

## 600 nA I<sub>Q</sub> Low Quiescent Current Boost DC/DC Converter for Energy Harvester

No.EA-423-231002

### OVERVIEW

R1810x is a boost DC/DC converter for electrical power storage devices, especially dedicated for 1 cell photovoltaic energy harvester since the start-up voltage is Typ.0.35V.

This product can start up with only 9μW, and applicable for charging 1 cell photovoltaic element. A system which is working under low-illuminance environment can be composed with the R1810x.

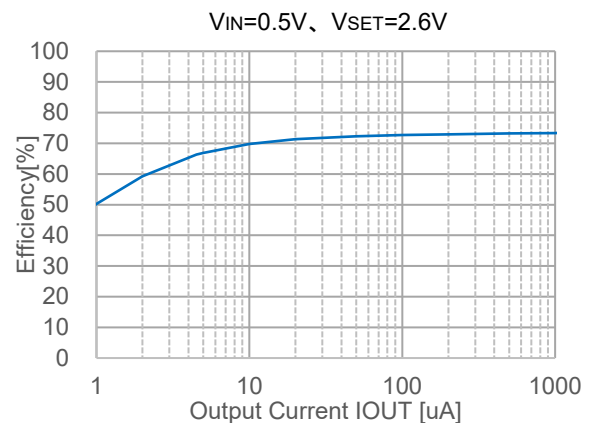
### KEY BENEFITS

- Providing a low quiescent current (I<sub>Q\_VOUT</sub> = Typ.600 nA), and high efficiency (66%@ I<sub>OUT</sub>=5 μA)
- Start up with low input energy, 9 μW (low illuminance) is possible.
- Maximum power point control function is built-in.

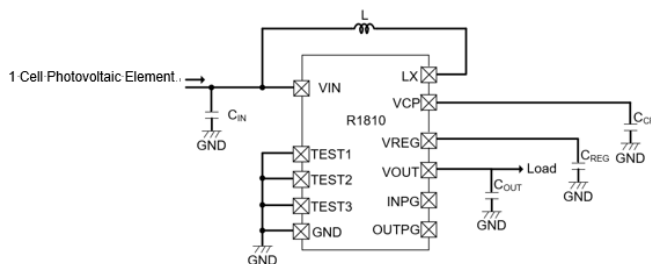
### KEY SPECIFICATIONS

- Start-up voltage: Typ. 0.35V  
Max. 0.50V (0°C ≤ Ta ≤ 65°C),  
Max. 0.55V (-40°C ≤ Ta ≤ 85°C)
- Input Voltage Range: 0.2 V to 2.1 V (V<sub>SET</sub>=2.7V)
- Output Voltage Range: 2.3 V to 4.5 V
- Output Voltage Accuracy: ±5.0%
- Low current consumption:  
Typ.600 nA (Ta = 25°C, at no load)
- Start-up power: 9 μW (V<sub>MPSET</sub> = 0.5V / V<sub>SET</sub> = 2.6V)
- Maximum Power Point Control Voltage Setting:  
from 0.2V to 2.1V , in 50 mV increments
- Input Power Good Function
- Output Power Good Function

### EFFICIENCY CURVE



### TYPICAL APPLICATION



L = 22 μH, C<sub>IN</sub> = 22 μF, C<sub>CP</sub> = 22 nF, C<sub>REG</sub> = 4.7 μF  
C<sub>OUT</sub> = 4.7 μF

### SELECTION GUIDE

Product name	Package	Quantity per Reel
R1810Zxxx\$-E2-F	WLCSP-15-P1	5,000 pcs
R1810Lxxx\$-E2	DFN2735-14	5,000 pcs

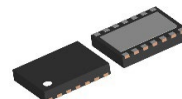
xxx: Select the combination Code number of the set output voltage (V<sub>SET</sub>) and the set maximum power voltage (V<sub>MPSET</sub>) ex. 001  
Refer to the Product-specific Electrical Characteristics for detail information.

\$: Set output power good low (PGL) (Refer to selection guide.)

### PACKAGES



**WLCSP-15-P1**  
2.88 x 1.68 x 0.36 (mm)



**DFN2735-14**  
3.5 x 2.7 x 0.6 (mm)

### APPLICATION

- Energy harvesting modules such as 1 cell photovoltaic element /thermoelectric power generation.

## SELECTION GUIDE

The set output voltage, the set maximum power point control voltage, and the output power good setting are user-selectable options.

### Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1810Zxxx\$-E2-F	WLCSP-15-P1	5,000 pcs	Yes	Yes
R1810Lxxx\$-E2	DFN2735-14	5,000 pcs	Yes	Yes

xxx: Select the combination of the set output voltage ( $V_{SET}$ ) and the set maximum power point control voltage ( $V_{MPSET}$ ) by the code number. Ex. 001

Output voltage: from 2.3 V to 4.5 V in 0.1 V increments

Maximum power point control voltage: from 0.2 V to 2.1 V in 0.05 V increments

Refer to the Product-specific Electrical Characteristics for detail information.

\* Contact our sales representatives for other codes.

It is recommended to set as  $V_{SET} \geq V_{MPSET} + 1.0$  V.

\$: Set output power good low (PGL) <sup>(1)</sup>

A ; Vset x 80%

B ; Vset x 70%

C ; Vset x 60%

D ; Vset x 50%

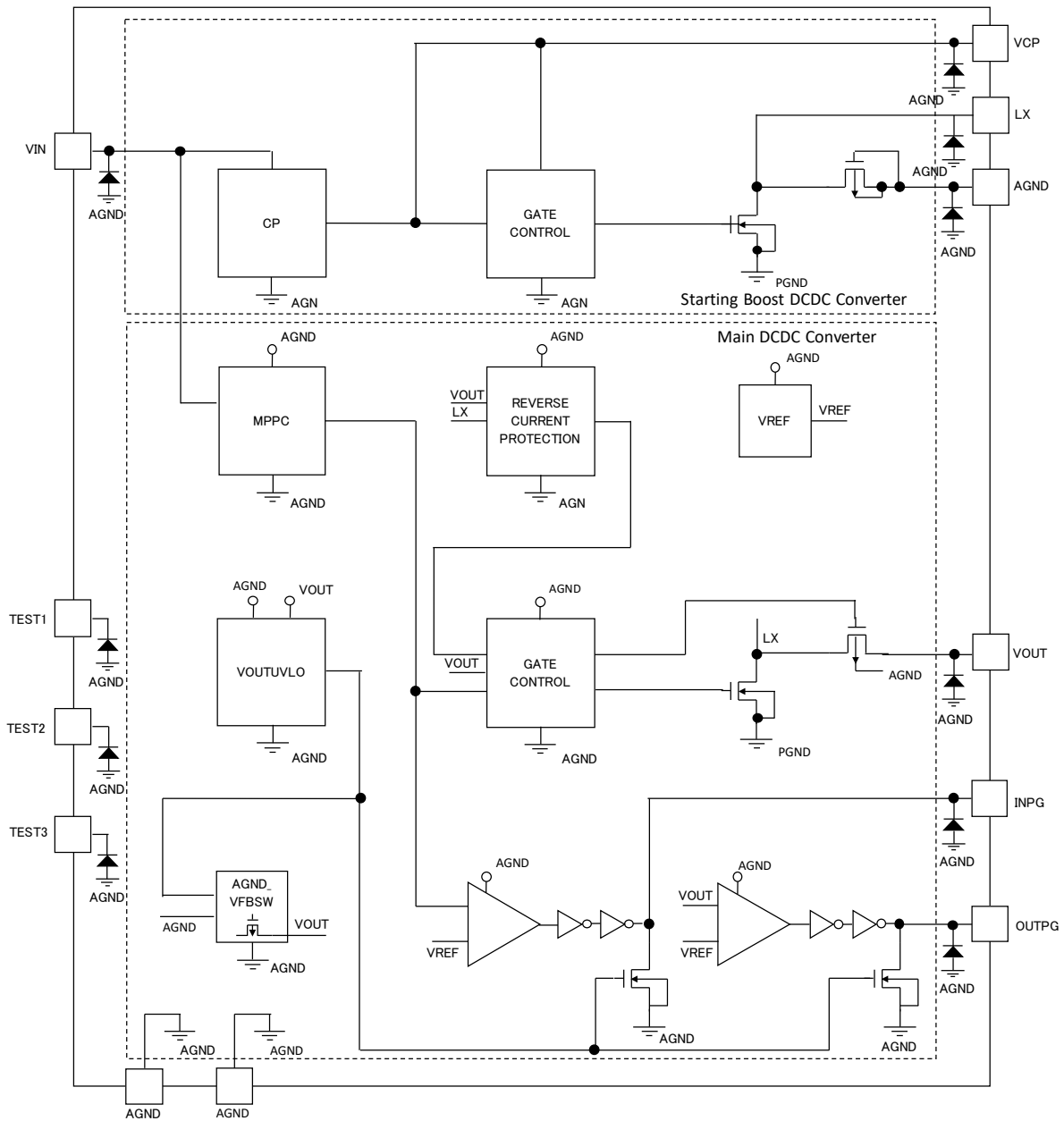
The accuracy of the OUTPG detection voltage depends on the output set voltage.

		Set Output Voltage Vset [V]																						
		2.3	2.4	2.5	2.6	2.7	2.8	2.9	3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4	4.1	4.2	4.3	4.4	4.5
\$	A	-	-	-	5.0%								4.0%											
	B	-	-	-	-	-	-	-	-	5.0%	4.0%													
	C	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0%									
	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0%

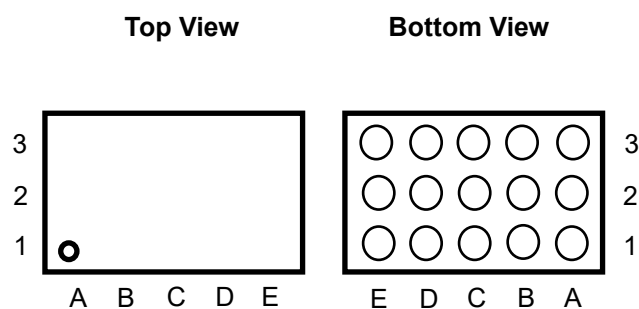
“-“; The OUTPG function cannot be used. please set the OUTPG pin to open.

<sup>(1)</sup> OUTPG outputs "Low" when the output is below the threshold of PGL according to the table above.

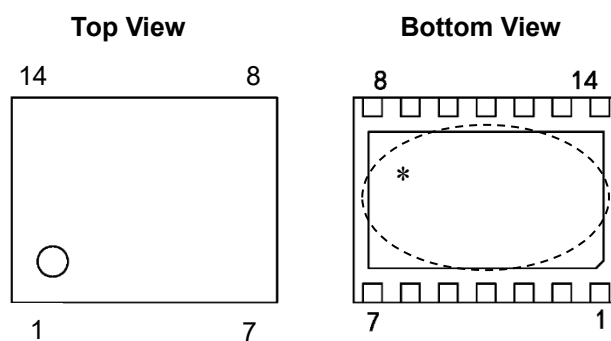
# BLOCK DIAGRAM



## PIN DESCRIPTIONS



**R1810Z (WLCSP-15-P1) Pin Configuration**



**R1810L (DFN2735-14) Pin Configuration**

- \* The tab on the bottom of the package enhances thermal performance and is electrically connected to GND (substrate level). The backside tab should be connected to the ground plane on the board.

## R1810Z 、 R1810L Pin Description

Symbol	Description	I/O	Pin No.	
			R1810Z	R1810L
VIN	Power Supply Input Pin. Apply input voltage between VIN pin and GND. Connect the input capacitor between the VIN pin and GND.	I	C3	5
VOUT	Output voltage pin of step-up DC / DC converter. Connect the output load between VOUT pin and GND. Connect the output capacitor between VOUT pin and GND.	O	D1,E1	8
INPG	Power good output pin for power input voltage ( $V_{IN}$ ). "High" level of the output voltage for CMOS output is the output voltage ( $V_{OUT}$ ) of the step-up DC / DC converter. Outputs "High" when $V_{IN}$ exceeds $V_{MPSET}$ and $V_{OUT}$ exceeds $V_{OUTUVLOR}^{*1}$ . Please left open when not in use.	O	A1	13
VREG	Output pin of step-up DC / DC converter (internal power supply) for startup. Supply voltage to the main DC / DC converter circuit that produces VOUT at startup. Please connect a capacitor between VREG pin and GND for voltage stabilization.	O	C1	11
LX	The drain of the internal MOSFET. Connect an inductor between VIN pin and LX pin.	O	D2,D3	6
VCP	Output pin of the startup internal step-up charge pump (internal power source). Supply voltage to the start-up DC / DC converter circuit that generates the VREG voltage at startup. Please connect a capacitor between the VCP pin and GND for voltage stabilization.	O	B1	12
OUTPG	Power good output pin for $V_{OUT}$ . "High" level of the output voltage for CMOS output is $V_{OUT}$ . Outputs "High" when $V_{OUT}$ is $V_{OUTPGH}^{*1}$ or higher, and outputs "Low" when $V_{OUT}$ is $V_{OUTPGL}^{*1}$ or lower. Please left open when not in use.	O	A2	14
TEST 1,2,3	Test pins for the IC. Be sure to connect to AGND.	—	C2,B2,A3	9,4,1
AGND	Analog ground of the internal circuit. Please connect to the PGND and GND.	—	B3	2
PGND	Power ground of the internal circuit. Please connect to the AGND and GND.	—	E2,E3	7
NC	No connection. It is recommended to make it open to prevent short circuit with adjacent pins during mounting.	—	—	3,10

\*1 : Refer to electrical characteristics.

