

Large Current External FET Controller Type Switching Regulators Step-up/down, High-efficiency Switching Regulators (Controller type)



BD8303MUV

No.13028EBT02

• General Description

ROHM's highly-efficient step-up/down switching regulator BD8303MUV generates step-up/down output including 3.3 V / 5 V from 1 cell of lithium battery, 4 batteries, or 2 cells of Li batteries with just one inductor.

This IC adopts an original step-up/down drive system and creates a higher efficient power supply than conventional Sepic-system or H-bridge system switching regulators.

• Features

- 1) Highly-efficient step-up/down DC/DC converter to be constructed just with one inductor.
- 2) Supports a wide range of power supply voltage range (input voltage: 2.7 V - 14.0 V)
- 3) Supports high-current application with external Nch FET.
- 4) Incorporates soft-start function.
- 5) Incorporates timer latch system short protecting function.
- 6) High heat radiation surface mounted package QFN16 pin, 3 mm × 3 mm

• Application

General portable equipment like DVC, single-lens reflex cameras, portable DVDs, or mobile PCs

• Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Maximum applied power voltage	VCC	15	V
	VREG	7	V
	Between BOOT 1, 2 and SW 1, 2	7	V
	Between BOOT 1, 2 and GND	20	V
	SW1, 2	15	V
Power dissipation	Pd	620	mW
Operating temperature range	Topr	−25 to +85	°C
Storage temperature range	Tstg	−55 to +150	°C
Junction temperature	Tjmax	+150	°C

When installed on a 70.0 mm × 70.0 mm × 1.6 mm glass epoxy board. The rating is reduced by 4.96 mW/°C at Ta = 25°C or more.

• Operating Conditions (Ta = 25°C)

Parameter	Symbol	Standard value			Unit
		MIN	TYP	MAX	
Power supply voltage	VCC	2.7	—	14	V
Output voltage	VOUT	1.8	—	12	V
Oscillation frequency	fosc	0.2	0.6	1.0	MHz

* These specifications are subject to change without advance notice for modifications and other reasons.

- Electrical Characteristics

(Unless otherwise specified, Ta = 25 °C, VCC = 7.4 V)

Parameter		Symbol	Target Value			Unit	Conditions
			Minimum	Typical	Maximum		
[Low voltage input malfunction preventing circuit]							
Detection threshold voltage		Vuv	-	2.4	2.6	V	VREG monitor
Hysteresis range		ΔVuvhy	50	100	200	mV	
[Oscillator]							
Oscillation frequency		fosc	480	600	720	kHz	RT=51kΩ
[Regulator]							
Output voltage		VREG	4.7	5.1	5.5	V	
[Error AMP]							
INV threshold voltage		VINV	0.9875	1.00	1.0125	V	
Input bias current		IINV	-50	0	50	nA	Vcc=12.0V , Iinv=6.0V
Soft-start time		Tss	2.4	4.0	5.6	msec	RT=51kΩ
Output source current		IEO	10	20	30	μA	VINV=0.8V , VFB =1.5V
Output sink current		IEI	0.6	1.3	3	mA	VINV=1.2V , VFB =1.5V
[PWM comparator]							
SW1 Max Duty		Dmax1	85	90	95	%	HG1 ON
SW2 Max Duty		Dmax2	85	90	95	%	LG2 ON
SW2 Min Duty		Dmin2	5	10	15	%	LG2 OFF
[Output]							
HG1, 2 High side ON resistance		RONHp	-	4	8	Ω	
HG1, 2 Low side ON resistance		RONHn	-	4	8	Ω	
LG1, 2 High side ON resistance		RONLp	-	4	8	Ω	
LG1, 2 Low side ON resistance		RONLn	-	4	8	Ω	
HG1-LG1 dead time		Tdead1	50	100	200	nsec	
HG2-LG2 dead time		Tdead2	50	100	200	nsec	
[STB]							
STB pin control voltage	Operation	VSTBH	2.5	-	VCC	V	
	No-operation	VSTBL	-0.3	-	0.3	V	
STB pin pull-down resistance		RSTB	250	400	700	kΩ	
[Circuit current]							
Standby current	VCC pin	ISTB	-	-	1	μA	
Circuit current at operation VCC		Icc1	-	650	1000	μA	VINV=1.2V
Circuit current at operation BOOT1,2		Icc2	-	120	240	μA	VINV=1.2V

