

1.2 A, 30 V Step-Down DC/DC Converter

NO.EA-190-240903

OUTLINE

The R1240x is a CMOS-based Step-down DC/DC converter with internal Nch high side Tr. ($0.35\ \Omega$), which can provide the maximum 1.2 A 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 is a 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 1.25 MHz.

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 2 ms 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 4.5 V to 30 V
- Internal Nch MOSFET Driver Typ. $R_{ON} = 0.35\ \Omega$
- Adjustable Output Voltage with External Resistor ... 0.8 V to 15 V
- Feedback Voltage $0.8\ V \pm 1.5\%$
- Peak Current Limit Function Typ. 2.0 A
- UVLO Function
- Operating Frequency 1.25 MHz (Ver. B: 310 kHz, Fold-back Condition)
- Short Protection for Output Ver. A: Latch with 2 ms delay or Ver. B: Fold-back
- Ceramic Capacitor Compatible
- Stand-by Function Typ. 0 μ A
- Package SOT-23-6W, DFN(PL)2527-10

APPLICATIONS

- Digital Home Appliances: Digital TVs, DVD Players
- OA Equipment: Printers, Fax
- Hand-held Communication Equipment, Cameras, VCRs, Camcorders
- Battery-powered Equipment

SELECTION GUIDE

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

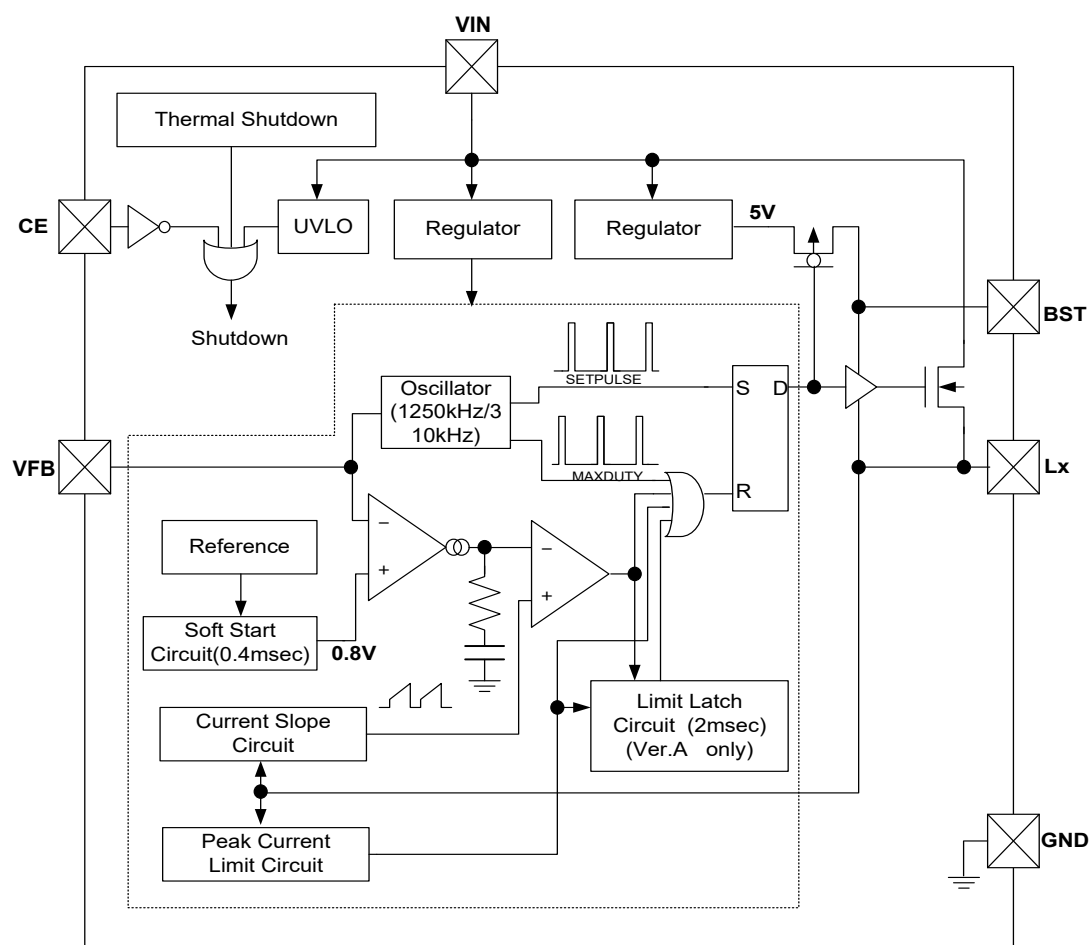
Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1240K003*-TR	DFN(PL)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.

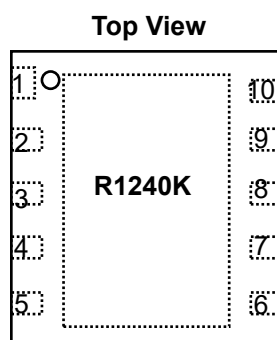
- (A) Latch Type protection
- (B) Fold-back Type protection

BLOCK DIAGRAM

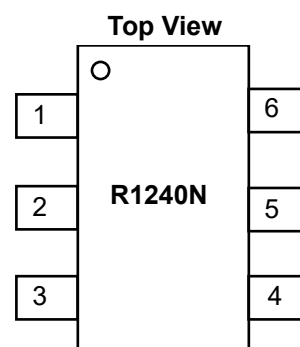
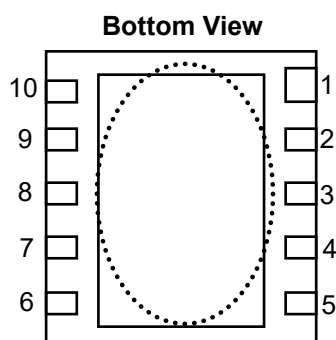


R1240x Block Diagram

PIN DESCRIPTIONS



DFN(PL)2527-10 Pin Configuration



SOT-23-6W Pin Configuration

R1240N001x Pin Description

Pin No.	Symbol	Description
1	CE	Chip Enable Pin, Active with "H"
2	VIN	Power Supply Pin
3	Lx	Lx Switching Pin
4	BST	Bootstrap Pin
5	GND	Ground Pin
6	VFB	Feedback Pin

