RICOH R1206N071B

STEP-UP DC/DC CONVERTER FOR WHITE LED BACK LIGHT

NO.EA-297-170620

OUTLINE

The R1206N071B is PWM control type step-up DC/DC converter IC with low supply current.

The R1206N071B is fully dedicated to drive White LEDs with constant current. Each of these ICs consists of an NMOS FET, an oscillator, a PWM comparator, a voltage reference unit, an error amplifier, a current limit circuit, an under voltage lockout circuit (UVLO), and an over-voltage protection circuit (OVP).

The R1206N071B can drive white LEDs in constant current with high efficiency by using an inductor, a diode , a resistor and capacitors as external components.

The LEDs current can be set by an external resistance value and can adjust the dimming of LEDs by CE pin according to the signal of PWM. Feedback voltage is 0.2V, therefore power loss by current setting resistance is small and efficiency is good. Maximum duty cycle is internally fixed, Typ. 91%. LEDs can be driven from low voltage. Protection circuits are the current limit of Lx peak current, the over voltage limit of output, and the under voltage lockout function.

It is controllable the dimming of LEDs quickly when the PWM signal (between 200Hz to 300kHz) input to CE pin. If the CE pin input is "L" in the fixed time (Typ. 0.5ms), the IC becomes the standby mode and turns OFF LEDs.

FEATURES

- Supply Current ..... Typ. 500μA
- Standby Current ..... Max. 5μA
- Input Voltage Range ..... 1.8V to 5.5V
- Feedback Voltage 0.2V
- Feedback Voltage Accuracy ..... ±1.0% (±10mV)
- Temperature-Drift Coefficient of Feedback Voltage ... ±150ppm/°C
- Oscillator Frequency ..... Typ. 1.2MHz
- Maximum Duty Cycle ..... Typ. 91%
- Switch ON Resistance ..... Typ. 1.35Ω
- UVLO Detector Threshold ..... Typ. 1.6V
- Lx Current Limit Protection ..... Typ. 700mA
- OVP Detector Threshold ..... Typ. 29.5V
- Switching Control ..... PWM
- LED dimming control ..... by external PWM signal (Frequency 200Hz to 300kHz)
- Packages SOT-23-6
- Ceramic capacitors are recommended 0.22μF

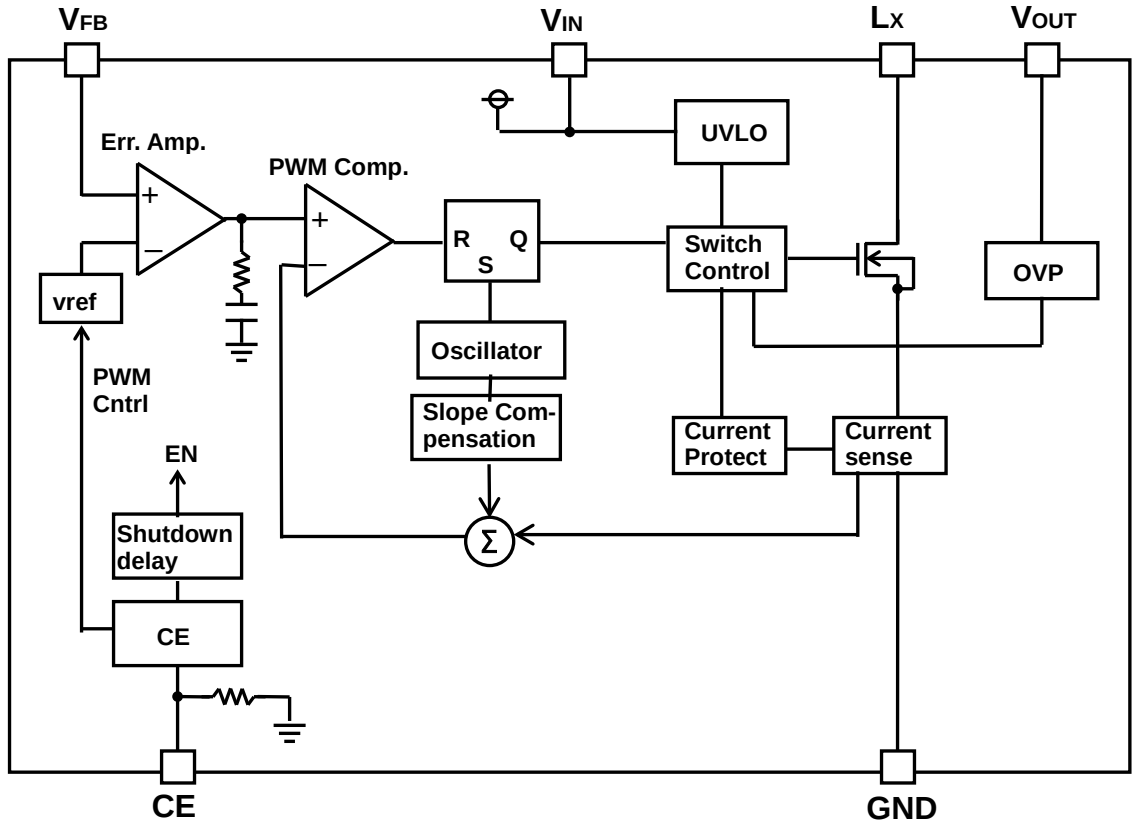
APPLICATIONS

- White LED Backlight for portable equipment

SELECTION GUIDE

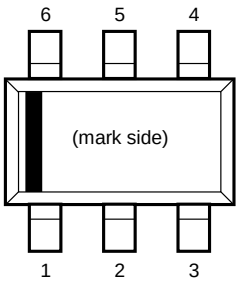
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1206N071B-TR-FE	SOT-23-6	3,000 pcs	Yes	Yes