## ABSOLUTE MAXIMUM RATINGS

### Absolute Maximum Ratings

(GND = 0 V)

Symbol	Parameter	Rating	Unit
$V_{IN}$	Input Pin Voltage	-0.3 to 2.3	V
$V_{LX}$	LX Pin Voltage	-0.3 to 6.5	V
$V_{OUT}$	Output Pin Voltage	-0.3 to 6.5	V
$V_{REG}$	Output Voltage of Boost DC to DC Converter for Start-up	-0.3 to 6.5	V
$V_{CP}$	Output Pin Voltage of Charge Pump Circuit	-0.3 to 6.5	V
$V_{TEST1\ to\ 3}$	Pin Voltage for Testing	-0.3 to 6.5	V
$V_{INPG}$	INPG Pin Voltage	-0.3 to 6.5	V
$I_{INPG}$	INPG Pin Current	10	mA
$V_{OUTPG}$	OUTPG Pin Voltage	-0.3 to 6.5	V
$I_{OUTPG}$	OUTPG Pin Current	10	mA
$P_D$	Power Dissipation	Refer to the Power Dissipation in the supplementary item	
$T_j$	Junction Temperature Range	-40 to 85	°C
$T_{stg}$	Storage Temperature Range	-55 to 125	°C

### ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings are not assured.

## RECOMMENDED OPERATING CONDITIONS

### Recommended Operating Conditions

Symbol	Parameter	Rating	Unit
$V_{IN}$	Input Voltage <sup>(1)</sup>	0.35 to 2.1	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 they are used over such conditions by momentary electronic noise or surge. The semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

<sup>(1)</sup> The lower limit of the input voltage depends on the set output voltage. Please refer to Page.22 for details.

## ELECTRICAL CHARACTERISTICS

The specifications surrounded by   are guaranteed by design at  $-40^{\circ}\text{C} \leq T_a \leq 85^{\circ}\text{C}$ , not mass production tested.

### R1810x Electrical Characteristics

( $T_a = 25^{\circ}\text{C}$ )

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$I_{Q\_VOUT}$	VOUT Pin Quiescent Current	$V_{IN} = 0.5\text{V}$ , $V_{OUT} = 4.5\text{V}$ , at no switching		600	3000	nA
$I_{Q\_VIN}$	VIN Pin Quiescent Current	$V_{IN} = 0.5\text{V}$ , $V_{OUT} = 4.5\text{V}$ , at no switching		400		nA
$V_{OUT}$	Output Pin Voltage	$V_{IN} > V_{MP}$	$\frac{V_{SET}}{\times 0.95}$		$\frac{V_{SET}}{\times 1.05}$	V
$V_{MP}$	Accuracy of Maximum Power Point Control Voltage	$V_{OUT} = V_{SET}$ , $V_{MPSET} \geq 0.5\text{V}$	$\pm 5$		$\pm 5$	%
		$V_{OUT} = V_{SET}$ , $V_{MPSET} < 0.5\text{V}$	$\pm 50$		$\pm 50$	mV
$V_{OUTPGH}$	OUTPG "High" Threshold Voltage	xxxA: $2.6\text{V} \leq V_{SET}$ xxxB: $3.1\text{V} \leq V_{SET}$ xxxC: $3.6\text{V} \leq V_{SET}$ xxxD: $4.3\text{V} \leq V_{SET}$	$\frac{V_{SET}}{\times 0.87}$	$V_{SET} \times 0.90$	$\frac{V_{SET}}{\times 0.93}$	V
$V_{OUTPGL}$	OUTPG "Low" Threshold Voltage	xxxA: $2.6\text{V} \leq V_{SET} < 3.3\text{V}$ xxxB: $3.1\text{V} \leq V_{SET} < 3.3\text{V}$	$\frac{V_{SET}}{\times (\text{PGL} - 0.05)}$	$V_{SET} \times \text{PGL}$	$\frac{V_{SET}}{\times (\text{PGL} + 0.05)}$	V
		xxxA: $3.3\text{V} \leq V_{SET}$ xxxB: $3.3\text{V} \leq V_{SET}$ xxxC: $3.6\text{V} \leq V_{SET}$ xxxD: $4.3\text{V} \leq V_{SET}$	$\frac{V_{SET}}{\times (\text{PGL} - 0.04)}$	$V_{SET} \times \text{PGL}$	$\frac{V_{SET}}{\times (\text{PGL} + 0.04)}$	V
$V_{INPGH}$	INPG "High" Threshold Voltage		$\frac{V_{MPSET}}{\times 1.05}$			V
$V_{INPGL}$	INPG "Low" Threshold Voltage				$\frac{V_{MPSET}}{\times 0.95}$	V
$V_{OUTUVLOR}$	$V_{OUTUVLO}$ Release Voltage				2.11	V
$V_{OUTUVLOF}$	$V_{OUTUVLO}$ Detection Voltage		1.55			V
$V_{OUTPGH}$	OUTPG "High" Output Voltage	$I_{OUTPG} = -1\mu\text{A}$	$\frac{V_{SET}}{\times 0.9}$			V
$V_{INPGH}$	INPG "High" Output Voltage	$I_{INPG} = -1\mu\text{A}$	$\frac{V_{SET}}{\times 0.9}$			V
$V_{OUTPGL}$	OUTPG "Low" Output Voltage	$I_{OUTPG} = 1\mu\text{A}$			0.1	V
$V_{INPGL}$	INPG "Low" Output Voltage	$I_{INPG} = 1\mu\text{A}$			0.1	V

All test items listed under Electrical Characteristics are done under the pulse load condition ( $T_j \approx T_a = 25^{\circ}\text{C}$ ). Test circuit is operated with "Open Loop Control" (GND = 0 V), unless otherwise specified.

The specifications surrounded by   are guaranteed by design engineering at  $-40^{\circ}\text{C} \leq T_a \leq 85^{\circ}\text{C}$

#### R1810xxxxA Product-specific Electrical Characteristics

Product Name	Output Voltage [V]			Maximum Power Point Control Voltage [V]			OUTPG"High" Detection Voltage [V]		
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.
R1810x003A	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">2.262</span>	2.34	<span style="border: 1px solid black; padding: 0 2px;">2.418</span>
R1810x005A	<span style="border: 1px solid black; padding: 0 2px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 2px;">4.725</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 2px;">4.185</span>
R1810x006A	<span style="border: 1px solid black; padding: 0 2px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 2px;">4.725</span>	<span style="border: 1px solid black; padding: 0 2px;">1.140</span>	1.2	<span style="border: 1px solid black; padding: 0 2px;">1.260</span>	<span style="border: 1px solid black; padding: 0 2px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 2px;">4.185</span>
R1810x007A	<span style="border: 1px solid black; padding: 0 2px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 2px;">4.725</span>	<span style="border: 1px solid black; padding: 0 2px;">1.995</span>	2.1	<span style="border: 1px solid black; padding: 0 2px;">2.205</span>	<span style="border: 1px solid black; padding: 0 2px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 2px;">4.185</span>
R1810x013A	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">1.425</span>	1.5	<span style="border: 1px solid black; padding: 0 2px;">1.575</span>	<span style="border: 1px solid black; padding: 0 2px;">2.349</span>	2.43	<span style="border: 1px solid black; padding: 0 2px;">2.511</span>
R1810x015A	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.250</span>	0.3	<span style="border: 1px solid black; padding: 0 2px;">0.350</span>	<span style="border: 1px solid black; padding: 0 2px;">2.349</span>	2.43	<span style="border: 1px solid black; padding: 0 2px;">2.511</span>
R1810x016A	<span style="border: 1px solid black; padding: 0 2px;">2.185</span>	2.3	<span style="border: 1px solid black; padding: 0 2px;">2.415</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	-	-	-
R1810x017A	<span style="border: 1px solid black; padding: 0 2px;">3.135</span>	3.3	<span style="border: 1px solid black; padding: 0 2px;">3.465</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">2.871</span>	2.97	<span style="border: 1px solid black; padding: 0 2px;">3.069</span>
R1810x018A	<span style="border: 1px solid black; padding: 0 2px;">3.135</span>	3.3	<span style="border: 1px solid black; padding: 0 2px;">3.465</span>	<span style="border: 1px solid black; padding: 0 2px;">1.995</span>	2.1	<span style="border: 1px solid black; padding: 0 2px;">2.205</span>	<span style="border: 1px solid black; padding: 0 2px;">2.871</span>	2.97	<span style="border: 1px solid black; padding: 0 2px;">3.069</span>
R1810x019A	<span style="border: 1px solid black; padding: 0 2px;">3.420</span>	3.6	<span style="border: 1px solid black; padding: 0 2px;">3.780</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">3.132</span>	3.24	<span style="border: 1px solid black; padding: 0 2px;">3.348</span>
R1810x022A	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">2.349</span>	2.43	<span style="border: 1px solid black; padding: 0 2px;">2.511</span>
R1810x023A	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">0.523</span>	0.55	<span style="border: 1px solid black; padding: 0 2px;">0.577</span>	<span style="border: 1px solid black; padding: 0 2px;">2.262</span>	2.34	<span style="border: 1px solid black; padding: 0 2px;">2.418</span>
R1810x024A	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.523</span>	0.55	<span style="border: 1px solid black; padding: 0 2px;">0.577</span>	<span style="border: 1px solid black; padding: 0 2px;">2.349</span>	2.43	<span style="border: 1px solid black; padding: 0 2px;">2.511</span>
R1810x025A	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">0.570</span>	0.6	<span style="border: 1px solid black; padding: 0 2px;">0.630</span>	<span style="border: 1px solid black; padding: 0 2px;">2.262</span>	2.34	<span style="border: 1px solid black; padding: 0 2px;">2.418</span>
R1810x026A	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.570</span>	0.6	<span style="border: 1px solid black; padding: 0 2px;">0.630</span>	<span style="border: 1px solid black; padding: 0 2px;">2.349</span>	2.43	<span style="border: 1px solid black; padding: 0 2px;">2.511</span>
R1810x027A	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">0.855</span>	0.9	<span style="border: 1px solid black; padding: 0 2px;">0.945</span>	<span style="border: 1px solid black; padding: 0 2px;">2.262</span>	2.34	<span style="border: 1px solid black; padding: 0 2px;">2.418</span>
R1810x028A	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.855</span>	0.9	<span style="border: 1px solid black; padding: 0 2px;">0.945</span>	<span style="border: 1px solid black; padding: 0 2px;">2.349</span>	2.43	<span style="border: 1px solid black; padding: 0 2px;">2.511</span>
R1810x029A	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">0.950</span>	1.0	<span style="border: 1px solid black; padding: 0 2px;">1.050</span>	<span style="border: 1px solid black; padding: 0 2px;">2.262</span>	2.34	<span style="border: 1px solid black; padding: 0 2px;">2.418</span>
R1810x030A	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.950</span>	1.0	<span style="border: 1px solid black; padding: 0 2px;">1.050</span>	<span style="border: 1px solid black; padding: 0 2px;">2.349</span>	2.43	<span style="border: 1px solid black; padding: 0 2px;">2.511</span>
R1810x031A	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">1.045</span>	1.1	<span style="border: 1px solid black; padding: 0 2px;">1.155</span>	<span style="border: 1px solid black; padding: 0 2px;">2.262</span>	2.34	<span style="border: 1px solid black; padding: 0 2px;">2.418</span>
R1810x032A	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">1.045</span>	1.1	<span style="border: 1px solid black; padding: 0 2px;">1.155</span>	<span style="border: 1px solid black; padding: 0 2px;">2.349</span>	2.43	<span style="border: 1px solid black; padding: 0 2px;">2.511</span>
R1810x033A	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.665</span>	0.7	<span style="border: 1px solid black; padding: 0 2px;">0.735</span>	<span style="border: 1px solid black; padding: 0 2px;">2.349</span>	2.43	<span style="border: 1px solid black; padding: 0 2px;">2.511</span>
R1810x034A	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.760</span>	0.8	<span style="border: 1px solid black; padding: 0 2px;">0.840</span>	<span style="border: 1px solid black; padding: 0 2px;">2.349</span>	2.43	<span style="border: 1px solid black; padding: 0 2px;">2.511</span>

If  $V_{SET} < 2.6\text{V}$ , the OUTPG function cannot be used.