● Reference Data

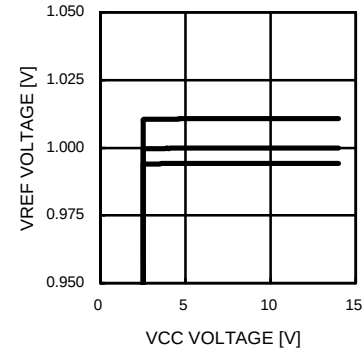


Fig.1 Standard voltage - Power supply property

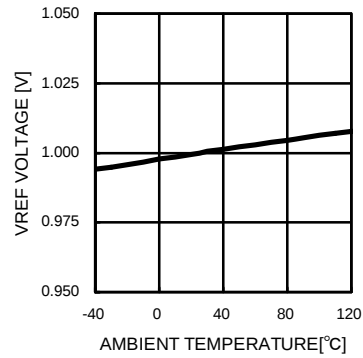


Fig.2 Standard voltage - Temperature property

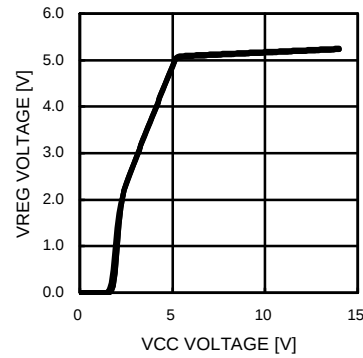


Fig.3 VREG voltage - Power supply property

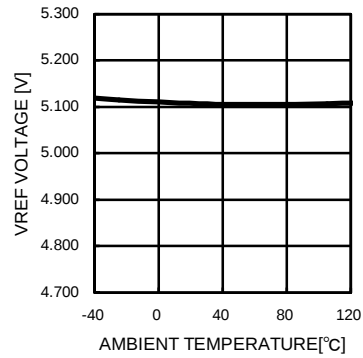


Fig.4 VREG voltage - Temperature property

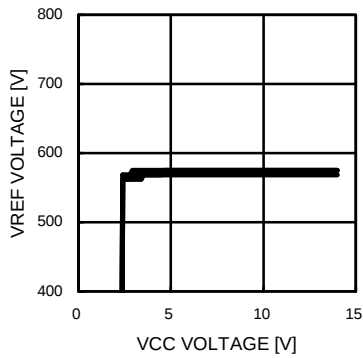


Fig.5 Oscillation frequency - Power supply property

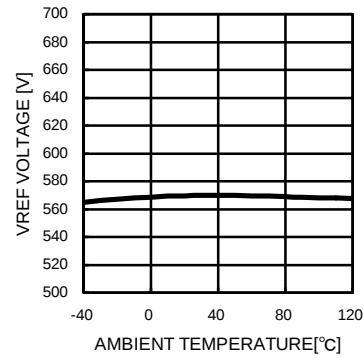


Fig.6 Oscillation frequency - Temperature property

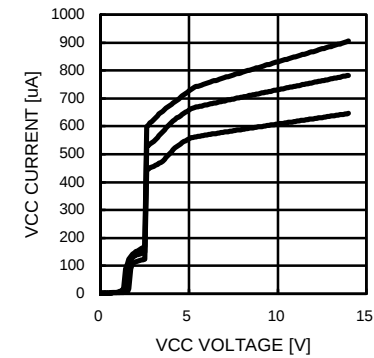


Fig.7 ICC - Power supply property

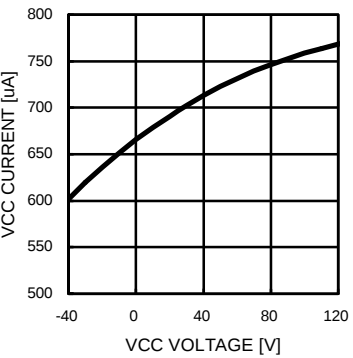


Fig.8 ICC - Temperature property

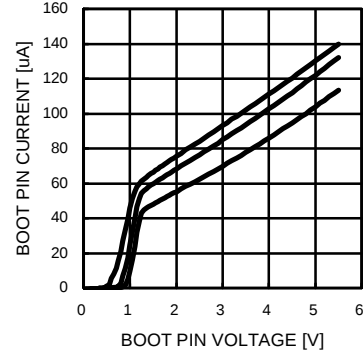


Fig.9 IBOOT - Power supply property

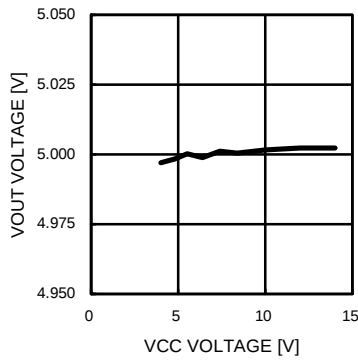


Fig.10 Line regulation

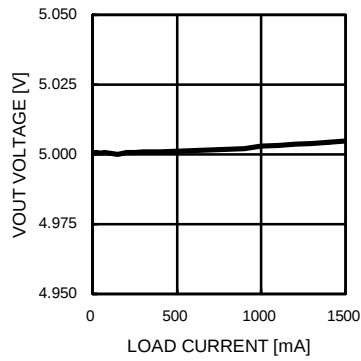


Fig.11 Load regulation

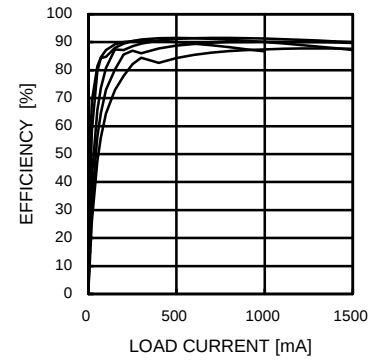


Fig.12 MAX Duty / MIN Duty temperature property

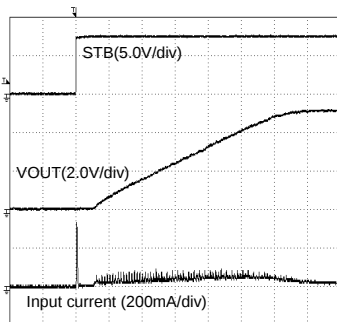


Fig.13 Starting waveform
(Example of Application Circuit [2])
 $L=10\mu\text{H}$, $C_{\text{out}} = 47\mu\text{H}$, $f_{\text{osc}} = 750\text{ kHz}$, unloaded

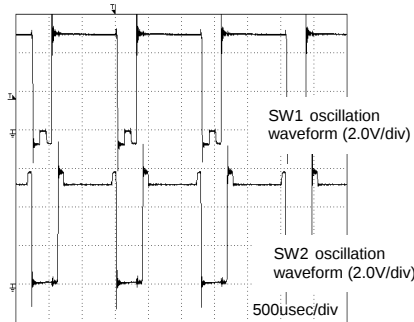


Fig.14 Oscillation waveform
 $V_{\text{CC}} = 5.0\text{ V}$, $V_{\text{out}} = 5.0\text{ V}$
 $I_{\text{LOAD}} = 1000\text{ mA}$

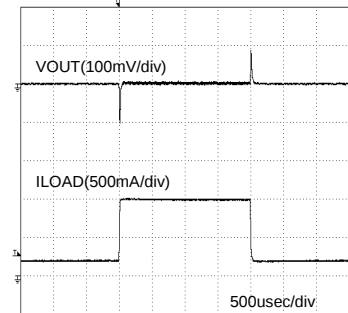


Fig.15 Load variation waveform
(Example of Application Circuit [2])
 $V_{\text{CC}} = 7.4\text{ V}$, $V_{\text{out}} = 5.0\text{ V}$,
 $I_{\text{LOAD}} = 200\text{ mA} \leftrightarrow 1000\text{ mA} : 40\text{ mA/usec}$

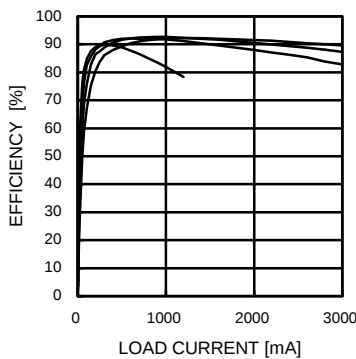


Fig.16
Efficiency data ($V_{\text{OUT}} = 3.3\text{ V}$)
Example of Application Circuit [1]

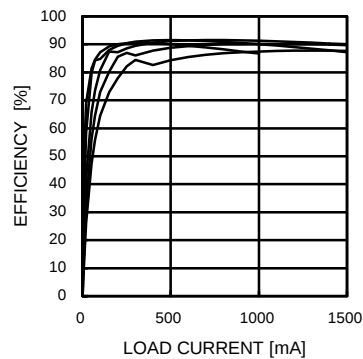


Fig.17
Efficiency data ($V_{\text{OUT}} = 5.0\text{ V}$)
Example of Application Circuit [2]

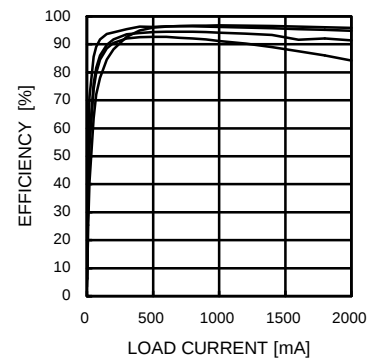


Fig.18
Efficiency data ($V_{\text{OUT}} = 8.4\text{ V}$)
Example of Application Circuit [3]

• Package Heat Reduction Curve

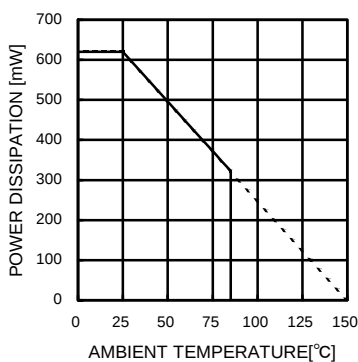


Fig.19 heat reduction curve (IC alone)
When used at $T_a = 25^\circ\text{C}$ or more, it is reduced by $4.96\text{ mW}/^\circ\text{C}$.