BLOCK DIAGRAM



PIN DESCRIPTIONS

● **SOT-23-6**



● **SOT-23-6**

Pin No	Symbol	Pin Description
1	L_X	Switching Pin (Open Drain Output)
2	GND	Ground Pin
3	V_{FB}	Feedback Pin
4	CE	Chip Enable Pin ("H" Active)
5	V_{OUT}	Output Pin
6	V_{IN}	Input Pin

ABSOLUTE MAXIMUM RATINGS

(GND=0V)

Symbol	Item	Rating	Unit
V_{IN}	V_{IN} Pin Voltage	−0.3 to 6.5	V
V_{CE}	CE Pin Voltage	−0.3 to V_{IN}+0.3	V
V_{FB}	V_{FB} Pin Voltage	−0.3 to V_{IN}+0.3	V
V_{OUT}	V_{OUT} Pin Voltage	−0.3 to 32	V
V_{LX}	L_X Pin Voltage	−0.3 to 32	V
I_{LX}	L_X Pin Current	1000	mA
P_D	Power Dissipation *	420	mW
Tj	Junction Temperature Range	−40 to 125	°C
Tstg	Storage Temperature Range	−55 to 125	°C

∗) Refer to *POWER DISSIPATION* for detailed information.

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 is not assured.

RECOMMENDED OPERATING CONDITIONS

Symbol	Item	Rating	Unit
V_{IN}	Operating Input Voltage	1.8 to 5.5	V
Ta	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 conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

ELECTRICAL CHARACTERISTICS

- **R1206N071B**

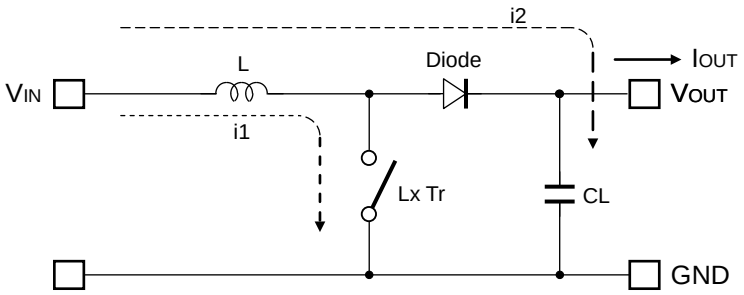
(Ta=25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
I_{DD}	Supply Current	V_{IN}=5.5V, V_{FB}=0V, Lx at no load		0.5	1.0	mA
Istandby	Standby Current	V_{IN}=5.5V, V_{CE}=0V		1.0	5.0	μA
V_{UVLO1}	UVLO Detector Threshold	V_{IN} falling	1.5	1.6	1.7	V
V_{UVLO2}	UVLO Released Voltage	V_{IN} rising		V_{UVLO1} +0.1	1.8	V
V_{CEH}	CE Input Voltage "H"	V_{IN}=5.5V	1.5			V
V_{CEL}	CE Input Voltage "L"	V_{IN}=1.8V			0.5	V
R_{CE}	CE Pull Down Resistance	V_{IN}=3.6V	600	1200	2200	kΩ
V_{FB}	V_{FB} Voltage Accuracy	V_{IN}=V_{CE}=3.6V	0.19	0.20	0.21	V
$\Delta V_{FB}/\Delta Ta$	V_{FB} Voltage Temperature Coefficient	V_{IN}=V_{CE}=3.6V, -40°C ≤ Ta ≤ 85°C		±150		ppm /°C
I_{FB}	V_{FB} Input Current	V_{IN}=5.5V, V_{FB}=0V or V_{IN}	−0.1		0.1	μA
R_{ON}	Switch ON Resistance	V_{IN}=3.6V, I_{LX}=100mA		1.35		Ω
I_{LXleak}	Switch Leakage Current	V_{LX}=30V		0	3.0	μA
I_{LXlim}	Switch Current Limit	V_{IN}=3.6V	400	700	1000	mA
fosc	Oscillator Frequency	V_{IN}=3.6V, V_{OUT}=V_{FB}=0V	1.0	1.2	1.4	MHz
Maxduty	Maximum Duty Cycle	V_{IN}=3.6V, V_{OUT}=V_{FB}=0V	86	91		%
V_{OVP1}	OVP Detector Threshold	V_{IN}=3.6V, V_{OUT} rising	28.7	29.5	30.3	V
$\Delta V_{OVP1}/\Delta Ta$	V_{OVP1} Voltage Temperature Coefficient	V_{IN}=V_{CE}=3.6V, −40°C ≤ Ta ≤ 85°C		±150		ppm /°C
V_{OVP2}	OVP Released Voltage	V_{IN}=3.6V, V_{OUT} falling		V_{OVP1} −1.55		V