Product Name	OUTPG"Low" Detection Voltage [V]			INPG"High" Detection Voltage [V]	INPG"Low" Detection Voltage [V]
	Min.	Typ.	Max.	Min.	Max.
R1810x003A	1.950	2.080	2.210	0.525	0.475
R1810x005A	3.420	3.600	3.780	0.525	0.475
R1810x006A	3.420	3.600	3.780	1.260	1.140
R1810x007A	3.420	3.600	3.780	2.205	1.995
R1810x013A	2.025	2.160	2.295	1.575	1.425
R1810x015A	2.025	2.160	2.295	0.315	0.285
R1810x016A	-	-	-	0.525	0.475
R1810x017A	2.508	2.640	2.772	0.525	0.475
R1810x018A	2.508	2.640	2.772	2.205	1.995
R1810x019A	2.736	2.880	3.024	0.525	0.475
R1810x022A	2.025	2.160	2.295	0.525	0.475
R1810x023A	1.950	2.080	2.210	0.578	0.523
R1810x024A	2.025	2.160	2.295	0.578	0.523
R1810x025A	1.950	2.080	2.210	0.630	0.570
R1810x026A	2.025	2.160	2.295	0.630	0.570
R1810x027A	1.950	2.080	2.210	0.945	0.855
R1810x028A	2.025	2.160	2.295	0.945	0.855
R1810x029A	1.950	2.080	2.210	1.050	0.950
R1810x030A	2.025	2.160	2.295	1.050	0.950
R1810x031A	1.950	2.080	2.210	1.155	1.045
R1810x032A	2.025	2.160	2.295	1.155	1.045
R1810x033A	2.025	2.160	2.295	0.735	0.665
R1810x034A	2.025	2.160	2.295	0.840	0.760

If VSET < 2.6V, the OUTPG function cannot be used.

The specifications surrounded by   are guaranteed by design engineering at  $-40^{\circ}\text{C} \leq T_a \leq 85^{\circ}\text{C}$

#### R1810xxxxB Product-specific Electrical Characteristics

Product Name	Output Voltage [V]			Maximum Power Point Control Voltage [V]			OUTPG"High" Detection Voltage [V]		
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.
R1810x003B	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	-	-	-
R1810x005B	<span style="border: 1px solid black; padding: 0 2px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 2px;">4.725</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 2px;">4.185</span>
R1810x006B	<span style="border: 1px solid black; padding: 0 2px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 2px;">4.725</span>	<span style="border: 1px solid black; padding: 0 2px;">1.140</span>	1.2	<span style="border: 1px solid black; padding: 0 2px;">1.260</span>	<span style="border: 1px solid black; padding: 0 2px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 2px;">4.185</span>
R1810x007B	<span style="border: 1px solid black; padding: 0 2px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 2px;">4.725</span>	<span style="border: 1px solid black; padding: 0 2px;">1.995</span>	2.1	<span style="border: 1px solid black; padding: 0 2px;">2.205</span>	<span style="border: 1px solid black; padding: 0 2px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 2px;">4.185</span>
R1810x013B	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">1.425</span>	1.5	<span style="border: 1px solid black; padding: 0 2px;">1.575</span>	-	-	-
R1810x017B	<span style="border: 1px solid black; padding: 0 2px;">3.135</span>	3.3	<span style="border: 1px solid black; padding: 0 2px;">3.465</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">2.871</span>	2.97	<span style="border: 1px solid black; padding: 0 2px;">3.069</span>
R1810x018B	<span style="border: 1px solid black; padding: 0 2px;">3.135</span>	3.3	<span style="border: 1px solid black; padding: 0 2px;">3.465</span>	<span style="border: 1px solid black; padding: 0 2px;">1.995</span>	2.1	<span style="border: 1px solid black; padding: 0 2px;">2.205</span>	<span style="border: 1px solid black; padding: 0 2px;">2.871</span>	2.97	<span style="border: 1px solid black; padding: 0 2px;">3.069</span>
R1810x019B	<span style="border: 1px solid black; padding: 0 2px;">3.420</span>	3.6	<span style="border: 1px solid black; padding: 0 2px;">3.780</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">3.132</span>	3.24	<span style="border: 1px solid black; padding: 0 2px;">3.348</span>
R1810x022B	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	-	-	-
R1810x023B	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">0.523</span>	0.55	<span style="border: 1px solid black; padding: 0 2px;">0.577</span>	-	-	-
R1810x024B	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.523</span>	0.55	<span style="border: 1px solid black; padding: 0 2px;">0.577</span>	-	-	-
R1810x025B	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">0.570</span>	0.6	<span style="border: 1px solid black; padding: 0 2px;">0.630</span>	-	-	-
R1810x026B	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.570</span>	0.6	<span style="border: 1px solid black; padding: 0 2px;">0.630</span>	-	-	-
R1810x027B	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">0.855</span>	0.9	<span style="border: 1px solid black; padding: 0 2px;">0.945</span>	-	-	-
R1810x028B	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.855</span>	0.9	<span style="border: 1px solid black; padding: 0 2px;">0.945</span>	-	-	-
R1810x029B	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">0.950</span>	1.0	<span style="border: 1px solid black; padding: 0 2px;">1.050</span>	-	-	-
R1810x030B	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.950</span>	1.0	<span style="border: 1px solid black; padding: 0 2px;">1.050</span>	-	-	-
R1810x031B	<span style="border: 1px solid black; padding: 0 2px;">2.470</span>	2.6	<span style="border: 1px solid black; padding: 0 2px;">2.730</span>	<span style="border: 1px solid black; padding: 0 2px;">1.045</span>	1.1	<span style="border: 1px solid black; padding: 0 2px;">1.155</span>	-	-	-
R1810x032B	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">1.045</span>	1.1	<span style="border: 1px solid black; padding: 0 2px;">1.155</span>	-	-	-
R1810x033B	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.665</span>	0.7	<span style="border: 1px solid black; padding: 0 2px;">0.735</span>	-	-	-
R1810x034B	<span style="border: 1px solid black; padding: 0 2px;">2.565</span>	2.7	<span style="border: 1px solid black; padding: 0 2px;">2.835</span>	<span style="border: 1px solid black; padding: 0 2px;">0.760</span>	0.8	<span style="border: 1px solid black; padding: 0 2px;">0.840</span>	-	-	-

If VSET < 3.1V, the OUTPG function cannot be used.

Product Name	OUTPG"Low" Detection Voltage [V]			INPG"High" Detection Voltage [V]	INPG"Low" Detection Voltage [V]
	Min.	Typ.	Max.	Min.	Max.
R1810x003B	-	-	-	0.525	0.475
R1810x005B	2.970	3.150	3.330	0.525	0.475
R1810x006B	2.970	3.150	3.330	1.260	1.140
R1810x007B	2.970	3.150	3.330	2.205	1.995
R1810x013B	-	-	-	1.575	1.425
R1810x017B	2.178	2.310	2.442	0.525	0.475
R1810x018B	2.178	2.310	2.442	2.205	1.995
R1810x019B	2.376	2.520	2.664	0.525	0.475
R1810x022B	-	-	-	0.525	0.475
R1810x023B	-	-	-	0.578	0.523
R1810x024B	-	-	-	0.578	0.523
R1810x025B	-	-	-	0.630	0.570
R1810x026B	-	-	-	0.630	0.570
R1810x027B	-	-	-	0.945	0.855
R1810x028B	-	-	-	0.945	0.855
R1810x029B	-	-	-	1.050	0.950
R1810x030B	-	-	-	1.050	0.950
R1810x031B	-	-	-	1.155	1.045
R1810x032B	-	-	-	1.155	1.045
R1810x033B	-	-	-	0.735	0.665
R1810x034B	-	-	-	0.840	0.760

If VSET < 3.1V, the OUTPG function cannot be used.

The specifications surrounded by   are guaranteed by design engineering at  $-40^{\circ}\text{C} \leq T_a \leq 85^{\circ}\text{C}$

#### R1810xxxxC Product-specific Electrical Characteristics

Product Name	Output Voltage [V]			Maximum Power Point Control Voltage [V]			OUTPG"High" Detection Voltage [V]		
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.
R1810x005C	<span style="border: 1px solid black; padding: 0 2px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 2px;">4.725</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 2px;">4.185</span>
R1810x006C	<span style="border: 1px solid black; padding: 0 2px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 2px;">4.725</span>	<span style="border: 1px solid black; padding: 0 2px;">1.140</span>	1.2	<span style="border: 1px solid black; padding: 0 2px;">1.260</span>	<span style="border: 1px solid black; padding: 0 2px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 2px;">4.185</span>
R1810x007C	<span style="border: 1px solid black; padding: 0 2px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 2px;">4.725</span>	<span style="border: 1px solid black; padding: 0 2px;">1.995</span>	2.1	<span style="border: 1px solid black; padding: 0 2px;">2.205</span>	<span style="border: 1px solid black; padding: 0 2px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 2px;">4.185</span>
R1810x017C	<span style="border: 1px solid black; padding: 0 2px;">3.135</span>	3.3	<span style="border: 1px solid black; padding: 0 2px;">3.465</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	-	-	-
R1810x018C	<span style="border: 1px solid black; padding: 0 2px;">3.135</span>	3.3	<span style="border: 1px solid black; padding: 0 2px;">3.465</span>	<span style="border: 1px solid black; padding: 0 2px;">1.995</span>	2.1	<span style="border: 1px solid black; padding: 0 2px;">2.205</span>	-	-	-
R1810x019C	<span style="border: 1px solid black; padding: 0 2px;">3.420</span>	3.6	<span style="border: 1px solid black; padding: 0 2px;">3.780</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">3.132</span>	3.24	<span style="border: 1px solid black; padding: 0 2px;">3.348</span>

Product Name	OUTPG"Low" Detection Voltage [V]			INPG"High" Detection Voltage [V]	INPG"Low" Detection Voltage [V]
	Min.	Typ.	Max.	Min.	Max.
R1810x005C	<span style="border: 1px solid black; padding: 0 2px;">2.520</span>	2.700	<span style="border: 1px solid black; padding: 0 2px;">2.880</span>	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>
R1810x006C	<span style="border: 1px solid black; padding: 0 2px;">2.520</span>	2.700	<span style="border: 1px solid black; padding: 0 2px;">2.880</span>	<span style="border: 1px solid black; padding: 0 2px;">1.260</span>	<span style="border: 1px solid black; padding: 0 2px;">1.140</span>
R1810x007C	<span style="border: 1px solid black; padding: 0 2px;">2.520</span>	2.700	<span style="border: 1px solid black; padding: 0 2px;">2.880</span>	<span style="border: 1px solid black; padding: 0 2px;">2.205</span>	<span style="border: 1px solid black; padding: 0 2px;">1.995</span>
R1810x017C	-	-	-	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>
R1810x018C	-	-	-	<span style="border: 1px solid black; padding: 0 2px;">2.205</span>	<span style="border: 1px solid black; padding: 0 2px;">1.995</span>
R1810x019C	<span style="border: 1px solid black; padding: 0 2px;">2.016</span>	2.160	<span style="border: 1px solid black; padding: 0 2px;">2.304</span>	<span style="border: 1px solid black; padding: 0 2px;">0.525</span>	<span style="border: 1px solid black; padding: 0 2px;">0.475</span>

If  $V_{SET} < 3.6\text{V}$ , the OUTPG function cannot be used.

