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## 600mA Step-down DC/DC Converter with Synchronous Rectifier Evaluation Board

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NO.EEV-305-033-190222

RP507K001B033-EV is the evaluation board for RP507 which has the below features, benefits and specifications.

### OUTLINE

The RP507K001B is a CMOS-based 600mA<sup>(1)</sup> step-down DC/DC converter with synchronous rectifier. Internally, a single converter consists of an oscillator, a reference voltage unit, an error amplifier, a switching control circuit, a soft-start circuit, an under voltage lockout (UVLO) circuit, an over current protection circuit, a thermal shutdown circuit and switching transistors.

Replacing diodes with built-in switching transistors improves the efficiency of rectification. Therefore, by simply using an inductor, resistors and capacitors as the external components, a low ripple high efficiency synchronous rectifier step-down DC/DC converter can be easily configured.

The RP507K001B has an over current protection circuit which supervises the inductor peak current in each switching cycle, and turns the high-side driver off if the current exceeds the Lx current limit. The RP507K001B also contains a thermal shutdown circuit which detects overheating of the converter and stops the converter operation to protect it from damage if the junction temperature exceeds the specified temperature.

The RP507K001B is PWM/VFM auto switching control in which mode automatically switches from PWM mode to high-efficiency VFM mode in low output current.

The RP507K001B is available in DFN(PLP)1616-6D package which achieves high-density mounting on boards. For an input capacitor (CIN) and an output capacitor (COUT), the smaller sized 0402/1005 (inch/ mm) capacitor can be used. Output voltage is adjustable with external divider resistors.

### FEATURES

- Input Voltage Range ..... 2.3V to 5.5V (Absolute maximum rating: 6.5V)
- Output Voltage Range ..... 0.7V to 5.5V  
(Note: As for 1.0V or less, input voltage range is limited.)
- Feedback Voltage Accuracy .....  $\pm 9\text{mV}$  ( $V_{\text{FB}}=0.6\text{V}$ )
- Temperature-Drift Coefficient of Feedback Voltage  
..... Typ.  $\pm 100\text{ppm}/^\circ\text{C}$
- Oscillator Frequency ..... Typ. 2.0MHz
- Maximum Duty Cycle ..... 100%
- Built-in Driver ON Resistance ..... Typ. Pch. 0.38 $\Omega$ , Nch. 0.3 $\Omega$  ( $V_{\text{IN}}=3.6\text{V}$ )
- Supply Current (at no load) ..... Typ. 34 $\mu\text{A}$
- Standby Current ..... Max. 5 $\mu\text{A}$
- UVLO Detector Threshold ..... Typ. 2.0V

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<sup>(1)</sup> This is an approximate value, because output current depends on conditions and external components.

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- Soft-start Time..... Typ. 150 $\mu$ s
- Lx Current Limit Circuit..... Typ. 1A
- Package ..... DFN(PLP)1616-6D
- For more details on RP507 IC, please refer to  
<https://www.e-devices.ricoh.co.jp/en/products/power/dcdc/rp507/rp507-ea.pdf>.