OPERATING DESCRIPTIONS

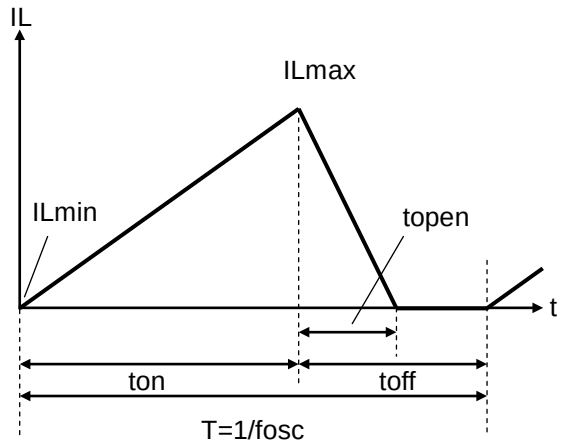
OPERATION OF STEP-UP DC/DC CONVERTER AND OUTPUT CURRENT

<Basic Circuit>

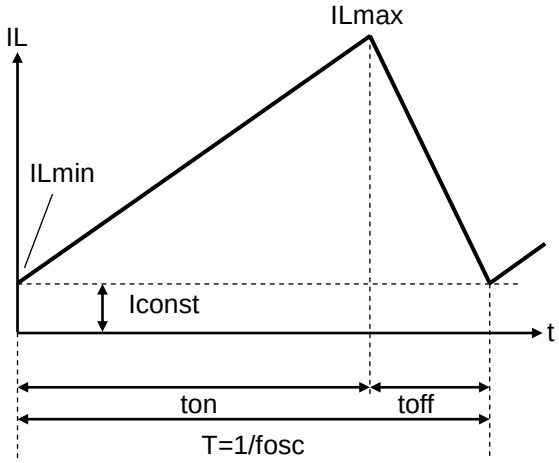


<Current through L>

Discontinuous mode



Continuous mode



There are two operation modes of the step-up PWM control-DC/DC converter. That is the continuous mode and discontinuous mode by the continuousness inductor.

When the transistor turns ON, the voltage of inductor L becomes equal to V_{IN} voltage. The increase value of inductor current (i1) will be

$$\Delta i1 = V_{IN} \times t_{on} / L \quad \text{.....Formula 1}$$

As the step-up circuit, during the OFF time (when the transistor turns OFF) the voltage is continually supply from the power supply. The decrease value of inductor current (i2) will be

$$\Delta i2 = (V_{OUT} - V_{IN}) \times t_{open} / L \quad \text{.....Formula 2}$$

At the PWM control-method, the inductor current become continuously when $t_{open}=t_{off}$, the DC/DC converter operate as the continuous mode.

In the continuous mode, the variation of current of i1 and i2 is same at regular condition.

$$V_{IN} \times ton / L = (V_{OUT} - V_{IN}) \times toff / L \quad \text{Formula 3}$$

The duty at continuous mode will be

$$Duty = ton / (ton + toff) = (V_{OUT} - V_{IN}) / V_{OUT} \quad \text{Formula 4}$$

The average of inductor current at $topen=toff$ will be

$$IL(Ave.) = V_{IN} \times ton / (2 \times L) \quad \text{Formula 5}$$

If the input power is equal to the output power, the I_{OUT} will be

$$I_{OUT} = V_{IN}^2 \times ton / (2 \times L \times V_{OUT}) \quad \text{Formula 6}$$

If the I_{OUT} value is large than above the calculated value (Formula 6), it will become the continuous mode, At this status, the peak current (IL_{max}) of inductor will be

$$IL_{max} = I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times ton / (2 \times L) \quad \text{Formula 7}$$

$$IL_{max} = I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times T \times (V_{OUT} - V_{IN}) / (2 \times L \times V_{OUT}) \quad \text{Formula 8}$$

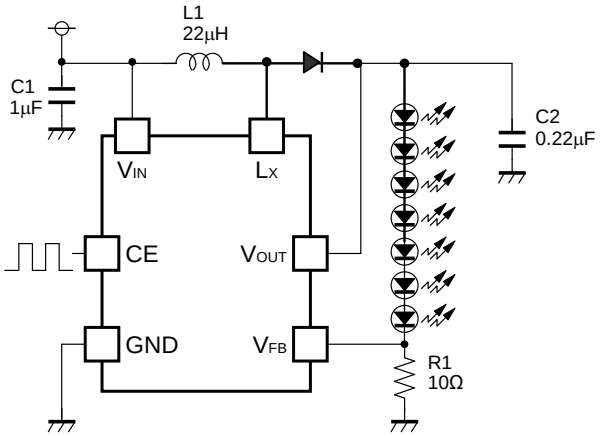
The peak current value is larger than the I_{OUT} value. In case of this, selecting the condition of the input and the output and the external components by considering of IL_{max} value.

The explanation above is based on the ideal calculation, and the loss caused by L_X switch and the external components are not included.

The actual maximum output current will be between 50% and 80% by the above calculations. Especially, when the IL is large or V_{IN} is low, the loss of V_{IN} is generated with on resistance of the switch. Moreover, it is necessary to consider V_F of the diode (approximately 0.8V) about V_{OUT}.