R1240K003x Pin Description

Pin No.	Symbol	Description
1	Lx	Lx Switching Pin
2	VIN	Power Supply Pin
3	VIN	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	VFB	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 MAXIMUM RATINGS

Absolute Maximum Ratings

(GND = 0 V)

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}	Lx Pin Voltage		−0.3 to V _{IN} +0.3		V
I _{LX}	Lx Pin Current		2		A
V _{CE}	CE Pin input Voltage		−0.3 to V _{IN} + 0.3		V
V _{FB}	VFB Pin Voltage		−0.3 to 4		V
P _D	Power Dissipation*	SOT-23-6W	Standard Land Pattern	430	mW
		DFN(PL)2527-10	Standard Land Pattern	910	
			High Wattage Land Pattern	1400	
T _j	Junction Temperature Range		−40 to 125		°C
T _{stg}	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

Recommended Operating Conditions

Symbol	Item	Rating	Unit
V_{IN}	Operating Input Voltage	4.5 to 30	V
T_a	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

Electrical Characteristics

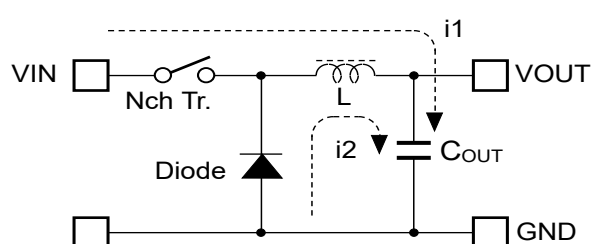
(Otherwise notified, $V_{IN} = 12\text{ V}$, $T_a = 25^\circ\text{C}$)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
I_{IN}	VIN Consumption Current	$V_{IN} = 30\text{ V}$, $V_{FB} = 1.0\text{ V}$		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}	VFB Voltage Tolerance		0.788	0.800	0.812	V
$\Delta V_{FB}/\Delta T_a$	VFB Voltage Temperature Coefficient	$-40^\circ\text{C} \leq T_a \leq 85^\circ\text{C}$		± 150		ppm/ $^\circ\text{C}$
fosc	Oscillator Frequency		1000	1250	1500	kHz
V_{FLB}	Fold-back Frequency (Ver. B)	$V_{FB} < 0.56\text{ V}$		310		kHz
Maxduty	Oscillator Max. Duty Cycle		75	85	90	%
tmin	Minimum On Time			100		nsec
tss	Soft-start Time	$V_{FB} = 0.72\text{ V}$	0.2	0.4	0.6	ms
tdly	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}	VFB 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 30°C		160		$^\circ\text{C}$
Istandby	Standby Current	$V_{IN} = 30\text{ V}$		0	5	μA

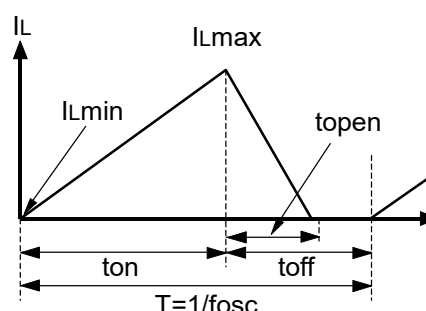
OPERATING DESCRIPTIONS

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

The step-down DC/DC converter charges energy in the inductor (L) when the LX transistor turns on, and discharges the energy from the inductor when LX transistor turns off and controls with less energy loss, so that a lower output voltage (V_{OUT}) than the input voltage (V_{IN}) can be obtained. The operation of the step-down DC/DC converter is explained in the following figures.



Basic Circuit



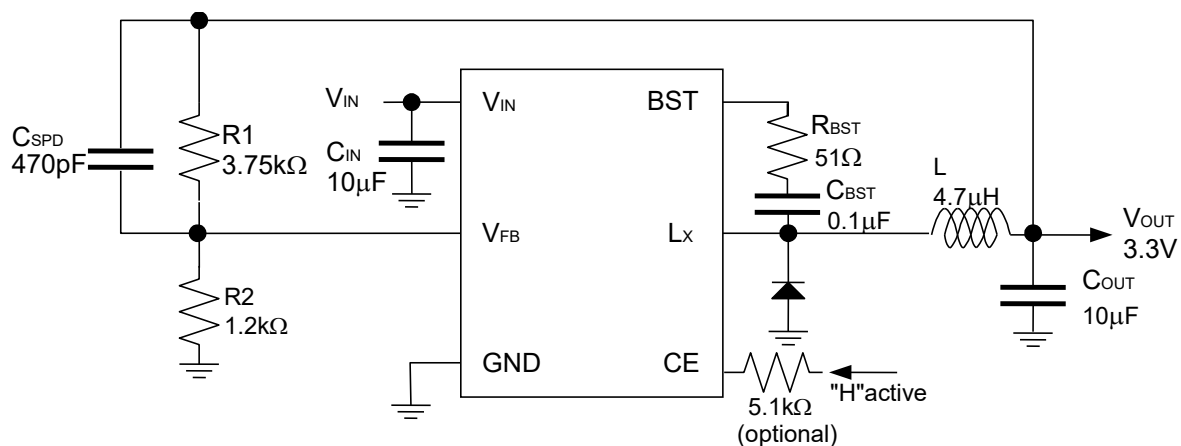
Inductor Current flowing through Inductor

- Step1.** The Nch transistor turns on and the inductor current (i_1) flows, L is charged with energy. At this moment, i_1 increases from the minimum inductor current (IL_{min}), which is 0 A, and reaches the maximum inductor current (IL_{max}) in proportion to the on-time period (ton) of the Nch transistor.
- Step2.** When the Nch transistor turns off, L tries to maintain IL at IL_{max} , so L turns the diode on and the inductor current (i_2) flows into L.
- Step3.** i_2 decreases gradually and reaches IL_{min} after the open-time period ($topen$) of the Nch transistor, and then the diode turns off. This is called discontinuous current mode.
- As the output current (I_{OUT}) increases, the off-time period ($toff$) of the Nch transistor runs out before IL reaches IL_{min} . The next cycle starts, and the Nch transistor turns on and the diode turns off, which means IL starts increasing from IL_{min} . This is called continuous current mode.

In the case of PWM mode, V_{OUT} is maintained by controlling ton . During PWM mode, the oscillator frequency (f_{osc}) is being maintained constant.

