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

NO.EA-271-111123

OUTLINE

The R1203x Series are PWM control type step-up DC/DC converter ICs with low supply current.

The R1203x 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 R1203x 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.

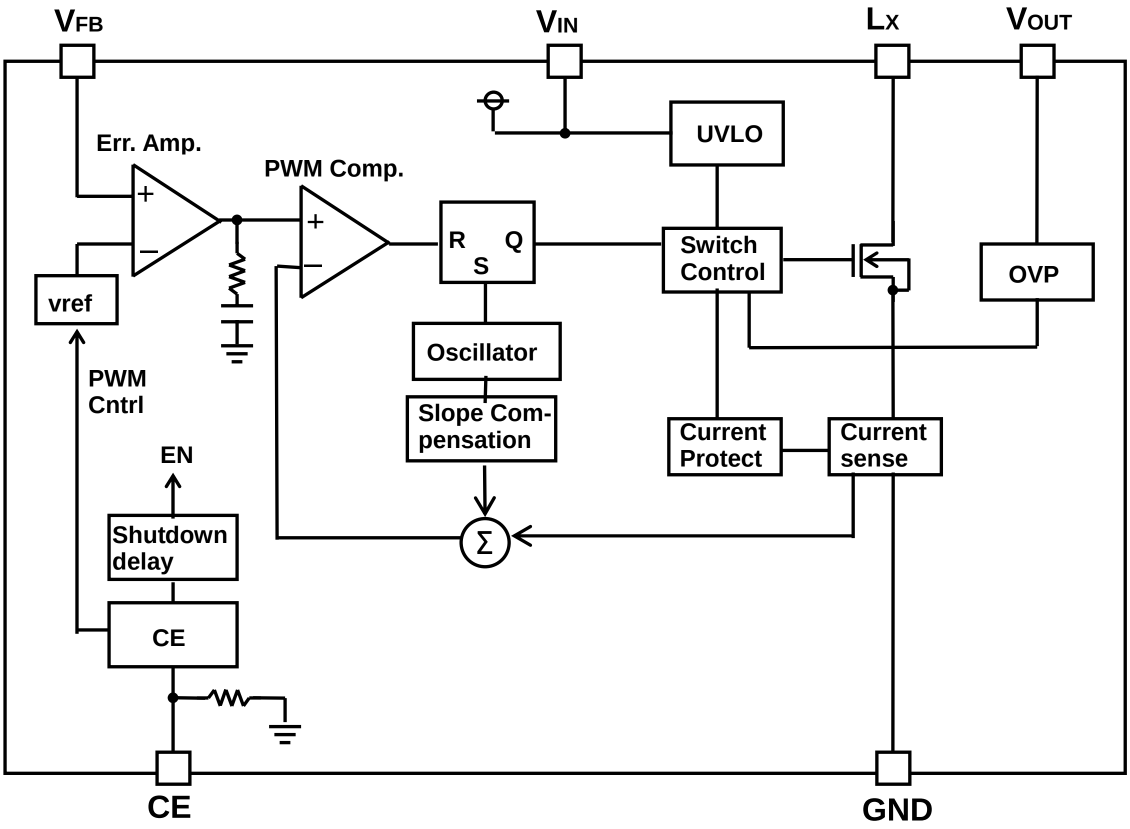
FEATURES

- 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 DFN1616-6B, SOT-23-6
- Ceramic capacitors are recommended..................... 0.22μF

APPLICATION

- White LED Backlight for portable equipment

BLOCK DIAGRAMS

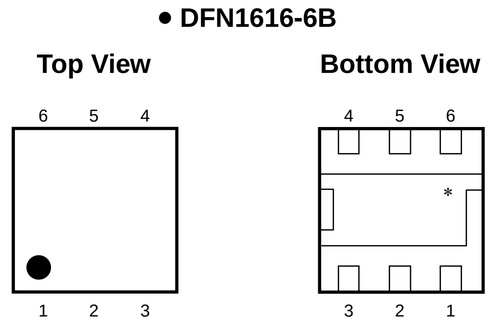


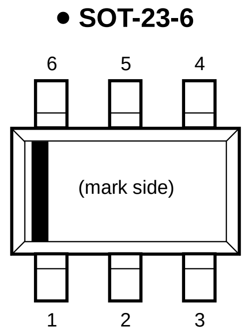
SELECTION GUIDE

The package for the ICs can be selected at the user's request.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1203L071B-TR	DFN1616-6B	5,000 pcs	Yes	Yes
R1203N071B-TR-FE	SOT-23-6	3,000 pcs	Yes	Yes

