1.2A, 30V Step Down DC/DC converter

NO.EA-293-111123

OUTLINE

The R1244N001B is CMOS-based Step-down DC/DC converter with an internal N-channel high side Tr. (R_{DSON} Typ. 0.35Ω) power switch. The R1244N001B can provide the maximum 1.2A output current. The IC consists of an oscillator, a PWM control circuit, a reference voltage unit, an error amplifier, phase compensation circuits, a slope compensation circuit, a soft-start circuit, protection circuits, an internal voltage regulator, and a switch for a bootstrap circuit. To make a step-down DC/DC converter with the R1244N001B, as external components, an inductor, resistors, a diode, and capacitors are necessary.

The R1244N001B is a current mode PWM step-down DC/DC converter, but the external current sense resistor is not necessary. Fast transient response and high efficiency characteristics are realized with the R1244N001B. The R1244N001B allows the use of ceramic capacitors. The oscillator frequency is internally fixed at 1.25MHz.

Cycle by cycle current limit provides protection against over-current. Fold back circuit reduces frequency into 1/4 against shorted output and realizes limiting the Lx current. Thermal shutdown function and UVLO are also built-in.

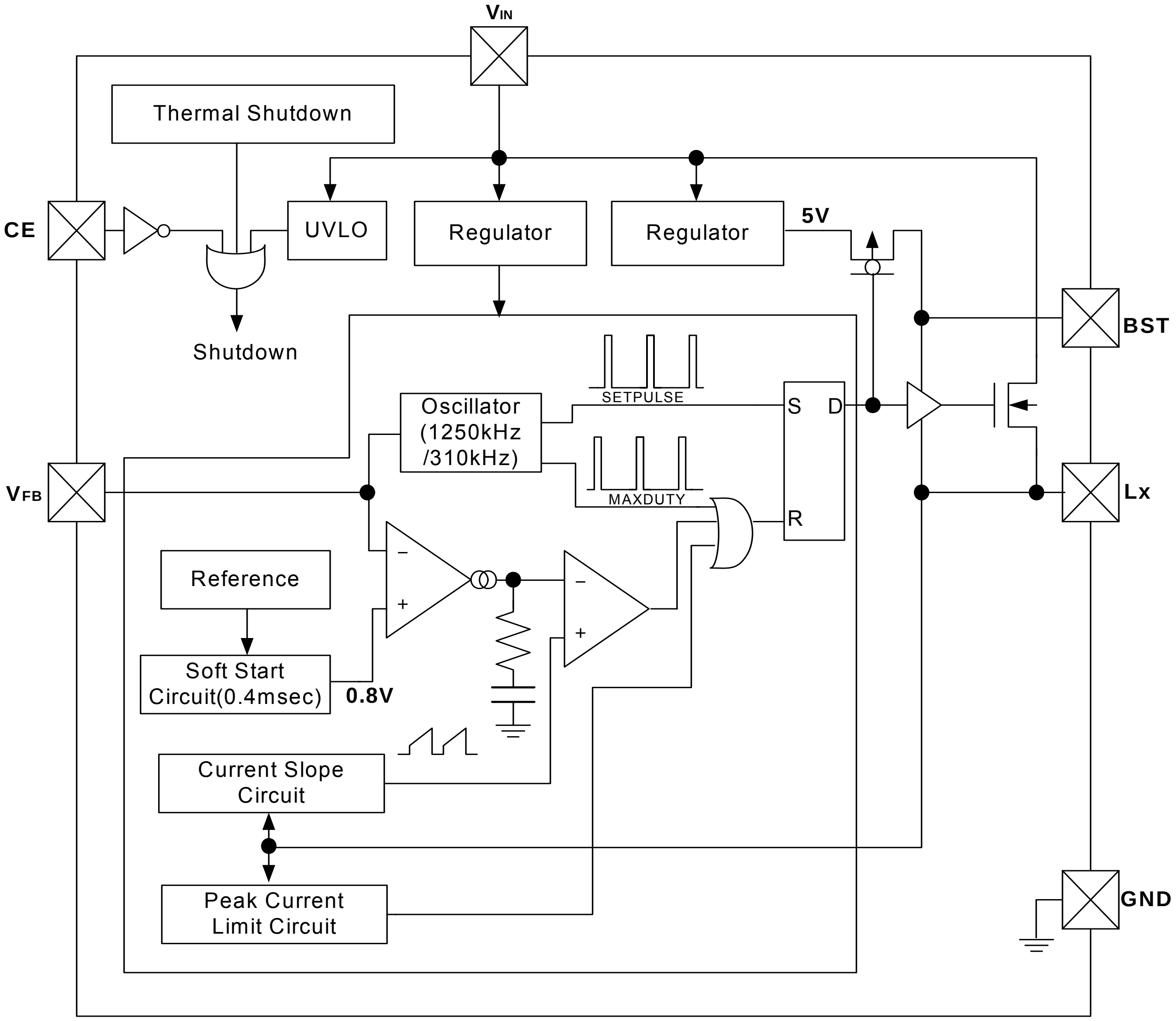
FEATURES

- Operating Voltage ··· 4.5V~30V
- Internal Nch MOSFET Driver································· Typ.R_{ON}=0.35Ω
- 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)
- Short protection for output ······································· Fold Back
- Ceramic Capacitor compatible
- Stand-by function ··· Typ. 0μA
- Package ··· SOT-23-6W