• Description of Pins

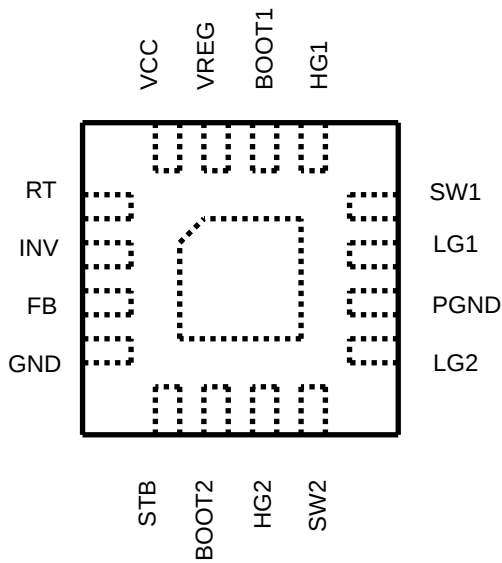


Fig. 20 Pin layout

Pin No.	Pin Name	Function
1	RT	Oscillation frequency set terminal
2	INV	Error AMP input terminal
3	FB	Error AMP output terminal
4	GND	Ground terminal
5	STB	ON/OFF terminal
6	BOOT2	Output side high-side driver input terminal
7	HG2	Output side high-side FET gate drive terminal
8	SW2	Output side coil connecting terminal
9	LG2	Output side low-side FET gate drive terminal
10	PGND	Driver part ground terminal
11	LG1	Input side low-side FET gate drive terminal
12	SW1	Input side coil connecting terminal
13	HG1	Input side high-side FET gate drive terminal
14	BOOT1	Input side high-side driver input terminal
15	VREG	5 V internal regulator output terminal
16	VCC	Power input terminal

• Block Diagram

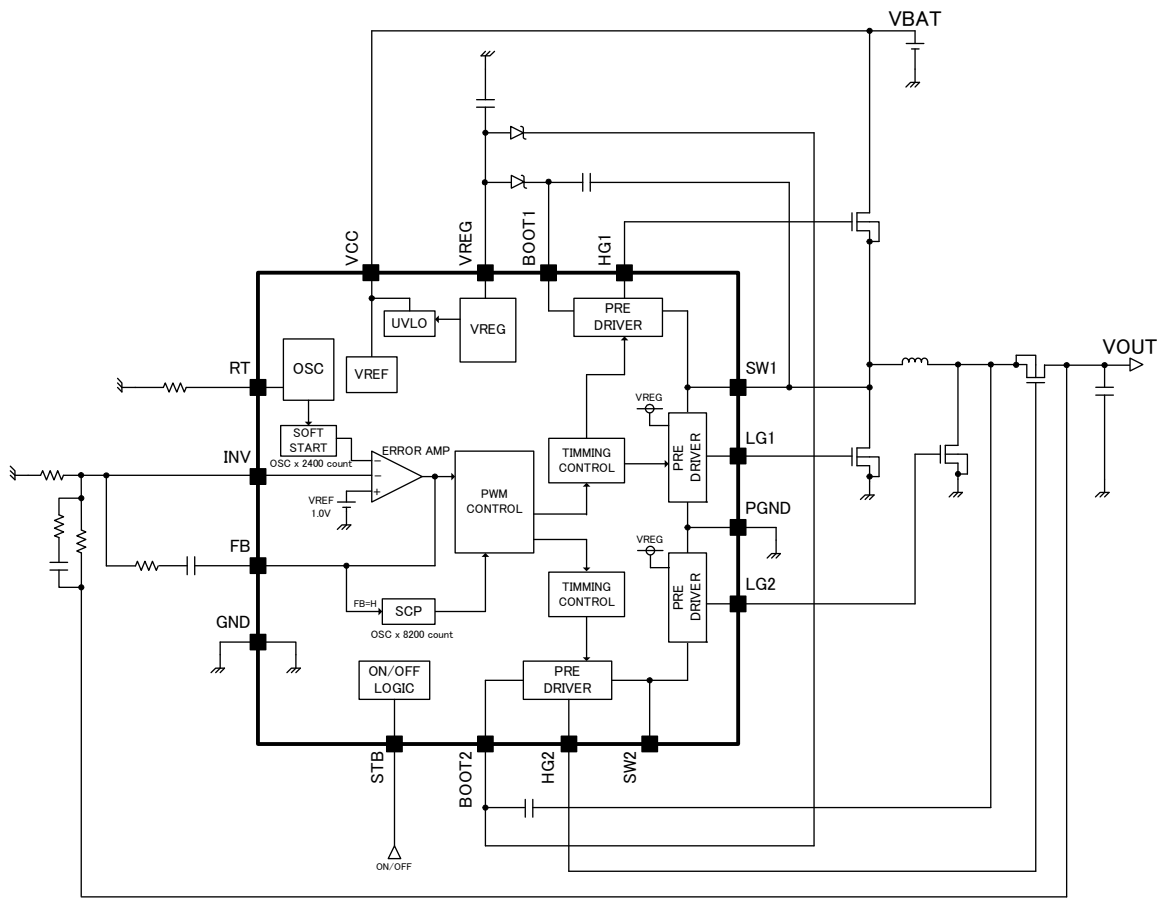


Fig. 21 Block diagram

- Description of Blocks

1. VREF

This block generates ERROR AMP reference voltage.
The reference voltage is 1.0 V.

2. VREG

5.0 V output voltage regulator. Used as power supply for IC internal circuit and BOOT pin supply.
Follows power supply voltage when it is 5.0 V or below and also drops output voltage.
For external oscillation preventive capacitor, 1.0 μ F is recommended.

3. UVLO

Circuit for preventing low voltage malfunction

Prevents malfunction of the internal circuit at activation of the power supply voltage or at low power supply voltage.
Monitors VREG pin voltage to turn off DC/DC converter output by changing output voltage of HG1, 2 and LG1, 2 pin to L-logic when VREG voltage is 2.4 V or below, and reset the timer latch of the internal SCP circuit and soft-start circuit.

4. SCP

Timer latch system short-circuit protection circuit

When the INV pin is the set 1.0 V or lower voltage, the internal SCP circuit starts counting.
The internal counter is in synch with OSC; the latch circuit activates after the counter counts about 8200 oscillations to turn off DC/DC converter output (about 13.6 msec when $RT = 51\text{ k}\Omega$).
To reset the latch circuit, turn off the STB pin once. Then, turn it on again or turn on the power supply voltage again.

5. OSC

Oscillation circuit to change frequency by external resistance of the RT pin (1 pin).
When $RT = 51\text{ k}\Omega$, operation frequency is set at 600 kHz.

6. ERROR AMP

Error amplifier for detecting output signals and output PWM control signals

The internal reference voltage is set at 1.0 V.

7. PWM COMP

Voltage-pulse width converter for controlling output voltage corresponding to input voltage

Comparing the internal SLOPE waveform with the ERROR AMP output voltage, PWM COMP controls the pulse width and outputs to the driver.

Also controls Max Duty and Min Duty.

Max Duty and Min Duty are set at the primary side and the secondary side of the inductor respectively, which are as follows:

Primary side (SW1)	HG1 Max Duty	: About 90 %,
	HG1 Min Duty	: 0 %
Secondary side (SW 2)	LG2 Max Duty	: About 90 %,
	LG2 Min Duty	: About 10 %,

8. SOFT START

Circuit for preventing in-rush current at startup by bringing the output voltage of the DC/DC converter into a soft-start
Soft-start time is in synch with the internal OSC, and the output voltage of the DC/DC converter reaches the set voltage after about 2400 oscillations (About 4 msec when $RT = 51\text{ k}\Omega$).

9. Nch DRIVER

CMOS inverter circuit for driving external Nch FET.

Dead time is provided for preventing feedthrough during switching of $HG1 = L \rightarrow LG1 = H$, $HG2 = L \rightarrow LG2 = H$ and $LG1 = L \rightarrow HG1 = H$, $LG2 = L \rightarrow HG2 = H$.

The dead time is set at about 100 nsec in the internal circuit.

10. ON/OFF LOGIC

Voltage applied on STB pin (5 pin) to control ON/OFF of IC. Turned ON when a voltage of 2.5 V or higher is applied and turned OFF when the terminal is open or 0 V is applied.

Incorporates approximately 400 k Ω pull-down resistance.