APPLICATION INFORMATION

- **Typical Application Circuit**



C1	CM105B105K06
C2	GRM21BR71H224
L1	LQH32CN220K53

- **LED Current setting**

When CE pin input is "H" (Duty=100%), LED current can be set with feedback resistor (R1)

$$I_{LED}=V_{FB} / R1$$

- **LED Dimming Control**

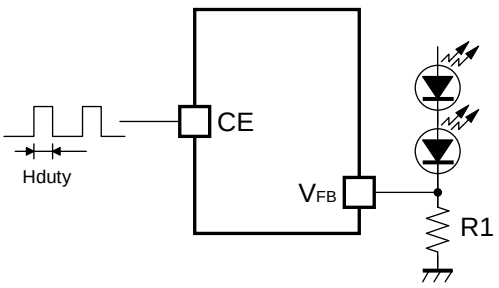
The LED brightness can be controlled by inputting the PWM signal to the CE pin. If the CE pin input is "L" in the fixed time (Typ.0.5ms), the IC becomes the standby mode and turns OFF LEDs.

The current of LEDs when the CE pin is "H" input (Duty=100%) is shown by the above expression. The current of LEDs can be controlled by Duty of the PWM signal of the input CE pin. The current of LEDs when High-Duty of the CE input is Hduty reaches the value as calculatable following formula.

$$I_{LED}=Hduty \times V_{FB} / R1$$

The frequency of the PWM signal is using the range between 200Hz to 300kHz.

When controlling the LED brightness by the PWM signal of 20kHz or less; The increasing or decreasing of the inductor current might be make a sounds in the hearable sound wave area. In that case, please use the PWM signal in the high frequency area.



Dimming control by CE pin input

- **Soft-Start**

The output of the error amplifier starts from 0V and the inrush current is suppressed when starting by the CE pin "H" input.

Moreover, the inrush current can be suppressed by gradually enlarging Duty of the PWM signal to the CE pin.

- **Selection of Inductors**

The peak current of the inductor at normal mode can be calculated as next formula:

$$ILmax=1.25 \times ILED \times VOUT / VIN + 0.5 \times VIN \times (VOUT - VIN) / (L \times VOUT \times fosc)$$

When the start-up or dimming control by CE pin, transient current flows, the peak current must be equal or less than the current limit of the IC. The peak current should not beyond the rating current of the inductor.

When 4-7LEDs are driven with VIN=3.6V, the recommended inductance value is 10μH -22μH.

- **Selection of Capacitors**

Set 1μF or more value bypass capacitor C1 between VIN pin and GND pin as close as possible.

Set 0.22μF or more capacitor C2 between VOUT pin and GND pin.

TECHNICAL NOTES

● Current path on PCB

The current paths in an application circuit are shown in Fig.2 and 3.
A current flows through the paths shown in Fig.2 at the time of MOSFET-ON, and shown in Fig.3 at the time of MOSFET-OFF.In the paths pointed with red arrows in Fig.3, current flows just in MOSFET-ON period or just in MOSFET-OFF period. Parasitic impedance / inductance and the capacitance of these paths influence stability of the system and cause noise outbreak. So please minimize this side effect. In addition, please shorten the wiring of other current paths shown in Fig.2 and 3 except for the paths of LED load.

● LAYOUT Guide for PCB

・Please shorten the wiring of the input capacitor(C1) between V_{IN} pin and GND pin of IC. The GND pin should be connected to the strong GND plane.

・The area of L_X land pattern should be smaller.

・The wiring between L_X pin and inductor and diode should be short and please put output capacitor(C2) close to the cathode of diode.

・Please make the GND side of output capacitor(C2) close to the GND pin of IC.

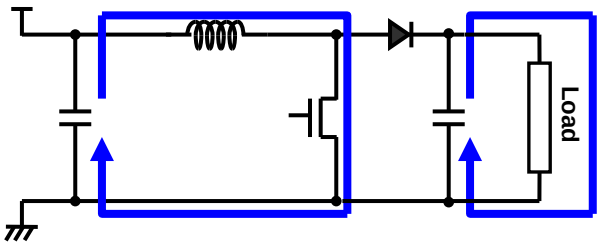


Fig.2 MOSFET-ON

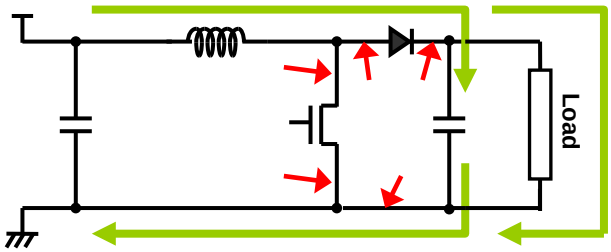
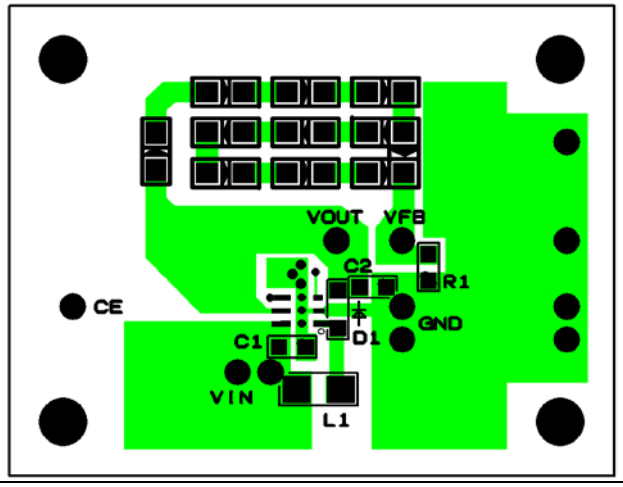
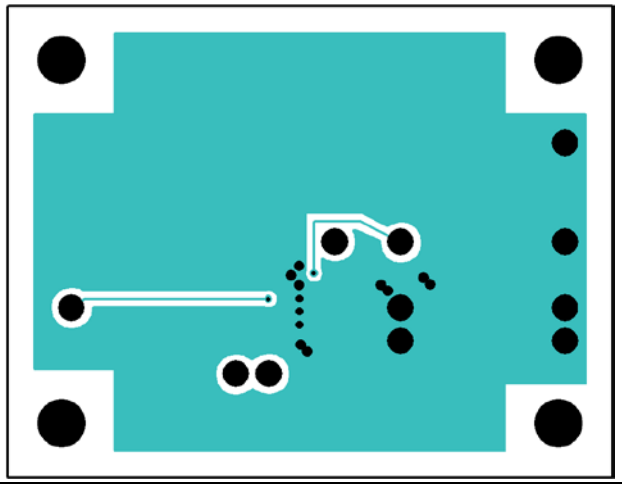


