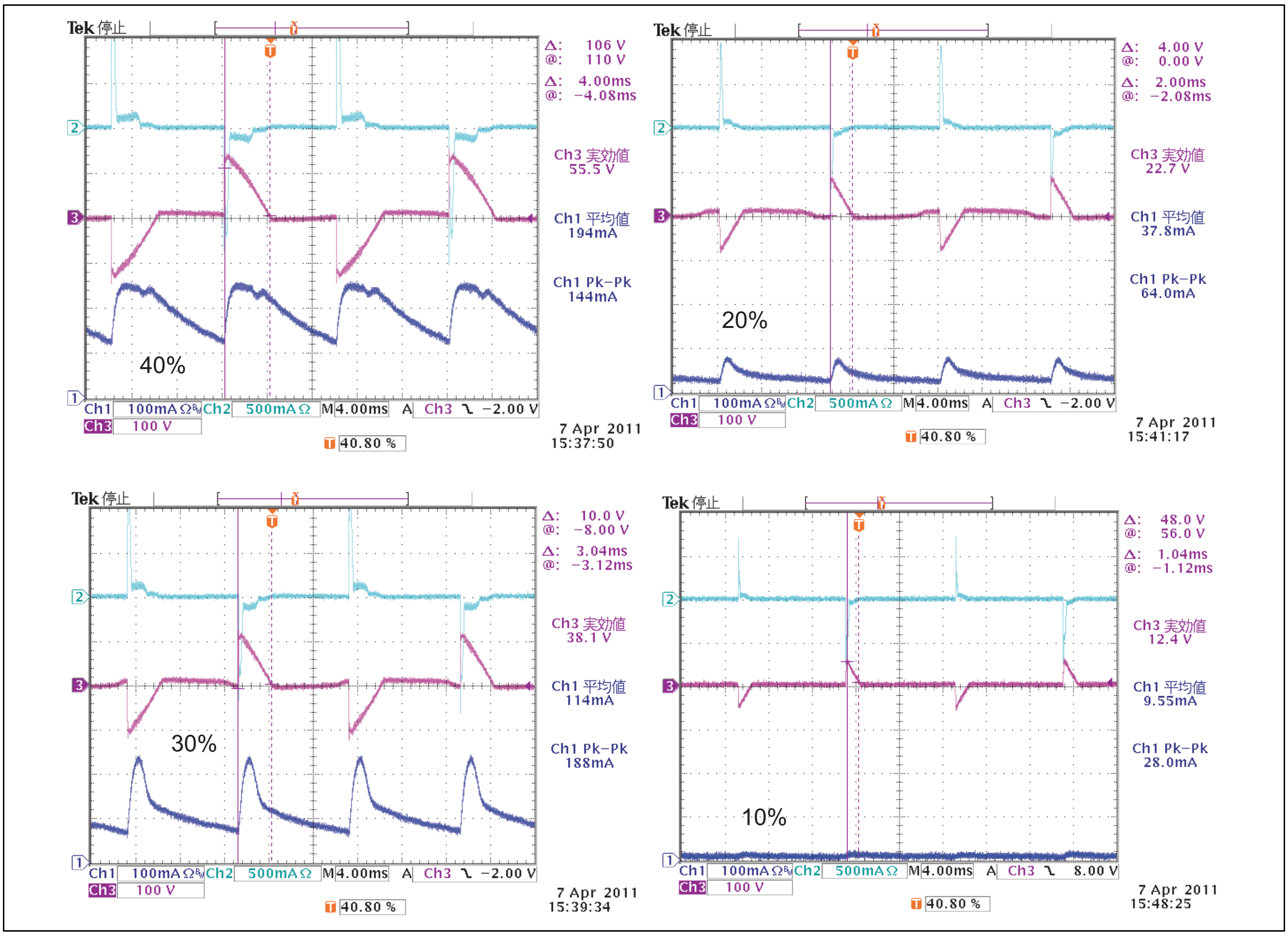

ΔIout [%]
Vout [V]

5.5.5 R2A20134EVB-ND Evaluation Data

(Vin = 85-132 Vrms, Iout = 0.24 A, VF = 30 V, breeding current = 20 mA)






Tek 停止
Δ: 106 V
@: 110 V
Δ: 4.00ms
@: −4.08ms
Ch3 実効値
55.5 V
Ch1 平均値
194mA
Ch1 Pk−Pk
144mA
40%
Ch1 100mA Ω
Ch2 500mA Ω
M 4.00ms
A Ch3 −2.00 V
Ch3 100 V
40.80 %
7 Apr 2011
15:37:50
Tek 停止
Δ: 4.00 V
@: 0.00 V
Δ: 2.00ms
@: −2.08ms
Ch3 実効値
22.7 V
Ch1 平均値
37.8mA
Ch1 Pk−Pk
64.0mA
20%
Ch1 100mA Ω
Ch2 500mA Ω
M 4.00ms
A Ch3 −2.00 V
Ch3 100 V
40.80 %
7 Apr 2011
15:41:17
Tek 停止
Δ: 10.0 V
@: −8.00 V
Δ: 3.04ms
@: −3.12ms
Ch3 実効値
38.1 V
Ch1 平均値
114mA
Ch1 Pk−Pk
188mA
30%
Ch1 100mA Ω
Ch2 500mA Ω
M 4.00ms
A Ch3 −2.00 V
Ch3 100 V
40.80 %
7 Apr 2011
15:39:34
Tek 停止
Δ: 48.0 V
@: 56.0 V
Δ: 1.04ms
@: −1.12ms
Ch3 実効値
12.4 V
Ch1 平均値
9.55mA
Ch1 Pk−Pk
28.0mA
10%
Ch1 100mA Ω
Ch2 500mA Ω
M 4.00ms
A Ch3 8.00 V
Ch3 100 V
40.80 %
7 Apr 2011
15:48:25

5.5.6 Basic Operation of R2A20134EVB-ND, and the Procedure to Calculate the External Constants

[Preconditions of Design]

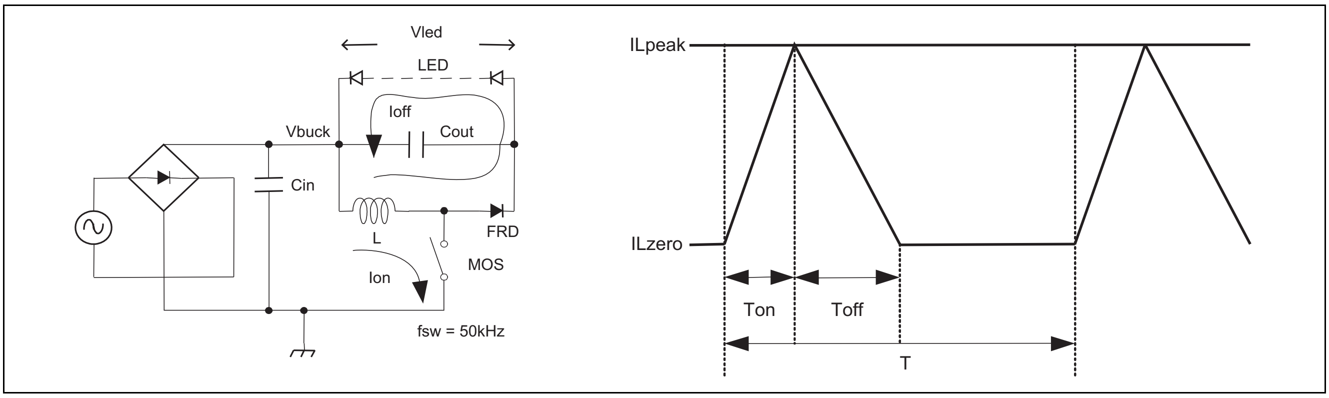
Vin = 85 Vac to 132 Vac, Vout = 30 Vdc, Iout = 0.24 A

1. Calculation of the resistance Rrt for setting the frequency and the inductance L, for the Fixed-Frequency mode
   Calculation of the external constants is same as the case of R2A20134EVB-NN2 except for the circuit blocks for the dimming.
   So, please refer to 5.4.4.

2. Basic operation of TRIAC dimmable LED lighting driver circuit, and the procedure to calculate the external constants

   <The explanation of the Peak-current operation mode by R2A20134SP>

   The circuit diagram of the Buck-Boost Discontinuous conduction mode and the timing chart of the inductor current (IL) are shown below.