PIN CONFIGURATIONS





PIN DESCRIPTIONS

- **DFN1616-6B**

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

∗) Tab is GND level. (They are connected to the reverse side of this IC.)
The tab is better to be connected to the GND, but leaving it open is also acceptable.

- **SOT-23-6**

Pin No	Symbol	Pin Description
1	CE	Chip Enable Pin ("H" Active)
2	V_{OUT}	Output Pin
3	V_{IN}	Input Pin
4	Lx	Switching Pin (Open Drain Output)
5	GND	Ground Pin
6	V_{FB}	Feedback 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 (DFN1616-6B)*	640	mW
	Power Dissipation (SOT-23-6)*	420	
Ta	Operating Temperature Range	−40 to 85	°C
Tstg	Storage Temperature Range	−55 to 125	°C

*) For Power Dissipation, please refer to PACKAGE 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.

ELECTRICAL CHARACTERISTICS

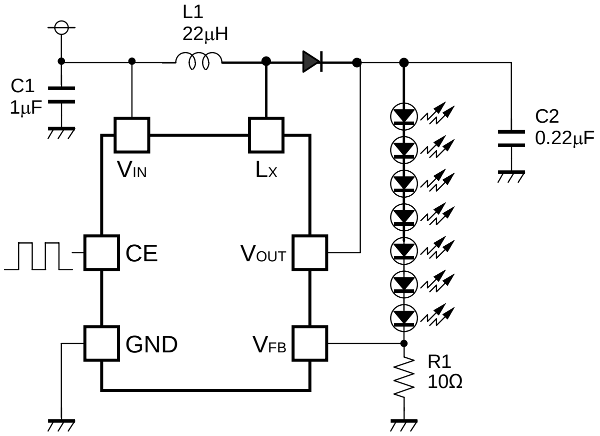
- **R1203x**

(Ta=25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Operating Input Voltage		1.8		5.5	V
I_{DD}	Supply Current	V_{IN}=5.5V, V_{FB}=0V, Lx at no load		0.5	1.0	mA
$I_{standby}$	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
f_{osc}	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

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)
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.

TYPICAL APPLICATIONS



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

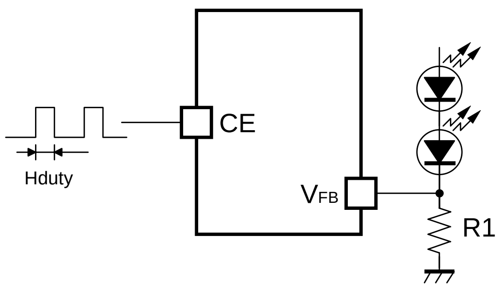
The LED brightness can be controlled by inputting the PWM signal to the CE pin. If the CE pin input is "L" in the fixed time (Typ.0.5ms), the IC becomes the standby mode and turns OFF LEDs.

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:

$$IL_{max}=1.25 \times I_{LED} \times V_{OUT} / V_{IN} + 0.5 \times V_{IN} \times (V_{OUT} - V_{IN}) / (L \times V_{OUT} \times f_{osc})$$

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 V_{IN}=3.6V, the recommended inductance value is 10μH -22μH.