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

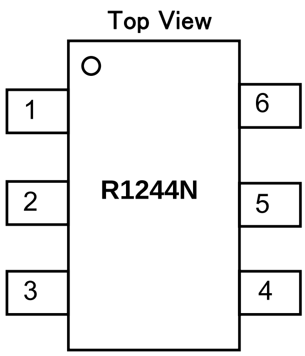


SELECTION GUIDE

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1244N001B-TR-FE	SOT-23-6W	3,000 pcs	Yes	Yes

PIN CONFIGURATION

- **SOT-23-6W**



PIN DESCRIPTION

- **R1244N001B**

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

ABSOLUTE MAXMUM RATINGS

(GND=0V)

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

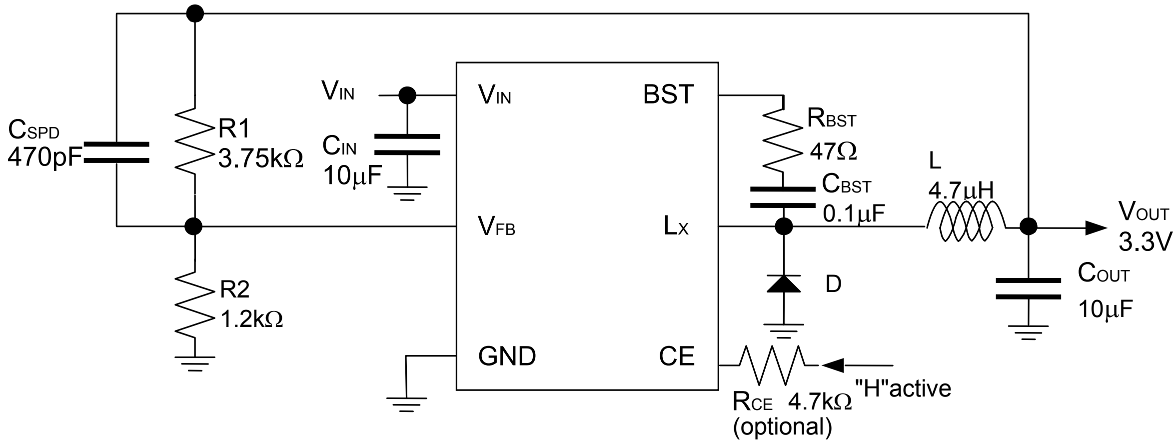
(Otherwise notified in Conditions, V_{IN}= 12V, Ta=25ºC)

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 Detector Voltage	Falling		V_{UVLO2} -0.2		V
V_{UVLO2}	UVLO Released Voltage	Rising	3.7	4.0	4.2	V
V_{FB}	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
f_{osc}	Oscillator Frequency		1000	1250	1500	kHz
f_{FLB}	Fold back Frequency	V_{FB}<0.56V		310		kHz
Maxduty	Oscillator Maximum. Duty Cycle			85		%
t_{MIN}	Minimum On Time			100		ns
t_{start}	Soft-start Time	V_{FB}=0.72V	0.2	0.4	0.6	ms
R_{LXH}	L_X High Side Switch ON Resistance			0.35		Ω
I_{LXHOFF}	L_X High Side Switch Leakage Current			0	5	μA
I_{LIMLXH}	L_X High Side Switch Limited Current			2.0		A
V_{CEH}	CE "H" Input Voltage		1.6			V
V_{CEL}	CE "L" Input Voltage				0.3	V
I_{FB}	V_{FB} Input Current		-1.0		1.0	μA
I_{CEH}	CE "H" Input Current		-1.0		1.0	μA
I_{CEL}	CE "L" Input Current		-1.0		1.0	μA
T_{TSD}	Thermal Shutdown Detect Temperature	Hysteresis 30ºC		160		ºC
$I_{standby}$	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)

● **Technical Notes on External Components**

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 placed close to the IC.