R2A20134 works at the Fixed-Frequency and in the Peak-current operation mode. So IL flows through the MOSFET to GND, and IL increases from ILzero to ILpeak while the MOSFET is turned on, that is, during Ton. And IL flows through FRD to LED, and IL decreases from ILpeak to ILzero while the MOSFET is turned off, that is, during Toff.
Therefore the average current of LED Iout(ave.) after the smoothing by Cout is;

Iout(ave.) = 0.5 × Toff/T × ILpeak

By using the relation,

Toff = L × ILpeak/Vled

Iout(ave.) is expressed as follows:

Iout(ave.) = 0.5 × L × ILpeak^2/(Vled × T)

In the case of the Evaluation Boards, Vled = 70 V, L = 1 mH and fsw = 47 kHz (T = 21.3 μs).
So finally, Iout(ave.) is shown as follows:

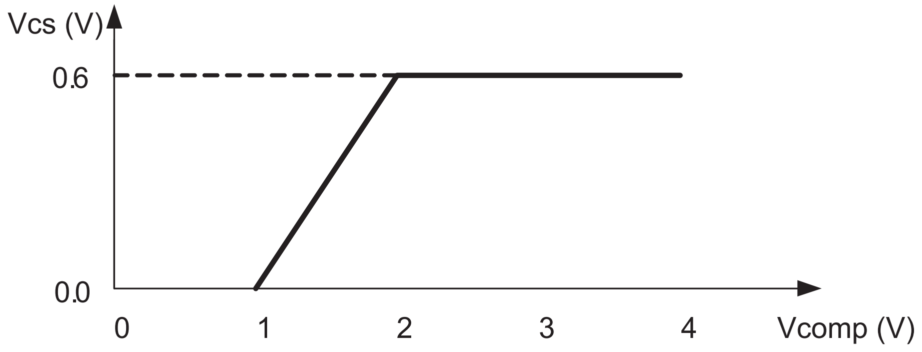
Iout(ave.) = 0.335 ILpeak^2

R2A20134 works to keep ILpeak at a certain level.

<Dimming by controlling the voltage of COMP-pin of R2A20134>

While R2A20134 is working in the Fixed-Frequency Peak-current mode, Vcomp, the voltage of COMP-pin while it is open, is clamped at 4.1 V typ by the internal Zener Diode.

When Vcomp is in the range from 2 V to 4 V, the detected level of the Peak-current would be the same as the level when COMP-pin is open. But when Vcomp is under 2 V, the level decreases. And when Vcomp is under 1 V, finally the level reaches to 0.0 V.



Therefore ILpeak in the relation below,

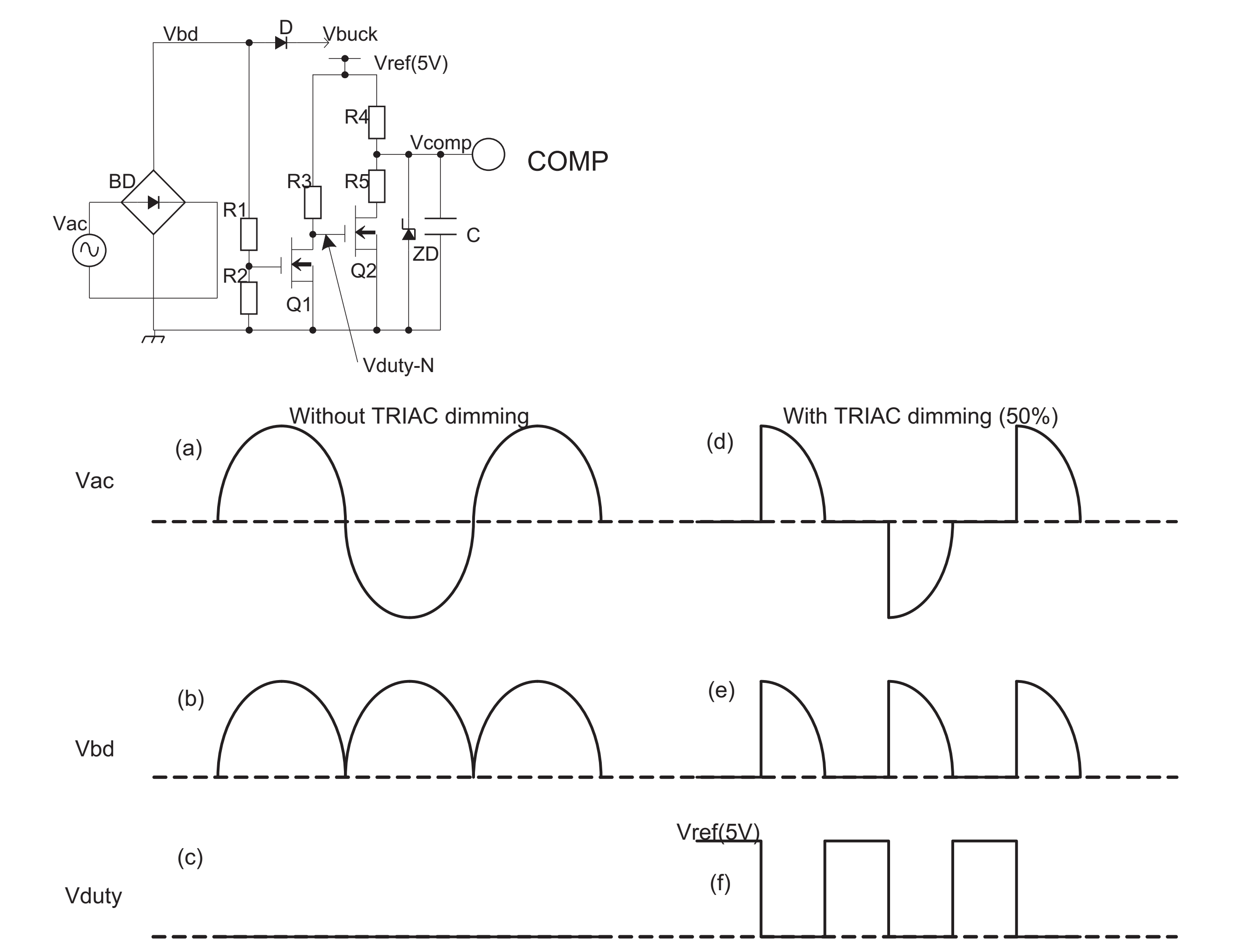
Iout(ave.) = 0.335 × Ilpeak^2

could be controlled linearly by detecting the phase angle of TRIAC dimming voltage after full-wave rectification and converting it to the voltage Vcomp.

Consequently, LED current, Iout(ave.), would be controlled non-linearly (square-law characteristics).

<TRIAC phase angle detection>

The circuit block for detecting TRIAC phase and the waveforms for the phase control are shown below.

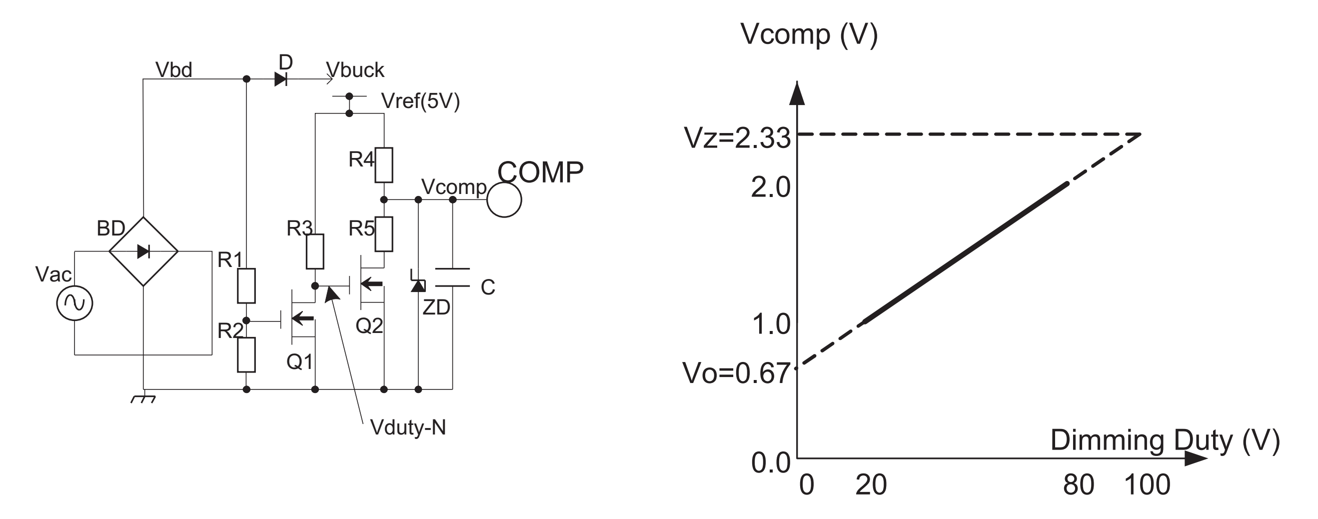


The bridge rectifier (BD) converts the AC voltage (Vac-(a)) to the full-wave rectification waveform (Vbd-(b)). In case of the AC voltage phase-controlled by TRIAC dimming circuit (Vac-(d)), the full-wave rectification waveform would be shown in Vbd-(e) when the phase is 50%, for example.

