STEP-UP DC/DC CONVERTER

NO.EA-272-120508

OUTLINE

The R1205x Series are CMOS-based PWM control type step-up DC/DC converter ICs with low supply current. Each of these ICs consists of an NMOS FET, a diode, an oscillator, a PWM comparator, a voltage reference unit, an error amplifier, a current limit circuit, an under voltage lockout circuit (UVLO), an over-voltage protection circuit (OVP), a soft-start circuit, a Maxduty limit circuit, and a thermal shutdown protection circuit. This step-up DC/DC converter can be easily built with a few external components such as a coil, a resistor, and a capacitor. As the protection functions, the R1205x Series have a Lx peak current limit function, an over voltage protection (OVP) function, an under voltage lock out (UVLO) function and a thermal shutdown function.

The R1205x Series present the R1205x8xxA version that is optimized for the constant voltage power source, and the R1205x8xxB version that is optimized for driving the white LED with the constant current. The R1205x8xxB is an adjustable version that can change the LED brightness dynamically by using a 200Hz to 300kHz PWM signal toward the CE pin.

The R1205x Series are available in DFN1616-6B and TSOT-23-6 packages.

FEATURES

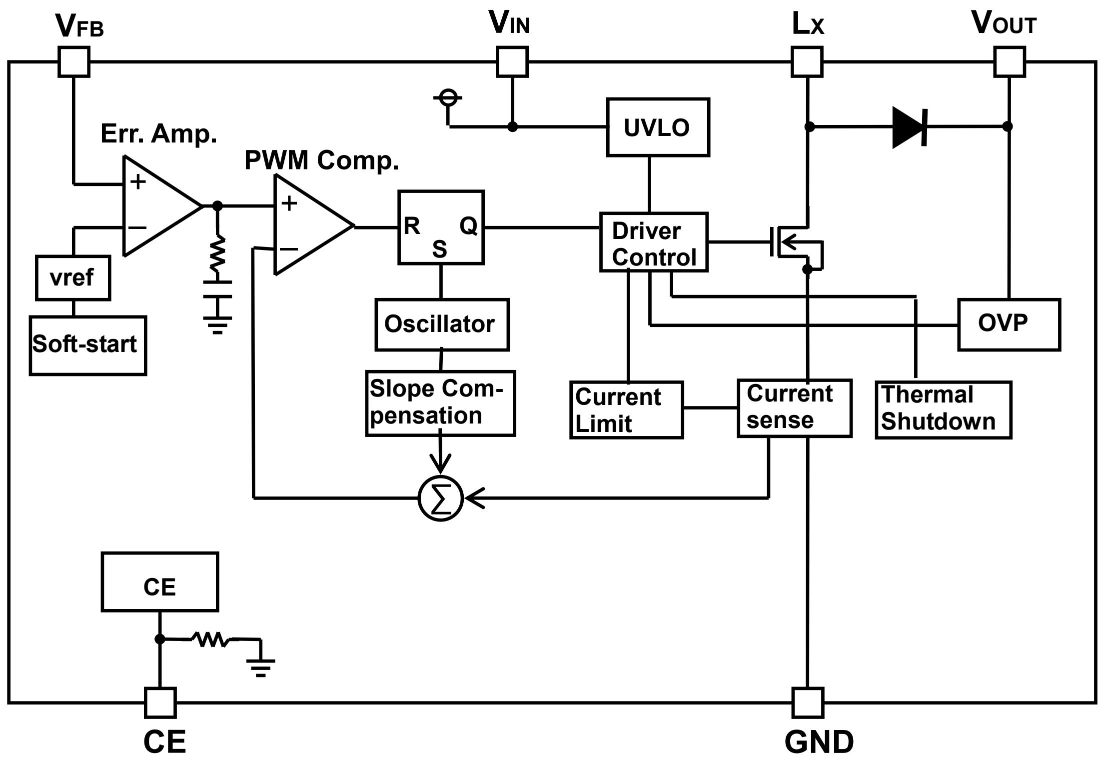
- Input Voltage Range .... 2.3V to 5.5V (R1205x8xxA)
  1.8V to 5.5V (R1205x8xxB)
- Supply Current .... Typ. 800μA
- Standby Current .... Max. 5μA
- Feedback Voltage .... 1.0V±1.5% (R1205x8xxA)
  0.2V±10mV (R1205x8xxB)
- Oscillator Frequency .... Typ. 1.2MHz
- Maximum Duty Cycle .... Typ. 91%
- UVLO Function Typ.2.0V (Hys.Typ.0.2V) (R1205x8xxA)
  Typ.1.6V (Hys.Typ.0.1V) (R1205x8xxB)
- Lx Current Limit Function .... Select from 350mA, 700mA
- Over Voltage Protection .... Typ. 25V
- LED dimming control (R1205x8xxB) .... by external PWM signal (Frequency 200Hz to 300kHz)
- Thermal Protection Function .... Typ.150ºC(Hys.Typ.50ºC)
- Switch ON Resistance .... Typ. 1.35Ω
- Packages DFN1616-6B, TSOT-23-6
- Ceramic capacitors are recommended

APPLICATION

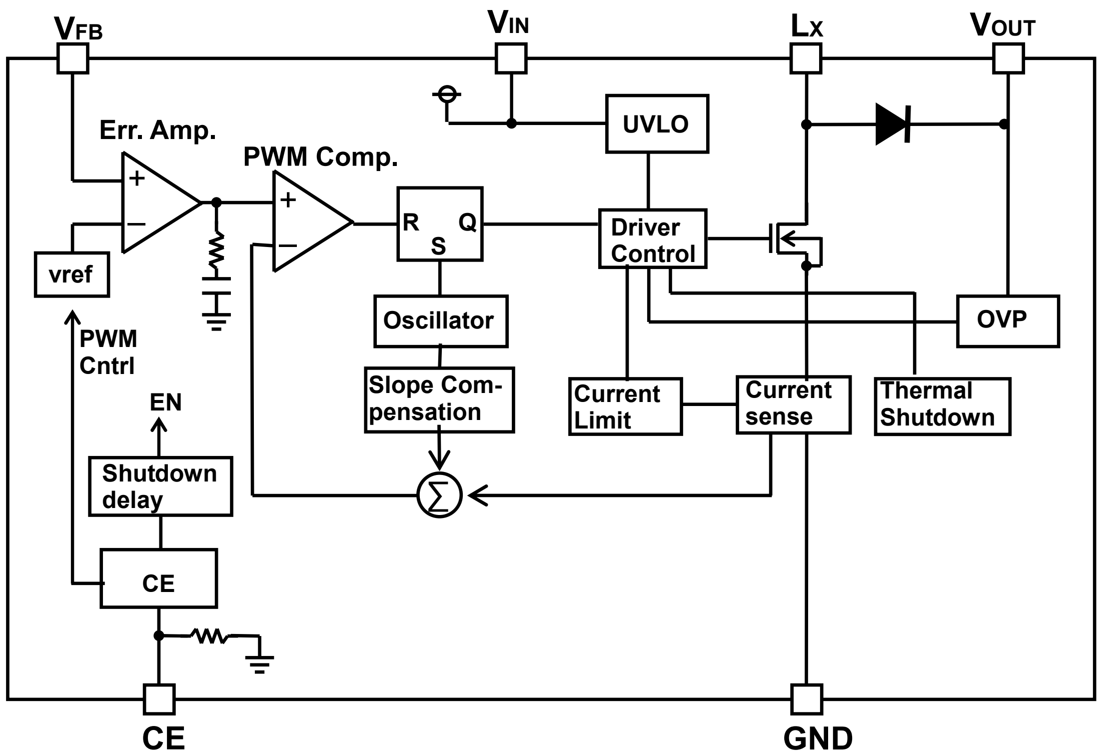
- Constant Voltage Power Source for portable equipment
- OLED power supply for portable equipment
- White LED Backlight for portable equipment

BLOCK DIAGRAMS

●R1205x8xxA



● R1205x8xxB



SELECTION GUIDE

The OVP threshold voltage, current limit, package and V_{FB}/Auto discharge are user-selectable options.

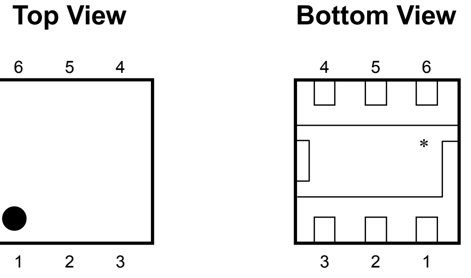
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1205L8x1∗-TR	DFN1616-6B	5,000 pcs	Yes	Yes
R1205N8x3∗-TR-FE	TSOT-23-6	3,000 pcs	Yes	Yes

x : Designation of current limit.
(1) 350mA
(2) 700mA

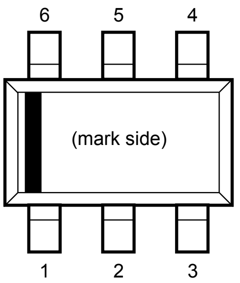
∗ : Designation of VFB.
(A) 1.0V
(B) 0.2V

PIN CONFIGURATIONS

• DFN1616-6B



• TSOT-23-6



PIN DESCRIPTIONS

• **DFN1616-6B**

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

*) The tab is substrate level (GND). The tab is better to be connected to the GND, but leaving it open is also acceptable.