If the impedance of power line and ground line is high, the internal voltage level may shift by the switching current and unstable operation may result. Make the power line and GND line sufficient. Step down regulator draws large current from the power supply and large switching current flows through the GND line, the inductor, Lx line, V_{OUT} line, therefore precaution for layout is necessary. Besides, the wiring between the divider resistor(R1) for setting output voltage and the inductor, and the wiring between the load and the inductor must be separated.

Ceramic capacitors have very low equivalent series resistance(ESR) and provide the best performance for the R1244N001B. Good values of C_{IN} capacitor between V_{IN} and GND is equal or more than 10μF, and good values of C_{OUT} capacitor is equal or more than 10μF if the output voltage, $V_{OUT} \geq 1.8V$. If the output voltage, $V_{OUT} < 1.8V$, equal or more than 20μF is recommended. Keep in mind that depending on the ceramic capacitor, the voltage bias characteristics and the temperature characteristics are different.

Select the inductor value in the range between 4.7μH and 10μH if the output voltage, $V_{OUT} \geq 5V$, 4.7μH if the output voltage is $5V > V_{OUT} \geq 1.8V$, and 2.2μH if the output voltage $V_{OUT} < 1.8V$. Phase compensation of this IC has been made according to the combination of these inductance values and C_{OUT} ceramic capacitor values. If the inductance value is smaller than the recommendation value, the over-current protection circuit may work by increasing the peak switching current at large load current.

Over-current protection circuit is influenced by self-heating of the IC by the operation and the condition of the heat radiation.

A Schottky diode is recommended for the catch diode. Choose the diode with small terminal capacitance, Ct. If Ct is too large, during the on time of switching, large switching current flows, and unstable operation may result.

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

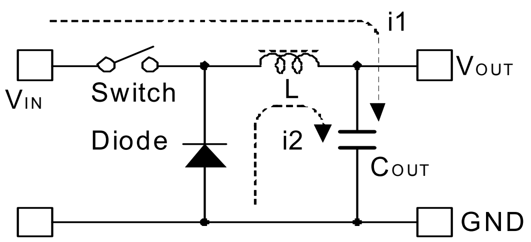
Symbol	Condition	Value	Parts Name	MFR
C_{IN}		10μF/50V 10μF/50V	UMK325BJ106MM-T KTS500B106M55N0T00	TAIYO YUDEN Nippon Chemi-Con
C_{OUT}	V_{OUT} >10V 10V> V_{OUT} >1.8V V_{OUT} <1.8V	10μF/50V 10μF/50V 10μF/25V 22μF/10V	UMK325BJ106MM-T KTS500B106M55N0T00 GRM31CR71E106K GRM31CR71A226M NOTE: The value of C_{OUT} depends upon the setting output voltage.	TAIYO YUDEN Nippon Chemi-Con muRata muRata
C_{BST}		0.1μF/50V	GRM21BB11H104KA01L	muRata
R_{BST}		47Ω		
L	40V/2.0A	10μH 4.7μH 2.2μH	SLF6045T-100M1R6-3PF SLF7045T-4R7M2R0-PF VLCF4020T-2R2N1R7	TDK TDK TDK
D	30V/2.0A 40V/2.0A 30V/1.5A 40V/2.0A	0.32V 0.49V 0.42V 0.43V	CMS06 CMS11 MA22D28 MA24D60 NOTE: Diode depends upon the input voltage and output Current.	TOSHIBA TOSHIBA Panasonic Panasonic
R_{CE}	In the IC, ESD protection diode is connected between CE pin and V_{IN} pin. If there is a possibility that the CE pin voltage becomes higher than the V_{IN} pin voltage, it is recommended to insert a 4.7kΩ resistance or more in order to prevent the large current flowing from CE pin into V_{IN} 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)

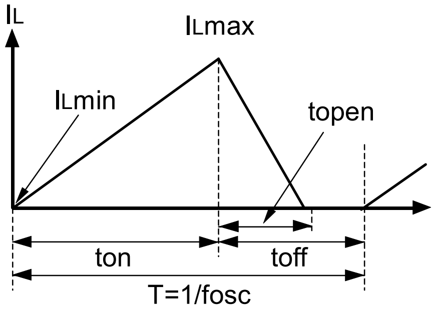
Operation of Step Converter and The Output Current

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 Il_{min} (=0) to reach Il_{max} 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 Il_{max}, and current IL (=I2) flows.

Step 3: IL (=I2) decreases gradually and reaches IL=Il_{min}=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 Il_{min} (>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.)