APPLICATION INFORMATION

TYPICAL APPLICATION CIRCUIT



R1240x Typical Application Circuit

External Parts

C_{IN}	10 μ F, KTS500B106M55N0T00 (Nippon Chemi-Con)
C_{OUT}	10 μ F, GRM31CR71E106K (Murata)
C_{BST}	0.1 μ F, GRM21BB11H104KA01L (Murata)
L	4.7 μ H, SLF7045T-4R7M2R0-PF (TDK)
D	CMS11 (TOSHIBA)

OUTPUT CURRENT AND SELECTION OF EXTERNAL COMPONENTS

The following equations explain the relationship between output current and peripheral components.

Ripple Current P-P value is described as I_{RP} , ON resistance of switch is described as R_{ONP} , forward drop voltage is described as V_F , and DC resistance of inductor is described as R_L .

First, when the switch is turned on, the following equation is satisfied.

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

Second, when the switch is turned off, the diode is turned on, the following equation is satisfied.

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

Put Equation 2 into Equation 1 to solve the ON duty of the switch ($D_{ON} = t_{on} / (t_{off} + t_{on})$):

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

Ripple Current is described as follows:

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

Peak current that flows through L and the switch is described as follows:

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

Notes: Please consider I_{Lmax} when setting conditions of input and output, as well as selecting the external components. The above calculation formulas are based on the ideal operation of the ICs in continuous mode.

TECHNICAL NOTES

The performance of a power source circuit using this device is highly dependent on a peripheral circuit. A peripheral component or the device mounted on PCB should not exceed its voltage, current or power ratings. When designing a peripheral circuit, please be fully aware of the following points. (Refer to our PCB layout for detailed information).

- 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 VIN 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, Lx, VOUT 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 VIN and GND is more than 10 μF, and C_{OUT} capacitor is more than 10 μF in the case V_{OUT} ≥ 1.8 V or more than 20 μF in the case 1.8 V > 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 4.7 μH and 10μH in the case of V_{OUT} ≥ 5 V, 4.7 μH in the case of 5 V > V_{OUT} ≥ 1.8 V and 2.2 μH in the case of 1.8 V > 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. there is a possibility that the operating of IC becomes unstable by the large switching current, if a diode with a large capacitance between terminals is used. The appropriate total capacitance value of the diode is 100pF or less at 10V(Reverse voltage). Also If a schottky diode with large Vf is used and output is shortened to GND, Lx pin voltage may be beyond the negative voltage rating, and IC may be damaged. Specifically, if Vf value is larger than 0.7V at If = 4A to 5A, the Vf value is too large and risky for using with this IC.
- 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 VFB pin increases, and pickup the noise may result. The recommendation value range of R2 is approximately between 1.2 kΩ to 16 kΩ. If the operation may be unstable, reduce the impedance of VFB pin.

- The current limit value may become extremely large if the output voltage becomes short with a high input voltage condition. (Refer to “THE MINIMUM ON-TIME” mentioned earlier) In the case, we recommend the foldback protection version. Also, please take external measures for current protection such as using a fuse, as necessary.

●THE MINIMUM ON-TIME

The minimum On-Time of the R1240 Series is set at 100 ns (Typ.). The minimum On-Time (100 ns) is determined by considering the tolerable delay time and the necessary stability of the current sense circuits. The R1240 Series has adopted the current control mode system, which does not require any sense resistor. By substituting the R_{ON} (Nch driver's on-resistance) value into the following equation, the I_{LX} (Inductor current) value can be obtained: $V_{IN} - V_{LX} = I_{LX} \times R_{ON}$. I_{LX} can be sensed only while the Nch driver is turned on ($LX = \text{High}$ period). If the I_{LX} is sensed during the switching surge immediately after the Nch driver is turned on, the switching surge may cause the malfunction. To avoid the malfunction caused by the switching surge, disable the current sensing function of Nch driver for a while immediately after the Nch driver is turned on.

Fig. 4 is a graph with the on time on the horizontal axis, and the limit current on the vertical. The graph shows that the delay time is occurred in the limited current circuit within 100 ns because the current sensing is not functioning normally. As a result, the detecting current is increased dramatically.

This could happen in the current control mode system as well. The current control mode system does not function normally under 100 ns but the operation becomes similar operation to the voltage control mode system that is low stable.

For the above reasons, the stability and the over-current limit accuracy of the R1240 Series degrades dramatically under 100 ns. In the case of setting the minimum on time equal or less than 100 ns, an adequate stability has to be ensured by the external parts and also the over current protection circuit has to be designed without depending on the current limit circuit of the IC.

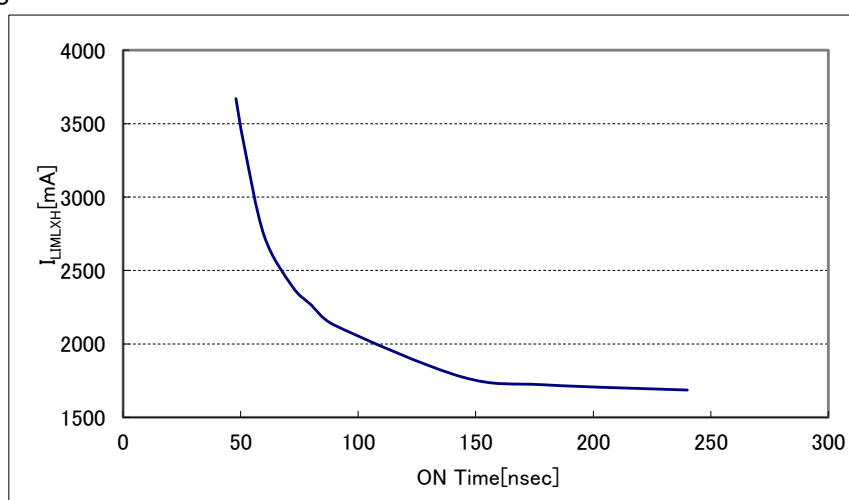


Fig. 4 On-time and Peak Current of L_x pin ($I_{LXLIMIT}$) at Current Limit Detection of L_x pin