• **TSOT-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	L_X	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 6.5	V
V_{FB}	V_{FB} Pin Voltage	–0.3 to 6.5	V
V_{OUT}	V_{OUT} Pin Voltage	–0.3 to 28	V
V_{LX}	L_X Pin Voltage	–0.3 to 28	V
I_{LX}	L_X Pin Current	1000	mA
P_D	Power Dissipation (DFN1616-6B)*	640	mW
	Power Dissipation (TSOT-23-6)*	460	
Ta	Operating Temperature Range	–40 to 85	°C
Tstg	Storage Temperature Range	–55 to 125	°C

∗) For details regarding Power Dissipation and Standard Test Land Pattern, 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.

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.

ELECTRICAL CHARACTERISTICS

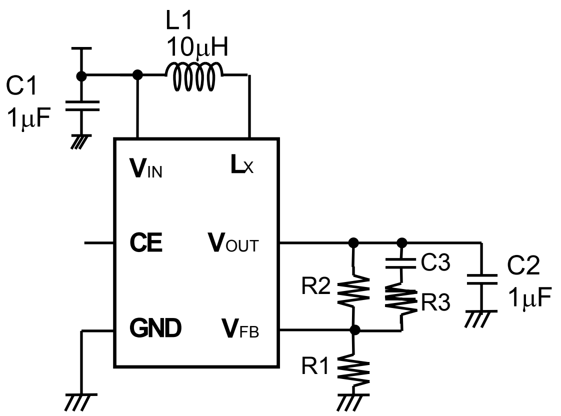
- **R1205x**

(Ta=25°C)

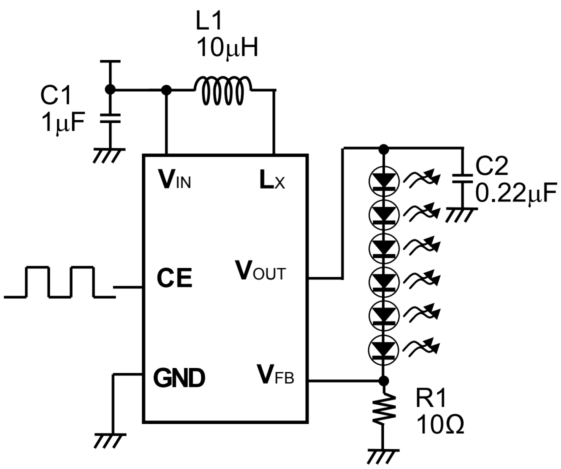
Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{IN}	Operating Input Voltage		R1205x8xxA	2.3		5.5	V
			R1205x8xxB	1.8		5.5	
I_{DD}	Supply Current	V_{IN}=5.5V, V_{FB}=0V , L_X at no load			0.8	1.2	mA
$I_{standby}$	Standby Current	V_{IN}=5.5V, V_{CE}=0V			1.0	5.0	μA
V_{UVLO1}	UVLO Detector Threshold	V_{IN} falling	R1205x8xxA	1.9	2.0	2.1	V
			R1205x8xxB	1.5	1.6	1.7	
V_{UVLO2}	UVLO Released Voltage	V_{IN} rising	R1205x8xxA		V_{UVLO1} +0.2	2.3	V
			R1205x8xxB		V_{UVLO1} +0.1	1.8	
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				1200		kΩ
V_{FB}	V_{FB} Voltage Accuracy	V_{IN}=3.6V	R1205x8xxA	0.985	1.000	1.015	V
			R1205x8xxB	0.19	0.2	0.21	
$\Delta V_{FB}/\Delta Ta$	V_{FB} Voltage Temperature Coefficient	V_{IN}=3.6V, $-40°C \le Ta \le 85°C$			±150		ppm /°C
I_{FB}	V_{FB} Input Current	V_{IN}=5.5V, V_{FB}=0V or 5.5V		-0.1		0.1	μA
t_{start}	Soft-start Time		R1205x8xxB		2.0	3.0	ms
R_{ON}	FET ON Resistance	I_{LX}=100mA			1.35		Ω
I_{OFF}	FET Leakage Current	V_{LX}=24V				3.0	μA
I_{LIM}	FET Current Limit		R1205x81xx	250	350	450	mA
			R1205x82xx	500	700	900	
V_F	Diode Forward Voltage	I_{SW}=100mA			0.8		V
$I_{DIODEleak}$	Diode Leakage Current	V_{OUT}=24V, V_{LX}=0V				10	μA
f_{osc}	Oscillator Frequency	V_{IN}=3.6V, V_{FB}=0V		1000	1200	1400	kHz
Maxduty	Maximum Duty Cycle	V_{IN}=3.6V, V_{FB}=0V		86	91		%
V_{OVP1}	OVP Detect Voltage	V_{IN}=3.6V, V_{OUT} rising		24.2	25	25.8	V
V_{OVP2}	OVP Release Voltage	V_{IN}=3.6V, V_{OUT} falling			V_{OVP1} -1.8		V
T_{TSD}	Thermal Shutdown Detect Temperature	V_{IN}=3.6V			150		°C
T_{TSR}	Thermal Shutdown Release Temperature	V_{IN}=3.6V			100		°C

TYPICAL APPLICATIONS

●R1205x8xxA



●R1205x8xxB



Recommended external Inductor

L1 (μH)	Parts No	Rated Current(mA)	Size(mm)
10	LQH32CN100K53	450	3.2×2.5×1.55
10	LQH2MC100K02	225	2.0×1.6×0.9
10	VLF3010A-100	490	2.8×2.6×0.9
22	LQH32CN220K53	250	3.2×2.5×1.55
22	LQH2MC220K02	185	2.0×1.6×0.9
22	VLF3010A-220	330	2.8×2.6×0.9

R1205x8xxA Recommended external components

	Rated voltage(V)	Part No.
C1	6.3	CM105B105K06
C2	25	GRM21BR11E105K
C3	25	220pF
R1		For V_{OUT} Setting
R2		For V_{OUT} Setting
R3		2kΩ

R1205x8xxB Recommended external components

	Rated voltage(V)	Part No.
C1	6.3	CM105B105K06
C2	25	GRM21BR11E224

● The Method of Output Voltage Setting (R1205x8xxA)

The output voltage (V_{OUT}) can be calculated with divider resistors (R1 and R2) values as the following formula:

Output Voltage (V_{OUT})= $V_{FB} \times (R1 + R2) / R1$

The total value of R1 and R2 should be equal or less than 300kΩ. Make the V_{IN} and GND line sufficient. The large current flows through the V_{IN} and GND line due to the switching. If this impedance (V_{IN} and GND line) is high, the internal voltage of the IC may shift by the switching current, and the operating may become unstable. Moreover, when the built-in L_X switch is turn OFF, the spike noise caused by the inductor may be generated. As a result of this, recommendation voltage rating of capacitor (C2) value is equal 1.5 times larger or more than the setting output voltage.

● LED Current setting (R1205x8xxB)

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 (R1205x8xxB)

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.

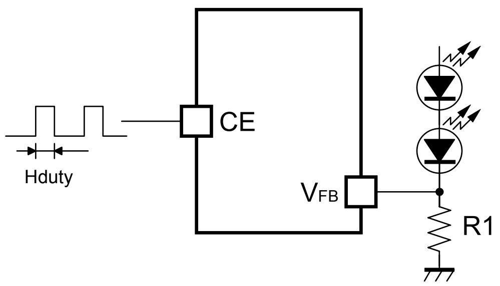
The current of LEDs can be controlled by Duty of the PWM signal of the input CE pin. The current of LEDs when High-Duty of the CE input is "Hduty" reaches the value as calculatable following formula.

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

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

When controlling the LED brightness by the PWM signal of 5kHz or less, R1202xxxxD/E are recomended to avoide discharge function during dimming control.

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 (R1205x8xxB)

The output and referrence of the error amplifier start from 0V and the referrence gradually rises up to 1.0V. After the softstart time (T_{SS}), output voltage rise up to the setting voltage.

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.

- **Current Limit Function**

Current limit function monitors the over current and if it reaches the peak current, it will turn off the driver. When the over current decreases, it will restart oscillation and will restart the monitoring.

- **Inductor Selection**

The peak current of the inductor under the stationary operation can be calculated by the following formula.

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

In the case of adjusting the brightness at the start-up or by the CE pin, the peak current can be transiently more than the above. Select the inductor that can limit the peak current within the current limit of the ICs.