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

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

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

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

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

Ripple Current is as follows:

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

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

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

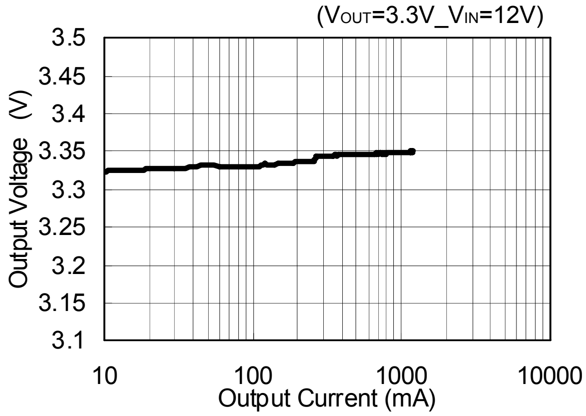
Consider I_{Lmax}, condition of input and output and select external components.

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

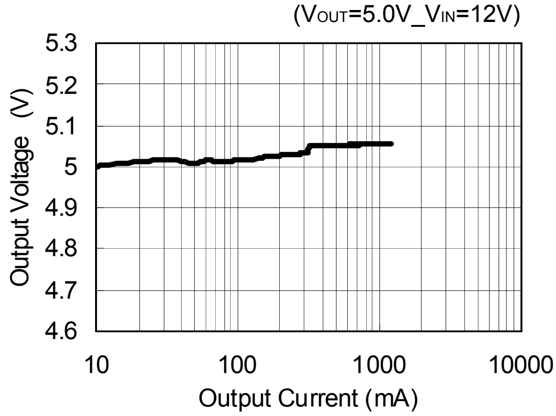
TYPICAL CHARACTERISTICS

1) Output Voltage VS. Output Current

R1244N001B

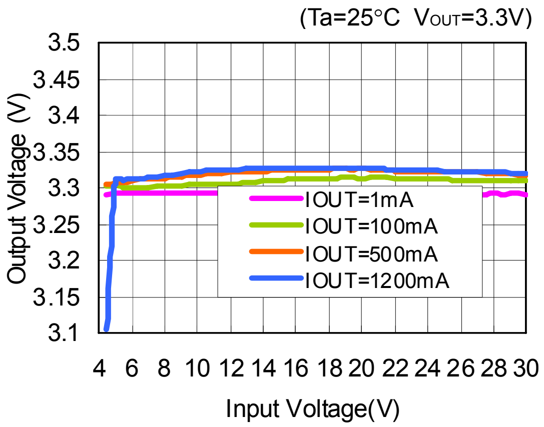