- Example of Application Circuit

* Example of application circuit: $V_{CC} = 2.7 - 5.5\text{V}$, $V_{out} = 3.3\text{V}$, $I_{out} = 100\text{mA} - 2000\text{mA}$

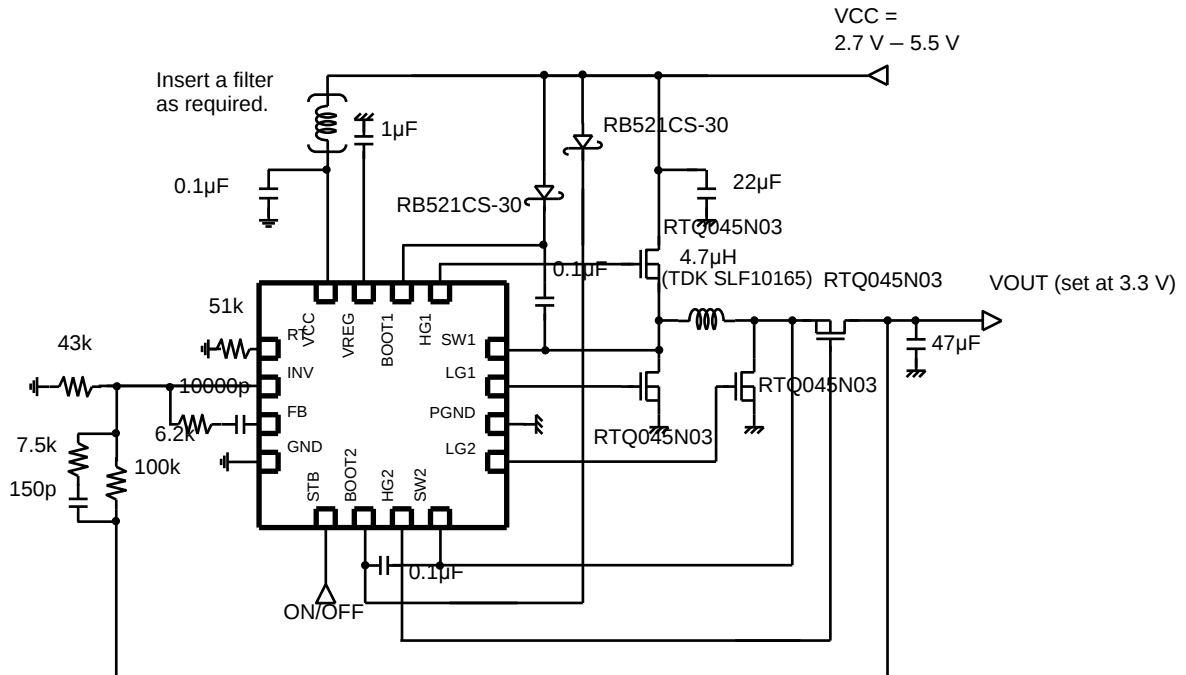


Fig. 22 Example of application circuit (1)

* Example of application circuit: $V_{CC} = 2.7 - 14\text{V}$, $V_{out} = 5.0\text{V}$, $I_{out} = 100\text{mA} - 1500\text{mA}$

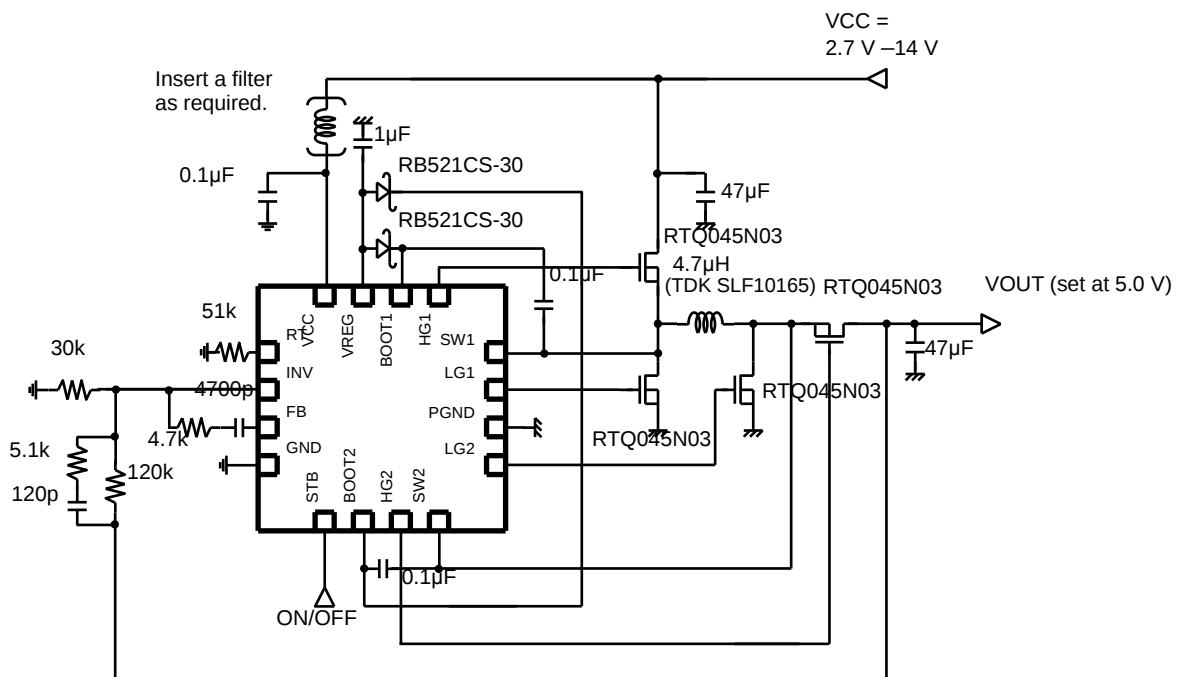


Fig. 23 Example of application circuit (2)

* Example of application circuit: $V_{CC}=4.0 - 14\text{ V}$, $V_{out}=8.4\text{ V}$, $I_{out}=100\text{ mA} - 1500\text{ mA}$

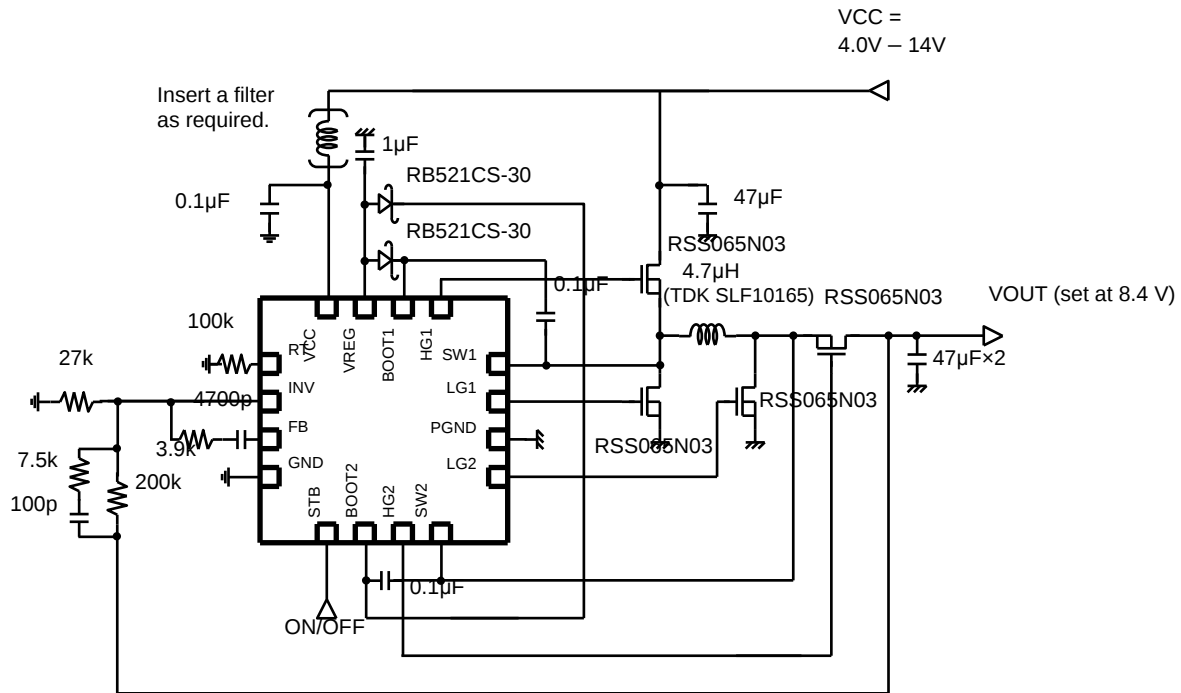


Fig. 24 Example of application circuit (3)