Fig.3 MOSFET-OFF

● PCB Layout

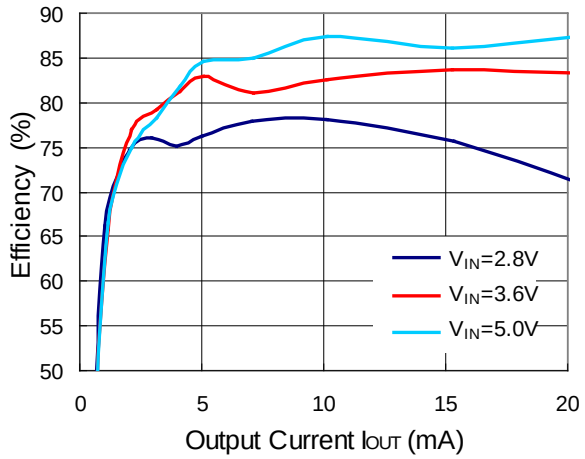
R1206N (PKG: SOT-23-6pin)

Topside	Backside
	

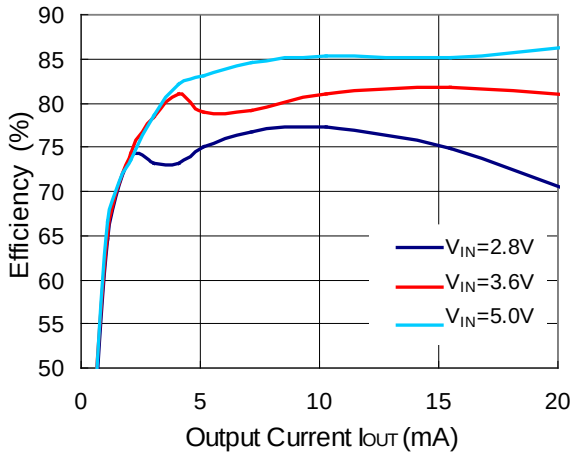
TYPICAL CHARACTERISTICS

1) Efficiency vs. Output Current Characteristics

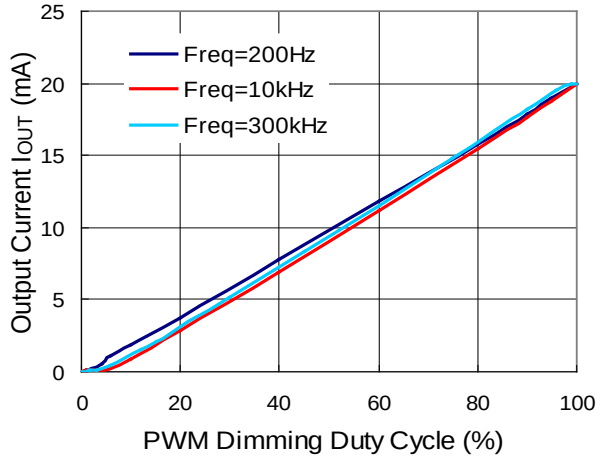
6LEDs



7LEDs

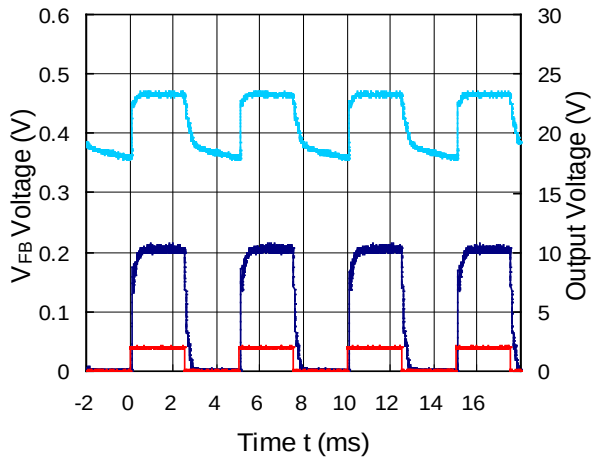


2) PWM Dimming Duty Cycle vs. Output Current(R1=10Ω)