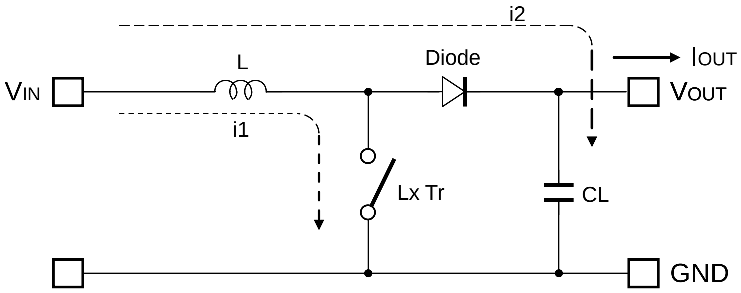
Selection of Capacitors

Set 1μF or more value bypass capacitor C1 between V_{IN} pin and GND pin as close as possible.

Set 0.22μF or more capacitor C2 between V_{OUT} pin and GND pin.

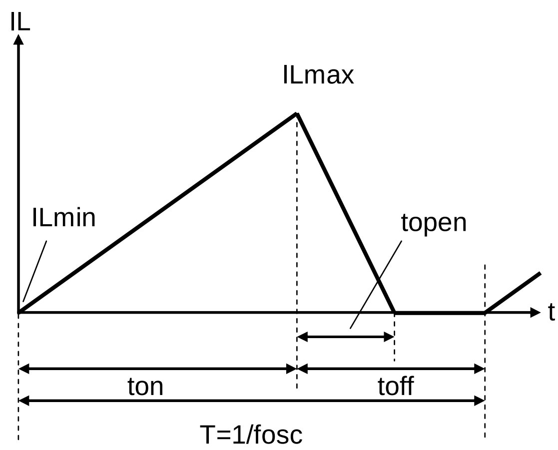
OPERATION OF STEP-UP DC/DC CONVERTER AND OUTPUT CURRENT

<Basic Circuit>

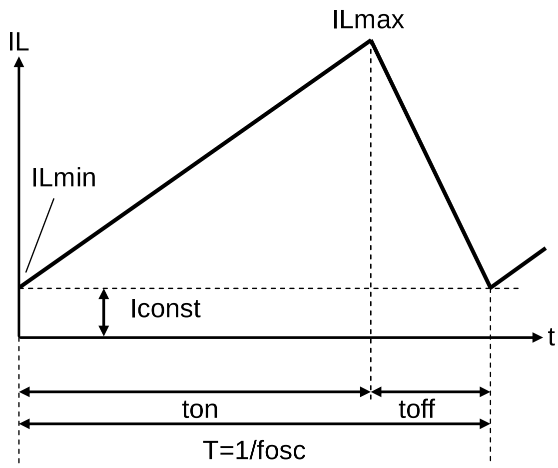


<Current through L>

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

$\Delta i1 = V_{IN} \times t_{on} / L$ ....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

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

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

$V_{IN} \times t_{on} / L = (V_{OUT} - V_{IN}) \times t_{off} / L$ .... Formula 3

The duty at continuous mode will be

$Duty = t_{on} / (t_{on} + t_{off}) = (V_{OUT} - V_{IN}) / V_{OUT}$ .... Formula 4

The average of inductor current at $t_{open}=t_{off}$ will be

$IL(Ave.) = V_{IN} \times t_{on} / (2 \times L)$ .... Formula 5

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

$I_{OUT} = V_{IN}^2 \times t_{on} / (2 \times L \times V_{OUT})$ .... 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

$IL_{max} = I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times t_{on} / (2 \times L)$ .... Formula 7

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

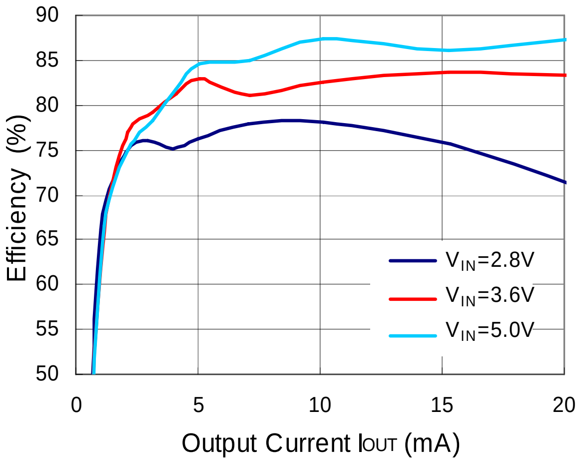
The explanation above is based on the ideal calculation, and the loss caused by L_X switch and the external components are not included.