* Example of application circuit: $V_{CC}=5 - 14\text{ V}$, $V_{out}=12\text{ V}$, $I_{out}=100\text{ mA} - 1500\text{ mA}$

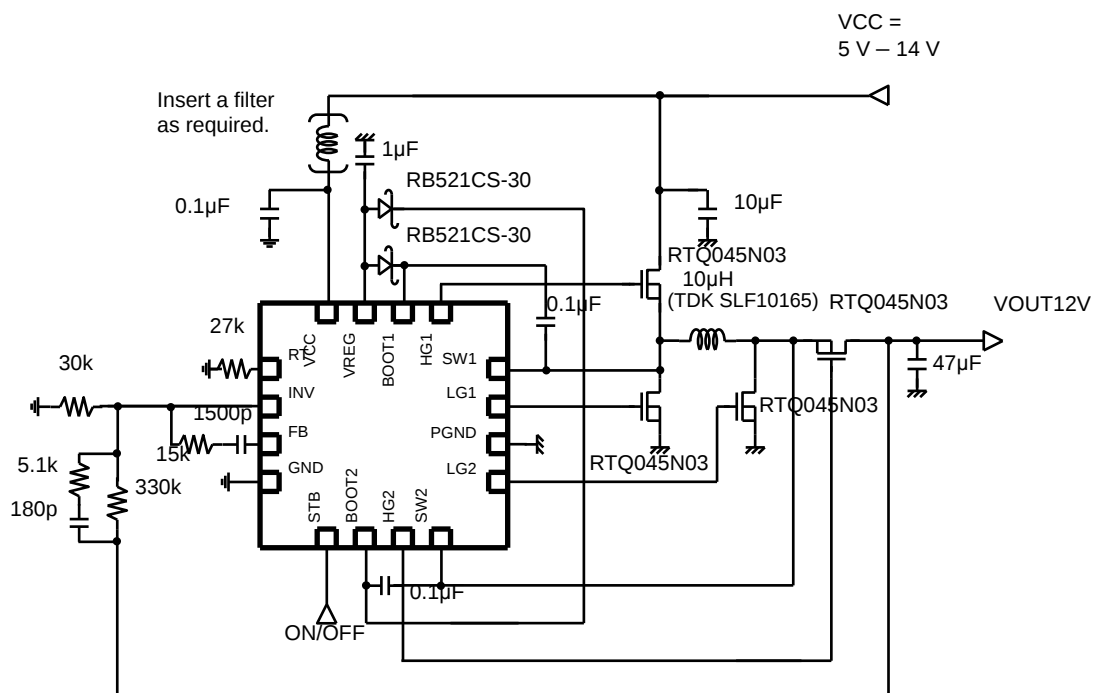


Fig. 25 Example of application circuit (4)

- Selection of parts for applications

(1) Output inductor

A shielded inductor that satisfies the current rating (current value, I_{peak} as shown in the drawing below) and has a low DCR (direct current resistance component) is recommended.

Inductor values affect output ripple current greatly.

Ripple current can be reduced as the coil L value becomes larger and the switching frequency becomes higher as the equations shown below.

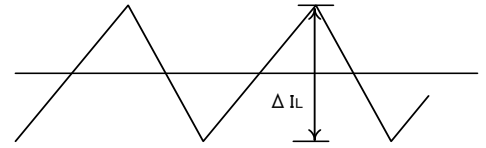


Fig. 26 Ripple current

$$I_{peak} = I_{out} \times (V_{out}/V_{in}) / \eta + \Delta I_L / 2 \text{ [A]} \quad (1)$$

$$\Delta I_L = \frac{(V_{in} - V_{out})}{L} \times \frac{V_{out}}{V_{in}} \times \frac{1}{f} \text{ [A]} \quad (\text{in step-down mode}) \quad (2)$$

$$\Delta I_L = \frac{|(V_{in} - V_{out})|}{L} \times \frac{V_{out} \times 2 \times 0.8}{(V_{in} + V_{out})} \times \frac{1}{f} \text{ [A]} \quad ((\text{in step-up/down mode}) \quad (3)$$

$$\Delta I_L = \frac{(V_{out} - V_{in})}{L} \times \frac{V_{in}}{V_{out}} \times \frac{1}{f} \text{ [A]} \quad (\text{in step-up mode}) \quad (4)$$

(η : Efficiency, ΔI_L : Output ripple current, f : Switching frequency)

As a guide, output ripple current should be set at about 20 to 50% of the maximum output current.

* Current over the coil rating flowing in the coil brings the coil into magnetic saturation, which may lead to lower efficiency or output oscillation. Select an inductor with an adequate margin so that the peak current does not exceed the rated current of the coil.

(2) Output capacitor

A ceramic capacitor with low ESR is recommended for output in order to reduce output ripple.

There must be an adequate margin between the maximum rating and output voltage of the capacitor, taking the DC bias property into consideration.

Output ripple voltage when ceramic capacitor is used is obtained by the following equation.

$$V_{pp} = \Delta I_L \times \frac{1}{2\pi \times f \times C_o} + \Delta I_L \times R_{ESR} \text{ [V]} \quad \dots (5)$$

$$V_{pp} = \Delta I_L \times \frac{1}{2\pi \times f \times C_o} + \Delta I_L \times R_{ESR} \text{ [V]} \quad \dots (5)$$

Setting must be performed so that output ripple is within the allowable ripple voltage.

(3) External FET

An external FET which satisfies the following items and has small C_{iss} (input capacitance), Q_g (total gate charge quantity) and $R_{DS(on)}$ resistance should be selected. There must be an adequate margin between the turn OFF time of MOS and the dead time to prevent through-current.

Drain-source voltage rating: (Output voltage + BodyDiode V_f of MOS or higher)

Gate-source voltage rating: 7.0 V or higher

Drain-source current rating: I_{PEAK} of Output inductor paragraph or higher

(5) BOOT-SW capacitor

The capacitor between BOOT and SW should be designed so that the gate drive voltage will not be below V_{gs} necessary for the FET to use, taking circuit current input to the BOOT pin into consideration. There must be an adequate margin between the maximum rating and gate drive voltage.

Gate drive voltage

$$= (V_{REG} \text{ voltage}) - (V_f \text{ of } D_i) - (\text{Voltage drop by BOOT pin consumption}) \text{ [V]} \quad (6)$$

Voltage drop by BOOT pin consumption

$$= (I_{boot} \times (1 / f_{osc}) + Q_g \text{ of external FET}) / C_{boot} \text{ [V]} \quad (7)$$

(6) REG-BOOT diode

A Schottky diode which satisfies the following items and has less forward pressure drop (V_f) should be selected.

