RICOH

R1240x SERIES

1.2A, 30V Step Down DC/DC converter

NO.EA-190-111123

OUTLINE

The R1240x series are CMOS-based Step-down DC/DC converter with internal Nch high side Tr. (0.35Ω), which can provide the maximum 1.2A output current. The ICs consists of an Oscillator, a PWM control circuit, a Reference Voltage unit, an Error amplifier, phase compensation circuits, a slope circuit, a soft-start circuit, protection circuits, internal voltage regulators, and a switch for boot strap circuit. The ICs can make up a Step-Down DC/DC Converter with the following external components: an inductor, resistors, a diode, and capacitors.

The R1240x series are current mode operating type DC/DC converter which does not require external current sense resistor, and it works high speed response time, high efficiency and compatible with ceramic capacitors. Oscillator frequency is internally set at 1.25MHz.

As a protection function, it has cycle by cycle peak current limit function, short protection function, thermal shutdown function and UVLO.

There are two types for short protection, A version has latch protection function with 2ms delay time, and B version has fold back protection function that keep operating at short condition with lower operating frequency and limiting the Lx current.

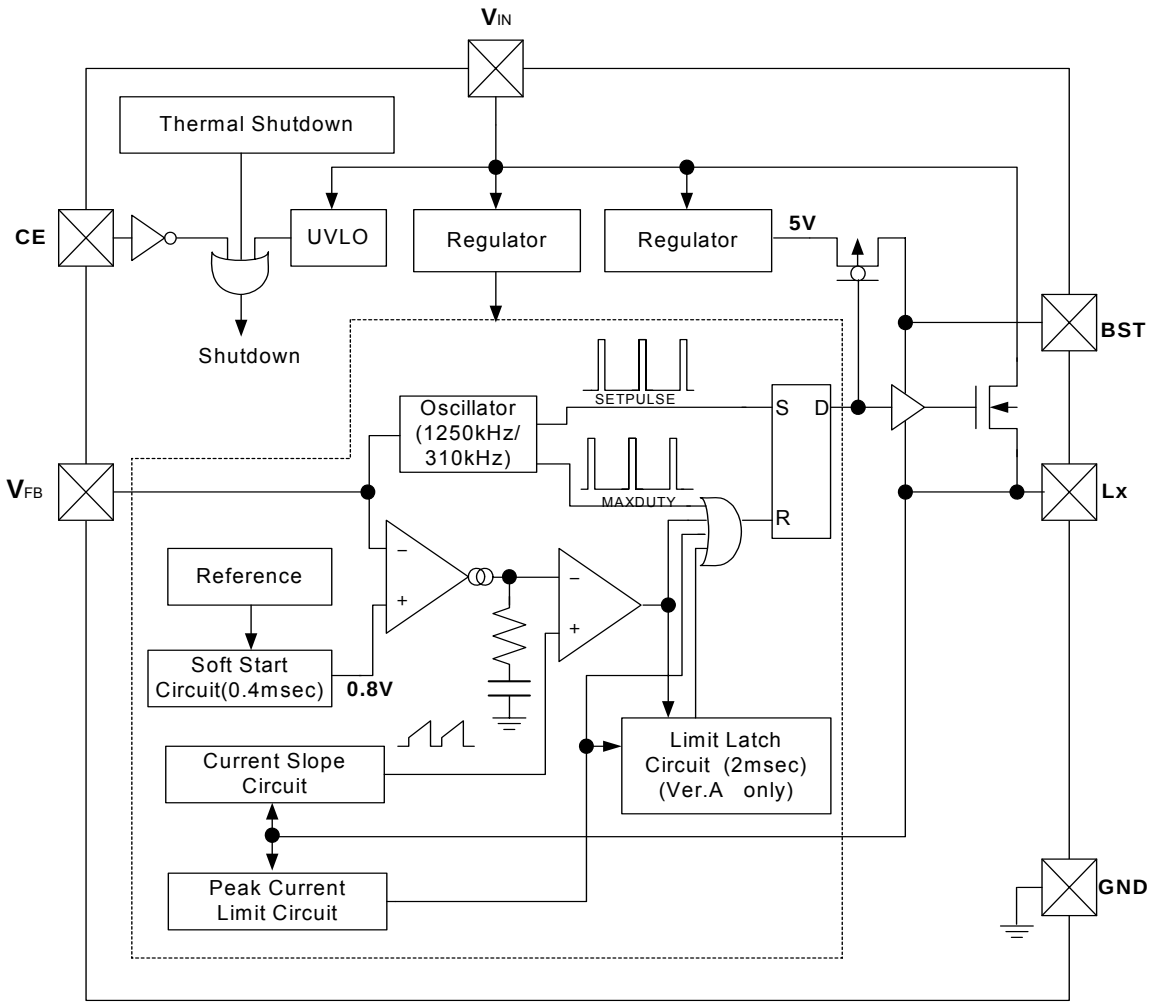
FEATURES

- Operating Voltage ····· 4.5V~30V
- Internal Nch MOSFET Driver ····· R_{ON}=0.35Ω Typ.
- Adjustable output voltage with external resistor ····· 0.8V~15V
- Feed back voltage ····· 0.8V±1.5%
- Peak Current limit function ····· Typ. 2.0A
- UVLO function
- Operating Frequency ····· 1.25MHz (310kHz : fold condition :Ver. B only)