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}.

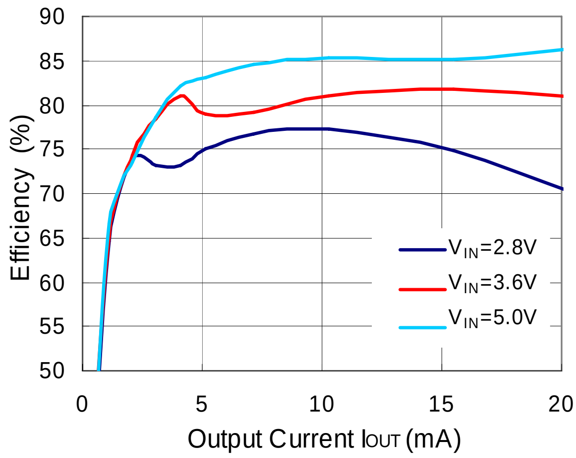
TYPICAL CHARACTERISTICS

1) Efficiency vs. Output Current Characteristics

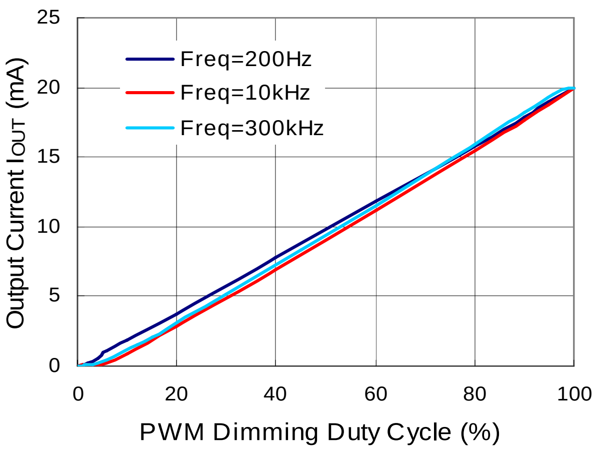
6LEDs



7LEDs

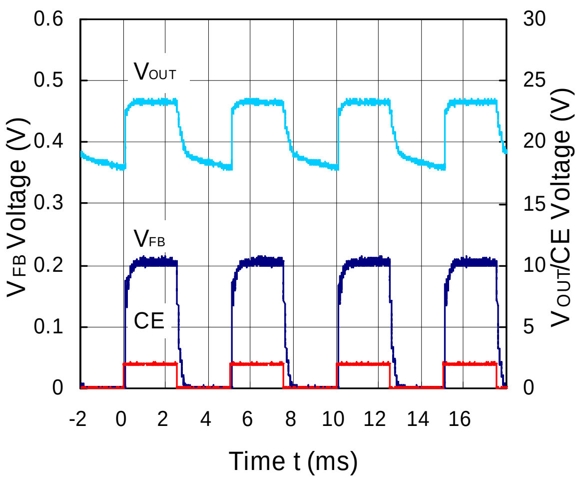


2) PWM Dimming Duty Cycle vs. Output Current(R1=10Ω)