Due to the effects of R1, R2, R3 and Q1, the full-wave rectification waveform (Vbd) would be converted to the inverse signal (Vduty N) of the duty signal corresponding to the phase of TRIAC dimming.

By smoothing this signal with the capacitor C connected to COMP-pin, the DC control with COMP-pin would be achieved.

<Setting the voltage for COMP-pin control>



As shown in < Dimming by controlling the voltage of COMP-pin of R2A20134>, the level of the Peak-current would be controlled linearly while the control voltage of COMP-pin is in the range from 1 V to 2 V.
ZCD voltage, R4 and R5 should be decided according to this range of COMP-pin control voltage.

- The procedure to set the dimming range and to calculate the duty conversion rate

The duty conversion rate could be calculated by using the dimming range.
The range of dimming duty is assumed here from 20% to 80%.
Because the duty from 20% to 80% would be converted to the control voltage from 1V to 2V, the conversion rate is calculated as 60%/V.
Using this ratio, the Zener Voltage (Vz) could be determined by calculating the voltage at 100% duty.

$Vz = (100\% - 80\%) / 60\% \times 1\ V + 2(V) = 2.33\ V$

Note: 1. The Zener diode should be selected not by checking the rated value of the Zener Voltage, but by checking that the Zener Voltage at the currents in the actual situations would be 2.33 V referring to the characteristic data.

In the next step, the voltage at 0% duty, V0, would be calculated as follows:

$Vo = 1\ V - 20\%/60\% \times 1\ V = 0.67\ V$

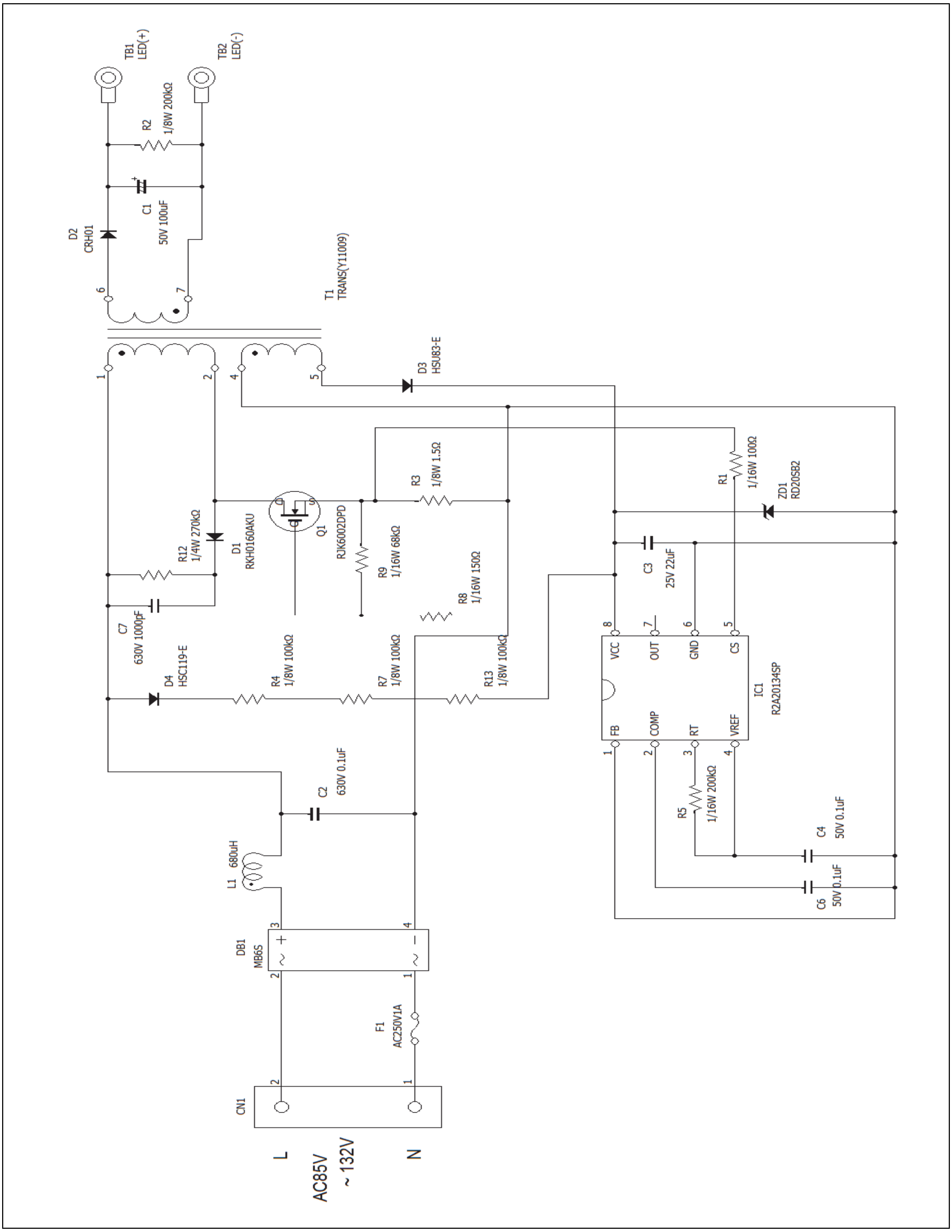
R4 and R5 should be determined to get 0.67 V at 0% duty.

$R4:R5 = 0.67*(5 - 0.67) = 6.46:1$

Note: 2. Because the current, 9.5 μA(typ.) is flowing through COMP-pin, the total resistance of R4 and R5 should be under 50 kΩ.

5.6 R2A20134EVB-IN (isolated, dimming, peak current controlled)

5.6.1 R2A20134EVB-IN Schematic

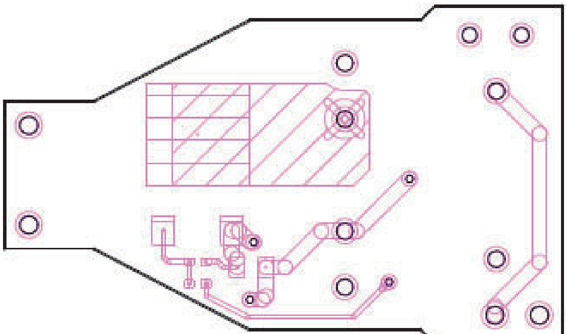


5.6.2 R2A20134EVB-IN Parts List

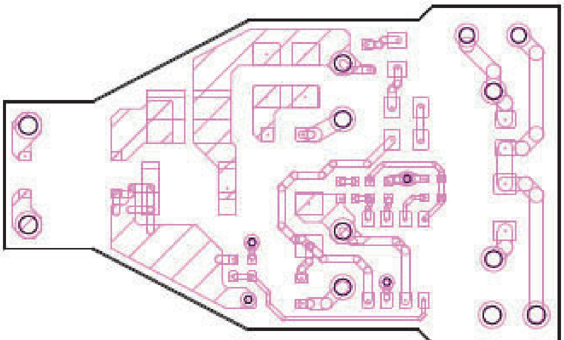
Vin = AC85 to 132 V, Vf = 35 V, ILED = 100 mA