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 Components

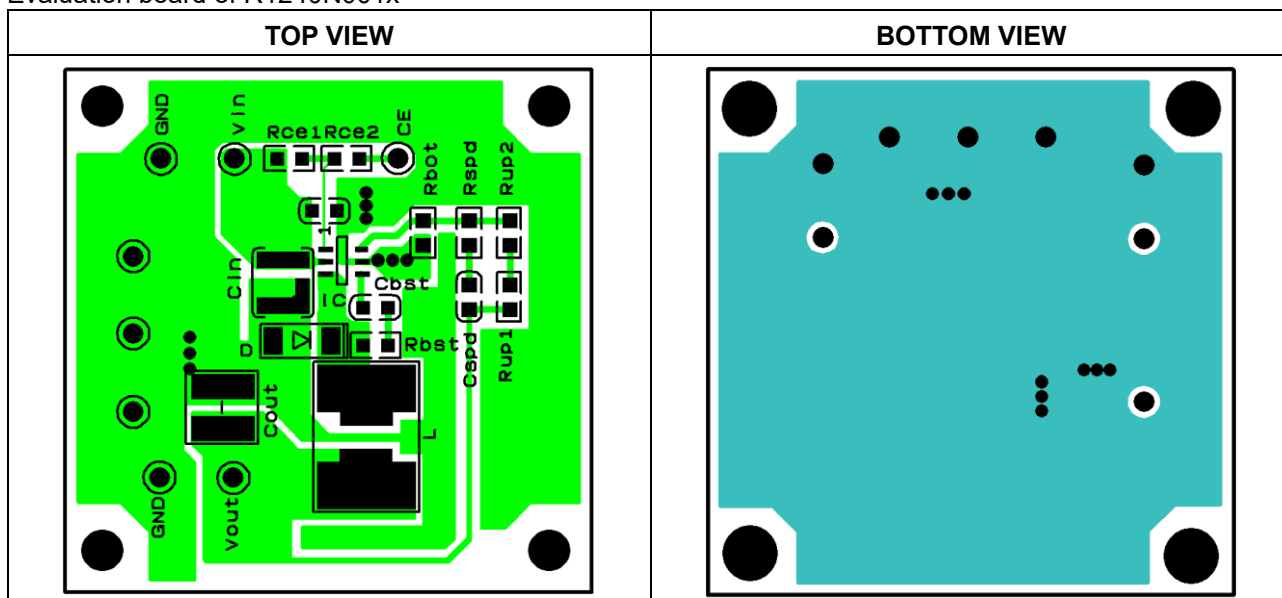
Symbol	Condition	Value	Parts Name	MFR
C _{IN}		10 μF/ 50 V 10 μF/ 50 V 10 μF/ 50 V	UMK325BJ106MM-P CGA6P3X7S1H106K KTS500B106M55N0T00	TAIYO YUDEN TDK Nippon Chemi-Con
C _{OUT}	V _{OUT} > 10 V 10 V > V _{OUT} > 1.8 V V _{OUT} < 1.8 V	10 μF/ 50 V 10 μF/ 50 V 10 μF/ 50 V 10 μF/ 25 V 22 μF/ 10 V	UMK325BJ106MM-P CGA6P3X7S1H106K KTS500B106M55N0T00 GRM31CR71E106K GRM31CR71A226M NOTE: The value of C _{OUT} depends on the setting output voltage.	TAIYO YUDEN TDK Nippon Chemi-Con Murata Murata
C _{BST}		0.1 μF/ 50 V	GRM21BB11H104KA01L	Murata
R _{BST}		51.0 Ω		
L	40 V/ 2.0 A	10 μH 4.7 μH 2.2 μH	SLF6045T-100M1R6-3PF SLF7045T-4R7M2R0-PF VLCF4020T-2R2N1R7	TDK TDK TDK
D	30 V/ 2.0 A 40 V/ 2.0 A	0.32 V 0.49 V	CMS06 CMS11 NOTE: Diode depends on the input voltage and output Current.	TOSHIBA TOSHIBA
R _{CE}	The diode is connected between the CE pin and the VIN 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 VIN pin, it is recommended to connect the 5 kΩ resistance with the CE pin for preventing a large current flows into the VIN pin from the CE pin.			

THE NOTE OF LAYOUT PATTERN

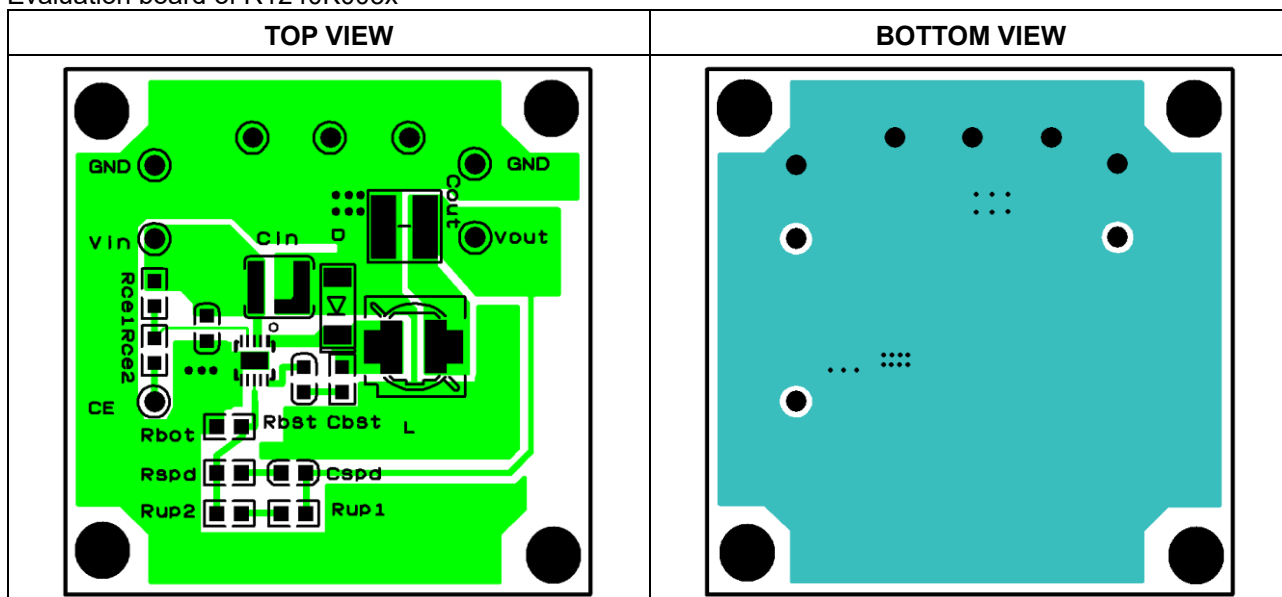
1. The wire of Power line (V_{IN} , GND) should be broad to minimize the parasitic inductance.
The Bypass capacitor must be connected as close as possible in between V_{IN} – GND
2. The wire between Lx pin and the inductor as short as possible to minimize the parasitic inductance
(This Evaluation Board is designed for the product evaluation board. Therefore large inductors or diodes can be set and the large space of Lx area has been secured.)
3. The ripple current flows through the output capacitor. If the GND side of the output capacitor is connected very close to GND pin of the IC, the noise might have a bad impact on the IC. Therefore, the GND side of the output capacitor is better to connect to the outside of the GND of the C_{IN} , or connect to the GND plain layer.
4. R1, R2, Cspd and Rspd should be mounted on the position as close as possible to the FB pin, and away from the inductor and BST pin.
5. The feed-back must be made as close as possible from the Output capacitor (C_{OUT})