Also, select the inductor of which peak current will not exceed the rated inductor value. The recommended inductance value is between 10μH to22μH.

- **Capacitor Selection**

The recommended capacitor value for C1 is in the range from 1.0μF to 4.7μF. Connect C1 between V_{IN} and GND pin as close as possible to the pins.

Connect a output capacitor in the range from 1.0μF to 4.7μF between V_{OUT} and GND pins. (R1205x8xxA)

Connect a output capacitor in the range from 0.22μF to 1.0μF between V_{OUT} and GND pins. (R1205x8xxB)

- **External Components Setting**

If the V_{OUT} spike noise is high, it may influence on the V_{FB} pin to cause the operation of R1205x8xxA unstable. To reduce the noise coming into V_{FB} pin, please place a 1kΩ to 5kΩ resistor in R3 in Fig 1.

- **Application of Using 5.5V or more Power Supply**

Other than the IC power supply, if there is a power supply greater than 5.5V, the high power output can be achieved by using the power supply as an inductor power supply. In this case, please place a capacitor between an inductor power supply and GND (shown in Fig 2.) aside from a bypass capacitor between the V_{IN} pin and GND of the IC.

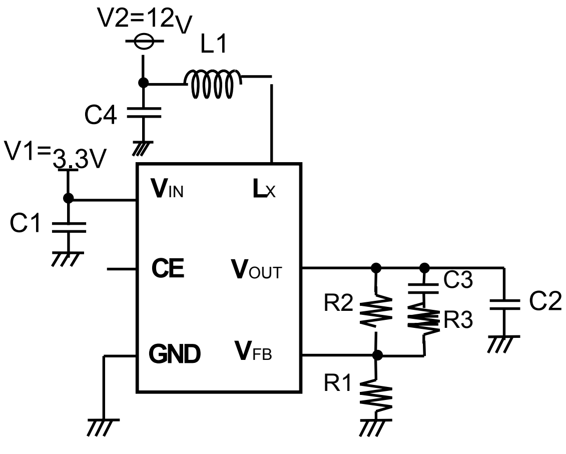


Fig 1. R1205x8xxA

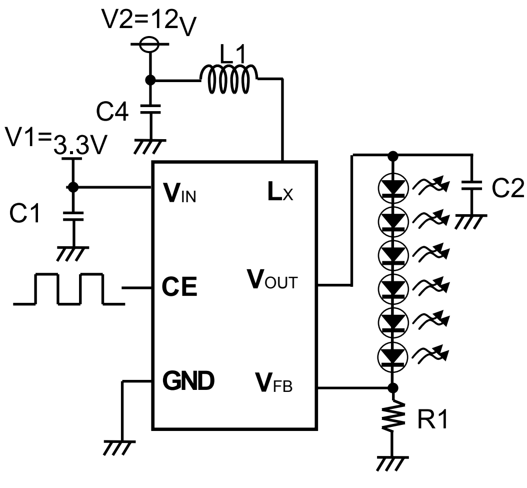
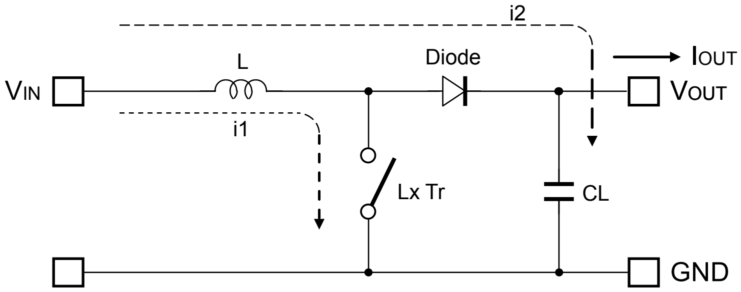


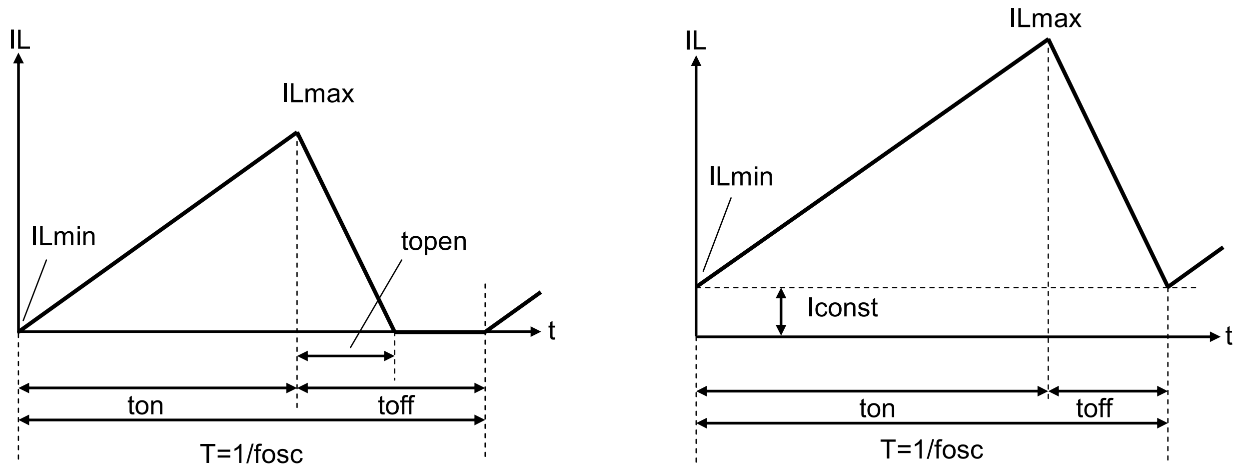
Fig 2. R1205x8xxB

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

<Basic Circuit>



<Current through L>



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.

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 tf = t_{off} will be

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

If the input voltage = output voltage, 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.

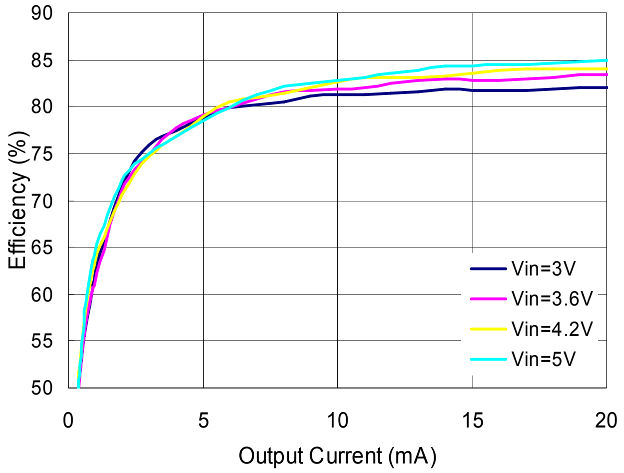
The explanation above is based on the ideal calculation, and the loss caused by L_X switch and the external components are not included.

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}.

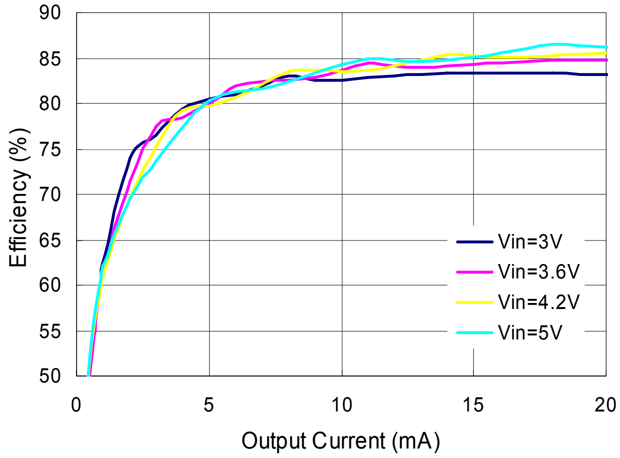
TYIPICAL CHARACTERISTICS

1) Efficiency vs. Output Current Characteristics (R1205N823A)

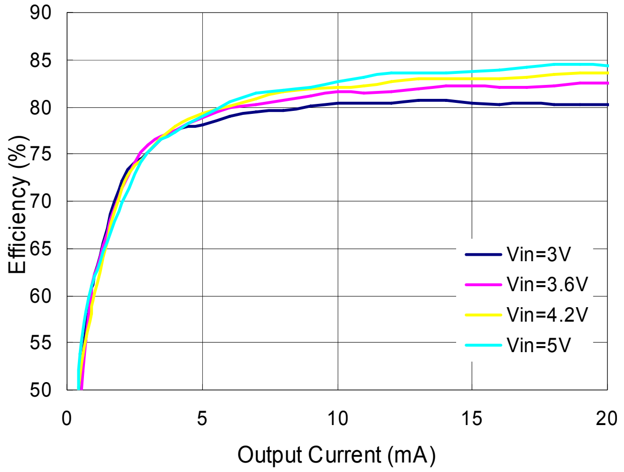
V_{OUT}=10V, L=10µH (LQH32CN100K53)