Symbol	Parts Name	Catalog No.	Q	Rating		Manufacture	Note
IC1	IC	R2A20134SP	1			Renesas	
Q1	MOSFET	RJK6002DPD	1	600V	1.6Ω MAX.	Renesas	
DB1	Diode Bridge	MB6S	1	600V	0.5A		
D1	Diode	RKH0160AKU	1	600V	200mA		
D2	Diode	CRH01	1	200V	1A		
D3	Diode	HSU83-E	1	250V	100mA	Renesas	
D4	Diode	HSC119	1	80V	100mA	Renesas	
ZD1	Zener Diode	RD20SB2	1	20V	200mW	Renesas	
C1	Chemical Capacitor	EKY-500ELL101MHB5D	1	50V	100μF		
C2	Capacitor	GRM43DR72J104KW01L	1	630V	0.1μF	Murata	4532 size
C3	Capacitor	GRM31CC8YA106KA12L	1	35V	10μF	Murata	3216 size
C4	Capacitor	GRM155R71C104KA88J	1	16V	0.1μF	Murata	1005 size
C5	Capacitor	open	1				1005 size
C6	Capacitor	GRM155R71C104KA88J	1	16V	0.1μF	Murata	1005 size
C7	Capacitor	GRM31B5C2J102JW01L	1	630V	1000pF	Murata	3216 size
R1	Resistor	100Ω	1	1/16W	100Ω		1005 size
R2	Resistor	200kΩ	1	1/8W	200kΩ		2012 size
R3	Resistor	1.5Ω	1	1/8W	1.5Ω		2012 size
R4	Resistor	100kΩ	1	1/8W	100kΩ		2012 size
R5	Resistor	200kΩ	1	1/16W	200kΩ		1005 size
R6	Resistor	open	1				1005 size
R7	Resistor	100kΩ	1	1/8W	100kΩ		2012 size
R8	Resistor	150Ω	1	1/16W	150Ω		1005 size
R9	Resistor	68kΩ	1	1/16W	68kΩ		1005 size
R10	Resistor	5.1kΩ	1	1/16W	5.1kΩ		1005 size
R11	Resistor	120kΩ	1	1/16W	120kΩ		1005 size
R12	Resistor	270kΩ	1	1/4W	270kΩ		3216 size
R13	Resistor	100kΩ	1	1/8W	100kΩ		2012 size
L1	Choke Coil	LQH43CN471K03	1		470μH	Murata	
T1	Transformer	Y11009	1			TDK	