- Short protection for output ····· Ver. A: Latch with 2ms delay or Ver. B: Fold Back
- Ceramic Capacitor compatible
- Stand-by function ····· Typ. 0μA
- Package ····· SOT-23-6W, DFN(PLP)2527-10

APPLICATIONS

- Power source for digital home appliance
- Power source for hand-held communication equipment, cameras, video instruments such as VCRs, camcorders.
- Power source for battery-powered equipment.
- Battery Charger

BLOCK DIAGRAMS



SELECTION GUIDE

In the R1240x Series, the Package, type of short protection (Latch or Fold back) can be selected at the user's request.

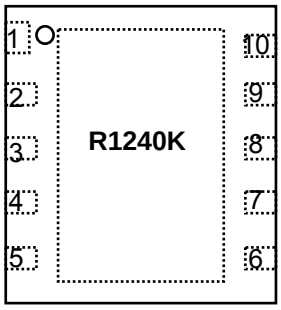
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1240K003∗-TR	DFN(PLP)2527-10	5,000 pcs	Yes	Yes
R1240N001∗-TR-FE	SOT-23-6W	3,000 pcs	Yes	Yes

∗ : Designation of Optional Function at off state are options as follows.
(A) Latch Type protection
(B) Fold back Type protection

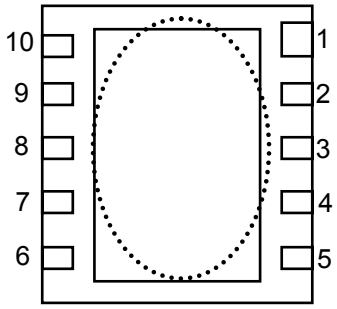
PIN CONFIGURATION

- **DFN(PLP)2527-10**

Top View

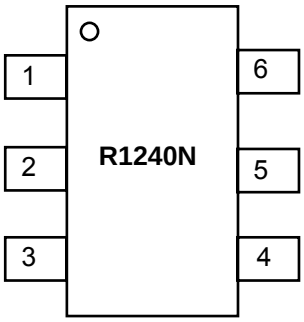


Bottom View



- **SOT-23-6W**

Top View



PIN DESCRIPTION

- **R1240N001x**

Pin No.	Symbol	Description
1	CE	Chip Enable Pin (Active with ”H”)
2	V_{IN}	Power Supply Pin
3	L_X	L_X Switching Pin
4	BST	Bootstrap Pin
5	GND	Ground Pin
6	V_{FB}	Feedback Pin

- **R1240K003x**

Pin No.	Symbol	Description
1	L_X	L_X Switching Pin
2	V_{IN}	Power Supply Pin
3	V_{IN}	Power Supply Pin
4	CE	Chip Enable Pin (Active with ”H”)
5	TEST	Test Pin (Open, do not connect to any line.)
6	GND	Ground Pin
7	NC	No Connection
8	V_{FB}	Feedback Pin
9	NC	No Connection
10	BST	Bootstrap 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.