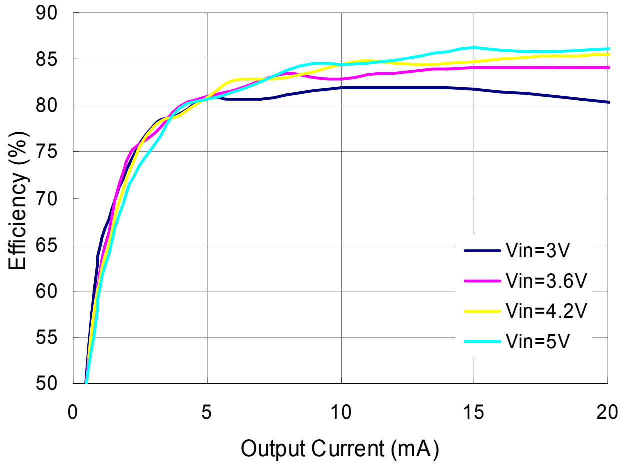
V_{OUT}=10V, L=22µH (LQH32CN220K53)



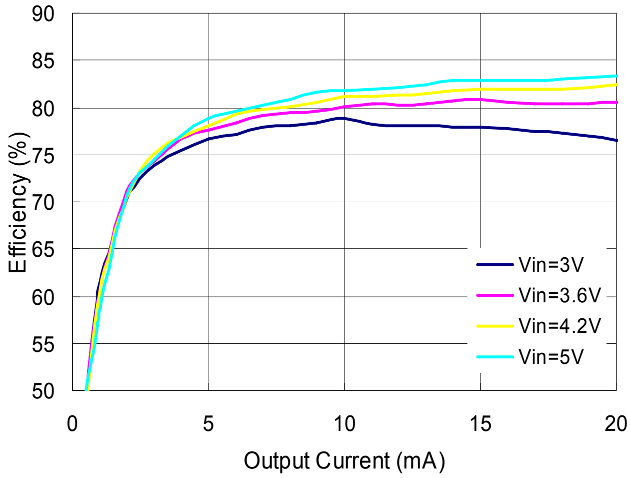
V_{OUT}=15V, L=10µH (LQH32CN100K53)



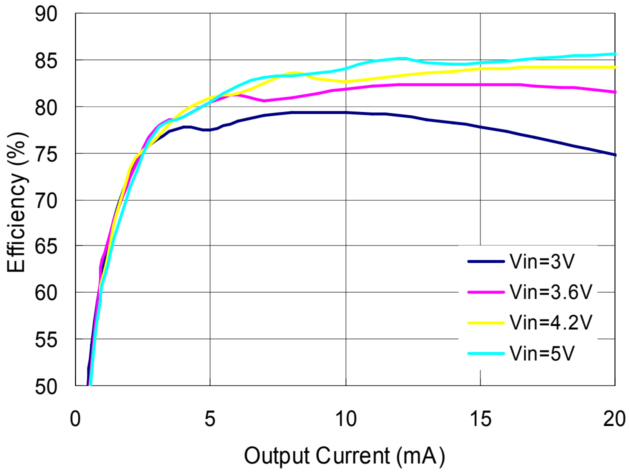
V_{OUT}=15V, L=22µH (LQH32CN220K53)



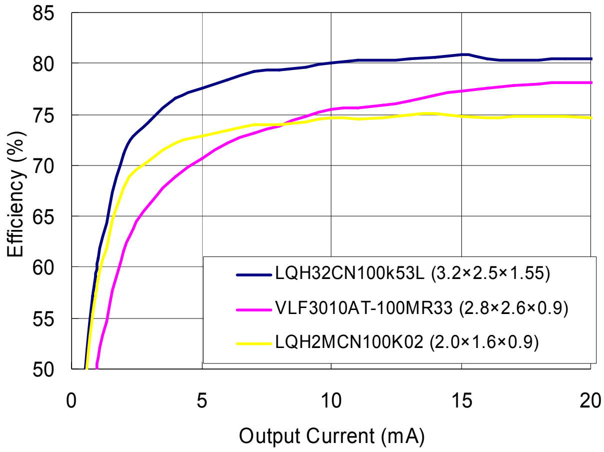
V_{OUT}=20V, L=10µH (LQH32CN100K53)



V_{OUT}=20V, L=22µH (LQH32CN220K53)

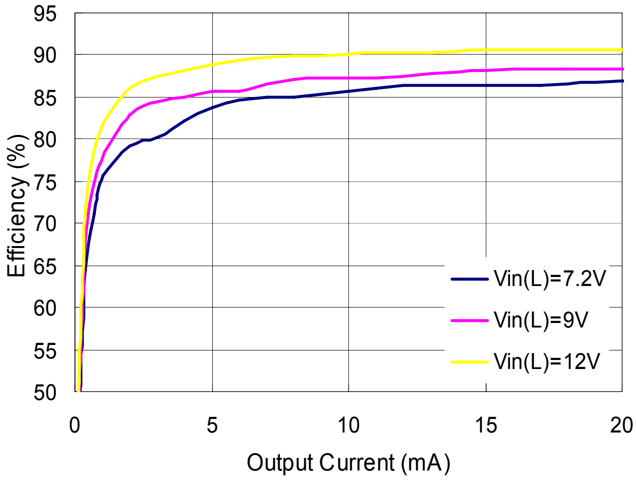


V_{OUT}=20V, V_{IN}=3.6V

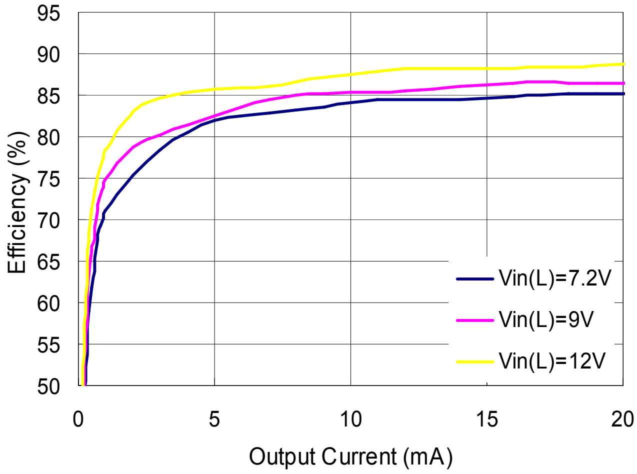


■Typical Applications with Using 5.5V or Greater

V_{OUT}=15V, L=10µH (LQH32CN100K53)

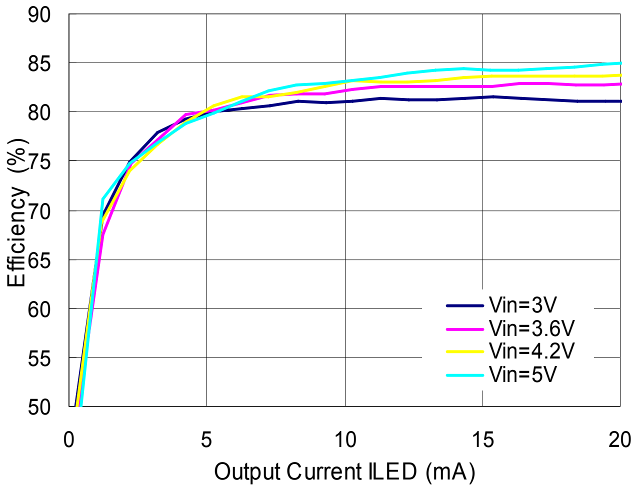


V_{OUT}=20V, L=10µH (LQH32CN100K53)

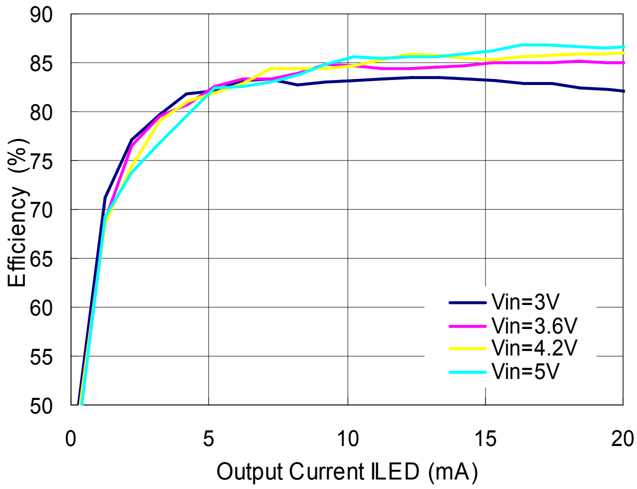


2）Efficiency vs. Output Current Characteristics (R1205N823B)