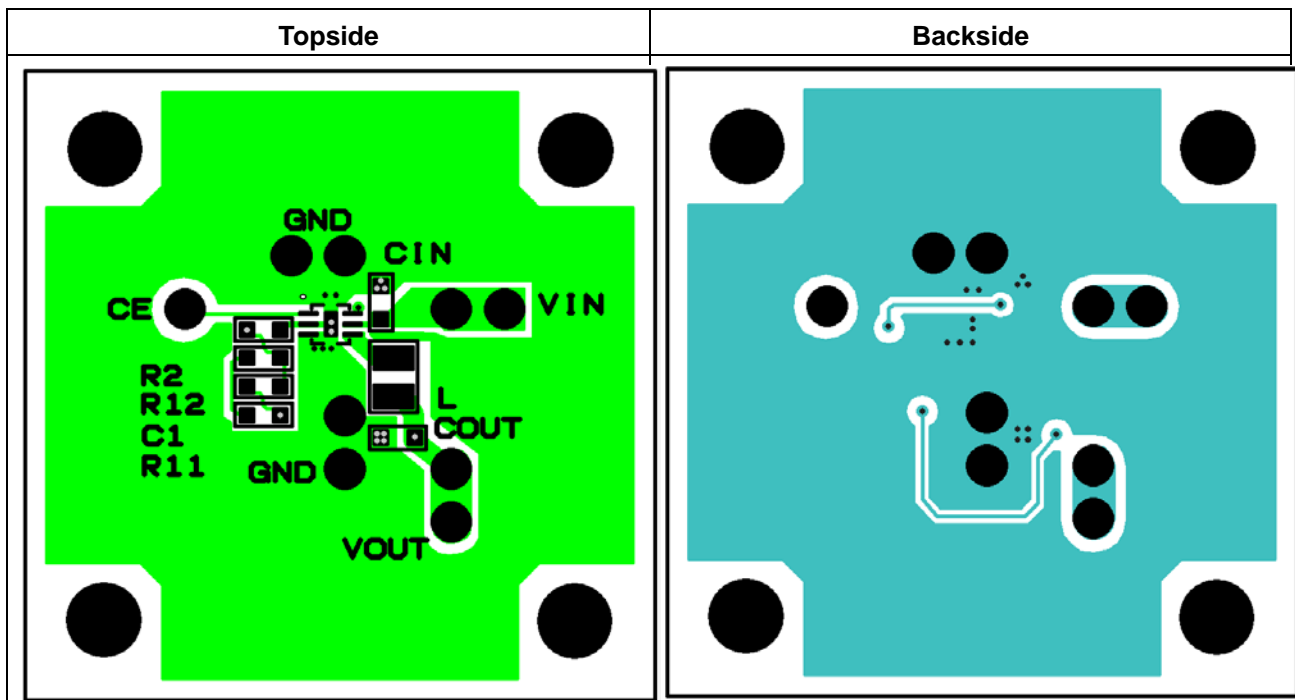
## Part Number Information

Product Name	Package
RP507K001B033-TR	DFN(PLP)1616-6D

001B: with auto-discharge function

033: 3.3 V, Output voltage

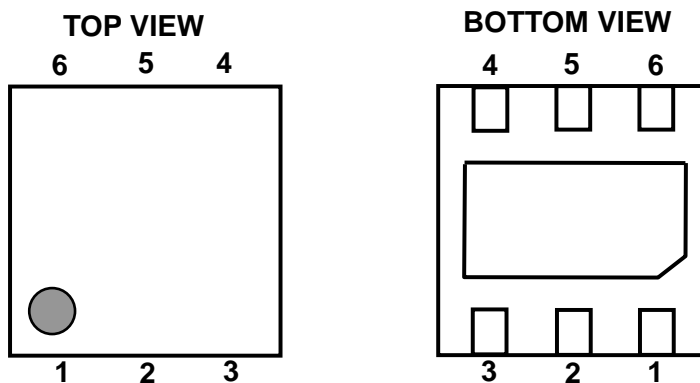
## PCB LAYOUT



R11 and R12 are arranged as a substitute for R1 so that two resistors can be connected in series.

## PIN DESCRIPTION

• DFN(PLP)1616-6D



### Pin Description

Pin No.	Symbol	Description
1	CE	Chip Enable Pin ("H" Active)
2	AGND	Ground Pin <sup>(1)</sup>
3	PGND	Ground Pin <sup>(1)</sup>
4	L <sub>x</sub>	L <sub>x</sub> Switching Pin
5	V <sub>IN</sub>	Input Pin
6	V <sub>FB</sub>	Feedback Pin

The exposed tab on the bottom of the package enhances thermal performance and is electrically connected to GND (substrate level). It is recommended that the exposed tab be connected to the ground plane on the board or otherwise be left open.

<sup>(1)</sup> No.2 pin and No.3 pin must be wired to the GND plane when mounting on boards.

## ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings (AGND=PGND=0V)

Symbol	Item	Rating	Unit
V <sub>IN</sub>	V <sub>IN</sub> Input Voltage	-0.3 to 6.5	V
V <sub>LX</sub>	L <sub>x</sub> Pin Voltage	-0.3 to V <sub>IN</sub> + 0.3	V
V <sub>CE</sub>	CE Pin Input Voltage	-0.3 to 6.5	V
V <sub>FB</sub>	V <sub>FB</sub> Pin Voltage	-0.3 to 6.5	V
I <sub>LX</sub>	L <sub>x</sub> Pin Output Current	1	A
P <sub>D</sub>	Power Dissipation <sup>(1)</sup> (DFN(PLP)1616-6D, JEDEC STD. 51-7)	1580	mW
T <sub>j</sub>	Junction Temperature	-40 to 125	°C
T <sub>stg</sub>	Storage Temperature Range	-55 to 125	°C

### ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the life time and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings are not assured.