The specifications surrounded by   are guaranteed by design engineering at  $-40^{\circ}\text{C} \leq T_a \leq 85^{\circ}\text{C}$

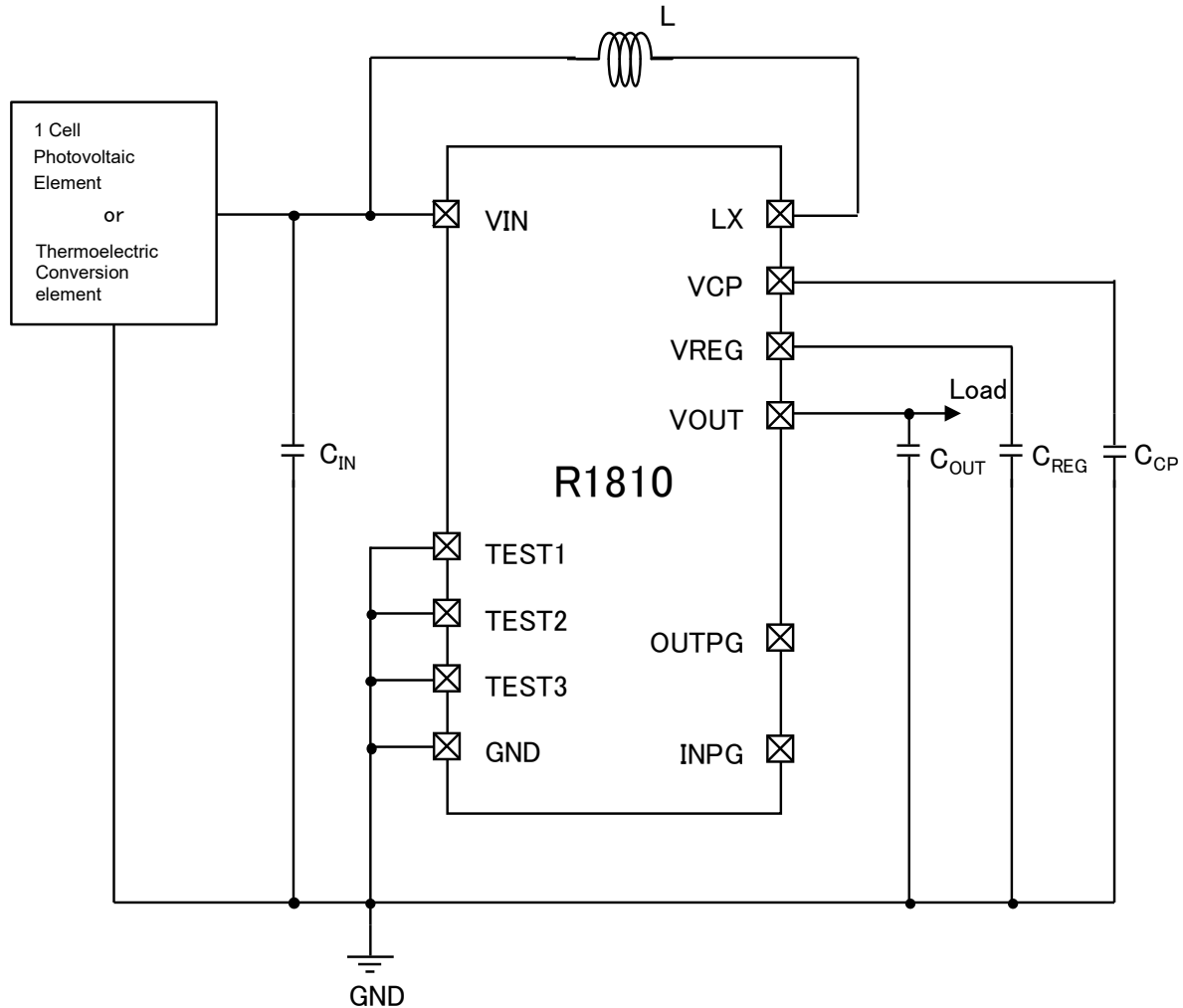
**R1810xxxxD Product-specific Electrical Characteristics**

Product Name	Output Voltage [V]			Maximum Power Point Control Voltage [V]			OUTPG"High" Detection Voltage [V]		
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.
R1810x005D	<span style="border: 1px solid black; padding: 0 5px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 5px;">4.725</span>	<span style="border: 1px solid black; padding: 0 5px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 5px;">0.525</span>	<span style="border: 1px solid black; padding: 0 5px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 5px;">4.185</span>
R1810x006D	<span style="border: 1px solid black; padding: 0 5px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 5px;">4.725</span>	<span style="border: 1px solid black; padding: 0 5px;">1.140</span>	1.2	<span style="border: 1px solid black; padding: 0 5px;">1.260</span>	<span style="border: 1px solid black; padding: 0 5px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 5px;">4.185</span>
R1810x007D	<span style="border: 1px solid black; padding: 0 5px;">4.275</span>	4.5	<span style="border: 1px solid black; padding: 0 5px;">4.725</span>	<span style="border: 1px solid black; padding: 0 5px;">1.995</span>	2.1	<span style="border: 1px solid black; padding: 0 5px;">2.205</span>	<span style="border: 1px solid black; padding: 0 5px;">3.915</span>	4.05	<span style="border: 1px solid black; padding: 0 5px;">4.185</span>
R1810x019D	<span style="border: 1px solid black; padding: 0 5px;">3.420</span>	3.6	<span style="border: 1px solid black; padding: 0 5px;">3.780</span>	<span style="border: 1px solid black; padding: 0 5px;">0.475</span>	0.5	<span style="border: 1px solid black; padding: 0 5px;">0.525</span>	-	-	-

Product Name	OUTPG"Low" Detection Voltage [V]			INPG"High" Detection Voltage [V]		INPG"Low" Detection Voltage [V]	
	Min.	Typ.	Max.	Min.	Max.	Min.	Max.
R1810x005D	<span style="border: 1px solid black; padding: 0 5px;">2.070</span>	2.250	<span style="border: 1px solid black; padding: 0 5px;">2.430</span>	<span style="border: 1px solid black; padding: 0 5px;">0.525</span>		<span style="border: 1px solid black; padding: 0 5px;">0.475</span>	
R1810x006D	<span style="border: 1px solid black; padding: 0 5px;">2.070</span>	2.250	<span style="border: 1px solid black; padding: 0 5px;">2.430</span>	<span style="border: 1px solid black; padding: 0 5px;">1.260</span>		<span style="border: 1px solid black; padding: 0 5px;">1.140</span>	
R1810x007D	<span style="border: 1px solid black; padding: 0 5px;">2.070</span>	2.250	<span style="border: 1px solid black; padding: 0 5px;">2.430</span>	<span style="border: 1px solid black; padding: 0 5px;">2.205</span>		<span style="border: 1px solid black; padding: 0 5px;">1.995</span>	
R1810x019D	-	-	-	<span style="border: 1px solid black; padding: 0 5px;">0.525</span>		<span style="border: 1px solid black; padding: 0 5px;">0.475</span>	

If  $V_{SET} < 4.3\text{V}$ , the OUTPG function cannot be used.

## TYPICAL APPLICATION CIRCUIT



R1810x Typical Application Circuit

## Recommended External Components

Symbol	Descriptions
$C_{IN}$	Ceramic Capacitor, 22 $\mu$ F or more
$C_{CP}$	Ceramic Capacitor, 0.022 $\mu$ F or more
$C_{REG}$	Ceramic Capacitor, 4.7 $\mu$ F or more
$C_{OUT}$	Ceramic Capacitor, 4.7 $\mu$ F or more
	Large-capacity Electrical Storage Device
$L$	Inductor, 22 $\mu$ H

## TECHNICAL NOTES

The performance of the IC largely depends on the external components and circuitry layout. Especially, design the circuit carefully not to exceed each rating (voltage, current, power) for each component and the IC and consider the best layout pattern.

Use a ceramic capacitor with low ESR (equivalent series resistance). We recommend 22uF as C<sub>IN</sub> which is set between V<sub>IN</sub> and GND.

We recommend 4.7uF ceramic capacitor or 10uF or more ceramic capacitor with large capacity of electrical storage device as C<sub>OUT</sub>. The capacitors should cover the operating temperature range, and effective capacitance should be more than our recommendation capacity with 0 bias. Note that insulation resistance should not be too small. If insulation resistance is small, the leakage current may increase. Such a system cannot be recommended. (Refer to Page.24, 31)

We recommend an inductor with equal or more current rating (400mA or more), ESR, DC superimposition characteristics as our recommendation part. If ESR is large, or bad DC superimposition characteristics may lead to the bad efficiency. If the current rating is too small, the inductor may be broken down.

If other than GND level is connected to the TEST1,2,3 pins, by the shoot current of logic circuits inside the IC, consumption current may increase. Make sure to connect these pins to the ground level.

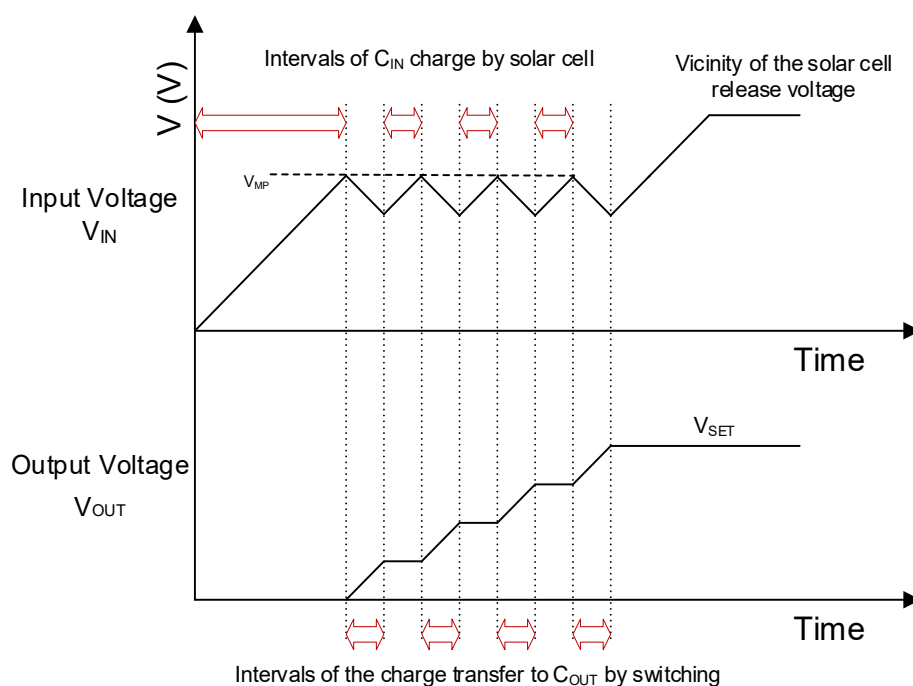
## **OPERATION**

### **Boost DC/DC Converters For Energy Harvesting**

Generally, boost DC/DC converters are used to make a suitable voltage for MCU and logic circuits by boost the input voltage. The R1810s is not a general boost DC to DC converter, but it is dedicated for energy harvesting, in other words, the power generated by a photovoltaic element is converted and accumulated to an electrical storage device with high efficiency. By intermittent operation by the power from the electrical storage device, the system can operate continuously without using a primary battery or power supply. The R1810x has the function of the maximum power point control to generate power at the best suitable voltage point. To realize single cell photovoltaic element base, the start-up voltage is 0.5V and once after start-up, even if the input voltage goes down to 0.2V, keeping on the operation is possible. Furthermore, start-up and charging to an electrical storage device with only 9 $\mu$ W input power, the system which operates under the low illuminance condition, can be built.



## Maximum Power Point Control

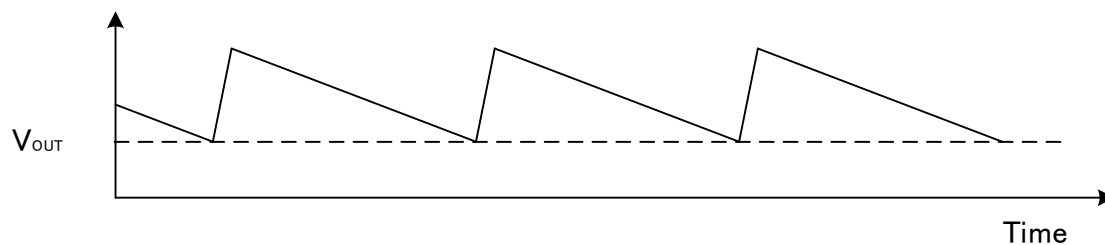


The R1810x converts the power from the photovoltaic cell at the voltage ( $V_{MP}$ ), which is the maximum power generation possible point, and transferred to the power to  $C_{OUT}$ .

In other words, when the input voltage of the R1810x increases by the power from a photovoltaic element, and when the voltage reaches maximum power voltage ( $V_{MP}$ ), switching operation starts and the R1810x transfers power to the  $C_{OUT}$  side.

In case that the power transfer amount exceeds the supplied power from the photovoltaic element, the input voltage decreases by switching. Then, when the voltage of  $V_{IN}$  becomes lower than  $V_{MP}$ , the next switching stops and  $C_{IN}$  is charged by the photovoltaic element and the voltage of  $V_{IN}$  increases. When the input voltage reaches the  $V_{MP}$  again, the R1810x transfers power to  $C_{OUT}$  side. By repeating this operation enables transferring power to the  $C_{OUT}$  side with keeping the maximum power generation point of the photovoltaic element.