ABSOLUTE MAXMUM RATINGS

(GND=0V)

Symbol	Item		Rating		Unit
V_{IN}	Input Voltage		-0.3~32		V
V_{BST}	BST Pin Voltage		V_{LX}-0.3~V_{LX}+6		V
V_{LX}	L_X Pin Voltage		-0.3~V_{IN}+0.3		V
I_{LX}	L_X Pin Current		2		A
V_{CE}	CE Pin input Voltage		-0.3~V_{IN}+0.3		V
V_{FB}	V_{FB} Pin Voltage		-0.3~4		V
P_D	Power Dissipation	SOT-23-6W	Standard Land Pattern	430*	mW
		DFN(PLP)2527-10	Standard Land Pattern	910*	
			High Wattage Land Pattern	1400*	
Ta	Operating Temperature Range		-40~85		ºC
Tstg	Storage Temperature Range		-55~125		ºC

*) 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

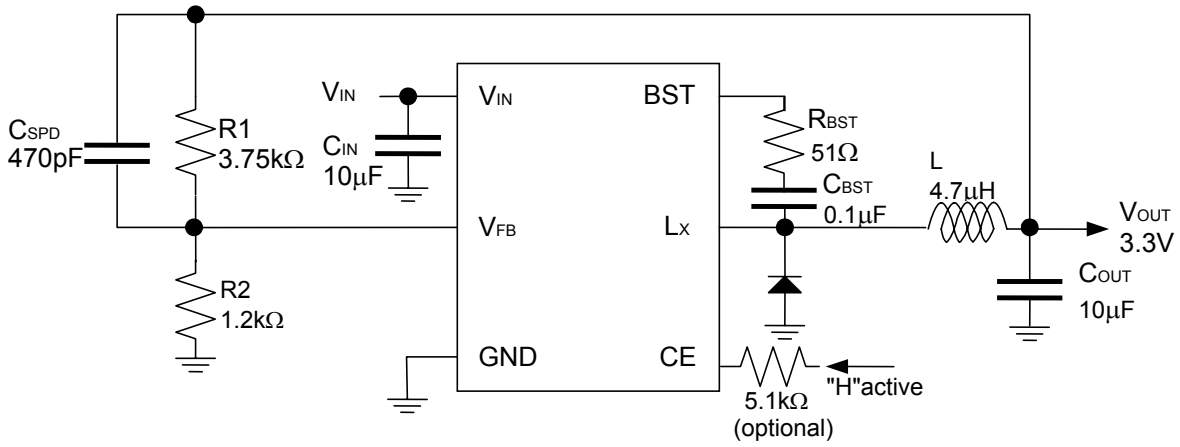
(Otherwise notified in Conditions, V_{IN}= 12V, Ta=25ºC)

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{IN}	Operating Input Voltage		4.5		30	V
I_{IN}	V_{IN} Consumption Current	V_{IN}=30V, V_{FB}=1.0V		0.5	1.0	mA
V_{UVLO1}	UVLO Detect Voltage	Falling	3.6	3.8	4.0	V
V_{UVLO2}	UVLO Released Voltage	Rising		V_{UVLO1} +0.2	4.2	V
V_{FB}	V_{FB} Voltage Tolerance		0.788	0.800	0.812	V
$\Delta V_{FB}/\Delta T$	V_{FB} Voltage Temperature Coefficient	-40ºC ≤ Ta ≤ 85ºC		±150		ppm/ºC
fosc	Oscillator Frequency		1000	1250	1500	kHz
f_{FLB}	Fold back Frequency (Ver.B)	V_{FB}<0.56V		310		kHz
Maxduty	Oscillator Maximum. Duty Cycle		75	85	90	%
t_{MIN}	Minimum On Time			100		nsec
t_{SS}	Soft-start Time	V_{FB}=0.72V	0.2	0.4	0.6	ms
t_{DLY}	Delay Time for Latch Protection (Ver.A)		1	2	4	ms
R_{LXH}	Lx High Side Switch ON Resistance			0.35		Ω
I_{LXHOFF}	Lx High Side Switch Leakage Current			0	5	μA
I_{LIMLXH}	Lx High Side Switch Limited Current			2.0		A
V_{CEL}	CE “L” Input Voltage				0.3	V
V_{CEH}	CE “H” Input Voltage		1.6			V
I_{FB}	V_{FB} Input Current		-1.0		1.0	μA
I_{CEL}	CE “L” Input Current		-1.0		1.0	μA
I_{CEH}	CE “H” Input Current		-1.0		1.0	μA
T_{TSD}	Thermal Shutdown Detect Temperature	Hysteresis 30ºC		160		ºC
Istandby	Standby Current	V_{IN}=30V		0	5	μA

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 APLICATION



(external parts)