PCB LAYOUT

Evaluation board of R1240N001x



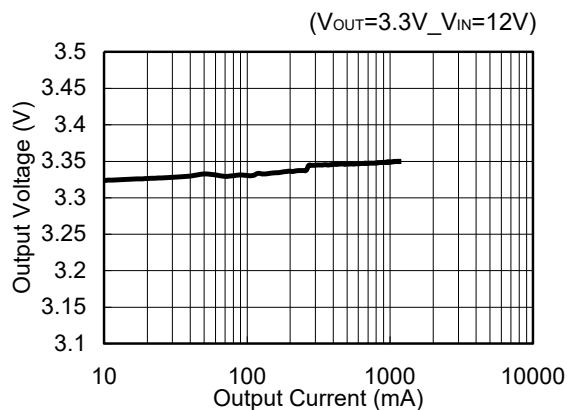
Evaluation board of R1240K003x



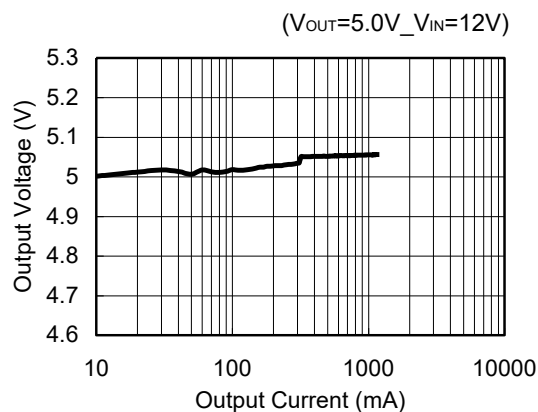
TYPICAL CHARACTERISTICS

1) Output Voltage VS. Output Current

R1240x00Xx

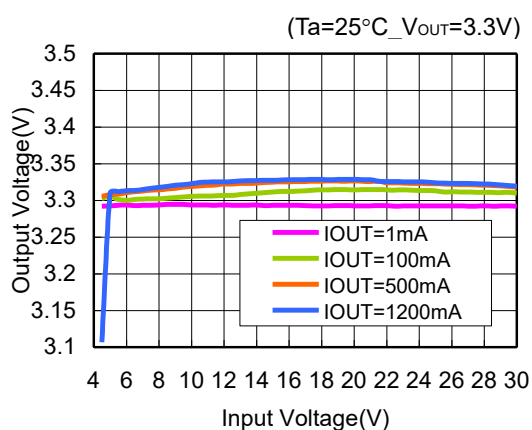


R1240x00Xx

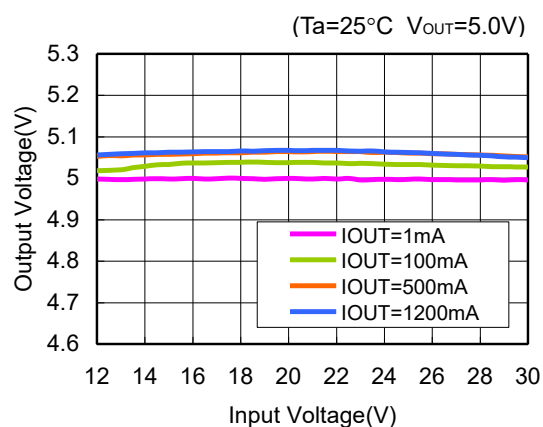


2) Output Voltage VS. Input Voltage

R1240x00Xx

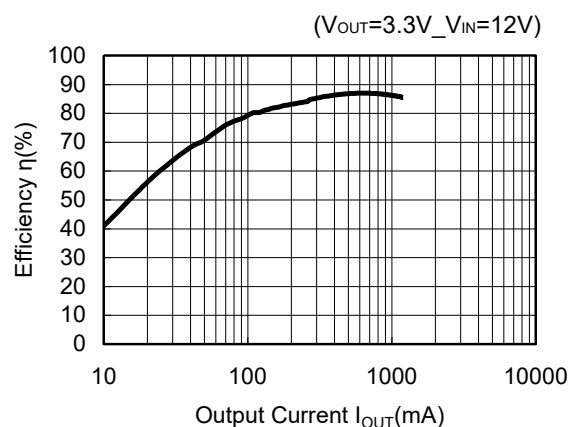


R1240x00Xx

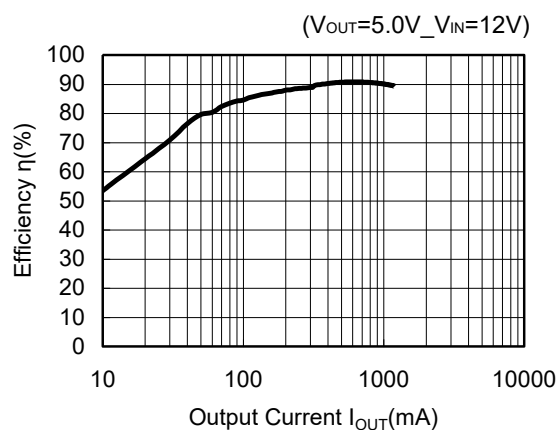


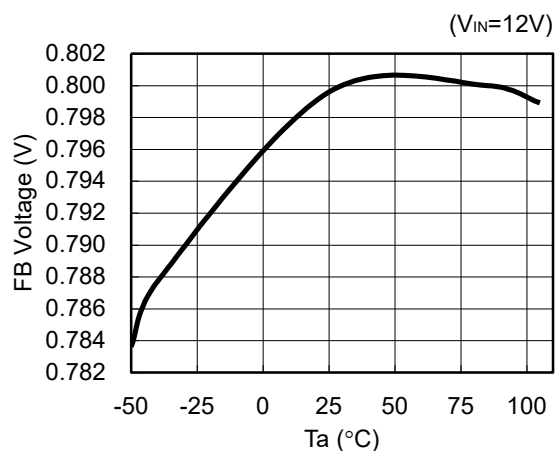
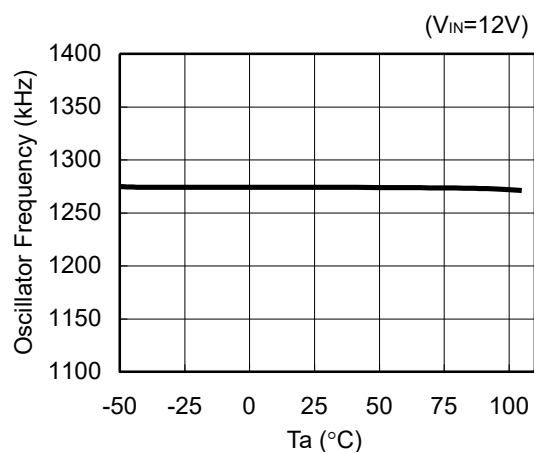
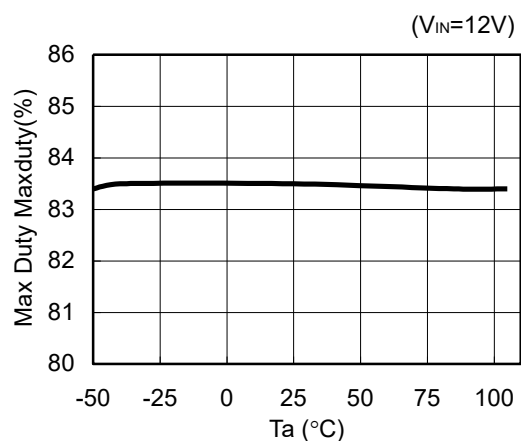