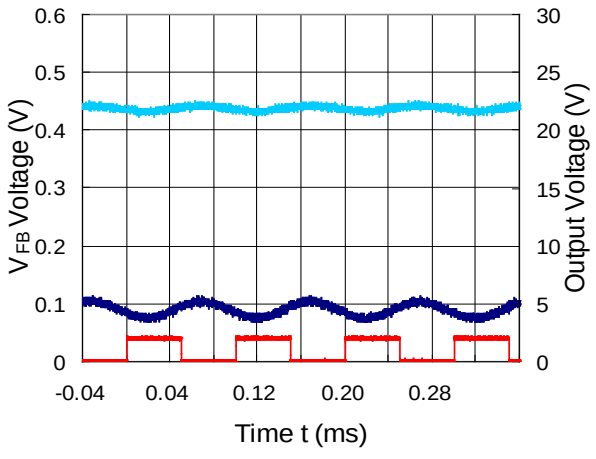


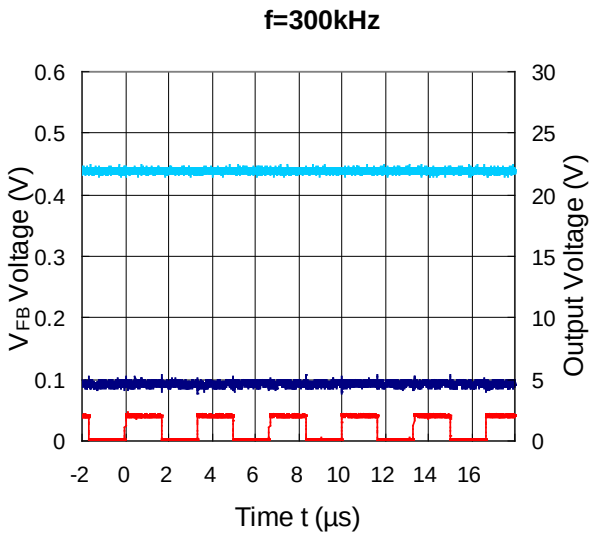
3) Output Current Ripple during PWM Dimming