C_{IN}	10μF KTS500B106M55N0T00 (Nippon Chemi-Con)
C_{OUT}	10μF GRM31CR71E106K (Murata)
C_{BST}	0.1μF GRM21BB11H104KA01L (Murata)
L	4.7μH SLF7045T-4R7M2R0-PF (TDK)
D	MA24D60 (Panasonic)

Notes concerning external parts

External components must be connected as close as possible to the ICs and make wiring as short as possible. Especially, the capacitor connected in between V_{IN} and GND pin must be wiring the shortest. The operating may be unstable due to the change of the electric potential of internal ICs by the switching current when the impedance of the power supply line and GND line is high. Make the power supply and GND lines sufficient. It is also necessary to give careful consideration to design the wiring of the power supply, GND, L_X, V_{OUT} and the inductor because of the large current by the function of switching is flowing into them. Besides, the wiring between the resistance (R1), which set the output voltage, and the wiring of the inductor must separate from the load wiring.

The ceramic capacitors have low ESR (Equivalent Series Resistance) type are recommended for the ICs. The recommendation of C_{IN} capacitor between V_{IN} and GND is more than 10μF, and C_{OUT} capacitor is more than 10μF in the case $V_{OUT} \geq 1.8V$ or more than 20μF in the case $1.8V > V_{OUT}$. Please check the bias dependence and the temperature variations of the ceramic capacitors.

Normally, please select the inductor value in the range between 4.7μH and 10μH in the case of $V_{OUT} \geq 5V$, 4.7μH in the case of $5V > V_{OUT} \geq 1.8V$ and 2.2μH in the case of $1.8V > V_{OUT}$. The internal phase compensation of this IC is designed with the above-mentioned inductor value and C_{OUT} ceramic capacitor value. When the inductor value is small, there is a possibility to trigger the over-current protection circuit by the peak switching current. As the peak switching current might reach to the limited value when the load current increase a lot.

Please note; the over-current protection circuit is influenced by the temperature shift caused by operation of the IC.

For the diode, please use the Schottky diode, which parasitic capacitance is small as possible, as, there is a possibility that the operating of IC becomes unstable by the large switching current.

Output voltage is set by $V_{OUT}=V_{FB} \times (R1+R2)/R2$. If the values of R1 and R2 are large, the impedance of V_{FB} pin increases, and pickup the noise may result. The recommendation value range of R2 is approximately between 1.2kΩ to 16kΩ. If the operation may be unstable, reduce the impedance of V_{FB} pin.

Recommended value for each output voltage

V_{OUT}(V)	0.8	1	1.2	1.3	1.5	1.8~6	6~15
R1(kΩ)	0	$=(V_{OUT} / 0.8 - 1) \times 1.2$					
R2(kΩ)	open	1.20	1.20	1.20	1.20	1.20	1.20
C_{SPD}(pF)	open	3300	2200	1500	470	470	330
C_{OUT}(μF)	22 × 2	10 × 2	10 × 2	10 × 2	10 × 2	10	10
L(μH)	2.2	2.2	2.2	2.2	2.2	4.7	10.0(4.7)

Recommended external Compornents

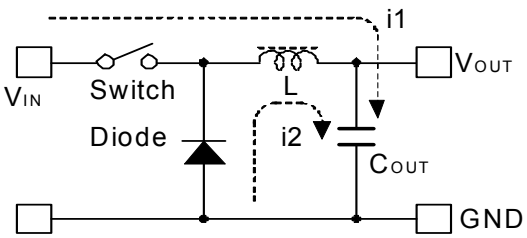
Symbol	Condition	Value	Parts Name	MFR
C_{IN}		10μF/50V	UMK325BJ106MM-T	TAIYO YUDEN
		10μF/50V	KTS500B106M55N0T00	Nippon Chemi-Con
C_{OUT}	V_{OUT} >10V	10μF/50V	UMK325BJ106MM-T	TAIYO YUDEN
		10μF/50V	KTS500B106M55N0T00	Nippon Chemi-Con
	10V> V_{OUT} >1.8V	10μF/25V	GRM31CR71E106K	muRata
	V_{OUT} <1.8V	22μF/10V	GRM31CR71A226M	muRata
			NOTE: The value of C_{OUT} depends upon the setting output voltage.	
C_{BST}		0.1μF/50V	GRM21BB11H104KA01L	muRata
R_{BST}		51.0Ω		
L	40V/2.0A	10μH	SLF6045T-100M1R6-3PF	TDK
		4.7μH	SLF7045T-4R7M2R0-PF	TDK
		2.2μH	VLCF4020T-2R2N1R7	TDK
D	30V/2.0A	0.32V	CMS06	TOSHIBA
	40V/2.0A	0.49V	CMS11	TOSHIBA
	30V/1.5A	0.42V	MA22D28	Panasonic
	40V/2.0A	0.43V	MA24D60	Panasonic
			NOTE: Diode depends upon the input voltage and output Current.	
R_{CE}	The UP DIODE is connected between the CE pin and the V_{IN} pin as the ESD protection element. If there is the possibility that the voltage of the CE pin becomes higher than the voltage of the V_{IN} pin, it is recommended to connect the 5.1kohm resistance with the CE pin for preventing a large current flows into the V_{IN} pin from the CE pin.			