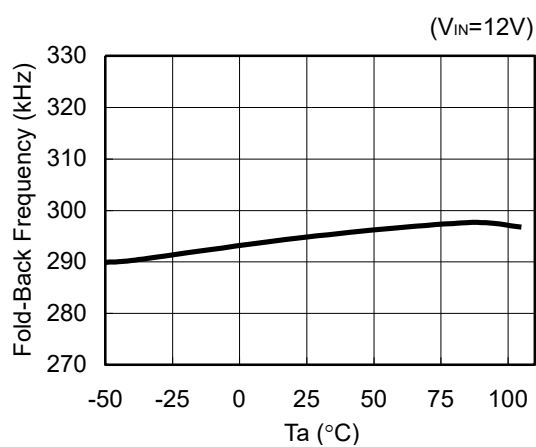
3) Efficiency VS. output Current

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

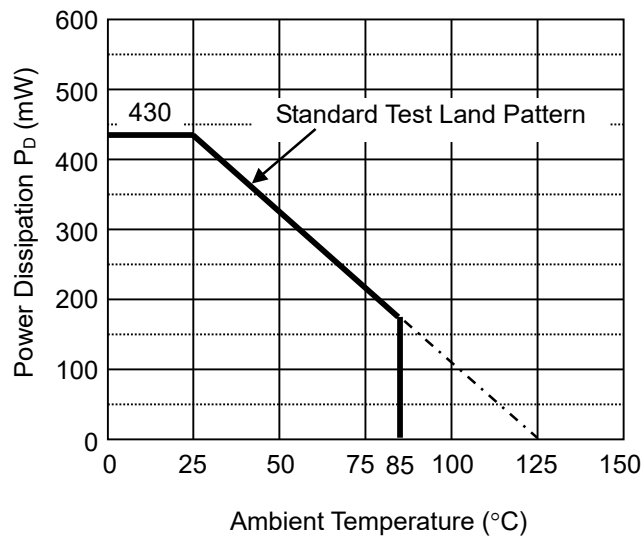
The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following conditions are used in this measurement.

Measurement Conditions

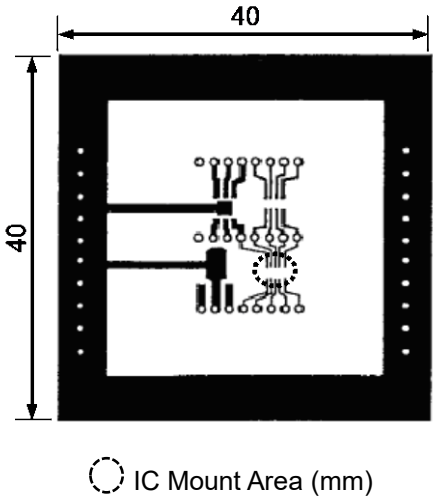
	Standard Test Land Pattern
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Double-Sided Board)
Board Dimensions	40 mm × 40 mm × 1.6 mm
Copper Ratio	Top Side: Approx. 50% Bottom Side: Approx. 50%
Through-holes	φ 0.5 mm × 44 pcs