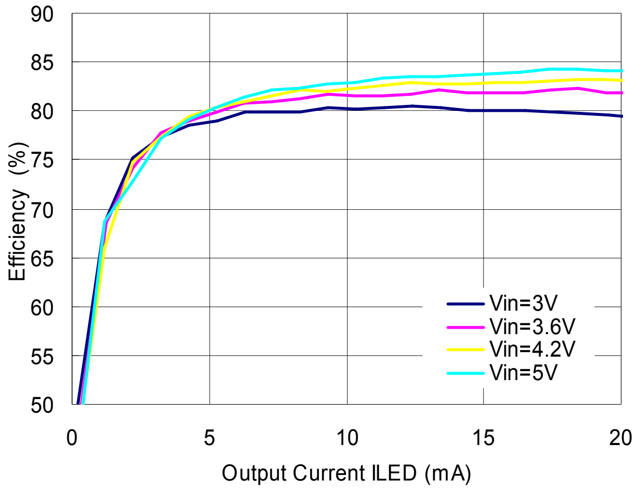
4LED, L=10µH (LQH32CN100K53)



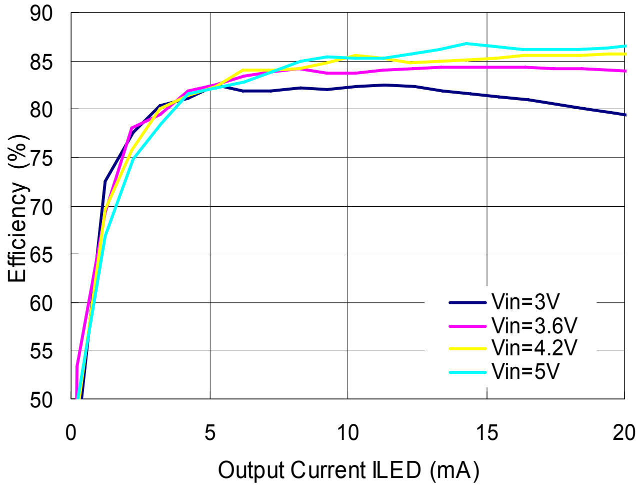
4LED, L=22µH (LQH32CN220K53)



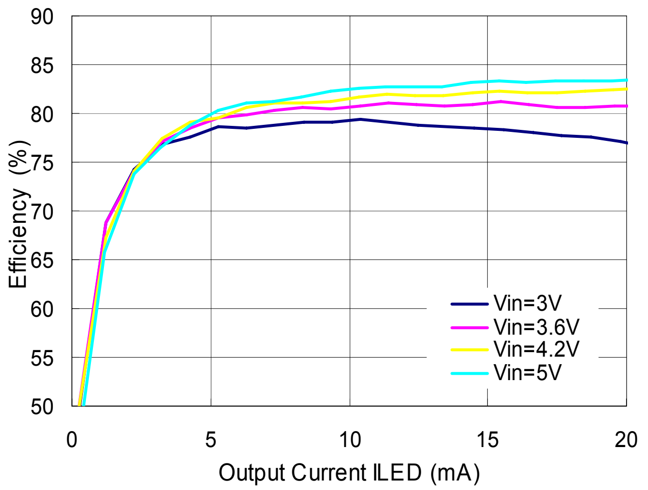
5LED, L=10µH (LQH32CN100K53)



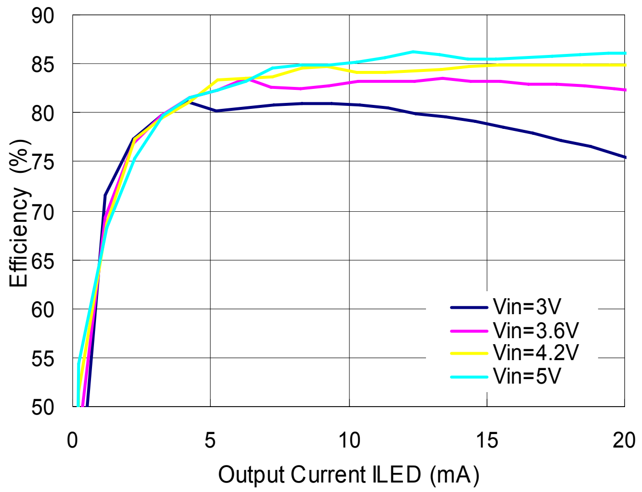
5LED, L=22µH (LQH32CN220K53)



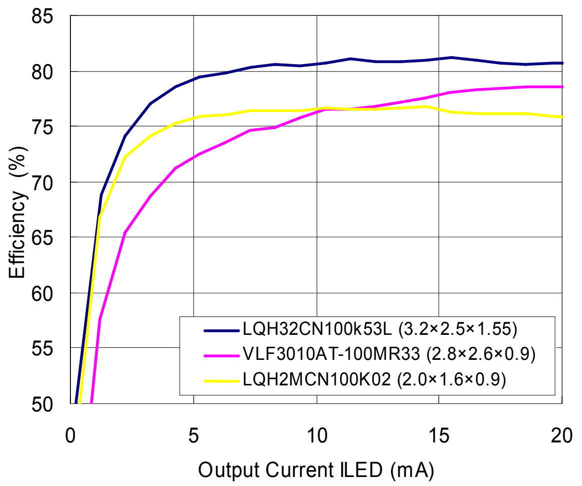
6LED, L=10µH (LQH32CN100K53)



6LED, L=22µH (LQH32CN220K53)

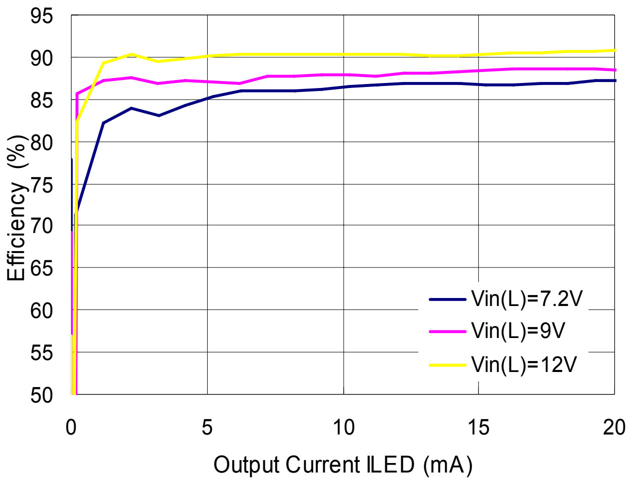


6LED, V_{IN}=3.6V

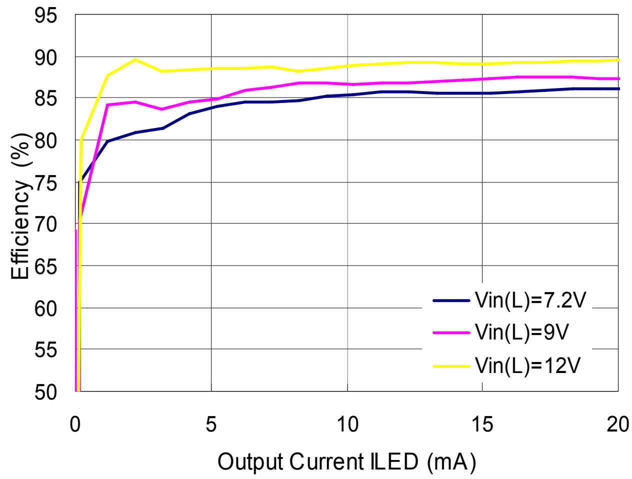


■Typical Applications with Using 5.5V or Greater

5LED, V_{IN}(IC)=3.6V

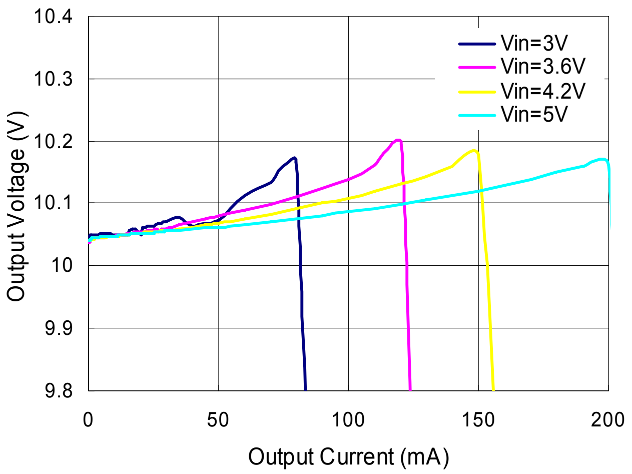


6LED, V_{IN}(IC)=3.6V

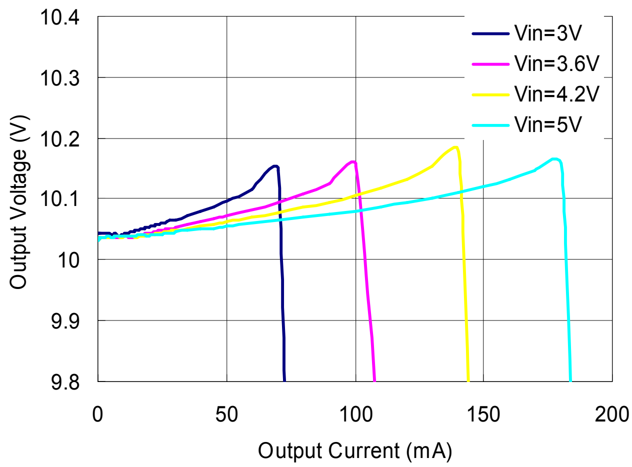


3) Output Voltage vs. Output Current (R1205N823A)

