

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

NO.EEV-305-033-230331

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

OUTLINE

The RP507K001B is a CMOS-based 600mA⁽¹⁾ 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(PL)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 ±9mV (V_{FB}=0.6V)
- Temperature-Drift Coefficient of Feedback Voltage
..... Typ. ±100ppm/°C
- Oscillator Frequency Typ. 2.0MHz
- Maximum Duty Cycle 100%
- Built-in Driver ON Resistance Typ. Pch. 0.38Ω, Nch. 0.3Ω (V_{IN}=3.6V)
- Supply Current (at no load) Typ. 34μA
- Standby Current Max. 5μA
- UVLO Detector Threshold Typ. 2.0V

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

- Soft-start Time..... Typ. 150μs
- Lx Current Limit Circuit..... Typ. 1A
- Package DFN(PL)1616-6D
- For more details on RP507 IC, please refer to
<https://www.nisshinbo-microdevices.co.jp/en/products/dc-dc-switching-regulator/spec/?product=rp507>

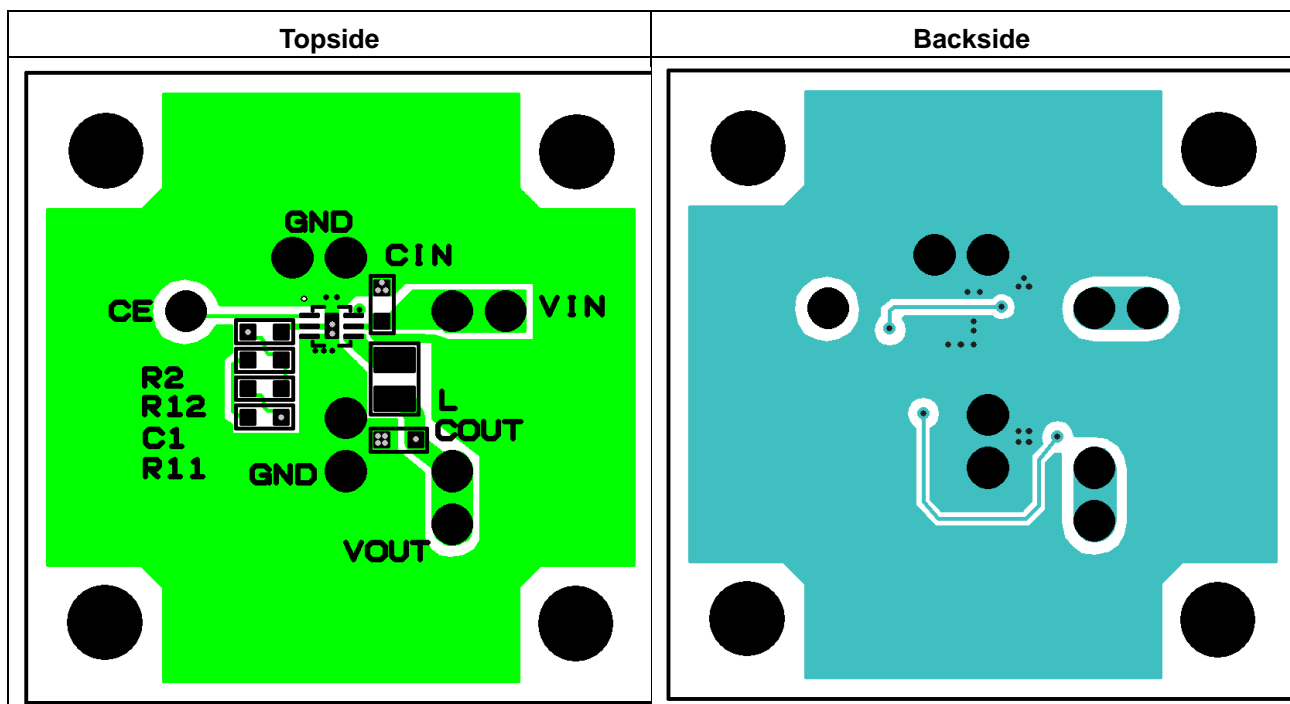
Part Number Information

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

001B: with auto-discharge function

033: 3.3 V, Output voltage

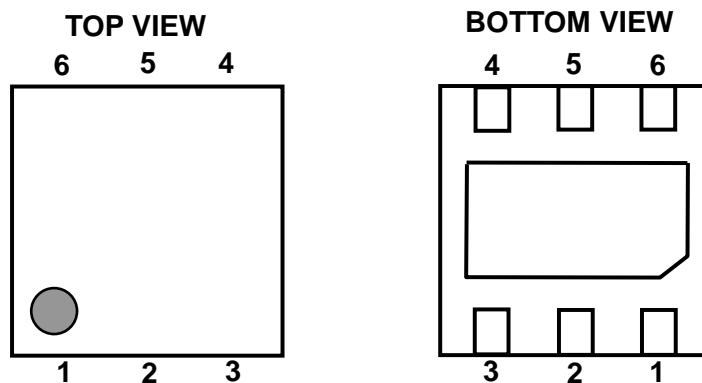
PCB LAYOUT



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

PIN DESCRIPTION