Average rectified current: There must be an adequate margin against the current consumed by MOSFET switching.

DC inverse voltage: Input voltage or higher

(3) Setting of oscillation frequency

Oscillation frequency can be set using a resistance value connected to the RT pin (1 pin).

Oscillation frequency is set at 600 kHz when $R_T = 51 \text{ k}\Omega$, and frequency is inversely proportional to R_T value.

See Fig. 27 for the relationship between R_T and frequency.

Soft-start time changes along with oscillation frequency.

See Fig. 28 for the relationship between R_T and soft-start time.

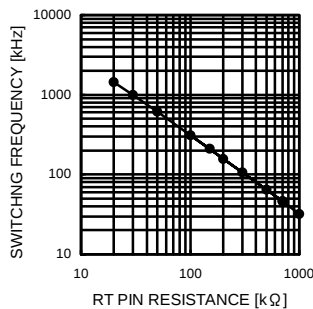


Fig. 27 Oscillation frequency – R_T pin resistance

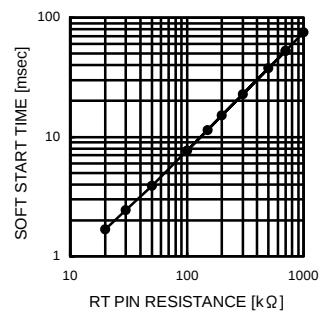
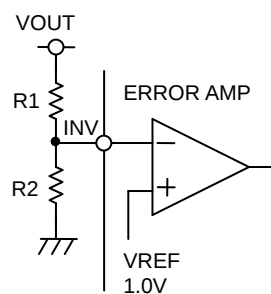


Fig. 28 Soft-start time – R_T pin resistance

* Note that the above example of frequency setting is just a design target value, and may differ from the actual equipment.

(4) Output voltage setting

The internal reference voltage of the ERROR AMP is 1.0 V. Output voltage should be obtained by referring to Equation (8) of Fig. 29.



$$V_o = \frac{(R_1 + R_2)}{R_2} \times 1.0 \text{ [V]} \dots (8)$$

Fig. 29 Setting of feedback resistance

(9) Determination of external phase compensation

Condition for stable application

The condition for feedback system stability under negative feedback is as follows:

- Phase delay is 135° or less when gain is 1 (0 dB) (Phase margin is 45° or higher)

Since DC/DC converter application is sampled according to the switching frequency, the GBW of the whole system (frequency at which gain is 0 dB) must be set to be equal to or lower than 1/5 of the switching frequency.

In summary, target property of applications is as follows:

- Phase delay must be 135° or lower when gain is 1 (0 dB) (Phase margin is 45° or higher).
- The GBW at that time (frequency when gain is 0 dB) must be equal to or lower than 1/5 of the switching frequency.

For this reason, switching frequency must be increased to improve responsiveness.

One of the points to secure stability by phase compensation is to cancel secondary phase delay (-180°) generated by LC resonance by the secondary phase lead (i.e. put two phase leads).

Since GBW is determined by the phase compensation capacitor attached to the error amplifier, when it is necessary to reduce GBW, the capacitor should be made larger.

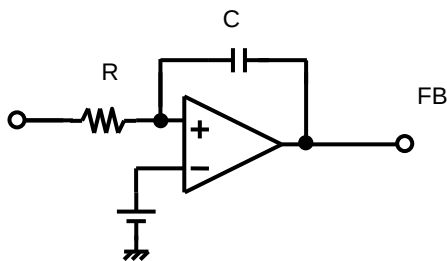


Fig.30 General integrator

Error AMP is a low-pass filter because phase compensation such as (1) and (2) is performed. For DC/DC converter application, R is a parallel feedback resistance.

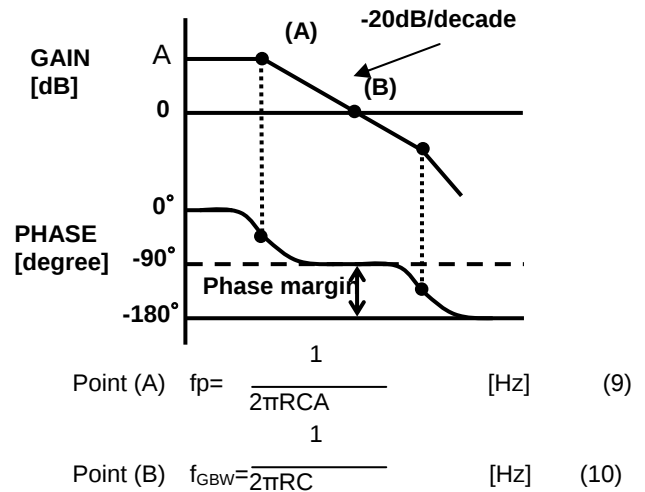


Fig.31 Frequency property of integrator

Phase compensation when output capacitor with low ESR such as ceramic capacitor is used is as follows:

When output capacitor with low ESR (several tens of mΩ) is used for output, secondary phase lead (two phase leads) must be put to cancel secondary phase lead caused by LC.

One of the examples of phase compensation methods is as follows:

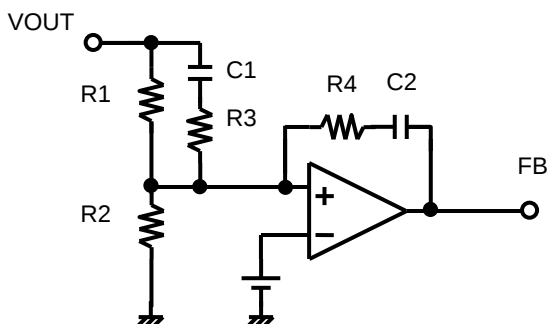


Fig.32 Example of setting of phase compensation

$$\text{Phase lead } f_{z1} = \frac{1}{2\pi R_1 C_1} \quad [\text{Hz}] \quad (11)$$

$$\text{Phase lead } f_{z2} = \frac{1}{2\pi R_4 C_2} \quad [\text{Hz}] \quad (12)$$

$$\text{Phase delay } f_{p1} = \frac{1}{2\pi R_3 C_1} \quad [\text{Hz}] \quad (13)$$

$$\text{LC resonance frequency} = \frac{1}{2\pi\sqrt{LC}} \quad [\text{Hz}] \quad (14)$$

For setting of phase-lead frequency, both of them should be put near LC resonance frequency.

When GBW frequency becomes too high due to the secondary phase lead, it may get stabilized by putting the primary phase delay in a frequency slightly higher than the LC resonance frequency to compensate it.