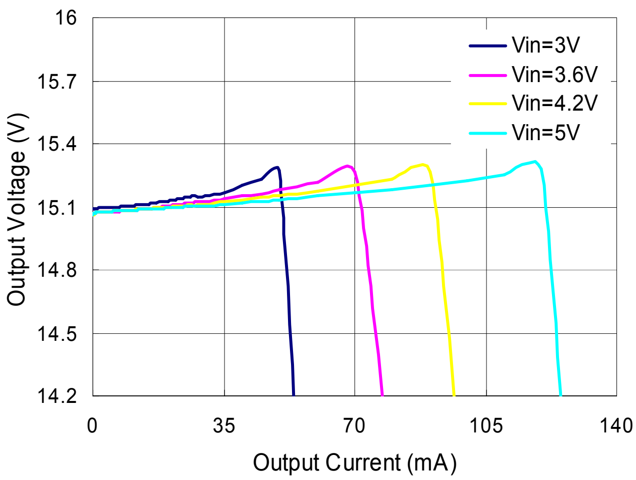
V_{OUT}=10V, L=10µH (LQH32CN100K53)



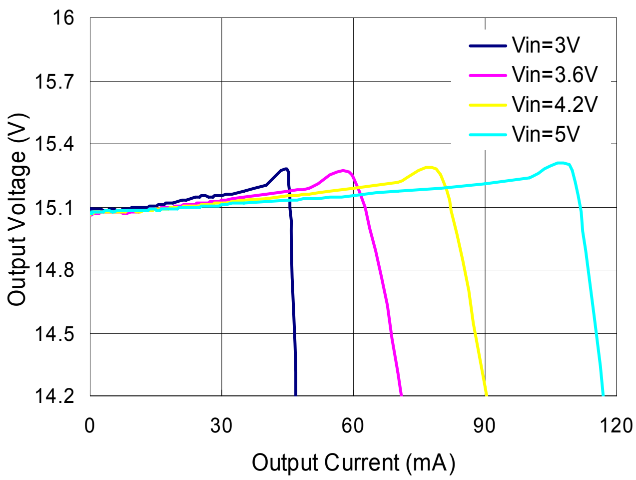
V_{OUT}=10V, L=22µH (LQH32CN220K53)



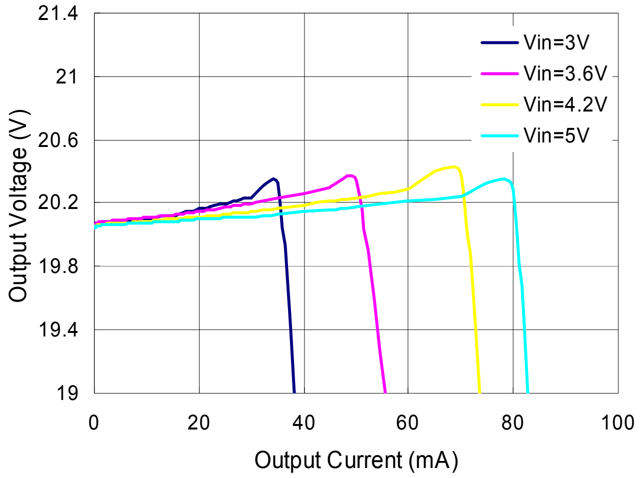
V_{OUT}=15V, L=10µH (LQH32CN100K53)



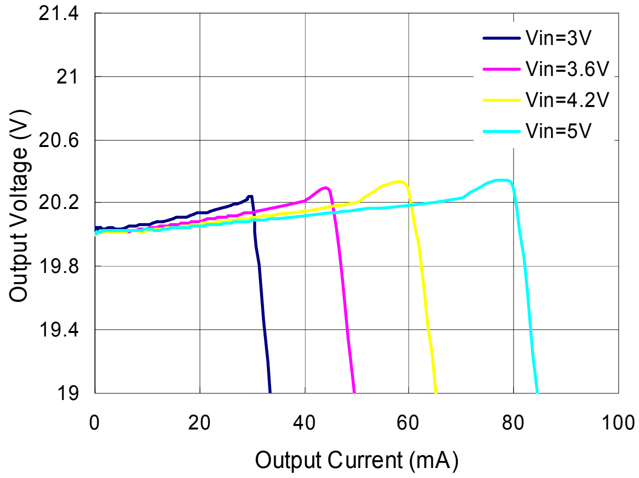
V_{OUT}=15V, L=22µH (LQH32CN220K53)



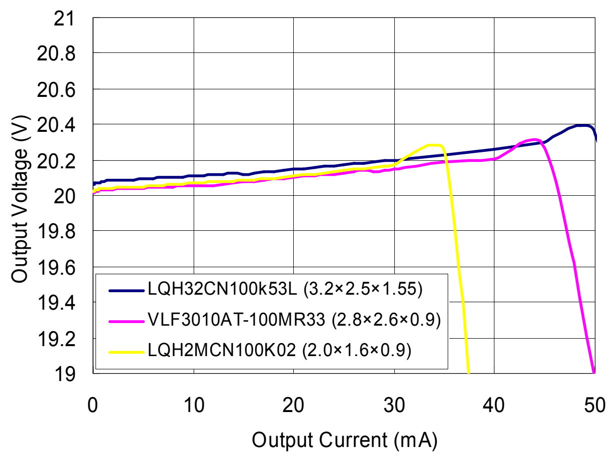
V_{OUT}=20V, L=10µH (LQH32CN100K53)



V_{OUT}=20V, L=22µH (LQH32CN220K53)

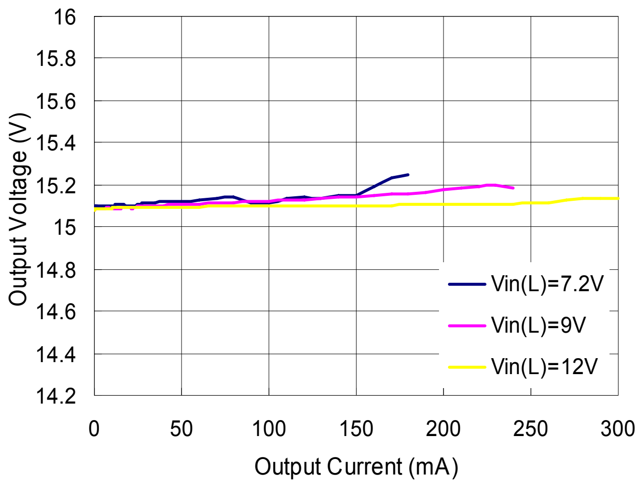


V_{OUT}=20V, V_{IN}=3.6V

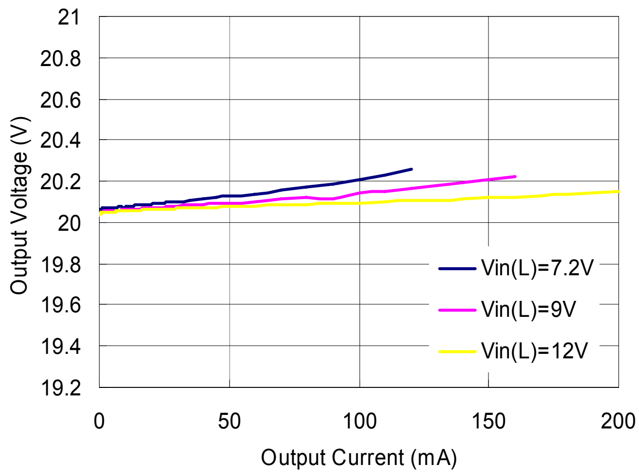


■Typical Applications with Using 5.5V or Greater

V_{OUT}=15V, L=10µH (LQH32CN100K53)



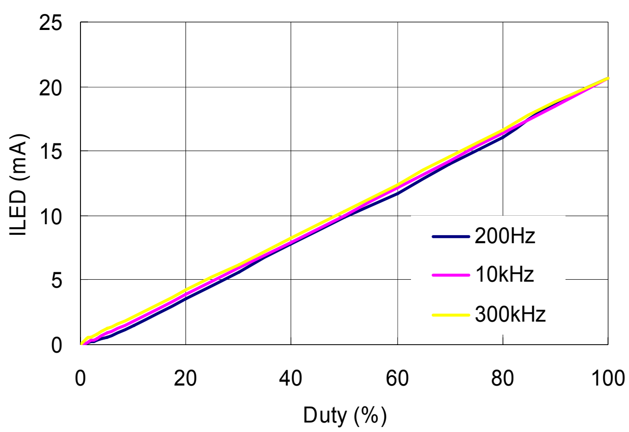
V_{OUT}=20V, L=10µH (LQH32CN100K53)