*The performance of power circuit using those ICs extremely depends upon the peripheral circuits. Pay attention in the selection of the peripheral circuits. In particular, design the peripheral circuits in a way that the values such as voltage, current, and power of each component, PCB patterns and the IC do not exceed their respected rated values. (such as the voltage, current , and power)

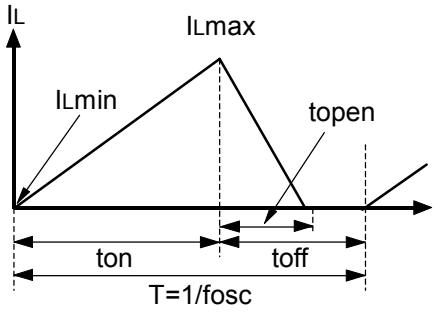
Operation of The Buck Converter and The Output Current

The DC/DC converter charges energy in the inductor when switch is ON, and discharges the energy from the inductor when switch is OFF and controls with less energy loss, so that a lower output voltage than the input voltage is obtained. The operation will be explained with reference to the following diagrams:

<Basic Circuits>



<Current through>



Step 1: Switch turns on and current IL (=i1) flows, and energy is charged into C_{OUT}. At this moment, IL increases from I_{Lmin} (=0) to reach I_{Lmax} in proportion to the on-time period (t_{on}) of Switch.

Step 2: When Switch turns off, Synchronous rectifier Diode turns on in order that L maintains IL at I_{Lmax}, and current IL (=i2) flows.

Step 3: IL (=i2) decreases gradually and reaches IL=I_{Lmin}=0 after a time period of topen, and Diode turns off. Provided that in the continuous mode, next cycle starts before I_L becomes to 0 because t_{off} time is not enough. In this case, IL value increases from this I_{Lmin} (>0).

In the case of PWM control system, the output voltage is maintained by controlling the on-time period (t_{on}), with the oscillator frequency (f_{osc}) being maintained constant.

Output Current and Selection of External Components

The relation between the output current and external components is as follows:

When Switch of L_X is ON:

(Wherein, Ripple Current P-P value is described as I_{RP}, ON resistance of Switch and Diode of L_X are respectively described as R_{ONH} and V_F and the DC resistor of the inductor is described as R_L.)

$$V_{IN} = V_{OUT} + (R_{ONH} + R_L) \times I_{OUT} + L \times I_{RP} / t_{on} \cdots\cdots \text{Equation 1}$$

When Switch is "OFF"(Diode is "ON") as t_{off}:

$$L \times I_{RP} / t_{off} = V_F + V_{OUT} + R_L \times I_{OUT} \cdots\cdots \text{Equation 2}$$

Put Equation 2 to Equation 1 and solve for ON duty of Switch, $t_{on} / (t_{off} + t_{on}) = D_{ON}$,

$$D_{ON} = (V_{OUT} + V_F + R_L \times I_{OUT})/(V_{IN} + V_F - R_{ONH} \times I_{OUT}) \cdots\cdots \text{Equation 3}$$