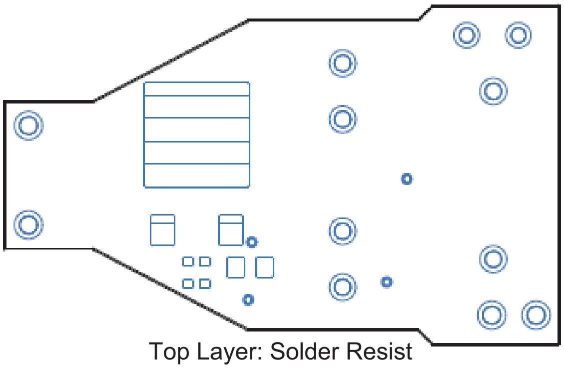
5.6.3 R2A20134EVB-IN Board Pattern



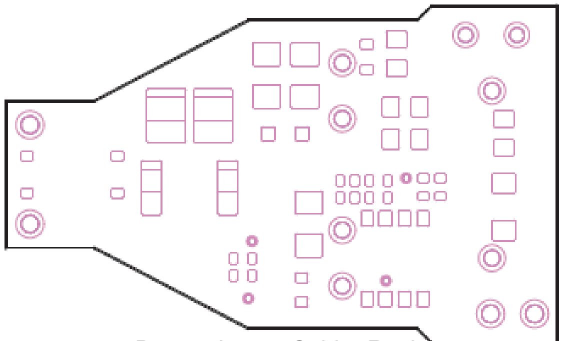
Top Layer: Circuit Pattern



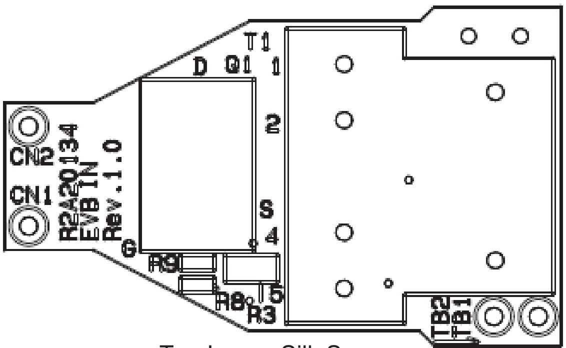
Bottom Layer: Circuit Pattern



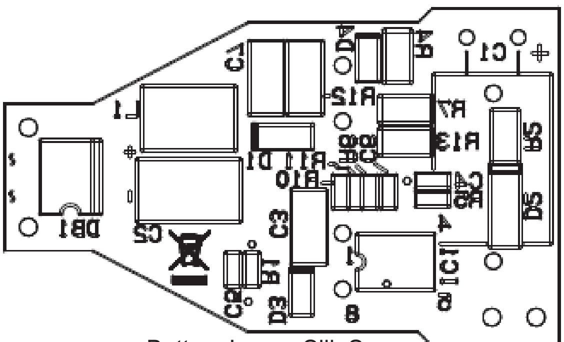
Top Layer: Solder Resist



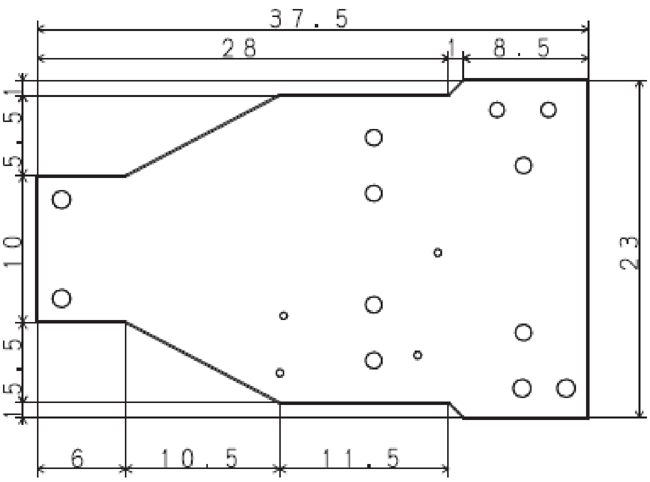
Bottom Layer: Solder Resist



Top Layer: Silk Screen

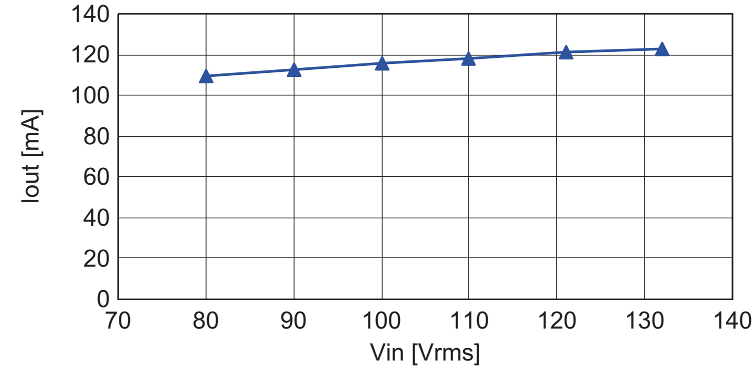


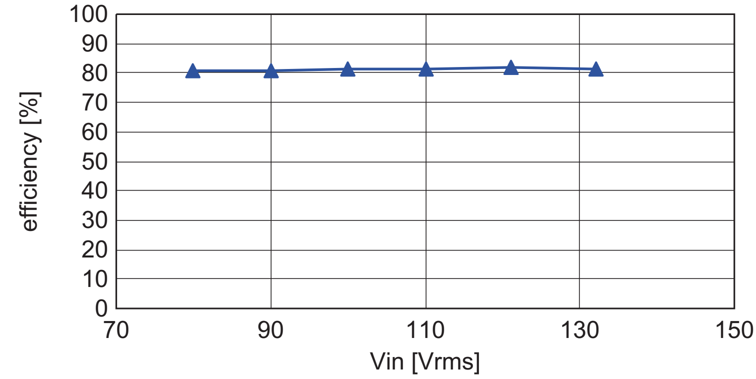
Bottom Layer: Silk Screen

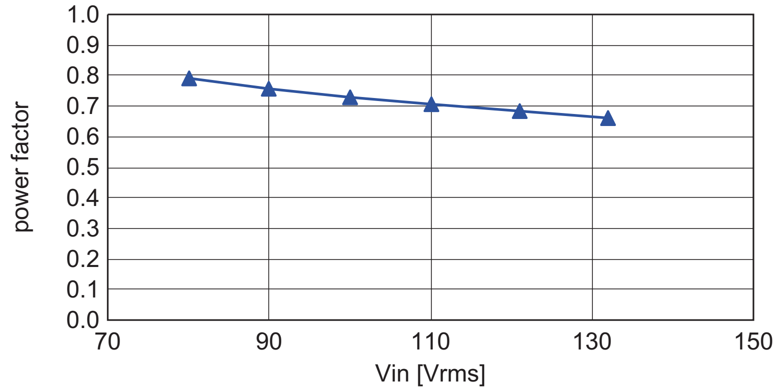


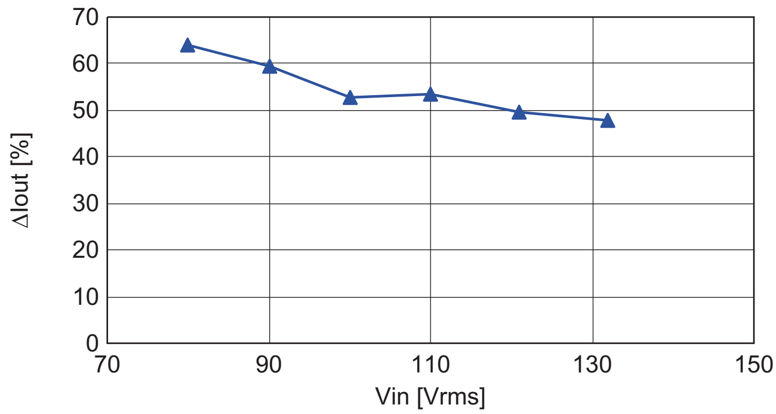
Outside view of the EVB

5.6.4 R2A20134EVB-IN Evaluation Data



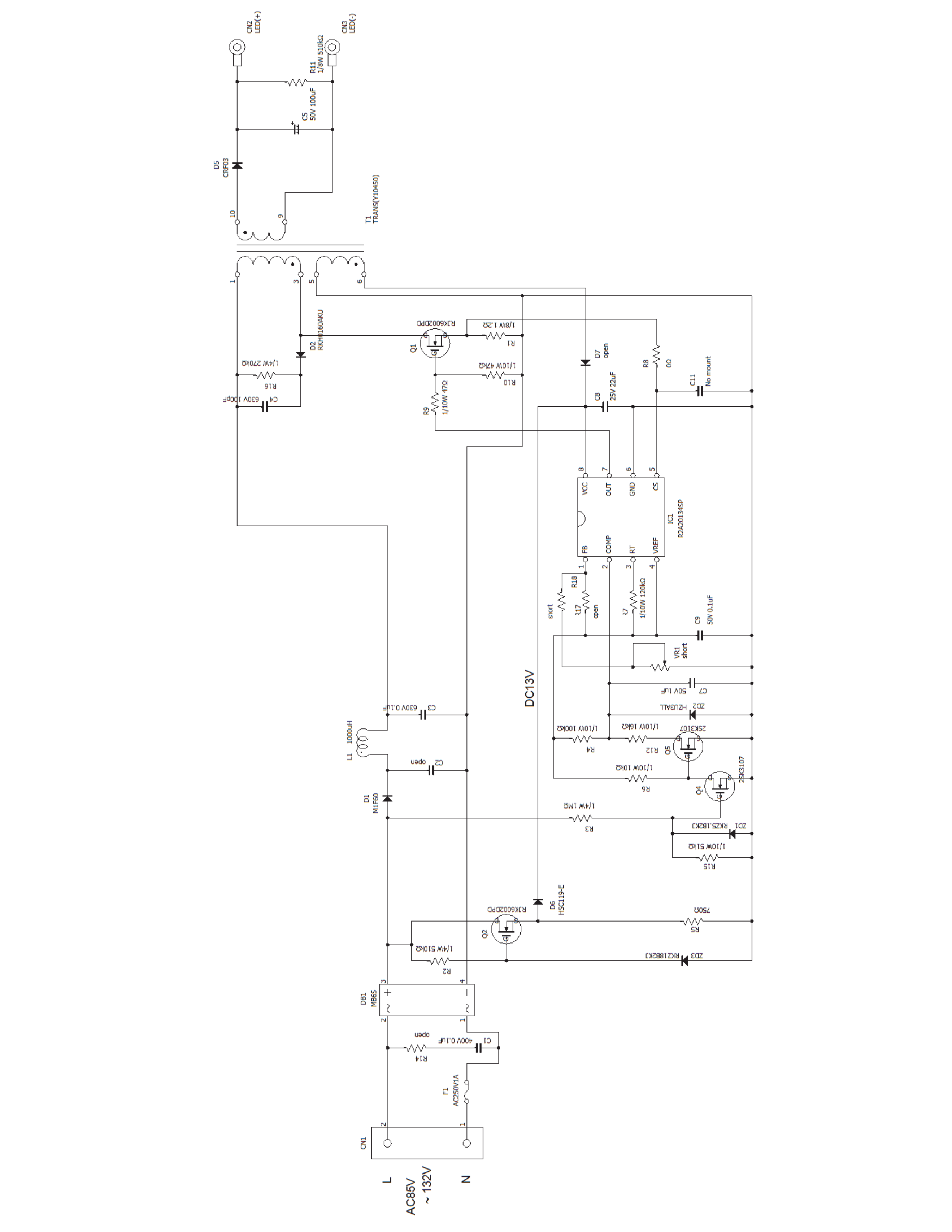




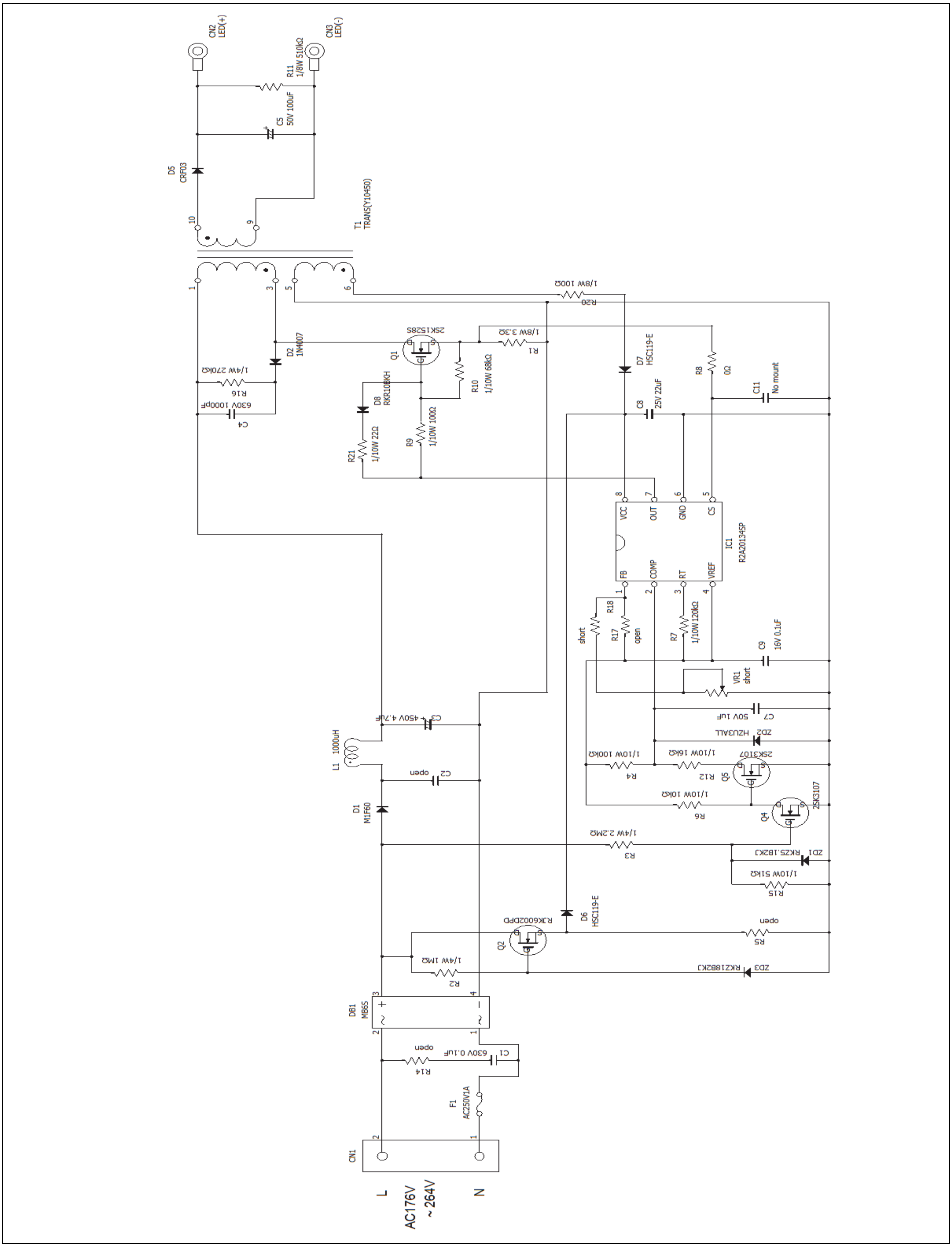


5.7 R2A20134EVB-ID (isolated, dimming, peak current controlled)

5.7.1 R2A20134EVB-ID 100 V Schematic



5.7.2 R2A20134EVB-ID 220 V Schematic



5.7.3 R2A20134EVB-ID 100 V Parts List

Symbol	Parts Name	Catalog No.	Q	Rating		Manufacture	Note
IC1	IC	R2A20134SP	1			Renesas	
Q1	MOSFET	RJK6002DPD	1	600V		Renesas	
Q2	MOSFET	RJK6002DPD	1	600V		Renesas	
Q4	MOSFET	2SK3107	1	30V	8Ω	Renesas	
Q5	MOSFET	2SK3107	1	30V	8Ω	Renesas	
DB1	Diode bridge	MB6S	1	600V	0.5A		
D1	Diode	M1F60	1	600V	1A	Shindengen	
D2	Diode	RKH0160AKU	1	600V	200mA	Renesas	
D3	—						
D4	—						
D5	Diode	CRF03	or	600V	0.7A	Toshiba	
D6	Diode	HSC119-E	1	80V	100mA	Renesas	
D7	Diode	open	1				
ZD1	Zener diode	RKZ5.1B2KJ	1	5V		Renesas	
ZD2	Zener diode	HZU3ALL-E	1	3V		Renesas	
ZD3	Zener diode	RKZ18B2KJ	1	18V		Renesas	
C1	Ceramic capacitor	RDER72J104K8K1C11B	1	630V	0.1μF	Murata	
C2	Ceramic capacitor	open	1	630V	0.1μF	Murata	4532 size
C3	Ceramic capacitor	GRM43DR72J104KW01L	1	630V	0.1μF	Murata	4532 size
C4	Ceramic capacitor	GRM31B5C2J102JW01L	1	630V	1000pF	Murata	3216 size
C5	Chemical capacitor	EKY-500ELL101MHB5D	1	50V	100μF	Nippon Chemi-Con	105°C, 8ϕ×11.5
C6	—						
C7	Ceramic capacitor	GRM21BR71H105KA12L	1	50V	1μF	Murata	2012 size
C8	Ceramic capacitor	GRM32EC81E226KE15L	1	25V	22μF	Murata	3225 size
		GRM32ER71E226KE18L	or	25V	22μF	Murata	3225 size
C9	Ceramic capacitor	GRM155R71C104KA88J	1	16V	0.1μF	Murata	1005 size
C10	—						
C11	Ceramic capacitor	open		50V			No mount
C12	—						

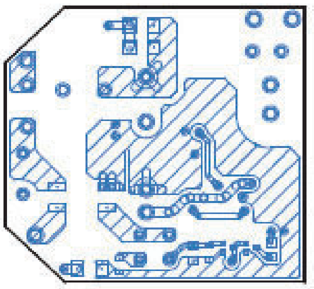
Symbol	Parts Name	Catalog No.	Q	Rating		Manufacture	Note
R1	Resistor	RK73H2ATTD1R20F	1	1/8W	1.2Ω	KOA	2012 size 1%
R2	Resistor	RCR25C514J	1	1/4W	510kΩ	KOA	high blocking voltage