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

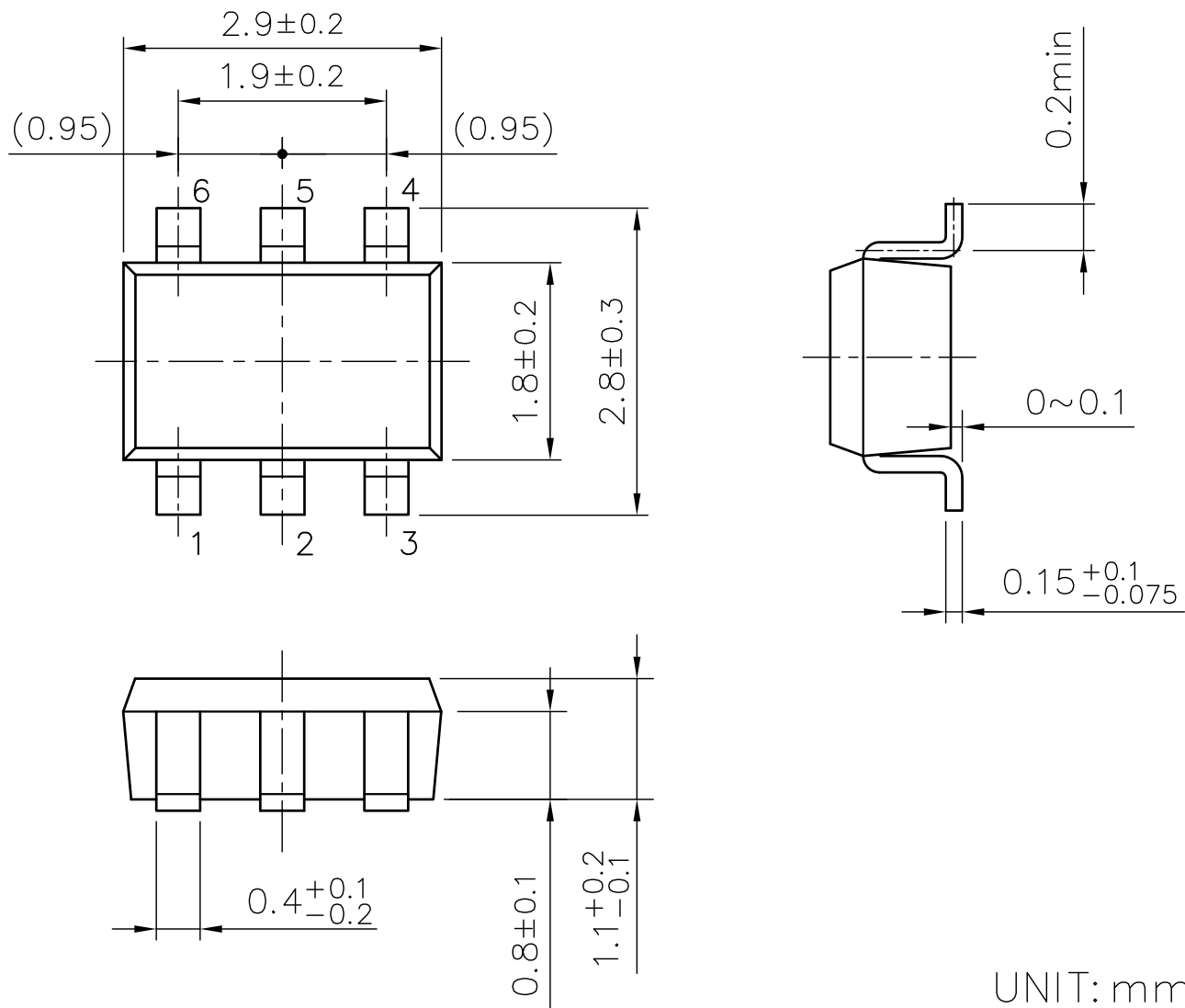
	Standard Test Land Pattern
Power Dissipation	430 mW
Thermal Resistance	$\theta_{ja} = (125 - 25^{\circ}\text{C}) / 0.43 \text{ W} = 233^{\circ}\text{C/W}$



Power Dissipation vs. Ambient Temperature



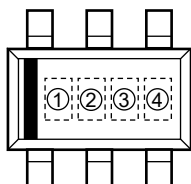
Measurement Board Pattern



SOT-23-6W Package Dimensions (Unit: mm)

R1240N SERIES MARK SPECIFICATION

- SOT-23-6W



①, ② : Product Code (Refer to Part Number vs. Product Code)

③, ④ : Lot Number

- Part Number vs. Product Code

Part Number	Product Code	
	①	②
R1240N001A	8	A
R1240N001B	8	B

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

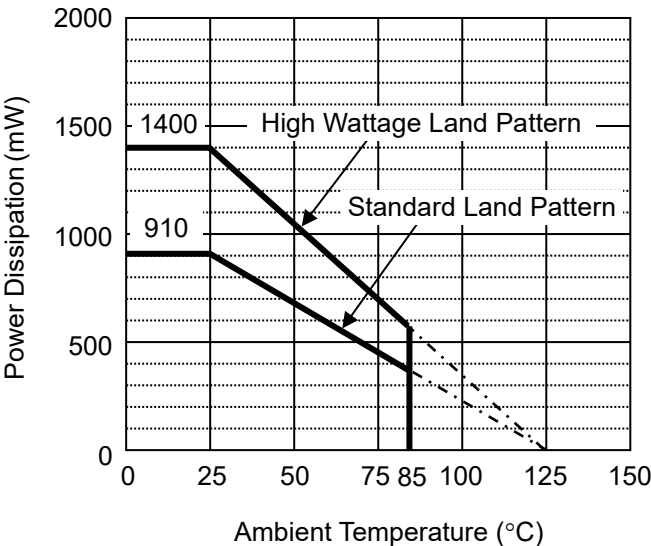
Measurement Conditions

	High Wattage Land Pattern	Standard Land Pattern
Environment	Mounting on Board (Wind Velocity = 0 m/s)	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)	Glass Cloth Epoxy Plastic (Double-Sided Board)
Board Dimensions	35 mm × 90 mm × 0.8 mm	40 mm × 40 mm × 1.6 mm
Copper Ratio	Outer Layers (First and Fourth Layers): Approx. 15% Inner Layers (Second and Third Layers): Approx. 15%	Top Side: Approx. 50% Bottom Side: Approx. 50%
Copper Foil Thickness	Outer Layers (First and Fourth Layers): Approx. 35 μm Inner Layers (Second and Third Layers): Approx. 18 μm	Top Side: Approx. 35 μm Bottom Side: Approx. 35 μm
Through-holes	φ 0.3 mm × 9 holes (connecting outer and inner layers to a package tab) φ 0.5 mm × 10 holes (connecting pins)	φ 0.54 mm × 30 holes