• DFN(PL)1616-6D



Pin Description

Pin No.	Symbol	Description
1	CE	Chip Enable Pin ("H" Active)
2	AGND	Ground Pin ⁽¹⁾
3	PGND	Ground Pin ⁽¹⁾
4	L _x	L _x Switching Pin
5	V _{IN}	Input Pin
6	V _{FB}	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.

⁽¹⁾ 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 _{IN}	V _{IN} Input Voltage	-0.3 to 6.5	V
V _{LX}	L _x Pin Voltage	-0.3 to V _{IN} + 0.3	V
V _{CE}	CE Pin Input Voltage	-0.3 to 6.5	V
V _{FB}	V _{FB} Pin Voltage	-0.3 to 6.5	V
I _{LX}	L _x Pin Output Current	1	A
P _D	Power Dissipation ⁽¹⁾ (DFN(PL)1616-6D, JEDEC STD. 51-7)	1580	mW
T _j	Junction Temperature	-40 to 125	°C
T _{stg}	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 _{IN}	Input Voltage	1.0V ≤ V _{SET} ⁽²⁾	V
		0.9V ≤ V _{SET} < 1.0V	
		0.7V ≤ V _{SET} < 0.9V	
T _a	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.

⁽¹⁾ Refer to *POWER DISSIPATION* for detailed information.

⁽²⁾ V_{SET}= Set Output Voltage

ELECTRICAL CHARACTERISTICS

● RP507K001B

(Ta=25°C)

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

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

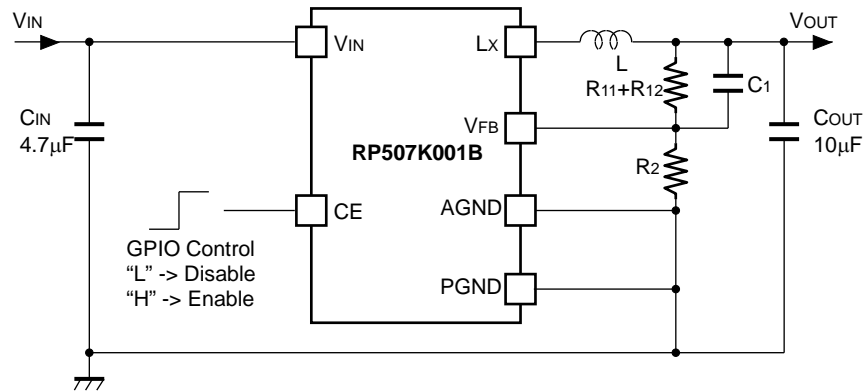
(1) V_{SET}= Set Output Voltage

(2) It starts when the CE pin is low and ends when V_{OUT} ≤ V_{SET} x 0.1.