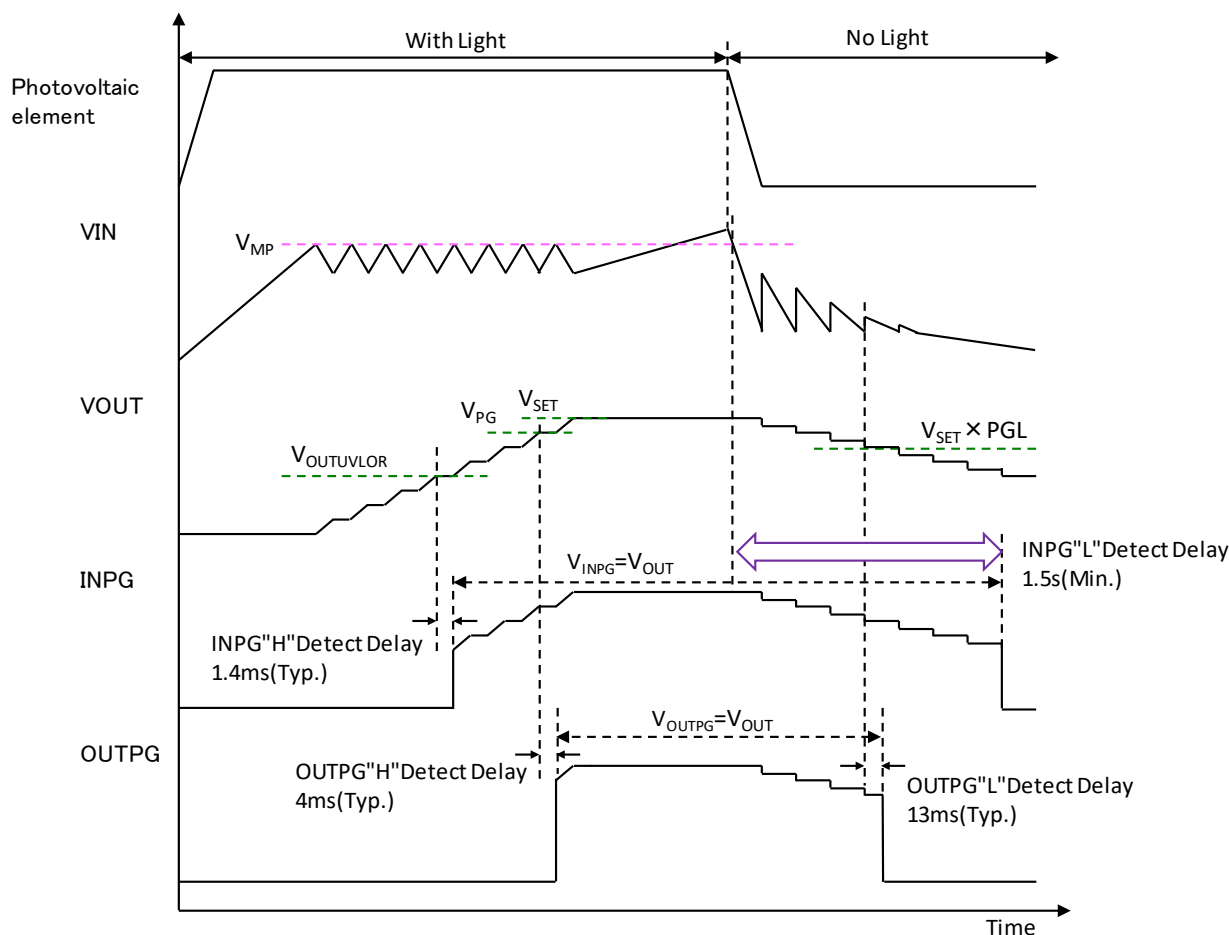
**Supplemental Remarks:** If the photovoltaic power supply is low while the secondary capacitor is charged with the photovoltaic cell, the input voltage ( $V_{IN}$ ) will fall at every energy transfer point. The boost ratio can be big by connecting a bigger capacitance capacitor ( $C_{IN}$ ), the efficiency at charging is also improved.

**Operation While The Output Voltage Is At Stable Set Output Voltage.**

Output Voltage Waveform at stable set output voltage point

When the output voltage reaches to set output voltage, the operation of the R1810x is as follows:  
When the output voltage becomes higher than the set output voltage, even if  $V_{IN}$  voltage is higher than  $V_{MP}$  voltage, the switching stops. When the output voltage becomes equal to set  $V_{OUT}$  voltage by a load, the switching resumes. By repeating this operation, the output voltage is maintained as the set output voltage.

## Power Good (PG) Function

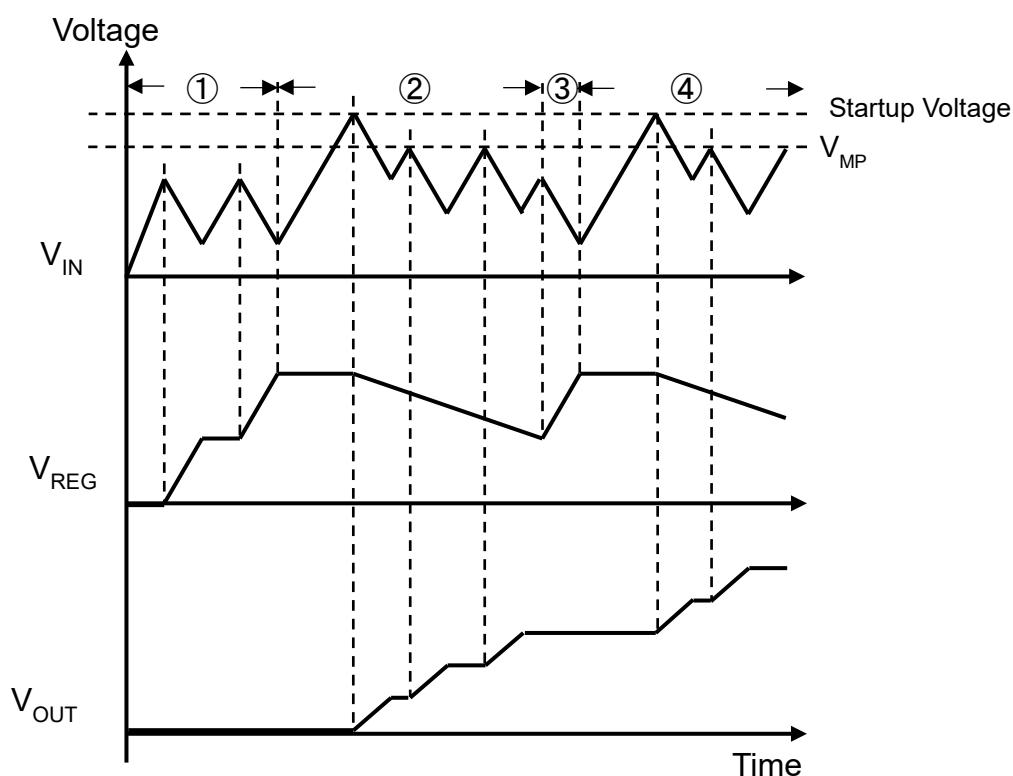


When  $V_{OUT}$  exceeds  $V_{OUT}$  released voltage,  $V_{OUTUVLOR}$ , the INPG pin becomes "High" (=  $V_{OUT}$  level). Otherwise, the INPG pin holds "Low". There are two cases the INPG pin becomes from "High" to "Low". One is when  $V_{OUT}$  falls below the  $V_{OUTUVLOR}$  detector threshold,  $V_{OUTUVLOR}$ , and the other is in the case that the switching stops for a certain time (Min. 1.5 sec.) (Refer to the chart above.). The halt of switching means  $V_{IN}$  voltage level is less than  $V_{MP}$  voltage, and the internal circuit recognizes the shading. If you do not use the INPG function, set the INPG pin to "Open".

Typ. 4ms from when the switching starts and the voltage of  $V_{OUT}$  exceeds 90% of  $V_{SET}$ , the OUTPG pin becomes "High". Depending on the PG pin voltage, the condition of the output can be judged, and sequence control is possible. While the OUTPG is "High", the output is same as set voltage. When the output becomes lower than the (PGL) of  $V_{SET}$ , the OUTPG pin becomes "Low". This preset value (PGL) can be selected from 50% and 80% with 10% increment depending on  $V_{SET}$ . Refer to the "SELECTION GUIDE" about PGL setting. OUTPG function operates with using the  $V_{OUT}$  voltage as the power supply, therefore regardless of the supply of  $V_{IN}$  voltage, the operation is possible. For example, supposed that a system substantially operates a few times a day, and a large capacitance electrical storage device is connected with  $C_{OUT}$ , even if  $V_{IN}$  voltage becomes too low, as long as  $V_{OUT}$  voltage is beyond the  $V_{OUTUVLOR}$  released voltage ( $V_{OUTUVLOR}$ ), OUTPG can maintain "High". However, if you use the OUTPG function, please note that the  $V_{SET}$  value varies in between 50% and 80% of the PGL value to ensure the minimum operating voltage of the OUTPG function. If you do not use the PG function, Set the OUTPG pin to "Open".

## Cold Start Function

When the start-up voltage or more voltage is input, initially the boost DC/DC converter for start-up operates. The internal power supply ( $V_{REG}$ ) for main DC/DC converter's operation is generated by the built-in start-up boost DC/DC converter. When the main converter starts the operation and output voltage rises high enough, the internal power supply is generated from the output of the main DC/DC converter, then the boost DC/DC converter for startup stops the operation.

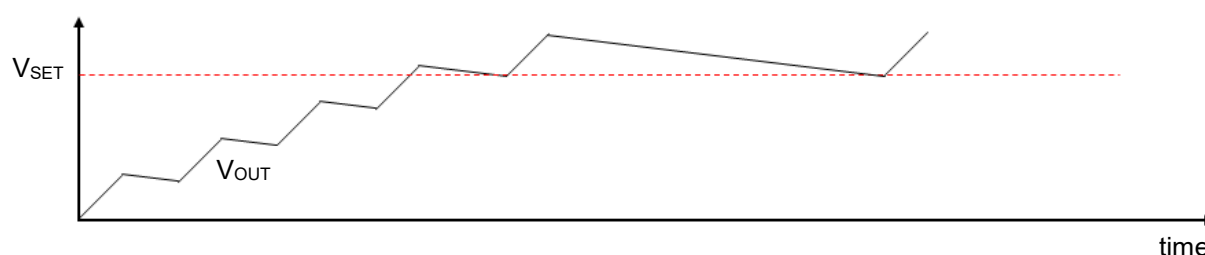


- ① Boost DC/DC converter for start-up operates and boost the power supply  $V_{REG}$  of internal circuits.
- ② When  $V_{REG}$  is beyond the threshold, the boost DC/DC converter for start-up stops, and the main DC/DC converter starts the operation. While  $V_{REG}$  maintains more than a certain voltage, the main DC/DC converter operates and boost  $V_{OUT}$  voltage.
- ③ Since the main DC/DC converter operates, the voltage of  $V_{REG}$  becomes down due to the consumption current of internal circuits. When the voltage of  $V_{REG}$  becomes lower than a certain voltage, the main DC/DC converter stops and the boost DC/DC converter for start-up boosts the voltage of  $V_{REG}$ .
- ④ When the voltage of  $V_{REG}$  becomes more than the threshold, the boost DC/DC converter for start-up stops and the main DC/DC converter starts operation.  
By repeating ③ and ④, the main converter boosts the voltage of  $V_{OUT}$  pin until set output voltage,  $V_{SET}$ .

## Output Voltage Feedback Control

Under the conditions that the cold start is completed and  $V_{OUT}$  is boosted by the main DC/DC converter, when the voltage of  $V_{OUT}$  reaches the  $V_{OUTUVLO}$  released voltage,  $V_{OUTUVLO}$ , the internal power supply  $V_{REG}$  and  $V_{OUT}$  are connected. This allows the main DC/DC converter to continue the operation without returning to the cold start condition, and to boost the output voltage until the set output voltage efficiently.

## Output Generation Function



The R1810x stops boost operation when the output voltage exceeds  $V_{SET}$ . The output voltage ( $V_{OUT}$ ) is tied to the internal power supply  $V_{REG}$  by the output voltage feedback control. When the voltage of  $V_{OUT}$  becomes lower than  $V_{SET}$  due to the internal circuit consumption current or the external load current, the boost operation starts again until ( $V_{OUT}$ ) exceeds  $V_{SET}$ . When a large capacitance electrical storage device described in "TYPICAL APPLICATION CIRCUIT" is connected, the ripple voltage will be extremely small.

## Reverse Current Protection Function

While the main DC/DC converter is operating, when the high-side MOSFET turns on,  $C_{OUT}$  connected  $V_{OUT}$  pin is charged, but due to the boost DC/DC converter's topology,  $V_{IN} < V_{OUT}$  is true. After the charge is transferred to the output capacitor, when the reverse condition of  $V_{OUT}$  and  $V_{IN}$  is detected by comparing  $L_X$  and  $V_{OUT}$ , the R1810x turns off the high-side driver not to flow the reverse current. By shading, the power generation level by a photovoltaic element decreases, the charge of  $C_{IN}$  consumes by the consumption current of the IC and input voltage,  $V_{IN}$  gradually decreases. Even if the input voltage is zero, reverse current protection function can operate. If input voltage becomes lower than output voltage,  $V_{OUT}$ , by the reverse current protection function, the storage charge of  $C_{OUT}$  or a large capacitance electrical storage device is not drained in reverse.

## Application Information

### Set Output Voltage and Input Voltage Range.

Depending on the setting value of the output voltage, the lower limit of the operable input voltage after the IC start-up is different.

Refer to the table below.

$V_{SET}$ [V]	Input Voltage Range [V]
$2.3 \leq V_{SET} \leq 2.7$	$0.20 \leq V_{IN} \leq 2.10$
$2.3 \leq V_{SET} \leq 3.3$	$0.25 \leq V_{IN} \leq 2.10$
$2.3 \leq V_{SET} \leq 3.6$	$0.30 \leq V_{IN} \leq 2.10$
$2.3 \leq V_{SET} \leq 4.5$	$0.35 \leq V_{IN} \leq 2.10$

### Case 1: The R1810 is connected to a Photovoltaic Element.

In Figure 1, 2 shown below are graphs of the input voltage dependence of the output voltage of the R1810 series.