- Example of Board Layout

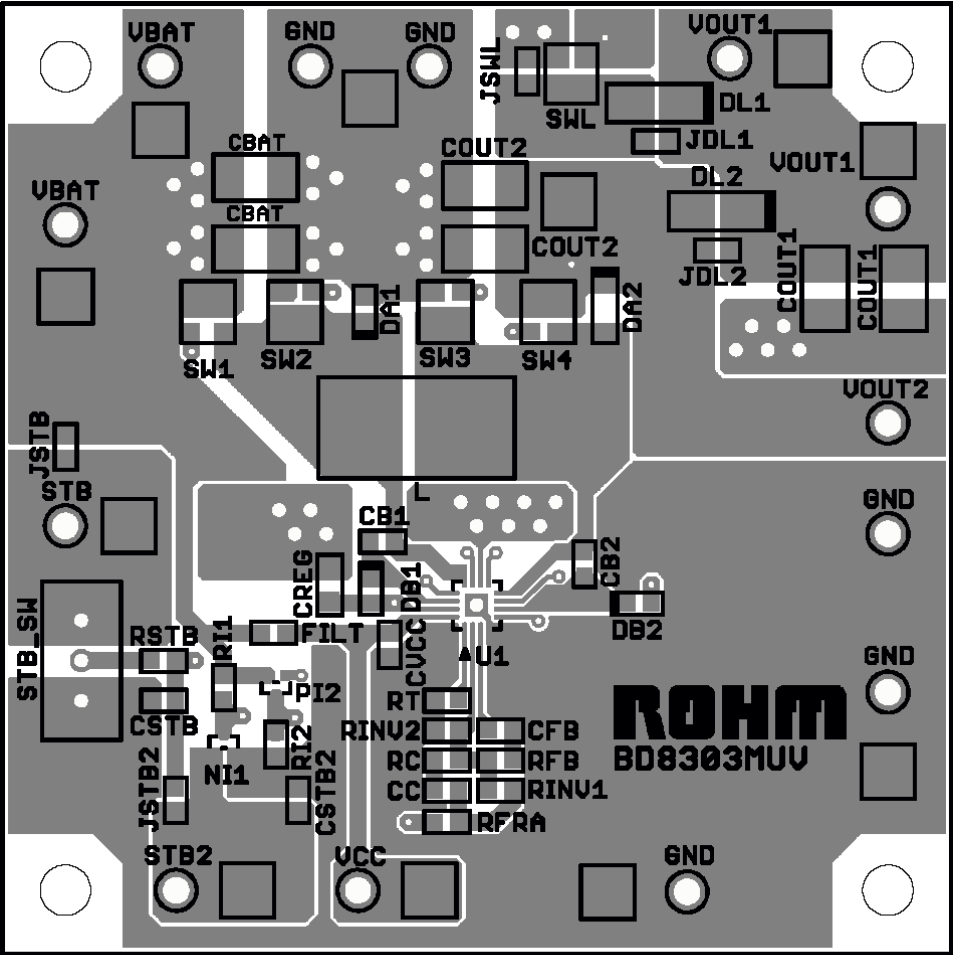


Fig.33 Example of Board Layout

• I/O Equivalence Circuit

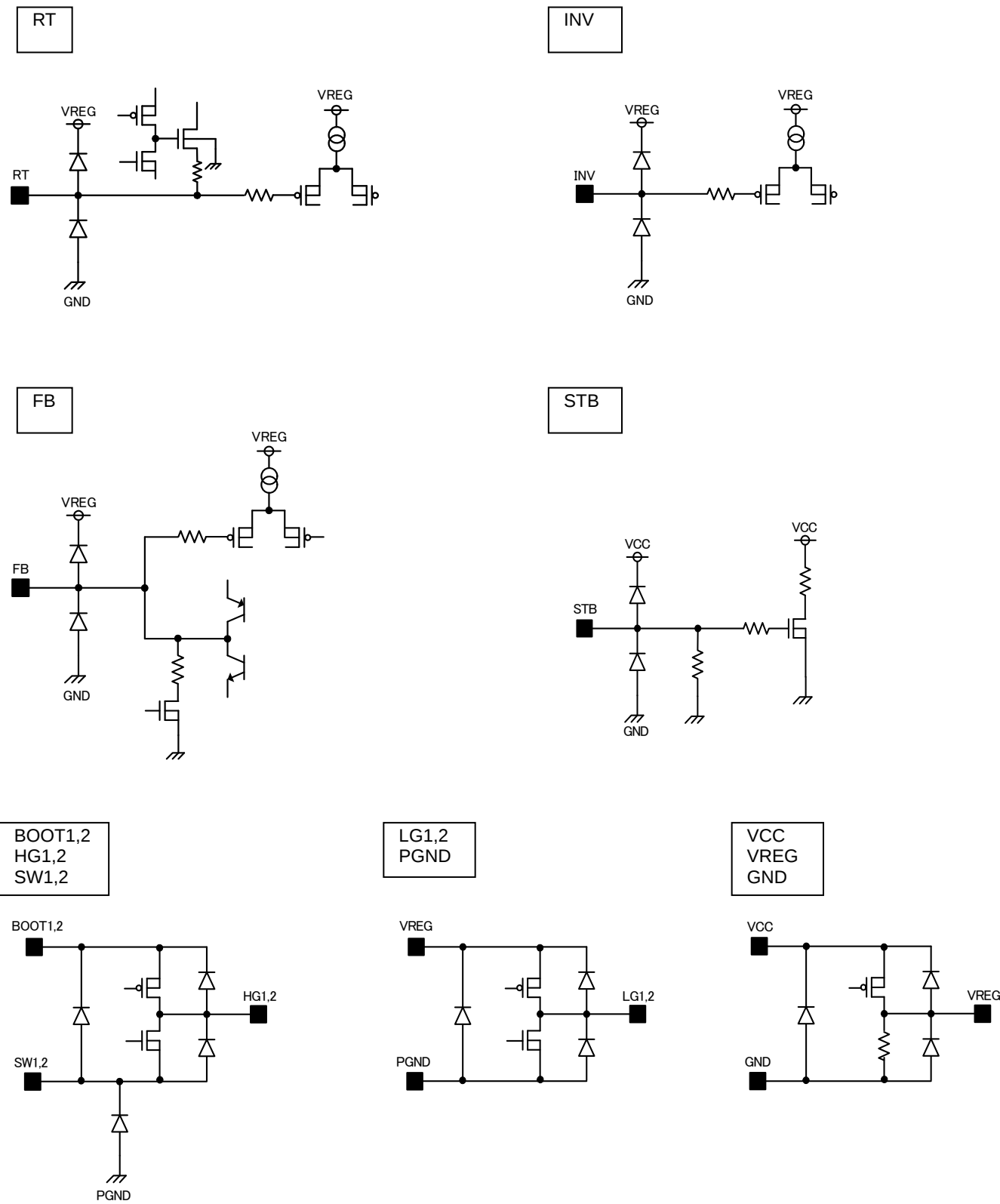


Fig.34 I/O equivalence circuit

● Precautions for Use

1) Absolute Maximum Rating

We dedicate much attention to the quality control of these products, however the possibility of deterioration or destruction exists if the impressed voltage, operating temperature range, etc., exceed the absolute maximum ratings. In addition, it is impossible to predict all destructive situations such as short-circuit modes, open circuit modes, etc. If a special mode exceeding the absolute maximum rating is expected, please review matters and provide physical safety means such as fuses, etc.

2) GND Potential

Keep the potential of the GND pin below the minimum potential at all times.

3) Thermal Design

Work out the thermal design with sufficient margin taking power dissipation (Pd) in the actual operation condition into account.

4) Short Circuit between Pins and Incorrect Mounting

Attention to IC direction or displacement is required when installing the IC on a PCB. If the IC is installed in the wrong way, it may break. Also, the threat of destruction from short-circuits exists if foreign matter invades between outputs or the output and GND of the power supply.

5) Operation under Strong Electromagnetic Field

Be careful of possible malfunctions under strong electromagnetic fields.

6) Common Impedance

When providing a power supply and GND wirings, show sufficient consideration for lowering common impedance and reducing ripple (i.e., using thick short wiring, cutting ripple down by LC, etc.) as much as you can.

7) Thermal Protection Circuit (TSD Circuit)

This IC contains a thermal protection circuit (TSD circuit). The TSD circuit serves to shut off the IC from thermal runaway and does not aim to protect or assure operation of the IC itself. Therefore, do not use the TSD circuit for continuous use or operation after the circuit has tripped.