APPLICATION INFORMATION

Typical Application

(Adjustable Output Voltage Type)



Recommended Components*1

Symbol	Value
CIN	4.7µF
COU ^T	10µF
L	4.7µH
C1	15pF
R11	270kΩ
R12	0kΩ
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_{OUT} 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_x may increase. The increased L_x peak current reaches "L_x 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 _{SET}	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_{OUT}) is adjustable by changing the R₁ and R₂ 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 R₁, R₂ and C₁ are as follows.

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

Set Output Voltage (V) V _{SET}	Resistor (kΩ)		Capacitor (pF)
	R ₁	R ₂	C ₁
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.

1. The products and the product specifications described in this document are subject to change or discontinuation of production without notice for reasons such as improvement. Therefore, before deciding to use the products, please refer to our sales representatives for the latest information thereon.
2. The materials in this document may not be copied or otherwise reproduced in whole or in part without the prior written consent of us.
3. This product and any technical information relating thereto are subject to complementary export controls (so-called KNOW controls) under the Foreign Exchange and Foreign Trade Law, and related politics ministerial ordinance of the law. (Note that the complementary export controls are inapplicable to any application-specific products, except rockets and pilotless aircraft, that are insusceptible to design or program changes.) Accordingly, when exporting or carrying abroad this product, follow the Foreign Exchange and Foreign Trade Control Law and its related regulations with respect to the complementary export controls.
4. The technical information described in this document shows typical characteristics and example application circuits for the products. The release of such information is not to be construed as a warranty of or a grant of license under our or any third party's intellectual property rights or any other rights.
5. The products listed in this document are intended and designed for use as general electronic components in standard applications (office equipment, telecommunication equipment, measuring instruments, consumer electronic products, amusement equipment etc.). Those customers intending to use a product in an application requiring extreme quality and reliability, for example, in a highly specific application where the failure or misoperation of the product could result in human injury or death should first contact us.
 - Aerospace Equipment
 - Equipment Used in the Deep Sea
 - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
 - Life Maintenance Medical Equipment
 - Fire Alarms / Intruder Detectors
 - Vehicle Control Equipment (automotive, airplane, railroad, ship, etc.)
 - Various Safety Devices
 - Traffic control system
 - Combustion equipment

In case your company desires to use this product for any applications other than general electronic equipment mentioned above, make sure to contact our company in advance. Note that the important requirements mentioned in this section are not applicable to cases where operation requirements such as application conditions are confirmed by our company in writing after consultation with your company.

6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, fire containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. The products have been designed and tested to function within controlled environmental conditions. Do not use products under conditions that deviate from methods or applications specified in this datasheet. Failure to employ the products in the proper applications can lead to deterioration, destruction or failure of the products. We shall not be responsible for any bodily injury, fires or accident, property damage or any consequential damages resulting from misuse or misapplication of the products.
8. **Quality Warranty**
 - 8-1. **Quality Warranty Period**

In the case of a product purchased through an authorized distributor or directly from us, the warranty period for this product shall be one (1) year after delivery to your company. For defective products that occurred during this period, we will take the quality warranty measures described in section 8-2. However, if there is an agreement on the warranty period in the basic transaction agreement, quality assurance agreement, delivery specifications, etc., it shall be followed.
 - 8-2. **Quality Warranty Remedies**

When it has been proved defective due to manufacturing factors as a result of defect analysis by us, we will either deliver a substitute for the defective product or refund the purchase price of the defective product.

Note that such delivery or refund is sole and exclusive remedies to your company for the defective product.
 - 8-3. **Remedies after Quality Warranty Period**

With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
9. Anti-radiation design is not implemented in the products described in this document.
10. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
11. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
12. Warning for handling Gallium and Arsenic (GaAs) products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.
13. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.



Nisshinbo Micro Devices Inc.

Official website

<https://www.nisshinbo-microdevices.co.jp/en/>

Purchase information

<https://www.nisshinbo-microdevices.co.jp/en/buy/>