When the R1810 is connected to an energy harvesting element (photovoltaic element), the input voltage  $V_{IN}$  depends on the power generation amount of the photovoltaic device and the load current.

When the voltage,  $V_{OUT}$  of the R1810 reaches  $V_{SET}$ ,  $V_{IN}$  becomes the value  $V_{IN1}$ , which is determined by the relationship between the IV curve of the photovoltaic element and the quiescent  $V_{IN}$  pin current (400nA) of R1810. (Fig. 3).

Input voltage  $V_{IN1}$  is higher than  $V_{MP}$ . Therefore, when the switching is resumed, the average value of  $V_{OUT}$  will be higher than  $V_{SET}$ . When the input charge is consumed by the switching and  $V_{IN}$  drops,  $V_{OUT}$  is controlled by the  $V_{MP}$  again, and the average value of  $V_{OUT}$  drops to the nominal value.

If the amount of the power generated by the photovoltaic element is greater than the power consumed by the switching of the R1810, even if the switching is resumed,  $V_{IN}$  does not drop to  $V_{MP}$ , the average value of  $V_{OUT}$  rises. The graphs shown below are typical characteristics of the average value of  $V_{OUT}$ .

Select the device connected to the R1810 which can operate with the average value of  $V_{OUT}$ .

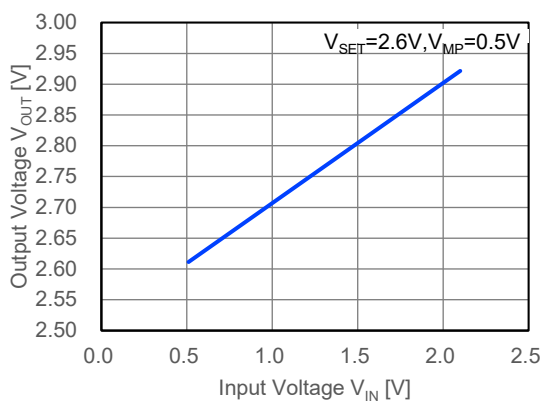


Figure1

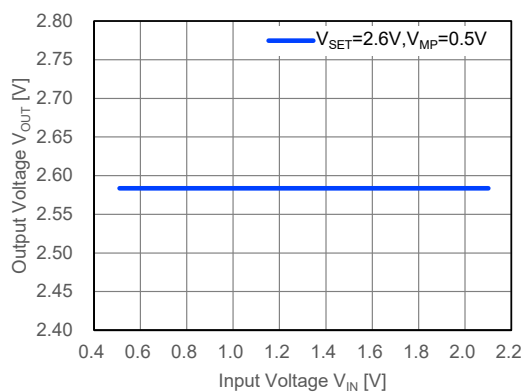


Figure2

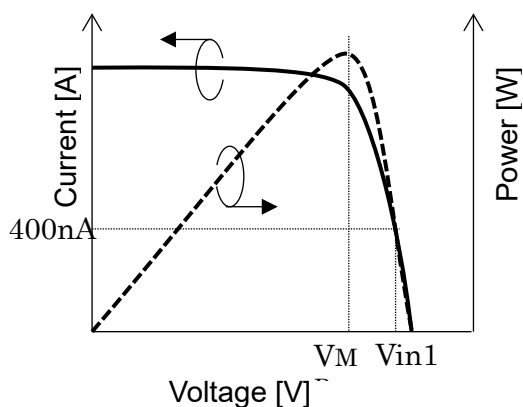


Figure3

Figure 1 : Input voltage dependence of the average value of the output voltage.

Figure 2 : Input voltage dependence of Bottom voltage (\*) of output voltage.

\* Bottom Voltage ; Minimum value of the output ripple.

Figure 3 : Characteristics of Photovoltaic Elements.

## Case 2: The R1810 is connected to a Large-Capacity Power Storage Device.

If the capacitance value of ceramic capacitor is small, output ripple becomes large, then the output ripple may exceed the voltage rating of the storage battery or rear-stage devices.

Please adjust the set output voltage and the value of the ceramic capacitor not to exceed the voltage rating with considering the ripple with the total capacity that can be calculated with the ceramic capacitor and the storage battery.

The guideline for the output ripple value from the total capacity of the ceramic capacitor and storage battery is calculated by the next formula.

$$1.35 \div C[\mu\text{F}] (\text{Total Capacitance Value}) \div (V_{\text{IN}}[\text{V}] - V_{\text{OUT}}[\text{V}]) + V_{\text{OUT}}[\text{V}] < V_{\text{ABSOLUTE}}[\text{V}] (\text{Absolute maximum rating value})$$

### Recommended example of large-capacity power storage device

Manufacturer	Product	Part#	Capacity	Type	Notes
TDK	CeraCharge™	BCT1812M101AG	100μAh	All-solid-state Li-ion	CeraCharge™ is a trademark of TDK.
Nichicon	SLB series	SLB03070LR35	350μAh	LiB	
NGK	EnerCera®	ET1210C-R ET2016C-R ET271704P-H	5mAh 25mAh 5mAh	LiB	EnerCera® is a trademark of NGK.

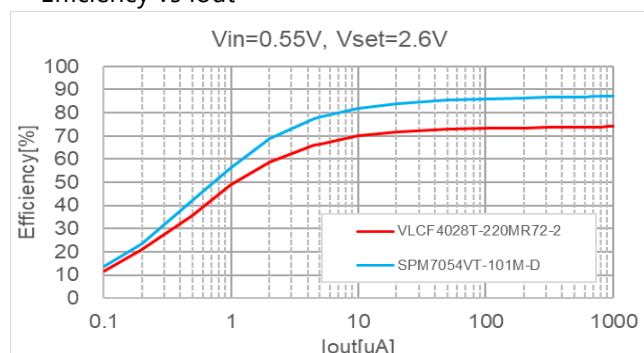
## Case 3: Efficiency Improvement Proposal Using 100μH Inductor.

The efficiency of the R1810 can be significantly improved by changing the external inductor from 22μH to 100μH as shown in the left plot below.

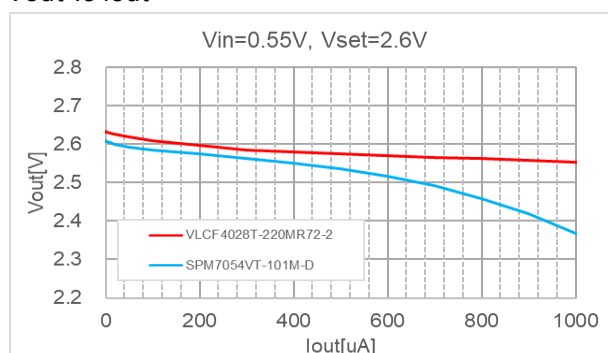
However, please note that electrical characteristics specified in this part are not guaranteed with the 100μH inductor. Especially, the load regulation degrades as shown in the right plot below. Also, when  $V_{\text{mp}} \geq 1.1\text{V}$  or boosting rate is high, the electric characteristics could change significantly. Please carefully evaluate the electric characteristics using the inductance value of 100μH.

The 100μH inductor should have equivalent characteristics to the 22μH inductor "VLCF4028T-220MR72-2", which was used for characterization for this datasheet, on the maximum rated current, equivalent DC resistance, and DC superimposed characteristics. (Example: SPM7054VT-101M-D)