RICOH

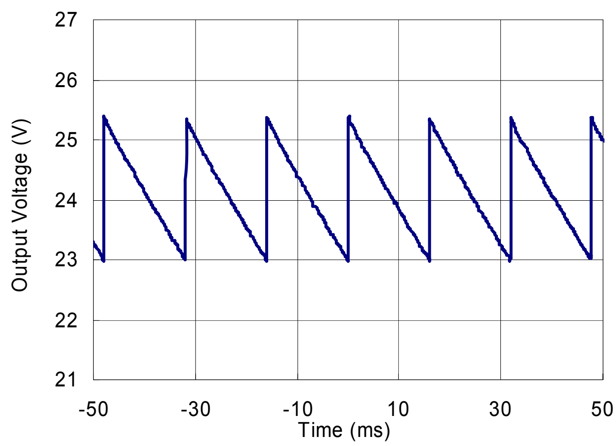
4) Maxduty vs. ILED

R1205N823A



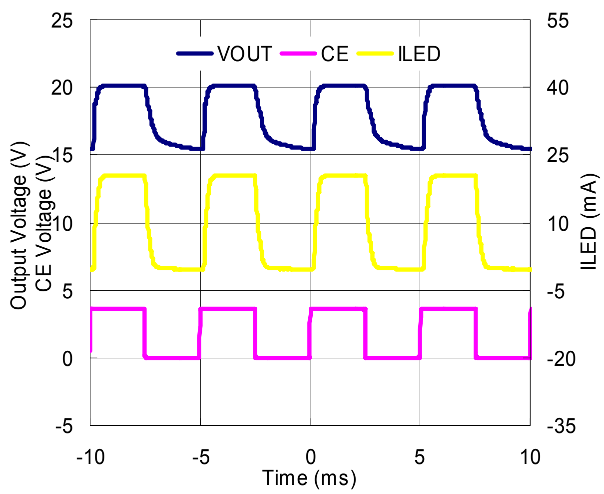
5) OVP Output Waveform

R1205N823B

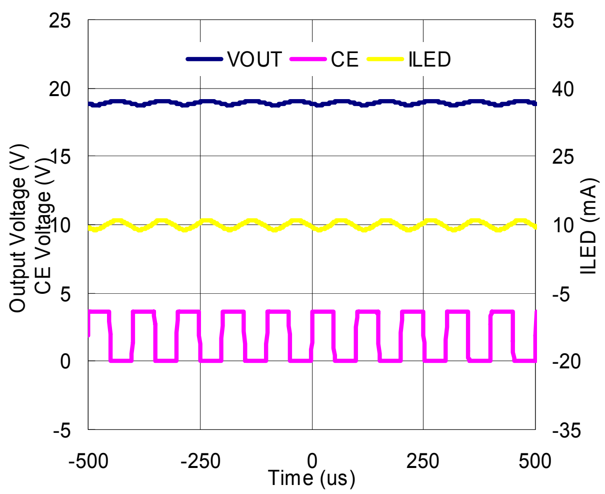


6) Waveform (6LED)

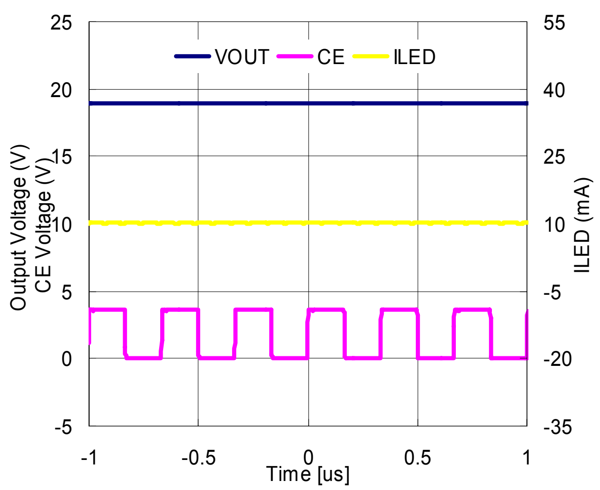
R1205N823B(CE Freq=200Hz)



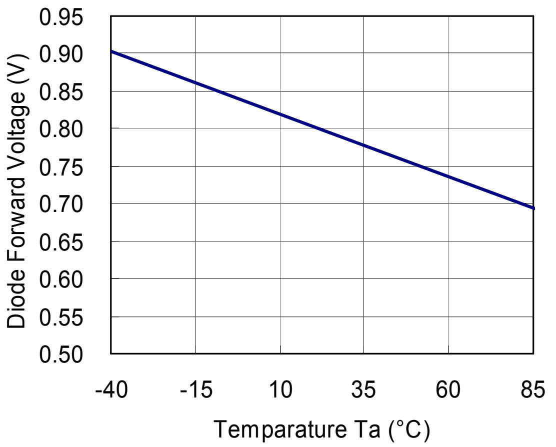
R1205N823B(CE Freq=10KHz)



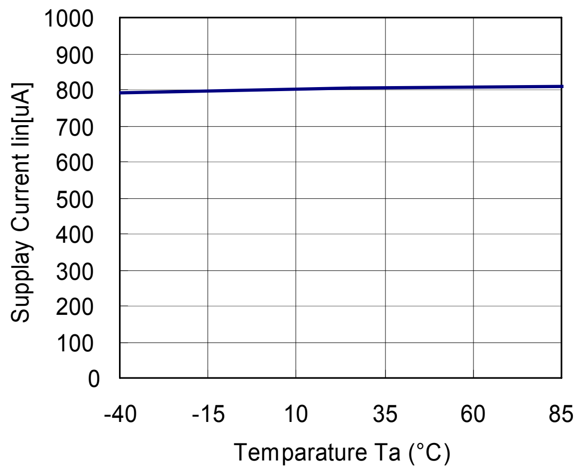
R1205N823B(CE Freq=300KHz)