## RECOMMENDED OPERATING CONDITIONS

Recommended Operating Conditions

Symbol	Item	Rating	Unit
V <sub>IN</sub>	Input Voltage	1.0V ≤ V <sub>SET</sub> <sup>(2)</sup>	V
		0.9V ≤ V <sub>SET</sub> < 1.0V	
		0.7V ≤ V <sub>SET</sub> < 0.9V	
T <sub>a</sub>	Operating Temperature Range	-40 to 85	°C

### RECOMMENDED OPERATING CONDITIONS

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such ratings by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

<sup>(1)</sup> Refer to *POWER DISSIPATION* for detailed information.

<sup>(2)</sup> V<sub>SET</sub>= Set Output Voltage

## ELECTRICAL CHARACTERISTICS

### ● RP507K001B

(Ta=25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V <sub>FB</sub>	Feedback Output Voltage	V <sub>IN</sub> =V <sub>CE</sub> =3.6V	0.591	0.600	0.609	V
ΔV <sub>FB</sub> /ΔT	Feedback Output Voltage Temperature Coefficient	-40°C ≤ Ta ≤ 85°C		±100		ppm/°C
f <sub>osc</sub>	Oscillator Frequency	V <sub>IN</sub> =V <sub>CE</sub> =3.6V (V <sub>SET</sub> <sup>(1)</sup> ≤2.6V), V <sub>IN</sub> =V <sub>CE</sub> =V <sub>SET</sub> +1V (V <sub>SET</sub> >2.6V)	1.7	2.0	2.3	MHz
I <sub>DD</sub>	Supply Current	V <sub>IN</sub> =V <sub>CE</sub> =V <sub>FB</sub> =3.6V		32	45	μA
I <sub>standby</sub>	Standby Current	V <sub>IN</sub> =5.5V, V <sub>CE</sub> =0V		0	5	μA
I <sub>CEH</sub>	CE "H" Input Current	V <sub>IN</sub> =V <sub>CE</sub> =5.5V	-1	0	1	μA
I <sub>CEL</sub>	CE "L" Input Current	V <sub>IN</sub> =5.5V, V <sub>CE</sub> =0V	-1	0	1	μA
I <sub>VFBH</sub>	VFB "H" Input Current	V <sub>IN</sub> =V <sub>FB</sub> =5.5V, V <sub>CE</sub> =0V	-1	0	1	μA
I <sub>VFBL</sub>	VFB "L" Input Current	V <sub>IN</sub> =5.5V, V <sub>CE</sub> =V <sub>FB</sub> =0V	-1	0	1	μA
t <sub>dis</sub>	Auto Discharge Time <sup>(2)</sup>	V <sub>IN</sub> =2.3V, V <sub>CE</sub> =0V, C <sub>OUT</sub> =10μF		5	10	ms
I <sub>LXLEAKH</sub>	Lx Leakage Current "H"	V <sub>IN</sub> =V <sub>LX</sub> =5.5V, V <sub>CE</sub> =0V	-1	0	5	μA
I <sub>LXLEAKL</sub>	Lx Leakage Current "L"	V <sub>IN</sub> =5.5V, V <sub>CE</sub> =V <sub>LX</sub> =0V	-5	0	1	μA
V <sub>CEH</sub>	CE "H" Input Voltage	V <sub>IN</sub> =5.5V	1.0			V
V <sub>CEL</sub>	CE "L" Input Voltage	V <sub>IN</sub> =2.3V			0.4	V
R <sub>ONP</sub>	On Resistance of Pch Tr.	V <sub>IN</sub> =3.6V, I <sub>LX</sub> =-100mA		0.38		Ω
R <sub>ONN</sub>	On Resistance of Nch Tr.	V <sub>IN</sub> =3.6V, I <sub>LX</sub> =-100mA		0.3		Ω
Maxduty	Maximum Duty Cycle		100			%
t <sub>start</sub>	Soft-start Time	V <sub>IN</sub> =V <sub>CE</sub> =3.6V (V <sub>SET</sub> ≤2.6V), V <sub>IN</sub> =V <sub>CE</sub> =V <sub>SET</sub> +1V (V <sub>SET</sub> >2.6V)		150	300	μs
I <sub>LXLIM</sub>	Lx Current Limit	V <sub>IN</sub> =V <sub>CE</sub> =3.6V (V <sub>SET</sub> ≤2.6V), V <sub>IN</sub> =V <sub>CE</sub> =V <sub>SET</sub> +1V (V <sub>SET</sub> >2.6V)	800	100 0		mA
V <sub>UVLO1</sub>	UVLO Detector Threshold	V <sub>IN</sub> =V <sub>CE</sub>	1.9	2.0	2.1	V
V <sub>UVLO2</sub>	UVLO Released Voltage	V <sub>IN</sub> =V <sub>CE</sub>	2.0	2.1	2.2	V
T <sub>TSD</sub>	Thermal Shutdown Temperature	Junction Temperature		140		°C
T <sub>TSR</sub>	Thermal Shutdown Released Temperature	Junction Temperature		100		°C

Note: Test circuit is "OPEN LOOP" and AGND=PGND=0V unless otherwise specified.