R3	Resistor	RCR25C105J	1	1/4W	1MΩ	KOA	high blocking voltage
R4	Resistor	RK73B1JTTD104J	1	1/10W	100kΩ	KOA	1608 size
R5	Resistor	RK73B3ATTD751J	1	1/4W	750Ω	KOA	3216 size
R6	Resistor	RK73B1JTTD103J	1	1/10W	10kΩ	KOA	1608 size
R7	Resistor	RK73B1JTTD124J	1	1/10W	120kΩ	KOA	1608 size
R8	Resistor	RK73Z1JTTD	1	1A	0Ω	KOA	1608 size
R9	Resistor	RK73B1JTTD470J	1	1/10W	47Ω	KOA	1608 size
R10	Resistor	RK73B1JTTD473J	1	1/10W	47kΩ	KOA	1608 size
R11	Resistor	RK73B2ATTD514J	1	1/8W	510kΩ	KOA	2012 size
R12	Resistor	RK73B1JTTD163J	1	1/10W	16kΩ	KOA	1608 size
R13	—						
R14	Resistor	open	1			KOA	3216 size
R15	Resistor	RK73B1JTTD513J	1	1/10W	51kΩ	KOA	1608 size
R16	Resistor	RK73B2BTTD274J	1	1/4W	270kΩ	KOA	3216 size
R17	Resistor	NM	1	1/10W	1MΩ	KOA	1608 size 1%
R18	Resistor	0Ω	1	1/10W	120kΩ	KOA	1608 size 1%
R19	—						
VR1	Variable resistor	Short with 0Ω1608	1	0.1W	22kΩ	Murata	PVZ2A
L1	Coil	TSL0709RA102	1		1mH	TDK	
T1	Transformer	Y10450-2A	1			TDK	
F1	Fuse	HTS 1A	1	AC250V	1A	Skygate	

5.7.4 R2A20134EVB-ID 220 V Parts List

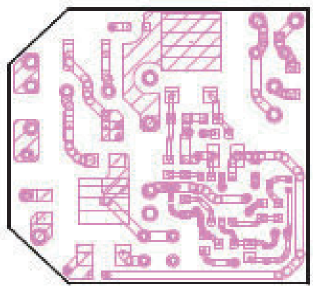
Symbol	Parts Name	Catalog No.	Q	Rating		Manufacture	Note
IC1	IC	R2A20134SP	1			Renesas	
Q1	MOSFET	2SK1528S	1	900V	4A	Renesas	LDPAK(S)-(1)
Q2	MOSFET	RJK6002DPD	1	600V	5A	Renesas	
Q4	MOSFET	2SK3107	1	30V	8Ω	Renesas	
Q5	MOSFET	2SK3107	1	30V	8Ω	Renesas	
DB1	Diode bridge	MB6S	1	600V	0.5A		
D1	Diode	M1F60	1	600V	1A	Shindengen	
D2	Diode	1N4007	1	1kV	1A	Fairchild	
D3	—						
D4	—						
D5	Diode	CRF03	1	600V	0.7A	Toshiba	
D6	Diode	HSC119-E	1	80V	100mA	Renesas	
D7	Diode	HSC119-E	1	80V	100mA	Renesas	
D8	Diode	RKR104BKH	1			Renesas	
ZD1	Zener diode	RKZ5.1B2KJ	1	5V		Renesas	
ZD2	Zener diode	HZU3ALL-E	1	3V		Renesas	
ZD3	Zener diode	RKZ20B2KJ	1	18V		Renesas	
C1	Ceramic capacitor	RDER72J104K8K1C11B	1	630V	0.1μF	Murata	
C2		(no mount)					
C3	Chemical capacitor	EKMG451ELL4R7MJ20S	1	450V	4.7μF	Nippon Chemi-Con	ϕ10×20
		BXC 450V 4.7μF	or	450V	4.7μF	Rubycon	ϕ10×20
		UVZ2W4R7MPD	or	450V	4.7μF		ϕ10×20
C4	Ceramic capacitor	GRM31B5C2J102JW01L	1	630V	1000pF	Murata	3216 size
C5	Chemical capacitor	EKY-500ELL101MHB5D	1	50V	100μF	Nippon Chemi-Con	105°C
C6	—						
C7	Ceramic capacitor	GRM21BR71H105KA12L	1	50V	1μF	Murata	2012 size
C8	Ceramic capacitor	GRM32EC81E226KE15L	1	25V	22μF	Murata	3225 size
		GRM32ER71E226KE18L	or	25V	22μF	Murata	3225 size
C9	Ceramic capacitor	GRM155R71C104KA88J	1	16V	0.1μF	Murata	1005 size
C10	—						
C11	Ceramic capacitor	open					No mount
C12	—						