Ripple Current is as follows:

$$I_{RP} = (V_{IN} - V_{OUT} - R_{ONH} \times I_{OUT} - R_L \times I_{OUT}) \times D_{ON} / f_{osc} / L \cdots\cdots \text{Equation 4}$$

wherein, peak current that flows through L, and Switch is as follows:

$$I_{Lmax} = I_{OUT} + I_{RP} / 2 \cdots\cdots \text{Equation 5}$$

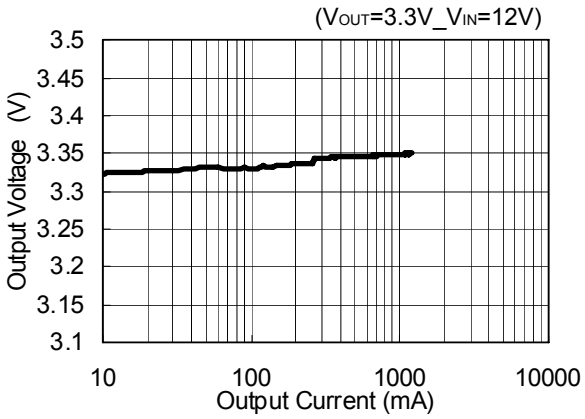
Consider I_{Lmax}, condition of input and output and select external components.

*The above explanation is directed to the calculation in an ideal case in continuous mode.