Efficiency vs Iout

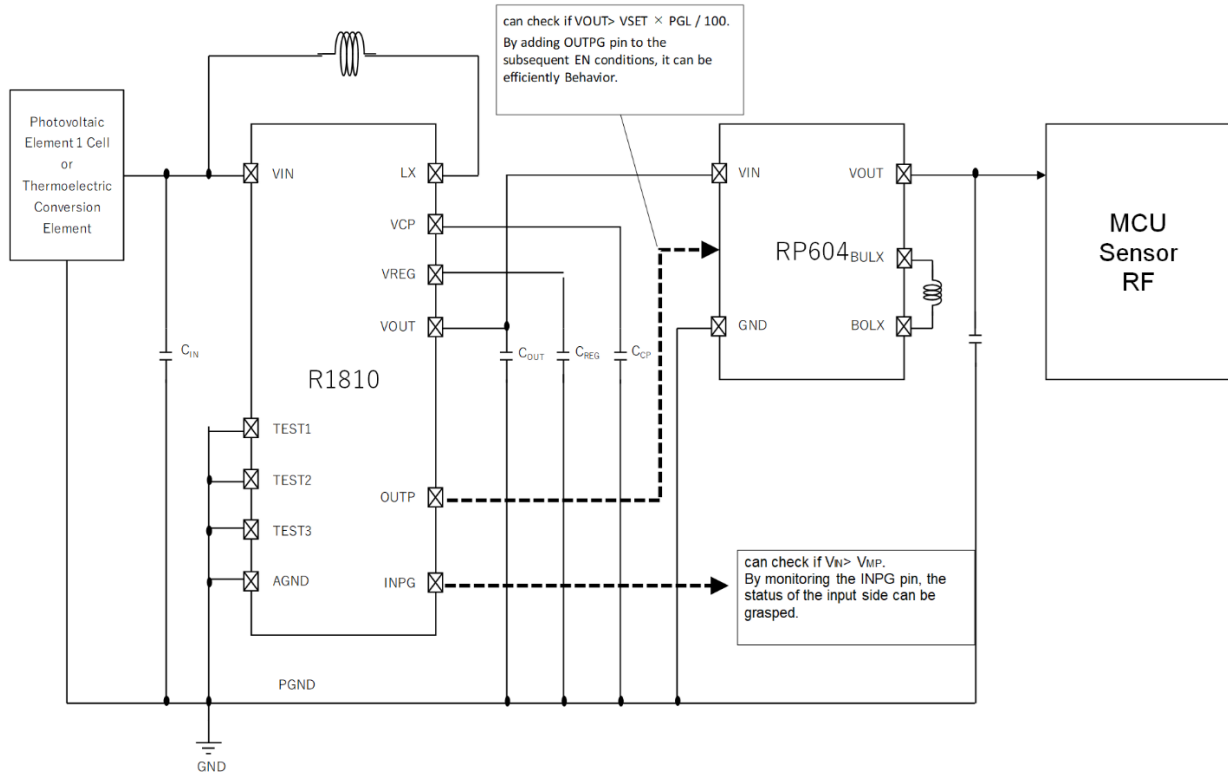


Vout vs Iout



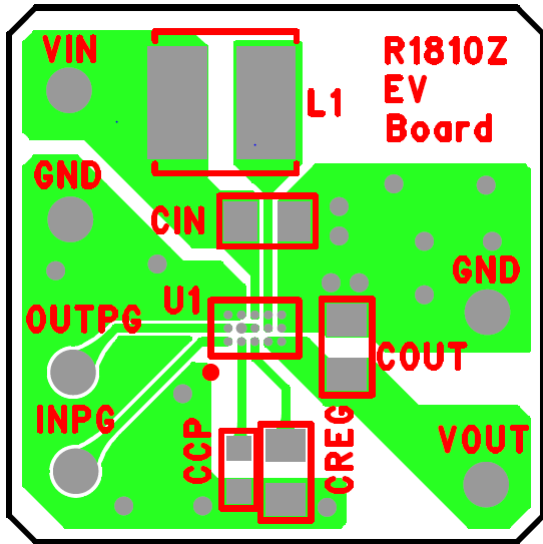


**Case 4: The R1810 is used with a Sensor.**

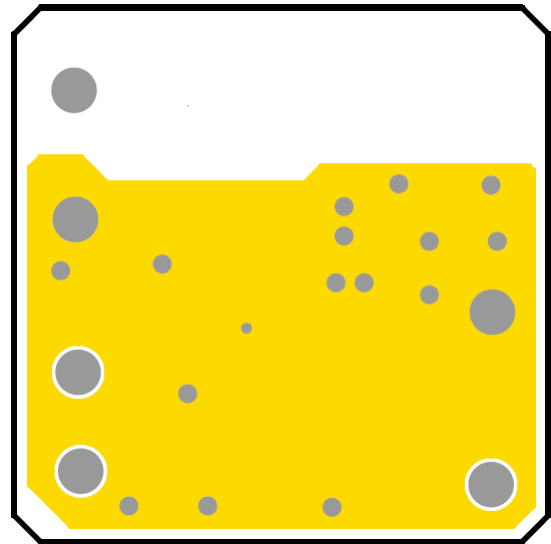


PCB Layout

R1810Z ( WLCSP-15-P1 ) Board Layout Diagram

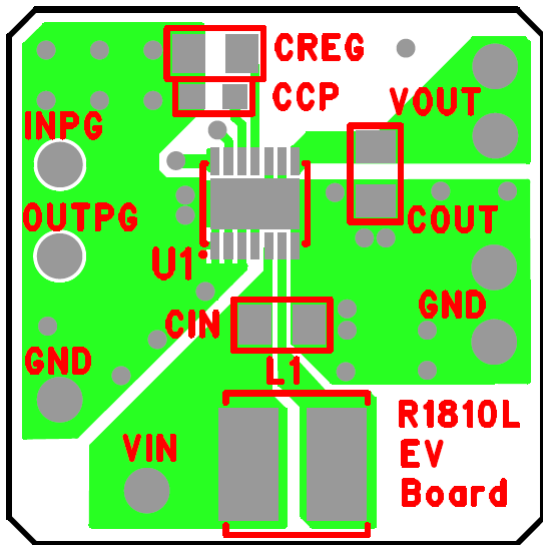


Top Layer

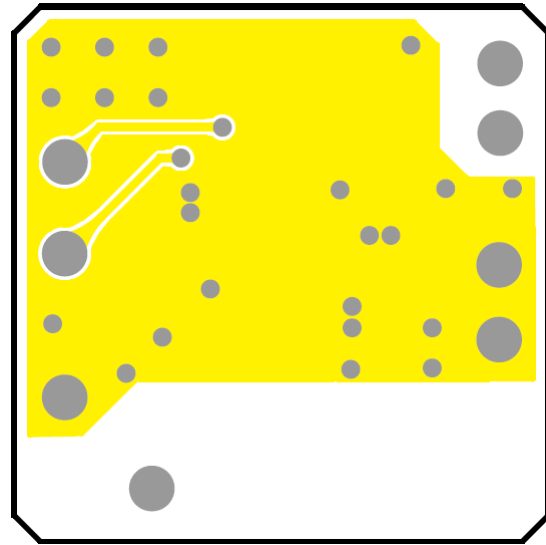


Bottom Layer

R1810L ( DFN2735-14 ) Board Layout Diagram



Top Layer



Bottom Layer

**Notes for PCB Layout.**

Since large current may flow through the  $V_{IN}$ ,  $V_{REG}$ ,  $V_{OUT}$ , AGND, and PGND wiring, if the impedance of the wiring is high, unexpected noise or the unstable operation may result. Therefore, the impedance of wiring should be as low as possible.

As for  $C_{IN}$ ,  $C_{CP}$ , and  $C_{OUT}$ , make the wiring as short as possible to the VIN pin, VCP pin, and VOUT pin, respectively.

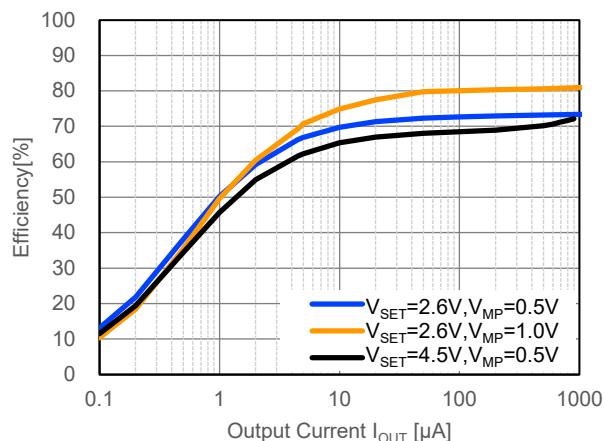
Connect the AGND and PGND with low impedance point of the same board layer as the layer mounted the IC.

Be sure to leave the NC pin node to "Open".

## TYPICAL CHARACTERISTICS

Note: Typical Characteristics are just reference data; not guaranteed with the value shown in the graphs.

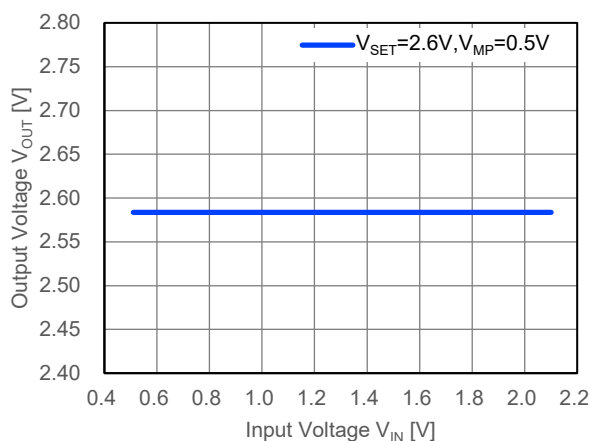
### 1) Efficiency vs. Output Current $T_a = 25^\circ\text{C}$



### 2) Input Voltage vs. Output Voltage

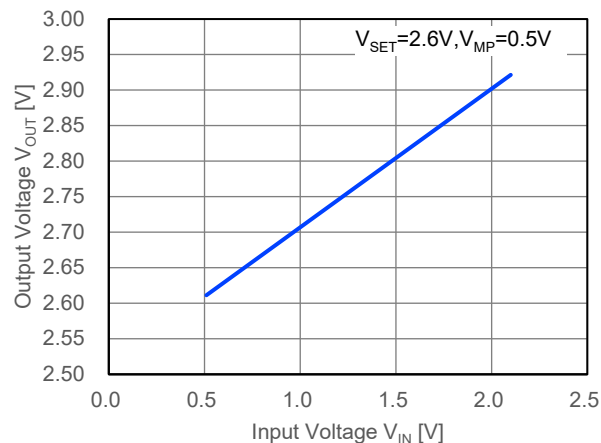
$V_{SET} = 2.6\text{V}, V_{MP} = 0.5\text{V}$   $T_a = 25^\circ\text{C}$

Bottom Voltage



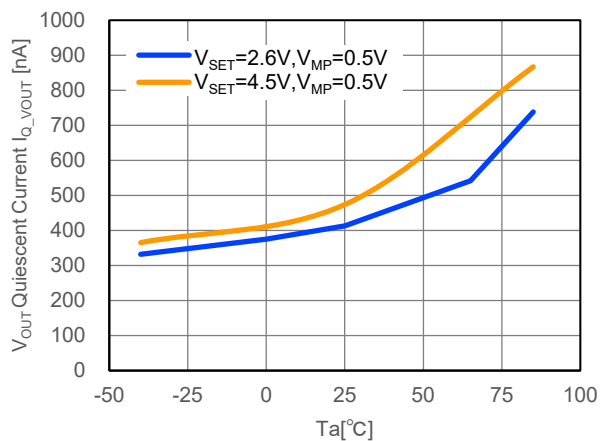
$V_{SET} = 2.6\text{V}, V_{MP} = 0.5\text{V}$   $T_a = 25^\circ\text{C}$

Average (Ripple Included)



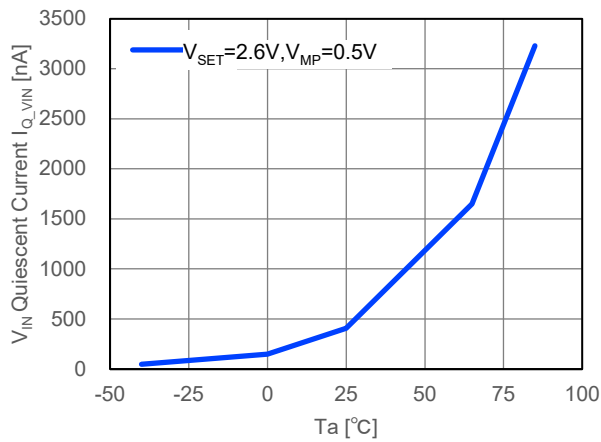
### 3) Operating Quiescent Current vs. Temperature

$V_{MP} = 0.5\text{V}$



4) Operating Quiescent Current vs. Temperature

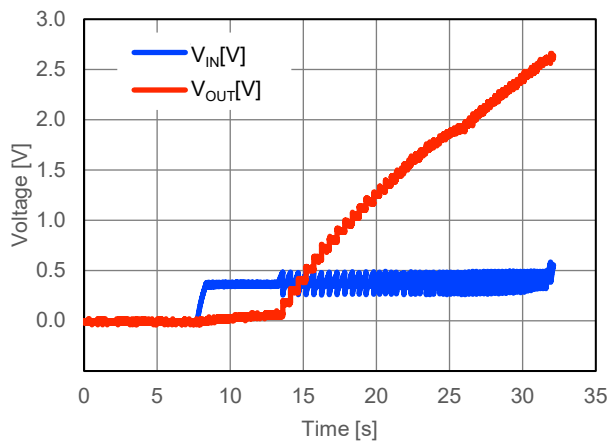
$V_{SET} = 2.6V, V_{MP} = 0.5V$



5) Minimum Starting Power Ramp up waveforms

$V_{SET} = 2.6V, V_{MP} = 0.5V, I_{IN} = 18\mu A$

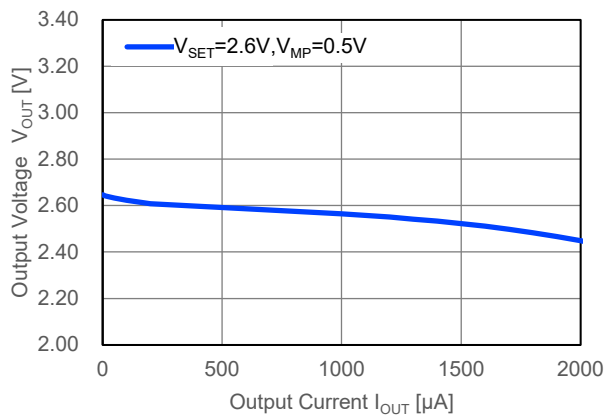
$T_a = 25^\circ C$



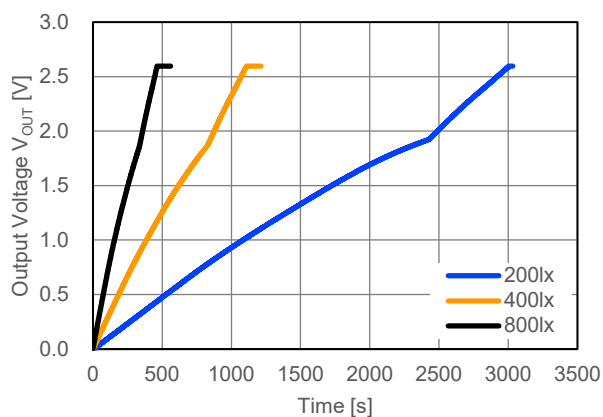
6) Output Voltage vs. Output Current

$V_{SET} = 2.6V, V_{MP} = 0.5V$

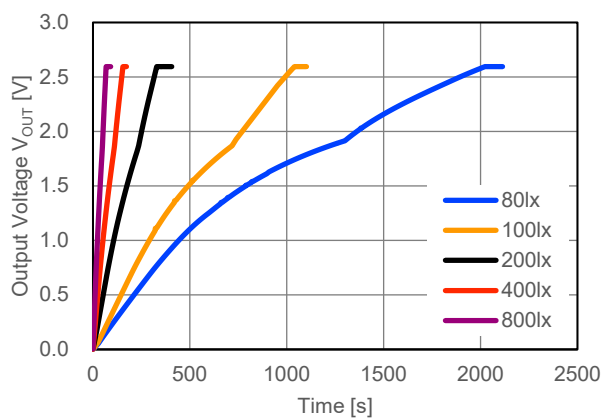
$T_a = 25^\circ C$



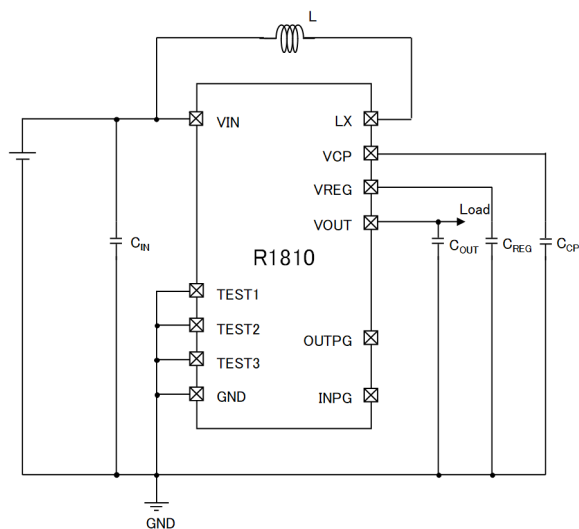
7) Start-up by the power generation element 1  
 R1810Z003A,  
 Photovoltaic Element = AM-30-11C (14.0 × 13.0mm)  
 $V_{SET} = 2.6V$ ,  $V_{MP} = 0.5V$ ,  $C_{OUT} = 1mF$   
 $T_a = 25^{\circ}C$



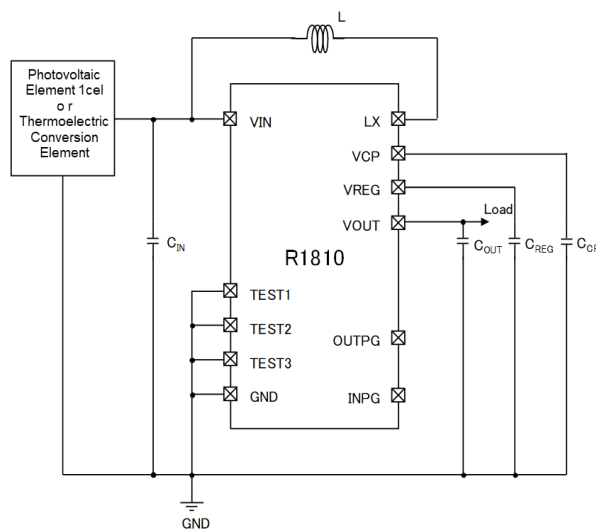
8) Start-up by the power generation element 2  
 R1810Z003A,  
 Photovoltaic Element = FDSC-FSC6FG (44.5 × 40.5mm)  
 $V_{SET} = 2.6V$ ,  $V_{MP} = 0.5V$ ,  $C_{OUT} = 1mF$   
 $T_a = 25^{\circ}C$



## Test Circuit



Test Circuit  
TYPICAL CHARACTERISTICS 1) to 6)



Test Circuit  
TYPICAL CHARACTERISTICS 7)、8)

## 【Components list for our evaluation】

Symbol	Part#	Description
C <sub>IN</sub>	C1608JB1A226M	22 μF, Ceramic Capacitor
C <sub>CP</sub>	GRM155R71E223K	0.022 μF, Ceramic Capacitor
C <sub>REG</sub>	C1608JB1E475K	4.7 μF, Ceramic Capacitor
C <sub>OUT</sub>	C1608JB1E475K	4.7 μF, Ceramic Capacitor
L	VLCF4028T-220MR72-2	22 μH, Inductor

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51.