R1244N001B

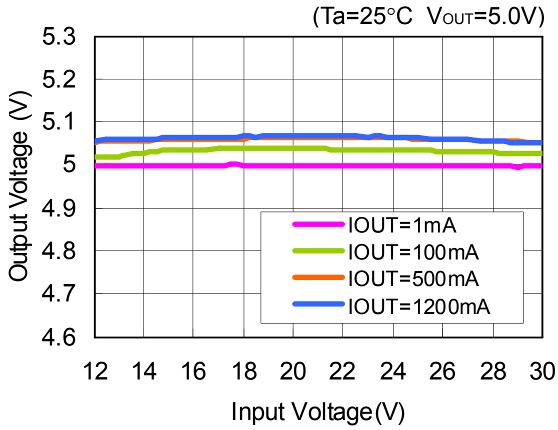


2) Output Voltage VS. Input Voltage

R1244N001B

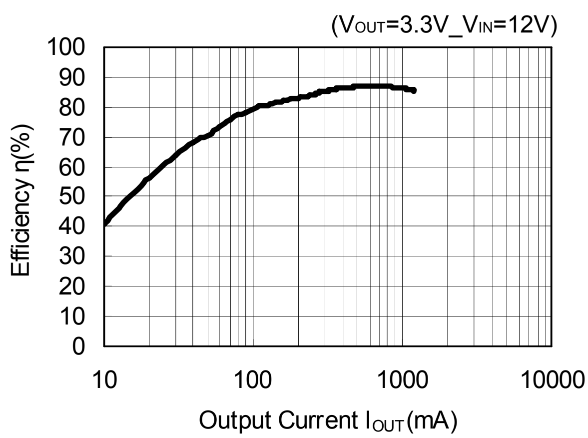


R1244N001B



3) Efficiency VS. output Current

R1244N001B



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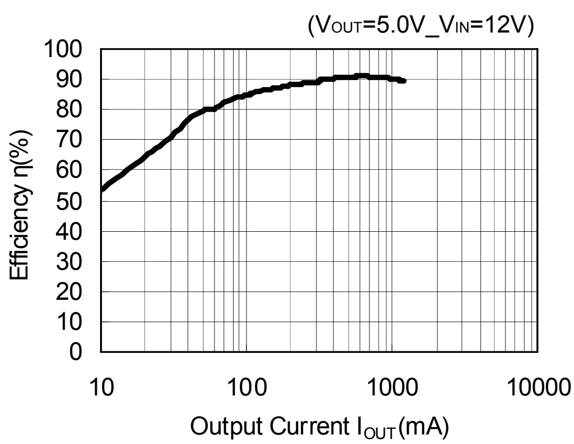
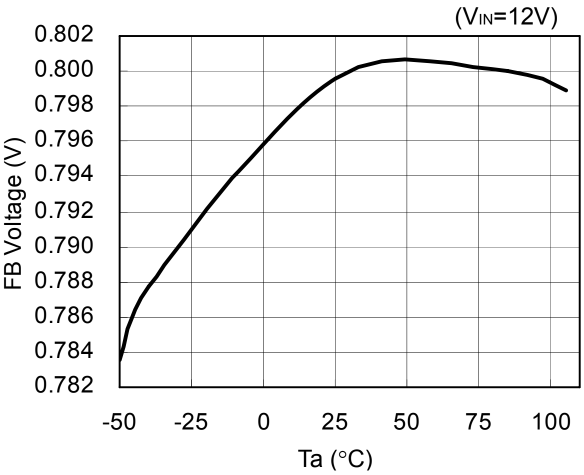
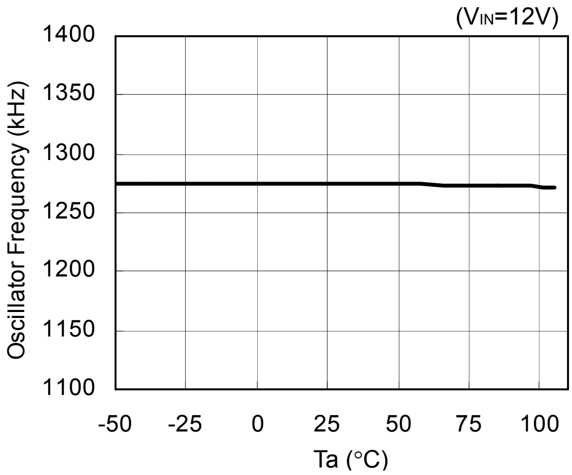


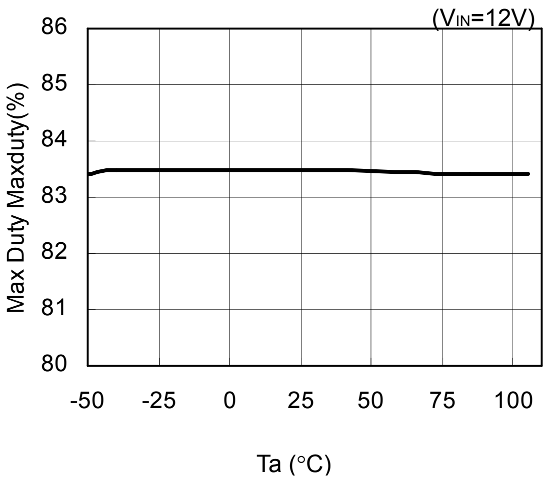
4) **FB Voltage VS. Temperature**
R1244N001B



5) **Oscillator Frequency VS. Temperature**
R1244N001B



6) **Maxduty VS. Temperature**
R1244N001B



7) **Fold-Back Frequency VS. Temperature**
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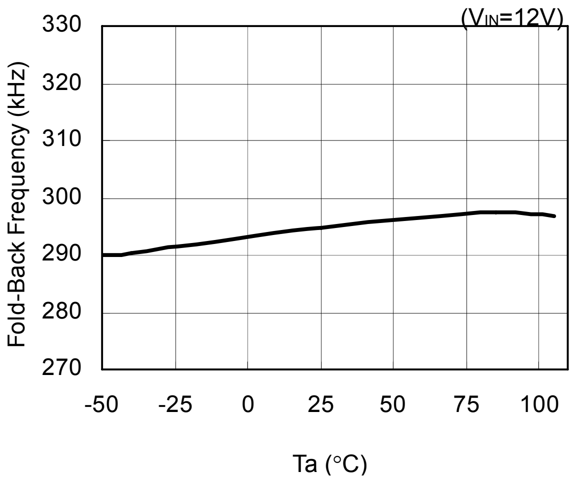

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