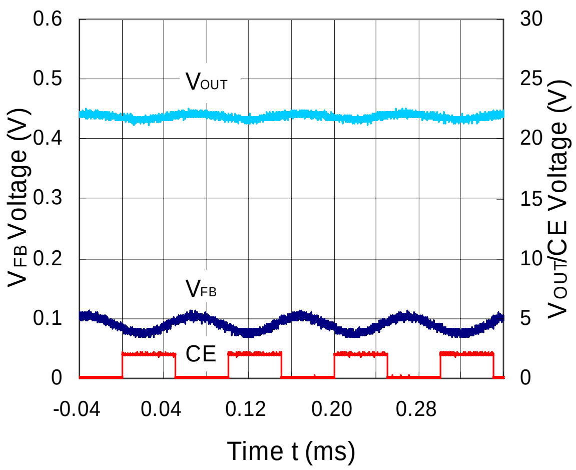


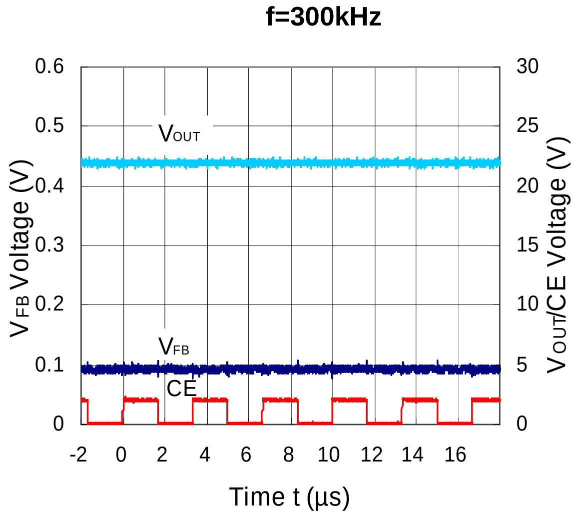
3) Output Current Ripple during PWM Dimming