8) Rush Current at the Time of Power Activation

Be careful of the power supply coupling capacity and the width of the power supply and GND pattern wiring and routing since rush current flows instantaneously at the time of power activation in the case of CMOS IC or ICs with multiple power supplies.

9) IC Terminal Input

This is a monolithic IC and has P+ isolation and a P substrate for element isolation between each element. P-N junctions are formed and various parasitic elements are configured using these P layers and N layers of the individual elements.

For example, if a resistor and transistor are connected to a terminal as shown on Fig.-8:

○ The P-N junction operates as a parasitic diode when $GND > (Pin A)$ in the case of a resistor or when $GND > (Pin B)$ in the case of a transistor (NPN)

○ Also, a parasitic NPN transistor operates using the N layer of another element adjacent to the previous diode in the case of a transistor (NPN) when $GND > (Pin B)$.

The parasitic element consequently rises under the potential relationship because of the IC's structure. The parasitic element pulls interference that could cause malfunctions or destruction out of the circuit. Therefore, use caution to avoid the operation of parasitic elements caused by applying voltage to an input terminal lower than the GND (P board), etc.

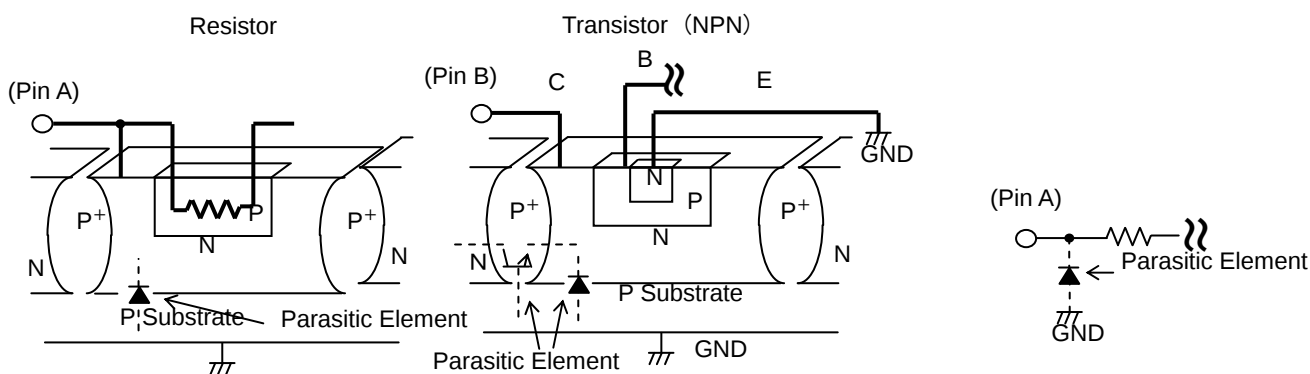


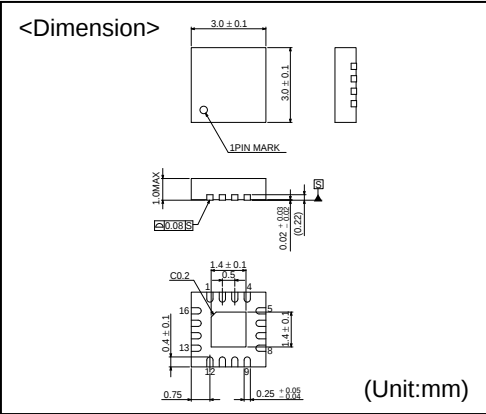
Fig.35 Example of simple structure of Bipolar IC

● Ordering part number

B	D	8	3	0	3	M	U	V	-	E	2
Part No.		Part No.				Package				Packaging and forming specification	
						MUV: VQFN016V3030				E2: Embossed tape and reel	

VQFN016V3030

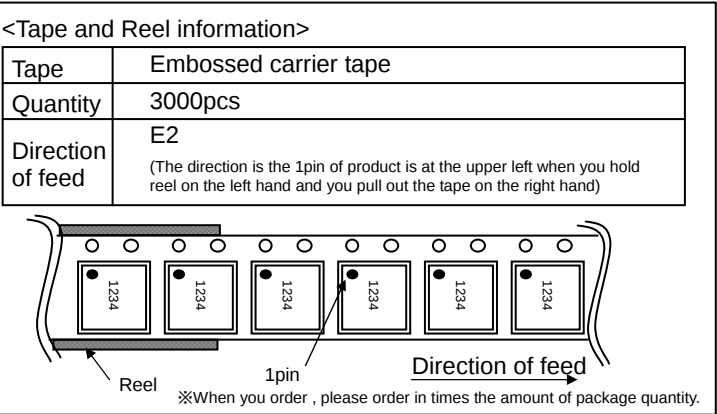
<Dimension>



(Unit:mm)

<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



Reel 1pin Direction of feed

※When you order , please order in times the amount of package quantity.

Notice

●General Precaution

- 1) Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.
- 2) All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using ROHM's Products, please confirm the latest information with a ROHM sales representative.

●Precaution on using ROHM Products

- 1) Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment, transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.
- 2) ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
 - [a] Installation of protection circuits or other protective devices to improve system safety
 - [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure
- 3) Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc. prior to use, must be necessary:
 - [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
 - [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
 - [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
 - [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
 - [f] Sealing or coating our Products with resin or other coating materials
 - [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
 - [h] Use of the Products in places subject to dew condensation
- 4) The Products are not subject to radiation-proof design.
- 5) Please verify and confirm characteristics of the final or mounted products in using the Products.
- 6) In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse) is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- 7) De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.
- 8) Confirm that operation temperature is within the specified range described in the product specification.
- 9) ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

● **Precaution for Mounting / Circuit board design**

- 1) When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
- 2) In principle, the reflow soldering method must be used; if flow soldering method is preferred, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

● **Precautions Regarding Application Examples and External Circuits**

- 1) If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.
- 2) You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

● **Precaution for Electrostatic**

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

● **Precaution for Storage / Transportation**

- 1) Product performance and soldered connections may deteriorate if the Products are stored in the places where:
 - [a] the Products are exposed to sea winds or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - [b] the temperature or humidity exceeds those recommended by ROHM
 - [c] the Products are exposed to direct sunshine or condensation
 - [d] the Products are exposed to high Electrostatic
- 2) Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
- 3) Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
- 4) Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

● **Precaution for Product Label**

QR code printed on ROHM Products label is for ROHM's internal use only.

● **Precaution for Disposition**

When disposing Products please dispose them properly using an authorized industry waste company.

● **Precaution for Foreign Exchange and Foreign Trade act**

Since our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

● **Precaution Regarding Intellectual Property Rights**

- 1) All information and data including but not limited to application example contained in this document is for reference only. ROHM does not warrant that foregoing information or data will not infringe any intellectual property rights or any other rights of any third party regarding such information or data. ROHM shall not be in any way responsible or liable for infringement of any intellectual property rights or other damages arising from use of such information or data.:
- 2) No license, expressly or implied, is granted hereby under any intellectual property rights or other rights of ROHM or any third parties with respect to the information contained in this document.

●Other Precaution

- 1) The information contained in this document is provided on an "as is" basis and ROHM does not warrant that all information contained in this document is accurate and/or error-free. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties resulting from inaccuracy or errors of or concerning such information.
- 2) This document may not be reprinted or reproduced, in whole or in part, without prior written consent of ROHM.
- 3) The Products may not be disassembled, converted, modified, reproduced or otherwise changed without prior written consent of ROHM.
- 4) In no event shall you use in any way whatsoever the Products and the related technical information contained in the Products or this document for any military purposes, including but not limited to, the development of mass-destruction weapons.
- 5) The proper names of companies or products described in this document are trademarks or registered trademarks of ROHM, its affiliated companies or third parties.