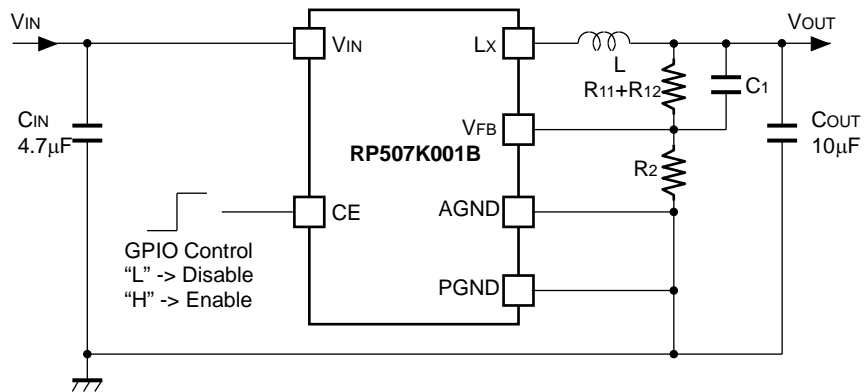
(1) V<sub>SET</sub>= Set Output Voltage

(2) It starts when the CE pin is low and ends when V<sub>OUT</sub> ≤ V<sub>SET</sub> x 0.1.

## APPLICATION INFORMATION

### Typical Application

(Adjustable Output Voltage Type)



### Recommended Components\*1

Symbol	Value
CIN	4.7µF
COU	10µF
L	4.7µH
C1	15pF
R11	270kΩ
R12	0Ω
R2	60kΩ (120kΩ  120kΩ)

\*1 The bill of materials will be attached on the shipment of each purchased evaluation board.

## TECHNICAL NOTES

When using the RP507K001B, please consider the following points.

- The Inductance value should be set within the range of 1.5μH to 4.7μH. However, the inductance value is limited by output voltage, so please refer to the table below. The phase compensation of this IC is designed according to the C<sub>OUT</sub> and L values. Choose an inductor that has small DC resistance, has enough allowable current and is hard to cause magnetic saturation. If the inductance value of an inductor is extremely small, the peak current of L<sub>x</sub> may increase. The increased L<sub>x</sub> peak current reaches "L<sub>x</sub> limit current" to trigger over current protection circuit even if the load current is less than 600mA.

**Table 1. Set Output Voltage Range vs. Inductance Range**

Set Output Voltage (V) V <sub>SET</sub>	Inductance		
	L=1.5μH	L=2.2μH	L=4.7μH
0.7~1.0	Ok	Good	-
1.1~1.7	-	Good	-
1.8~2.5	-	Good	Ok
2.6~	-	Ok	Good

- Over current protection circuit may be affected by self-heating or power dissipation environment.
- The output voltage (V<sub>OUT</sub>) is adjustable by changing the R<sub>1</sub> and R<sub>2</sub> values as follows.

$$V_{OUT} = V_{FB} \times (R_1 + R_2) / R_2 \quad (0.7V \leq V_{OUT} \leq 5.5V)$$

- The recommended resistance values for R<sub>1</sub>, R<sub>2</sub> and C<sub>1</sub> are as follows.

**Table 2. Set Output Voltage Range vs. Resistor & Capacitor Range**

Set Output Voltage (V) V <sub>SET</sub>	Resistor (kΩ)		Capacitor (pF)
	R <sub>1</sub>	R <sub>2</sub>	C <sub>1</sub>
1.0	120	180	22
1.2	180	180	22
1.5	270	180	22
1.8	240	120	22
2.5	380	120	15
2.8	275	75	15
3.3	270	60	15

- ★ The performance of power source circuits using this IC largely depends on the peripheral circuits. When selecting the peripheral components, please consider the conditions of use. Do not allow each component, PCB pattern and the IC to exceed their respected rated values (voltage, current, and power) when designing the peripheral circuits.



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