7) Diode Forward Voltage vs. Temperature

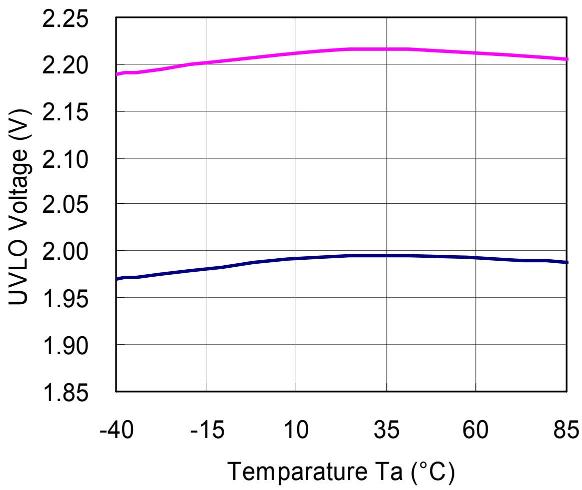


8) Supply Current vs. Temperature

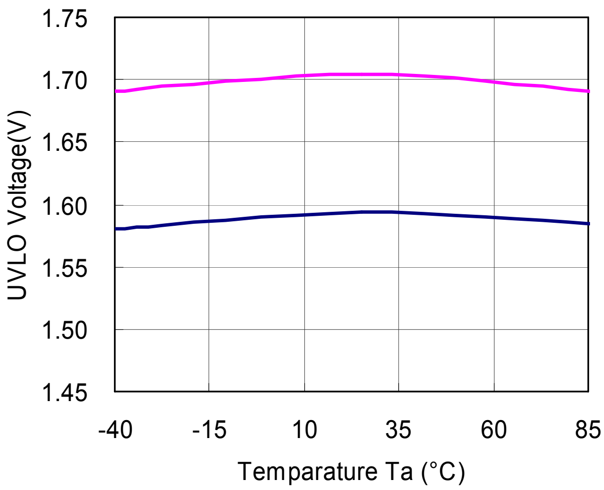


9) UVLO Output Voltage vs. Temperature

R1205x8xxA

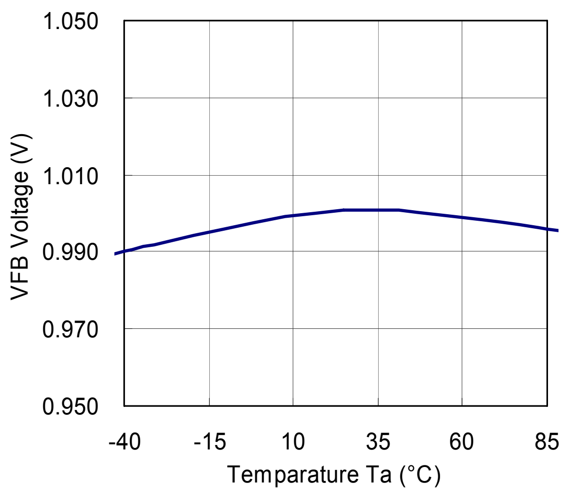


R1205x8xxB

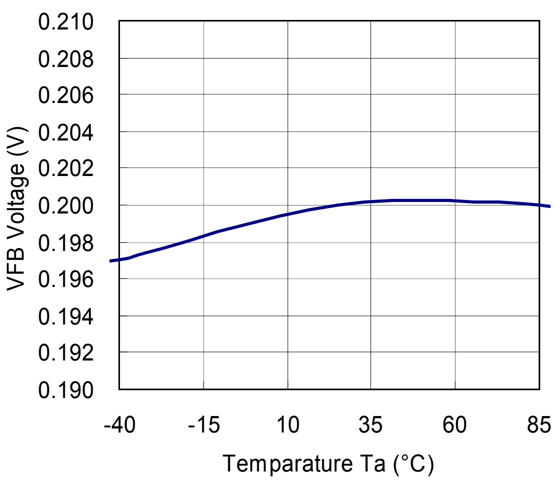


10) VFB Voltage vs. Temperature

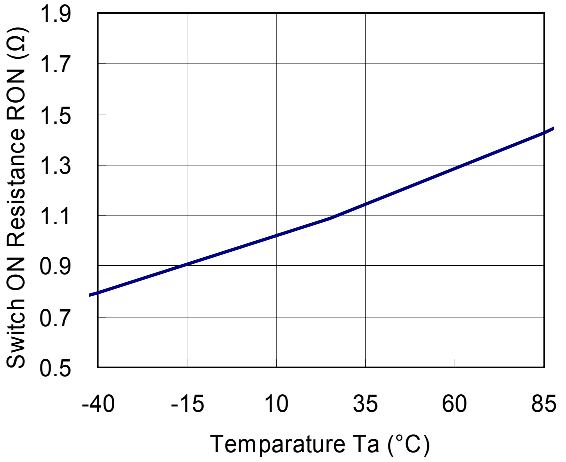
R1205x8xxA



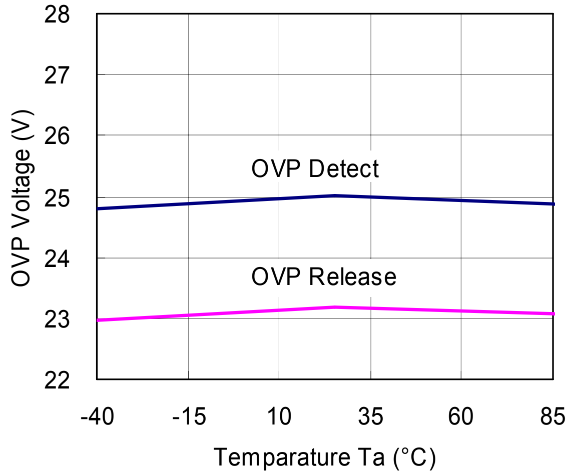
R1205x8xxB



11) Switch ON Resistance RON vs. Temperature

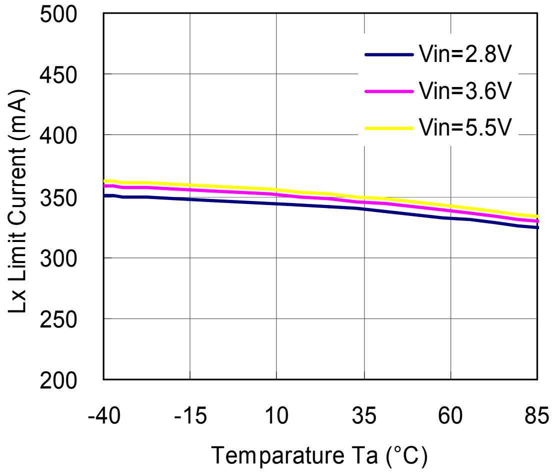


12) OVP Voltage vs. Temperature

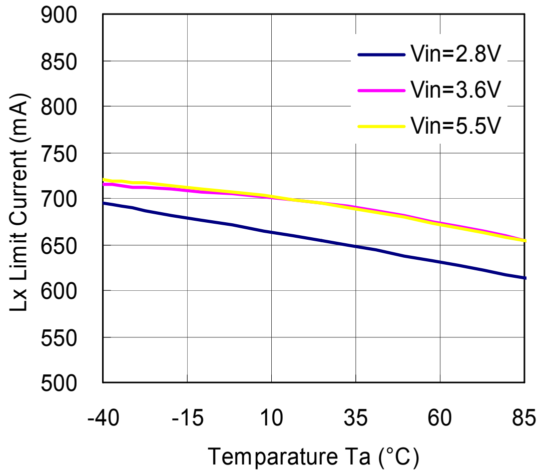


13) Lx Current Limit vs. Temperature

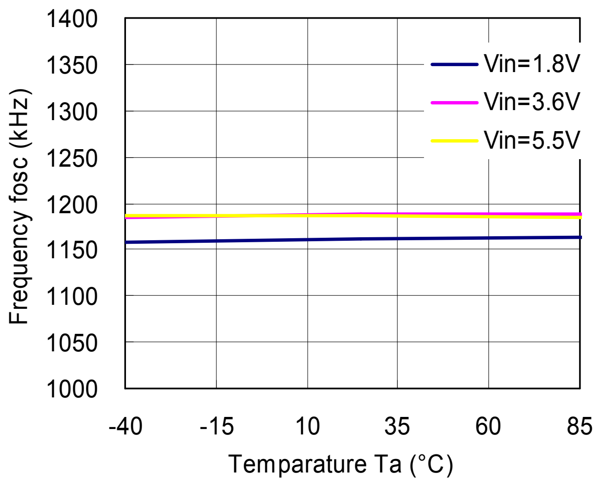
R1205x81xx



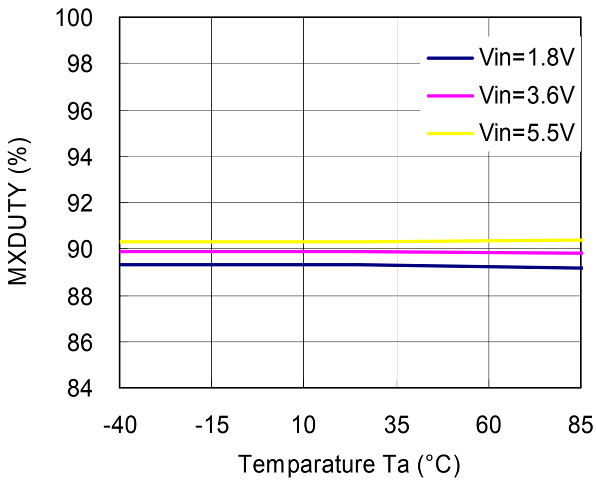
R1205x82xx



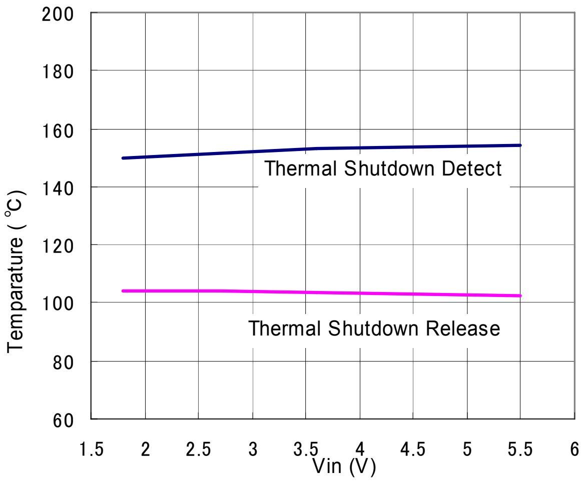
14) Oscillator Frequency vs. Temperature



15) Maxduty vs. Temperature



15) Thermal Shutdown Detect / Release Temperature vs. Input Voltage



RICOH COMPANY, LTD. Electronic Devices Company

日本経営品質賞 1999年度受賞

■Ricoh presented with the Japan Management Quality Award for 1999.
Ricoh continually strives to promote customer satisfaction, and shares the achievements of its management quality improvement program with people and society.

■Ricoh awarded ISO 14001 certification.
The Ricoh Group was awarded ISO 14001 certification, which is an international standard for environmental management systems, at both its domestic and overseas production facilities. Our current aim is to obtain ISO 14001 certification for all of our business offices.

RoHS Compliant

Ricoh completed the organization of the Lead-free production for all of our products. After Apr. 1, 2006, we will ship out the lead free products only. Thus, all products that will be shipped from now on comply with RoHS Directive.

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