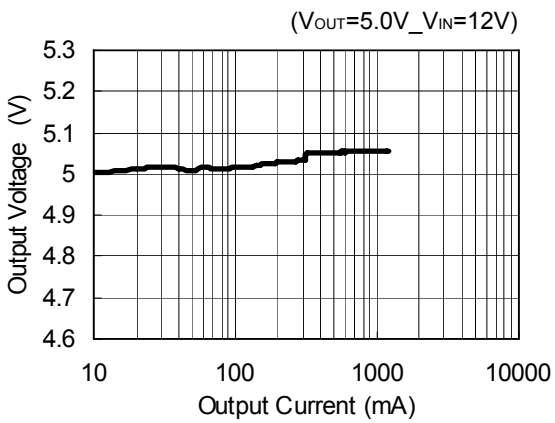
TYPICAL CHARACTERISTICS

1) Output Voltage VS. Output Current

R1240x00Xx

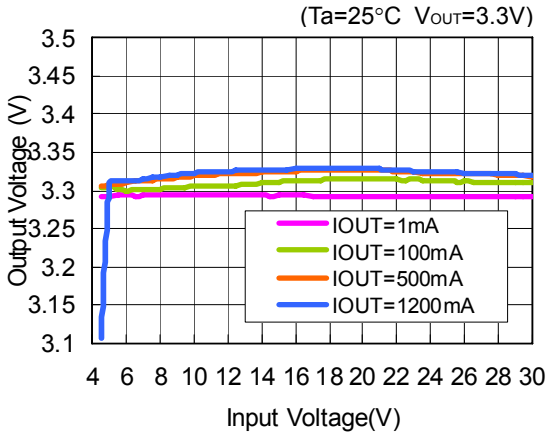


R1240x00Xx

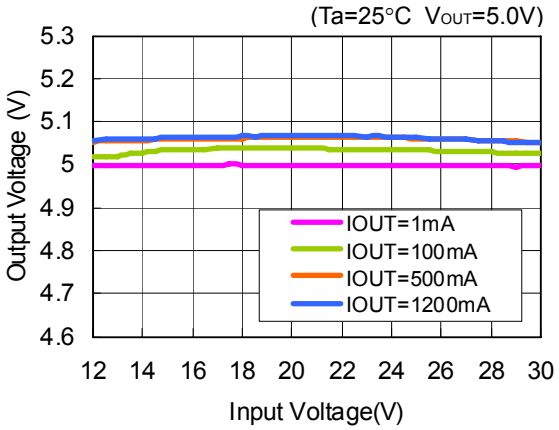


2) Output Voltage VS. Input Voltage

R1240x00Xx

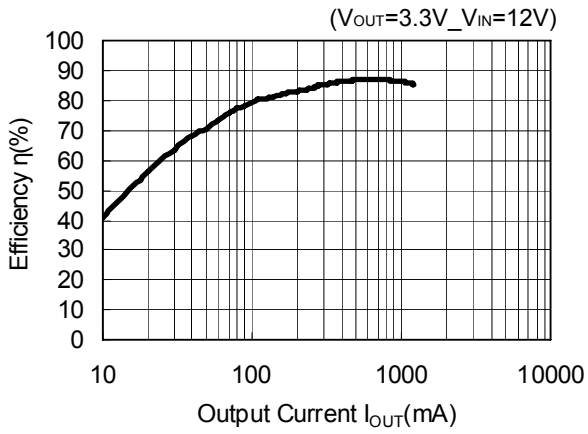


R1240x00Xx

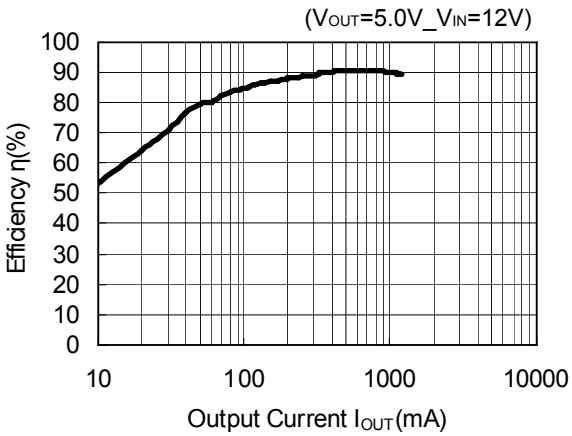


3) Efficiency VS. output Current

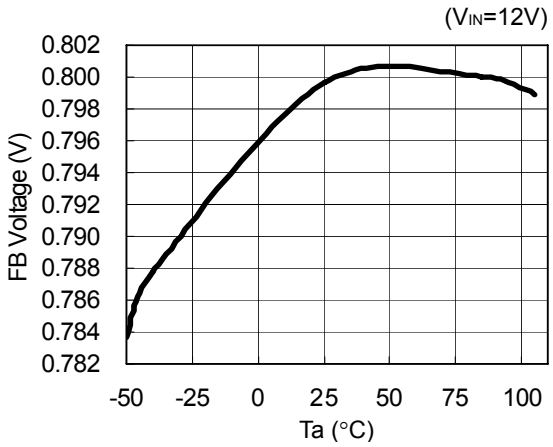
R1240x00Xx



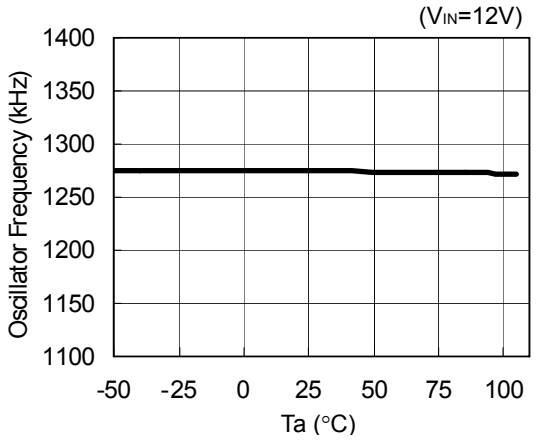
R1240x00Xx



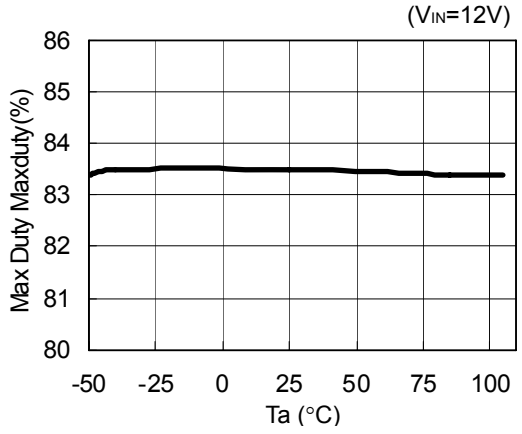
4) FB Voltage VS. Temperature
R1240x00Xx



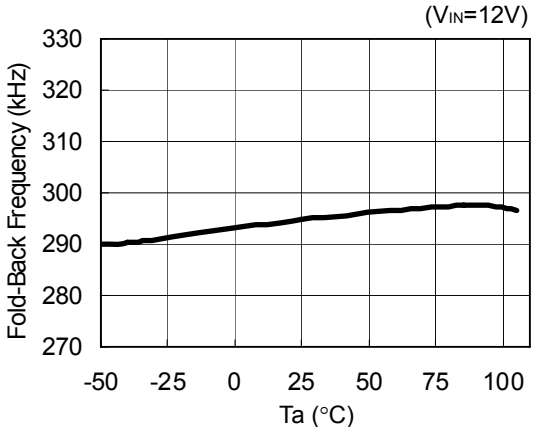
5) Oscillator Frequency VS. Temperature
R1240x00Xx



6) Maxduty VS. Temperature
R1240x00Xx



7) Fold-Back Frequency VS. Temperature
R1240x00XB



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■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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