Symbol	Parts Name	Catalog No.	Q	Rating		Manufacture	Note
R1	Resistor	3.3Ω	1	1/8W	3.3Ω		2012 size 1%
R2	Resistor	1MΩ	1	1/4W	1MΩ		high blocking voltage
R3	Resistor	2.2MΩ	1	1/4W	2.2MΩ		high blocking voltage
R4	Resistor	100kΩ	1	1/10W	100kΩ		1608 size
R5	Resistor		1				3216 size
R6	Resistor	10kΩ	1	1/10W	10kΩ		1608 size
R7	Resistor	120kΩ	1	1/10W	120kΩ		1608 size
R8	Resistor	0Ω	1	1A	0Ω		1608 size
R9	Resistor	100Ω	1	1/10W	100Ω		1608 size
R10	Resistor	68kΩ	1	1/10W	68kΩ		1608 size
R11	Resistor	510kΩ	1	1/8W	510kΩ		2012 size
R12	Resistor	16kΩ	1	1/10W	16kΩ		1608 size
R13	—						
R14	Resistor		1				3216 size
R15	Resistor	51kΩ	1	1/10W	51kΩ		1608 size
R16	Resistor	270kΩ	1	1/4W	270kΩ		3216 size
R17	Resistor	1MΩ	1	1/10W	1MΩ		1608 size 1%
R18	Resistor	120kΩ	1	1/10W	120kΩ		1608 size 1%
R19	—						
R20	Resistor	RK73B2ATTD101J	1	1/8W	100Ω	KOA	2012 size
R21	Resistor	RK73B1JTTD220J	1	1/10W	22Ω	KOA	1608 size
	Diode	RKR104BKH	1			Renesas	
VR1	Variable resistor	Short with 0Ω1608	1	0.1W	22kΩ	Murata	PVZ2A
L1	Coil	TSL0709RA102	1		1mH	TDK	
T1	Transformer	Y10450-4	1			TDK	Primary: 5mH
F1	Fuse	HTS 1A	1	AC250V	1A	Skygate	