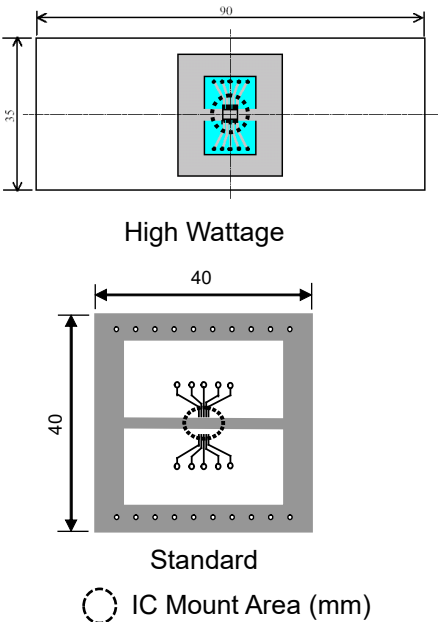
Measurement Result

(Ta = 25°C, Tjmax = 125°C)

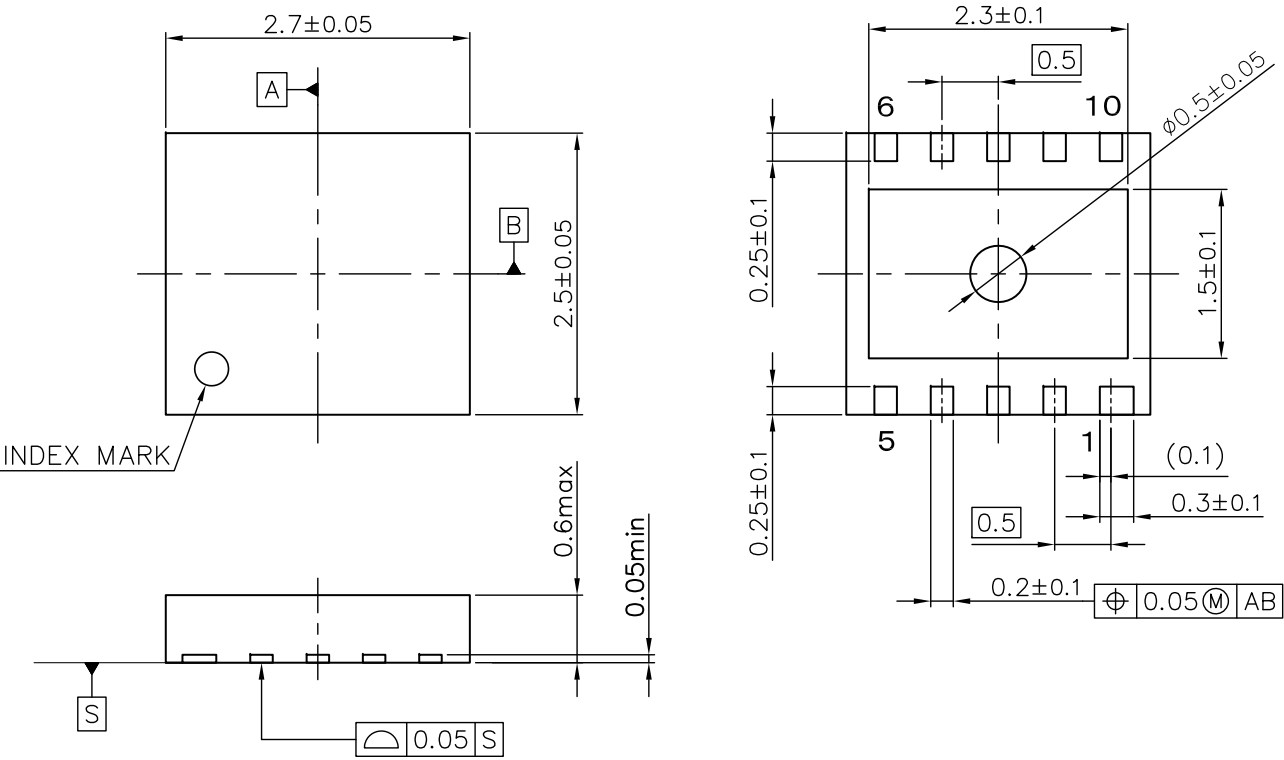
	High Wattage Land Pattern	Standard Land Pattern
Power Dissipation	1400 mW (Tjmax = 125°C)	910 mW (Tjmax = 125°C)
Thermal Resistance	$\theta_{ja} = (125 - 25^{\circ}\text{C}) / 1.4 \text{ W} = 71^{\circ}\text{C/W}$	$\theta_{jc} = (125 - 25^{\circ}\text{C}) / 0.91 \text{ W} = 110^{\circ}\text{C/W}$



Power Dissipation vs. Ambient Temperature



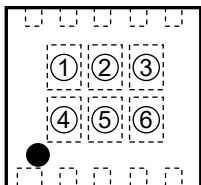
Measurement Board Pattern



DFN(PL)2527-10 Package Dimensions (mm)

R1240K SERIES MARK SPECIFICATION

- DFN(PL)2527-10



① to ④ : Product Code (Refer to Part Number vs. Product Code)

⑤ , ⑥ : Lot Number

- Part Number vs. Product Code

Part Number	Product Code			
	①	②	③	④
R1240K003A	A	Q	0	3
R1240K003B	A	Q	0	4

1. The products and the product specifications described in this document are subject to change or discontinuation of production without notice for reasons such as improvement. Therefore, before deciding to use the products, please refer to our sales representatives for the latest information thereon.
2. The materials in this document may not be copied or otherwise reproduced in whole or in part without the prior written consent of us.
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 - Equipment Used in the Deep Sea
 - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
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 - Fire Alarms / Intruder Detectors
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 - Various Safety Devices
 - Traffic control system
 - Combustion equipment

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8. **Quality Warranty**
 - 8-1. **Quality Warranty Period**

In the case of a product purchased through an authorized distributor or directly from us, the warranty period for this product shall be one (1) year after delivery to your company. For defective products that occurred during this period, we will take the quality warranty measures described in section 8-2. However, if there is an agreement on the warranty period in the basic transaction agreement, quality assurance agreement, delivery specifications, etc., it shall be followed.
 - 8-2. **Quality Warranty Remedies**

When it has been proved defective due to manufacturing factors as a result of defect analysis by us, we will either deliver a substitute for the defective product or refund the purchase price of the defective product.

Note that such delivery or refund is sole and exclusive remedies to your company for the defective product.
 - 8-3. **Remedies after Quality Warranty Period**

With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
9. Anti-radiation design is not implemented in the products described in this document.
10. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
11. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
12. Warning for handling Gallium and Arsenic (GaAs) products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.
13. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.



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