f=200Hz

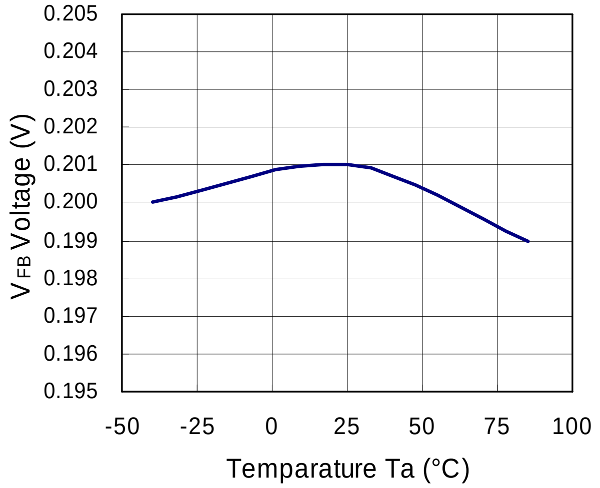


f=10kHz

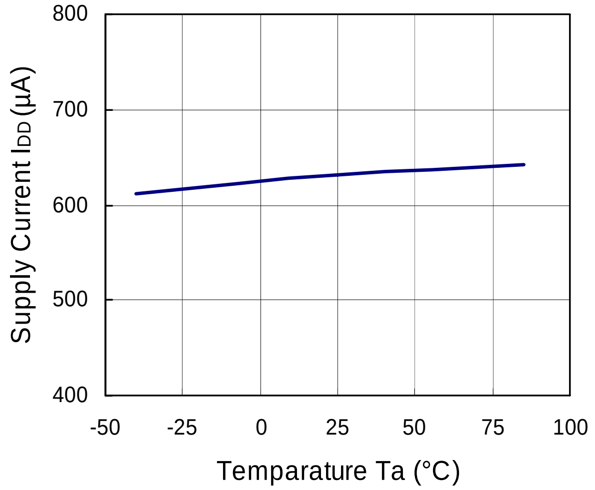




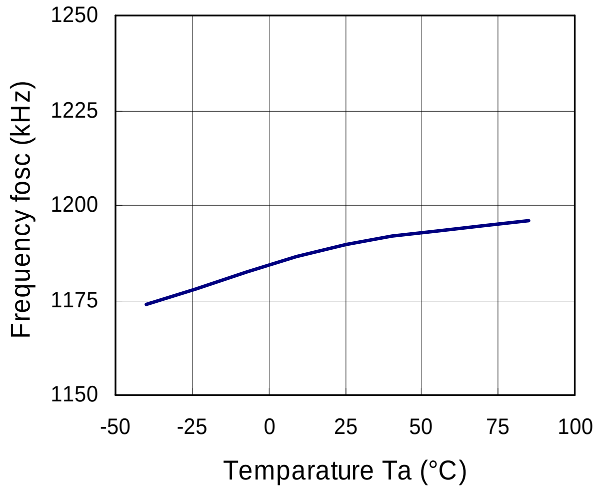
4) VFB Voltage vs. Temperature



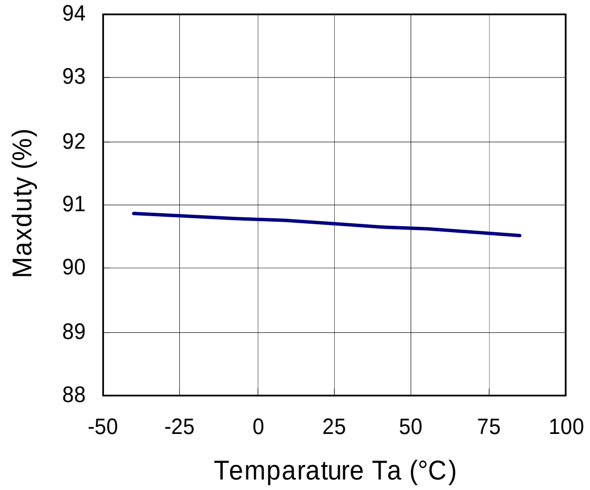
5) Supply Current vs. Temperature



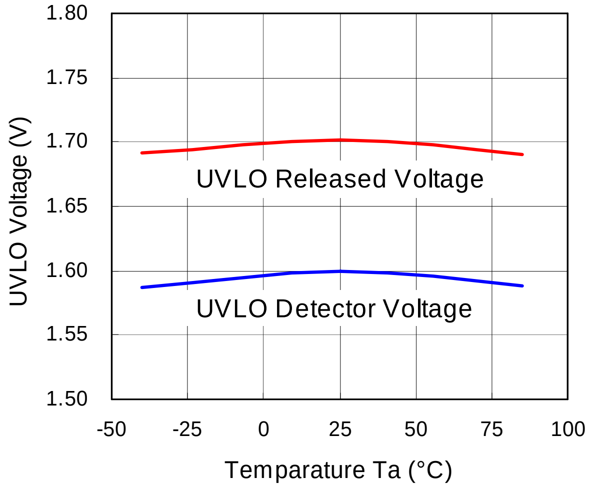
6) Oscillator Frequency vs. Temperature



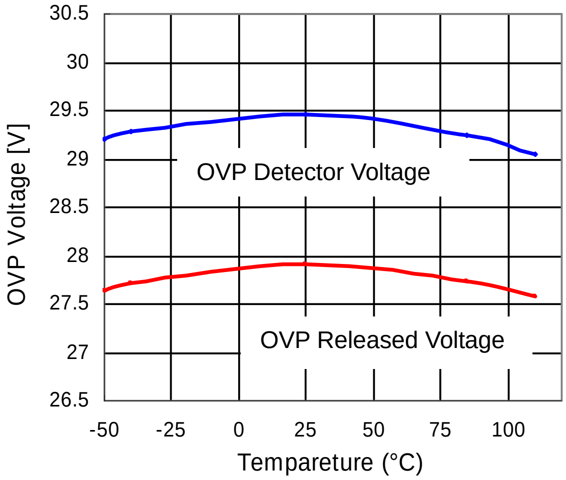
7) Maxduty vs. Temperature



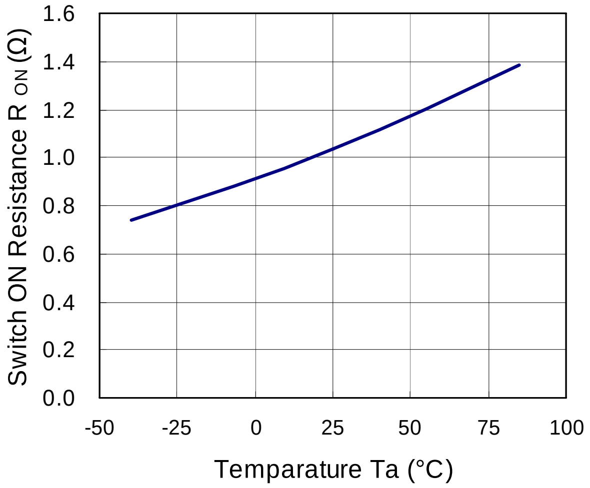
8) UVLO Output Voltage vs. Temperature



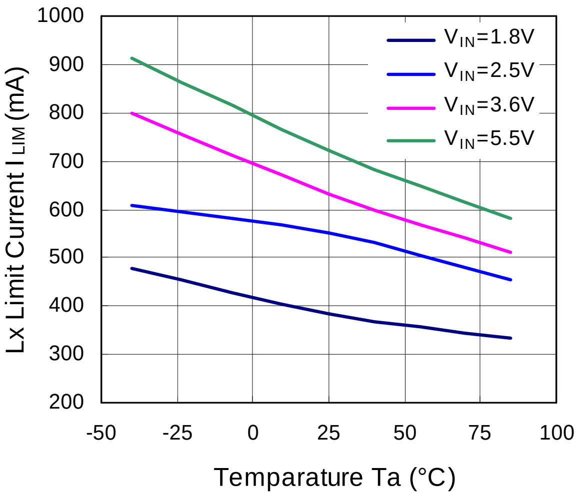
9) OVP Voltage vs. Temperature



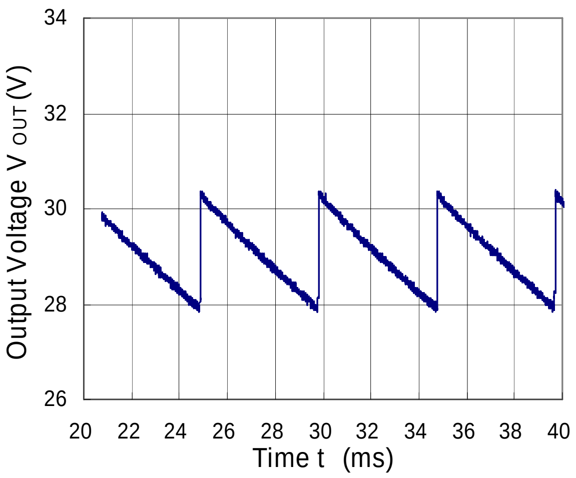
10) Switch ON Resistance vs. Temperature



11) Lx Current Limit vs. Temperature



12) OVP Operating Output Voltage Waveform



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http://www.e-devices.ricoh.co.jp/en/

Sales & Support Offices