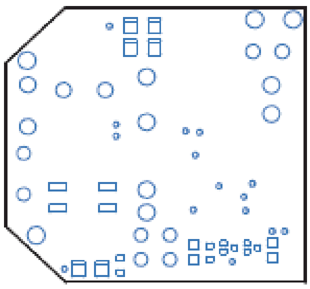
5.7.5 R2A20134EVB-ID Board Pattern



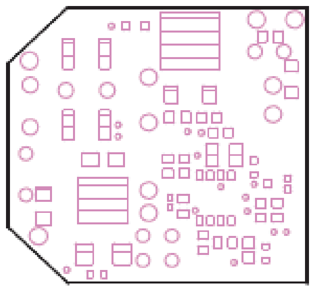
Top Layer: Circuit Pattern



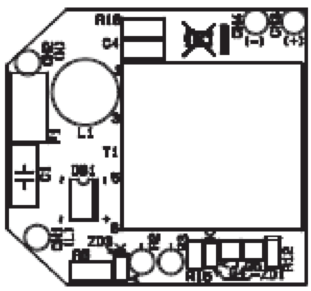
Bottom Layer: Circuit Pattern



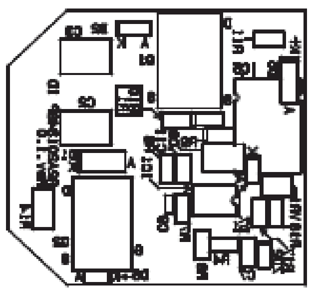
Top Layer: Solder Resist



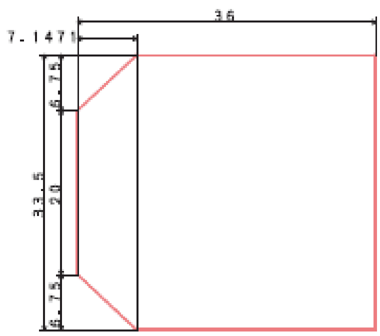
Bottom Layer: Solder Resist



Top Layer: Silk Screen



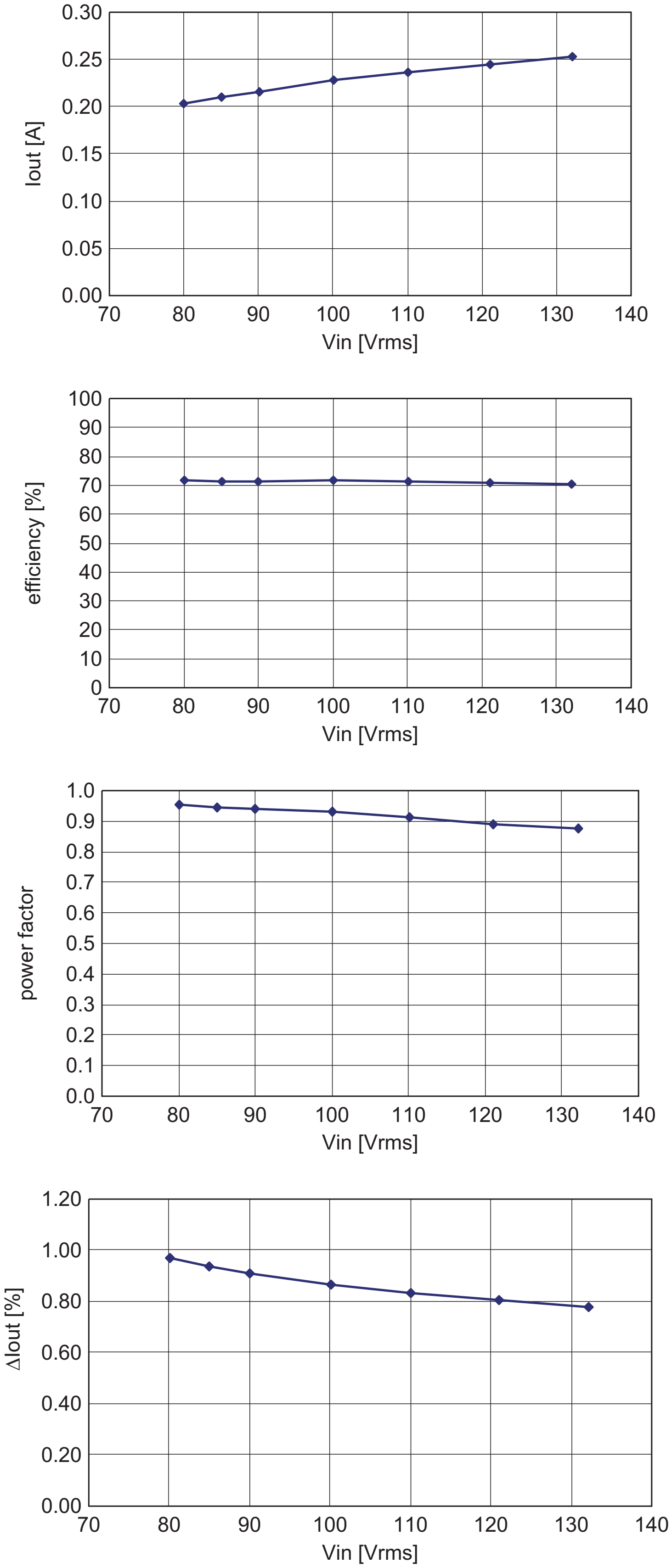
Bottom Layer: Silk Screen

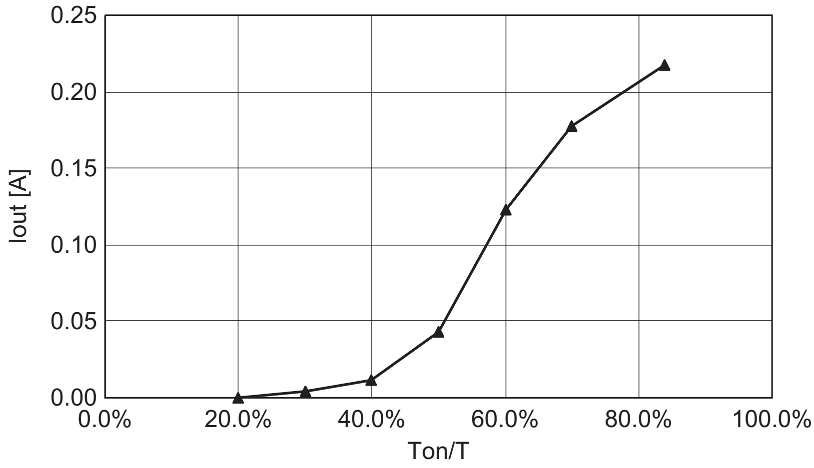


Outside view of the EVB

5.7.6 R2A20134EVB-ID Board Evaluation Data 100 V

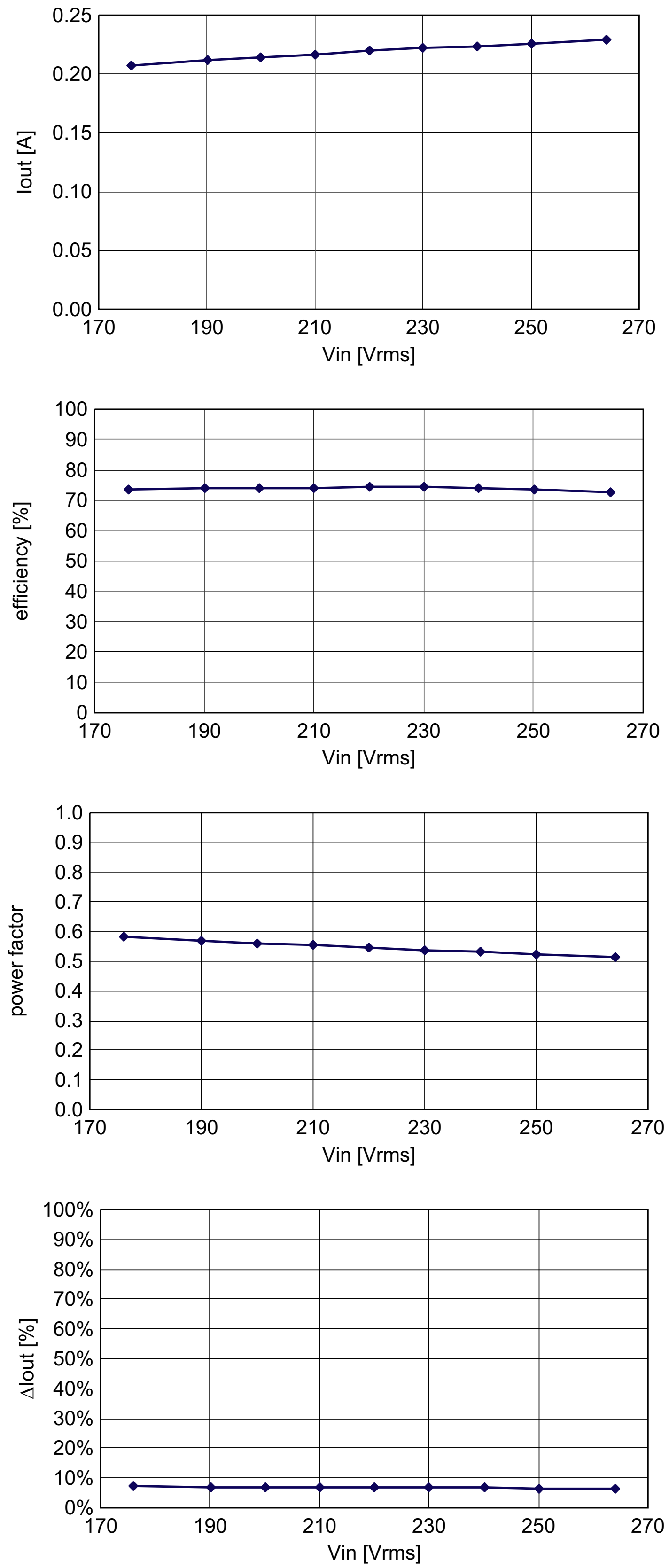
*** Efficiency data is without dummy load**

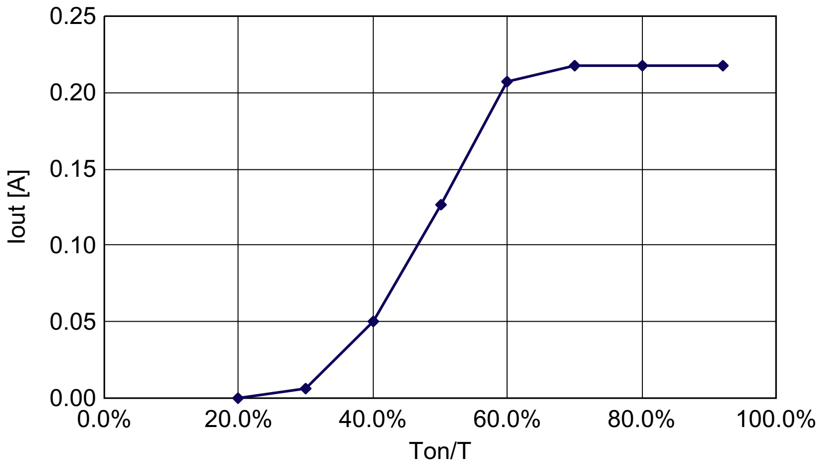



0.25
0.20
0.15
0.10
0.05
0.00
Iout [A]
0.0%
20.0%
40.0%
60.0%
80.0%
100.0%
Ton/T

5.7.7 R2A20134EVB-ID Board Evaluation Data 220 V

*** Efficiency data is without dummy load**




0.25
0.20
0.15
0.10
0.05
0.00
Iout [A]
0.0%
20.0%
40.0%
60.0%
80.0%
100.0%
Ton/T

5.7.8 The Approach to Calculate Each Constant Value for R2A20134EVB-IN, ID

[Conditions precedent of design]
Vin = 85 Vac to 132 Vac, Vout = 35 Vdc, Iout = 0.2 A, at fixed switching frequency = 80 kHz

In the case of peak current control type at fixed frequency condition, it's a control method to keep input power as same level.

** The current flowing through a inductor is discontinuous.

- The way to decide Frequency
  Firstly frequency value should be set 80kHz to avoid Audio frequency band.

- The way to decide "Rrt"
  Please refer to the expression of section 3.4.
  Although Rrt is 120.5kΩ, this value should be 120kΩ by cutting off to the closest whole number.
  Then, Frequency value should be changed to 80.3kHz.

- The way to decide the first-order winding Inductance
  Input power can be calculated by following expression.
  Input Power=(Output power)/(Efficiency)
  If Output Power is 7W and Efficiency is 80%, Input power should be 8.75W.
  In addition, the case of Minimum input voltage=80V, input current should be 109mA.
  Maximum Duty ratio is 50%, then peak current of FET should be 2×Iin/Duty=438mA.
  On-Term is 6.2μs, then Lp=Vin×Ton/Ip=1.132mH. But Lp should be just 1mH by allowable tolerance.

- The way to decide the first-order turns
  Np=Vin×Ton/Ae/BT
  The first-order winding Inductance is 1mH, then Ton can be gotten by following to fulfill Pin=8.75W.
  Ton=√(Iave×2×T×L/Vin)=√(Pin×2×T×L)/Vin=√(8.75W×2/80.3kHz×1mH)/80V=5.8μs
  At the condition using EE16-Core (Ae=19.8mm2) and setting Saturation magnetic flux density: BT=300mT,
  Np=80V×5.8μs/19.8mm2/300mT×1000000000=78.6
  According to making consideration Np>79, Winding width of Transmitter and Gap measurement,
  Finally Np should be set 86.

- The way to decide the ratio of winding number : the first order VS the second order
  It should be set the critical operation of Duty ratio=50% at Minimized Input voltage & Output Voltage.
  In the case of Vin=80V, Vout=20V, Vf=1.5V which is rectifier diode for the second order, the ratio of winding number is "Np:Ns=Vin:(Vout+Vf)=80:21.5".
  Since Np is 86, Ns becomes 23.11.
  If the secondly winding number is not integer number, it should be rounded and sets discontinuous operation.
  Thus, Ns should be 24.

- The way to decide auxiliary winding for IC power supply
  Auxiliary winding is generated as below.
  Winding direction is commeasurable with Output power,
  IC power supply: Vcc can keep over UVLO at Minimum Output Voltage.
  Ns:Nb=(Vout+Vf):(Vcc+Vf)=21.5:11.4
  By above expression; Ns=24 and Nb=13
  ** It's possible to get higher voltage against to target one. It depends on IC power supply load is lower value. Therefore please try to adjust winding number in actual condition.

- The way to decide Rcs
  Iin(peak)=√(Pin×2×T/L)=√(8.75W×2/80.3kHz/1mH)=467mA At Vcs=0.6V and Rcs=1.2Ω

- The way to decide Dimming Circuits
  Please refer to the section of "ND". Thanks.

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Revision Record

Rev.	Date	Description	
		Page	Summary
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2.00	Feb 14, 12	—	Second edition issued

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