f=200Hz

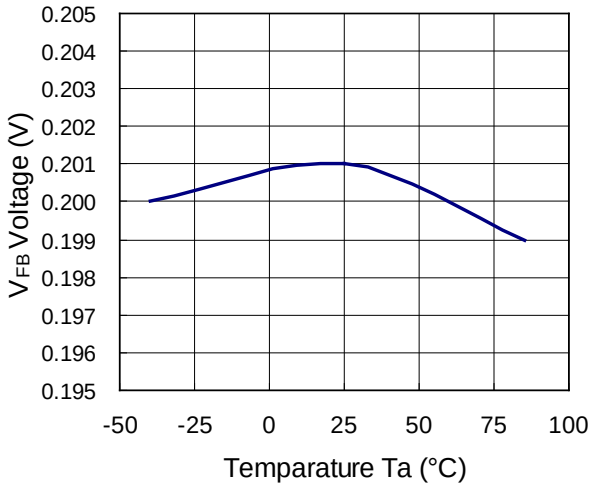


f=10kHz

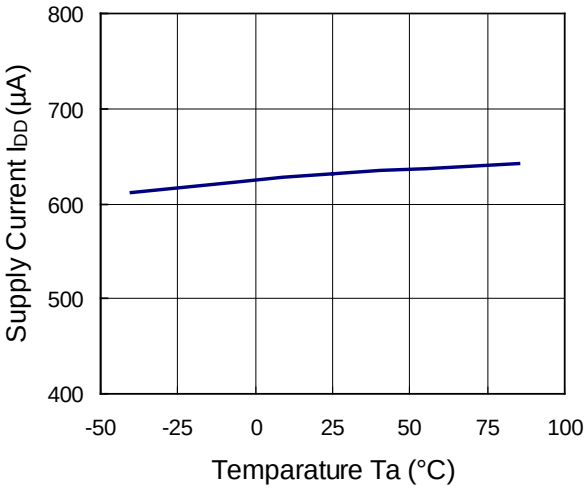




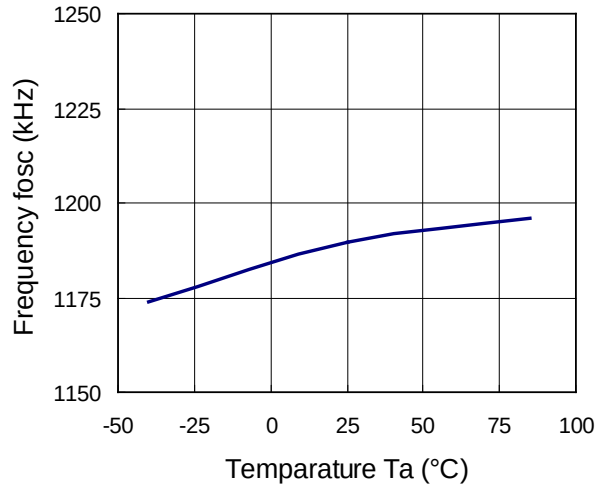
4) VFB Voltage vs. Temperature



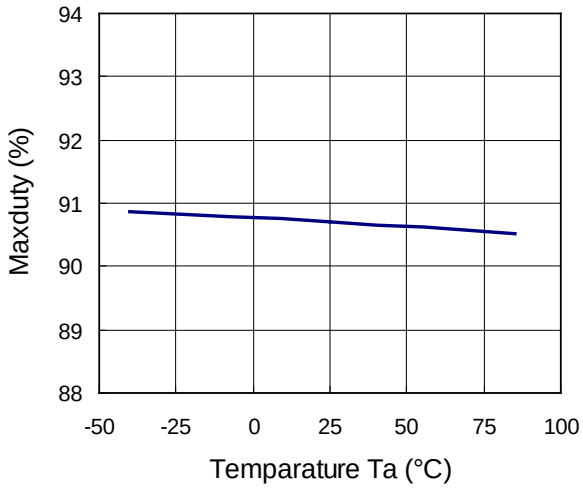
5) Supply Current vs. Temperature



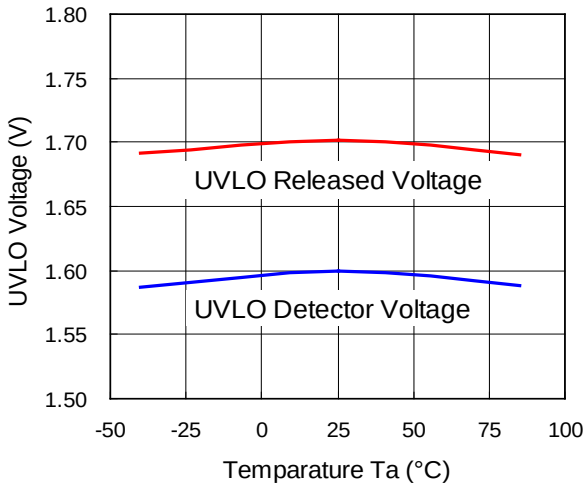
6) Oscillator Frequency vs. Temperature



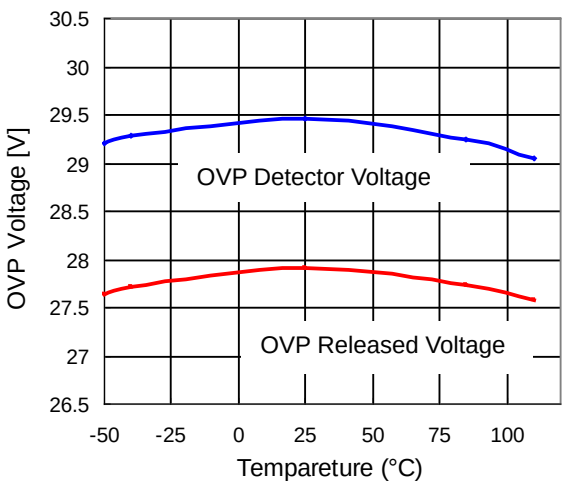
7) Maxduty vs. Temperature



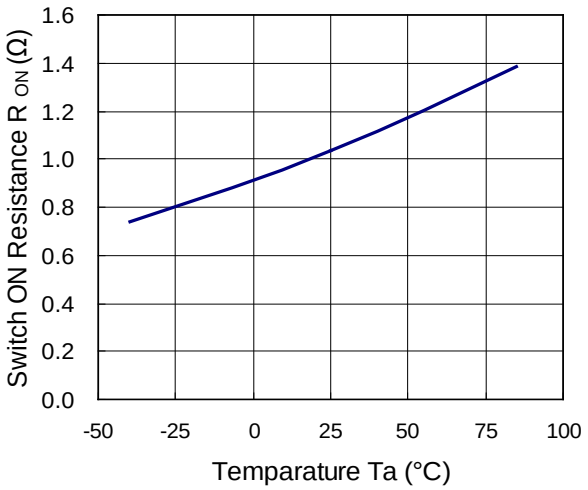
8) UVLO Output Voltage vs. Temperature



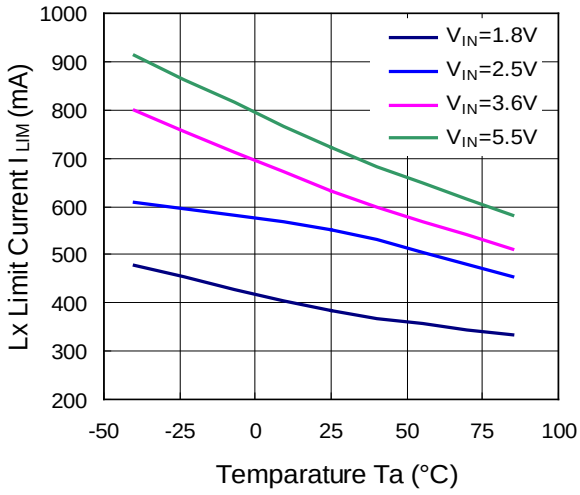
9) OVP Voltage vs. Temperature



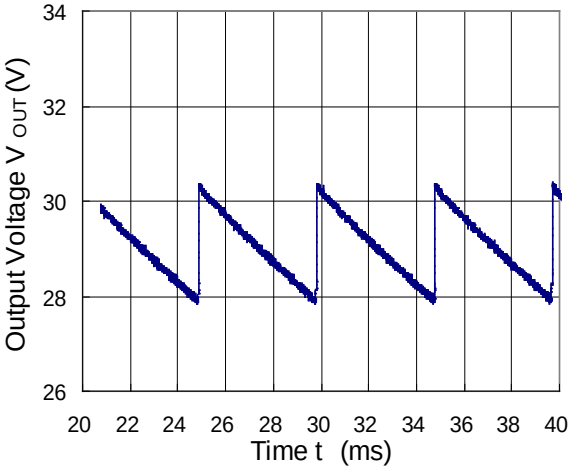
10) Switch ON Resistance vs. Temperature