RICOH ELECTRONIC DEVICES CO., LTD.
Higashi-Shinagawa Office (International Sales)
3-32-3, Higashi-Shinagawa, Shinagawa-ku, Tokyo 140-8655, Japan
Phone: +81-3-5479-2857 Fax: +81-3-5479-0502

RICOH EUROPE (NETHERLANDS) B.V.
Semiconductor Support Centre
Prof. W.H. Keesomlaan 1, 1183 DJ Amstelveen, The Netherlands
Phone: +31-20-5474-309

RICOH ELECTRONIC DEVICES KOREA CO., LTD.
3F, Haesung Bldg, 504, Teheran-ro, Gangnam-gu, Seoul, 135-725, Korea
Phone: +82-2-2135-5700 Fax: +82-2-2051-5713

RICOH ELECTRONIC DEVICES SHANGHAI CO., LTD.
Room 403, No.2 Building, No.690 Bibo Road, Pu Dong New District, Shanghai 201203, People's Republic of China
Phone: +86-21-5027-3200 Fax: +86-21-5027-3299

RICOH ELECTRONIC DEVICES CO., LTD.
Taipei office
Room 109, 10F-1, No.51, Hengyang Rd., Taipei City, Taiwan (R.O.C.)
Phone: +886-2-2313-1621/1622 Fax: +886-2-2313-1623