11) Lx Current Limit vs. Temperature



12) OVP Operating Output Voltage Waveform



Ver. A

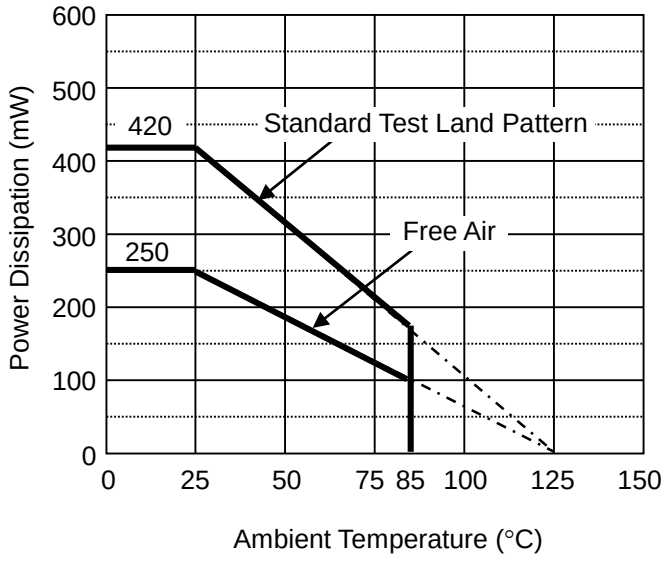
The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following conditions are used in this measurement.

Measurement Conditions

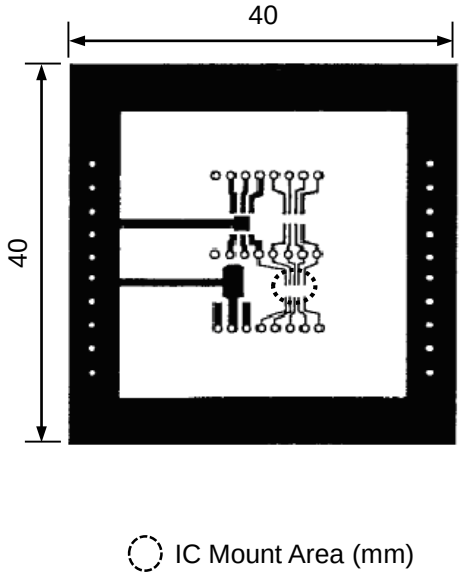
	Standard Test Land Pattern
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Double-Sided Board)
Board Dimensions	40 mm x 40 mm x 1.6 mm
Copper Ratio	Top Side: Approx.50% Bottom Side: Approx. 50%
Through-holes	ϕ 0.5 mm x 44 pcs

Measurement Result (Ta = 25°C, Tjmax = 125°C)

	Standard Test Land Pattern	Free Air
Power Dissipation	420 mW	250 mW
Thermal Resistance	θja = (125 − 25°C) / 0.42 W = 238°C/W	400°C/W



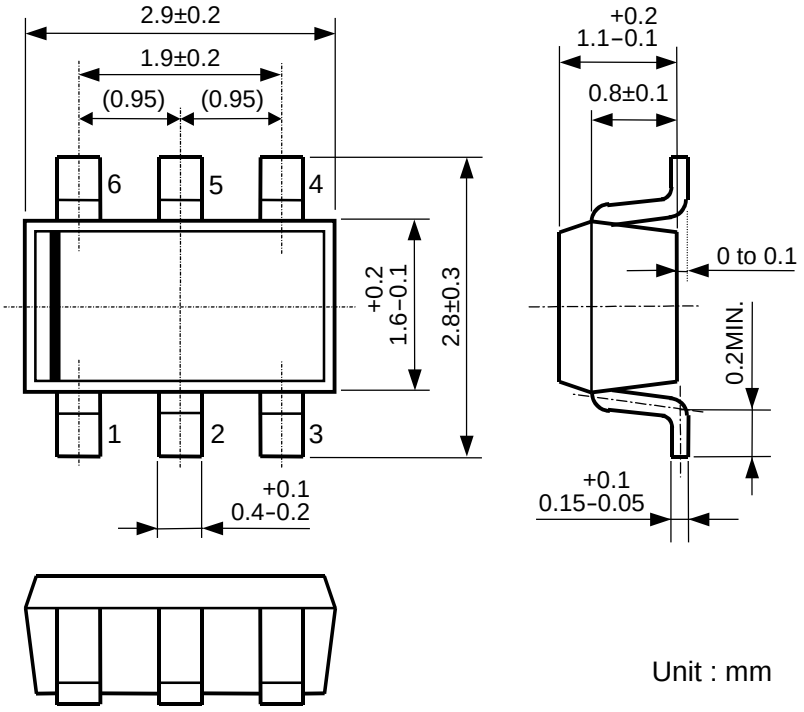
Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

RICOH

Ver. A



Unit : mm

SOT-23-6 Package Dimensions

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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 (aircraft, spacevehicle, nuclear reactor control system, traffic control system, automotive and transportation equipment, combustion equipment, safety devices, life support system etc.) should first contact us.
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. Anti-radiation design is not implemented in the products described in this document.
8. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
9. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
10. There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact Ricoh sales or our distributor before attempting to use AOI.
11. Please contact Ricoh sales representatives should you have any questions or comments concerning the products or the technical information.

RoHS Compliant
Halogen Free

Ricoh is committed to reducing the environmental loading materials in electrical devices with a view to contributing to the protection of human health and the environment.
Ricoh has been providing RoHS compliant products since April 1, 2006 and Halogen-free products since April 1, 2012.

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