**Measurement Conditions**

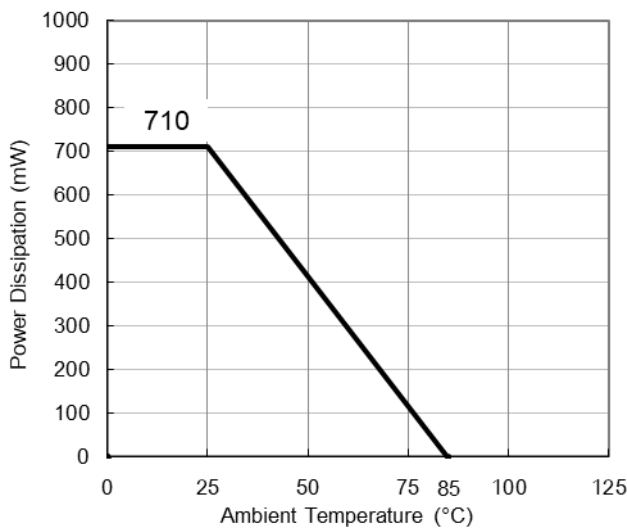
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	101.5 mm x 114.5 mm x 1.6 mm
Copper Ratio	Outer Layer (First Layer): 10% Inner Layers (Second and Third Layers): 99.5 x 99.5mm 100% Outer Layer (Fourth Layer): 10%

**Measurement Result**

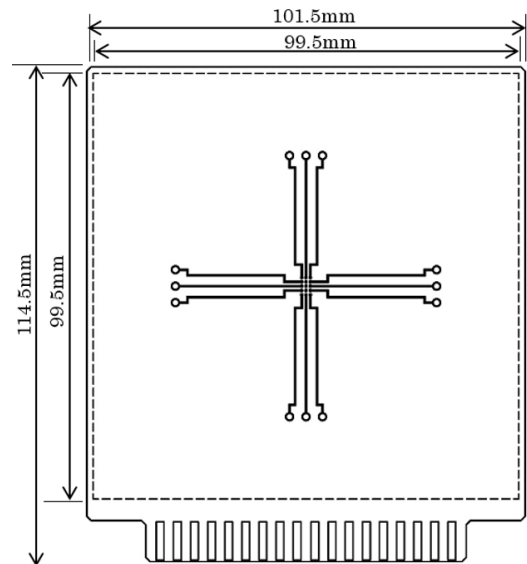
(Ta = 25°C, Tjmax = 85°C)

Item	Measurement Result
Power Dissipation	710 mW
Thermal Resistance ( $\theta_{ja}$ )	$\theta_{ja} = 84^\circ\text{C/W}$

$\theta_{ja}$ : Junction-to-Ambient Thermal Resistance



**Power Dissipation vs. Ambient Temperature**



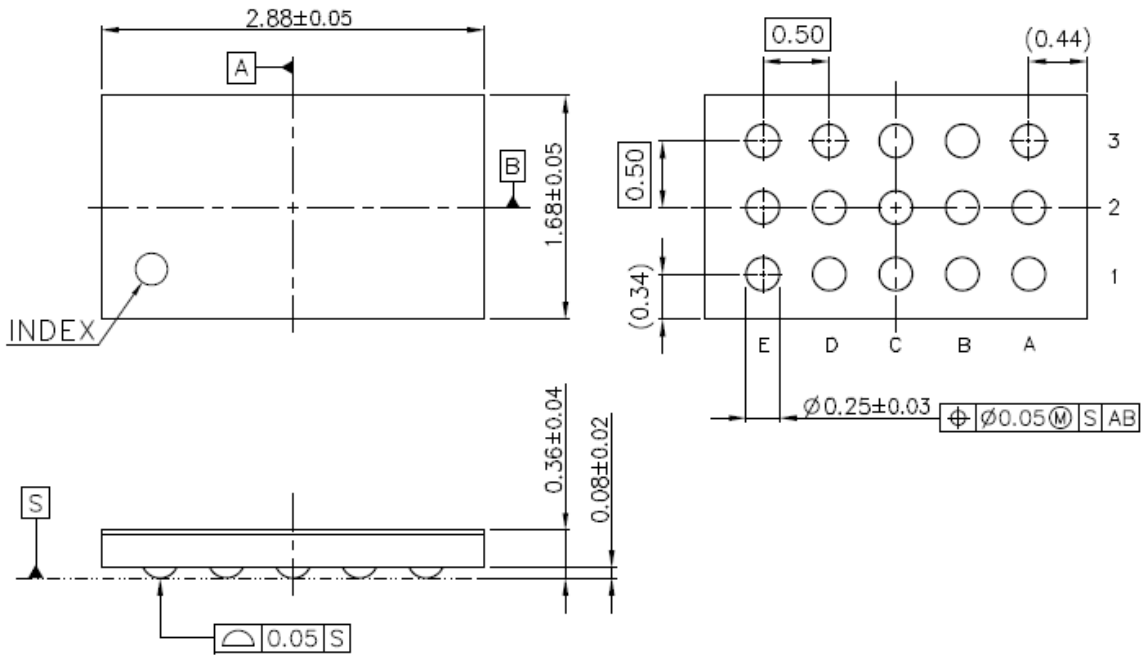
**Measurement Board Pattern**



# PACKAGE DIMENSIONS

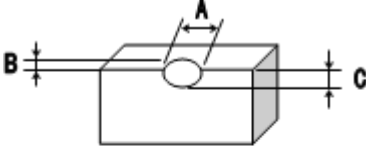
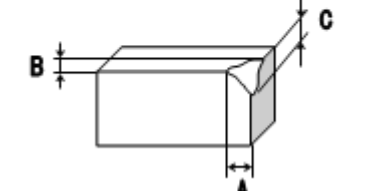
# WLCSP-15-P1

DM-WLCSP-15-P1-JE-A

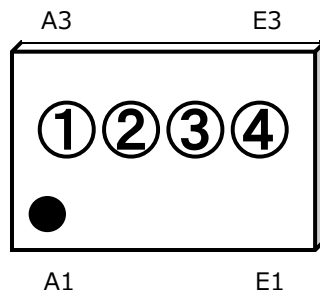


UNIT: mm

WLCSP-15-P1 Package Dimensions

No.	Inspection Items	Inspection Criteria	Figure
1	Package chipping	<p><math>A \geq 0.2\text{mm}</math> is rejected  <math>B \geq 0.2\text{mm}</math> is rejected  <math>C \geq 0.2\text{mm}</math> is rejected                      And, Package chipping to Si surface and to bump is rejected.</p>	
2	Si surface chipping	<p><math>A \geq 0.2\text{mm}</math> is rejected  <math>B \geq 0.2\text{mm}</math> is rejected  <math>C \geq 0.2\text{mm}</math> is rejected                      But, even if <math>A \geq 0.2\text{mm}</math>, <math>B \leq 0.1\text{mm}</math> is acceptable.</p>	
3	No bump	No bump is rejected.	
4	Marking miss	To reject incorrect marking, such as another product name marking or another lot No. marking.	
5	No marking	To reject no marking on the package.	
6	Reverse direction of marking	To reject reverse direction of marking character.	
7	Defective marking	To reject unreadable marking. (Microscope: X15/ White LED/ Viewed from vertical direction)	
8	Scratch	To reject unreadable marking character by scratch. (Microscope: X15/ White LED/ Viewed from vertical direction)	
9	Stain and Foreign material	To reject unreadable marking character by stain and foreign material. (Microscope: X15/ White LED/ Viewed from vertical direction)	

- ①②: Product Code ... Refer to *Part Marking List*
- ③④: Lot Number ... Alphanumeric Serial Number



**R1810Z (WLCSP-15-P1) Part Markings**

**NOTICE**

There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact our sales or distributor before attempting to use AOI.

**R1810Z Part Marking List**

Product Name	① ②	Product Name	① ②	Product Name	① ②	Product Name	① ②
R1810Z003A	10	R1810Z003B	20				
R1810Z005A	12	R1810Z005B	22	R1810Z005C	30	R1810Z005D	40
R1810Z006A	13	R1810Z006B	23	R1810Z006C	31	R1810Z006D	41
R1810Z007A	14	R1810Z007B	24	R1810Z007C	32	R1810Z007D	42
R1810Z013A	15	R1810Z013B	25				
R1810Z015A	1V						
R1810Z016A	16						
R1810Z017A	17	R1810Z017B	26	R1810Z017C	33		
R1810Z018A	18	R1810Z018B	27	R1810Z018C	34		
R1810Z019A	19	R1810Z019B	28	R1810Z019C	35	R1810Z019D	43
R1810Z022A	1A	R1810Z022B	29				
R1810Z023A	1C	R1810Z023B	2A				
R1810Z024A	1E	R1810Z024B	2C				
R1810Z025A	1F	R1810Z025B	2E				
R1810Z026A	1G	R1810Z026B	2F				
R1810Z027A	1H	R1810Z027B	2G				
R1810Z028A	1J	R1810Z028B	2H				
R1810Z029A	1K	R1810Z029B	2J				
R1810Z030A	1L	R1810Z030B	2K				
R1810Z031A	1N	R1810Z031B	2L				
R1810Z032A	1P	R1810Z032B	2N				
R1810Z033A	1R	R1810Z033B	2P				
R1810Z034A	1T	R1810Z034B	2R				

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51.

**Measurement Conditions**

Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	φ 0.3 mm × 32 pcs

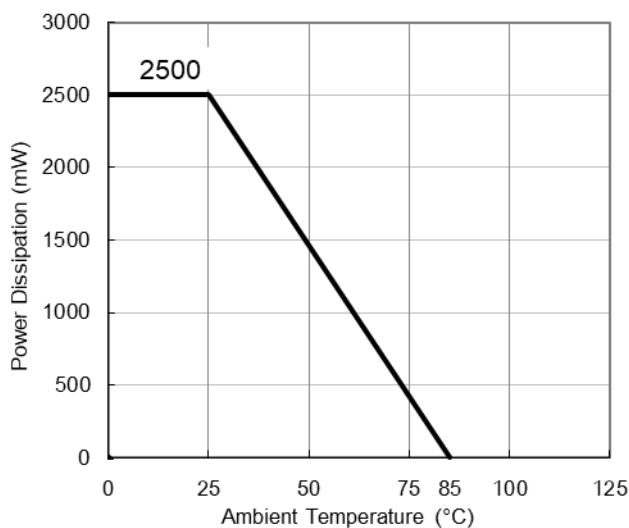
**Measurement Result**

(Ta = 25°C, Tjmax = 85°C)

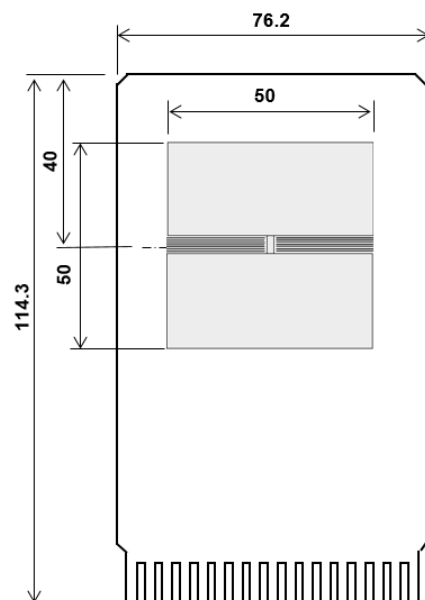
Item	Measurement Result
Power Dissipation	2500 mW
Thermal Resistance (θja)	θja = 24°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 4°C/W

θja: Junction-to-Ambient Thermal Resistance

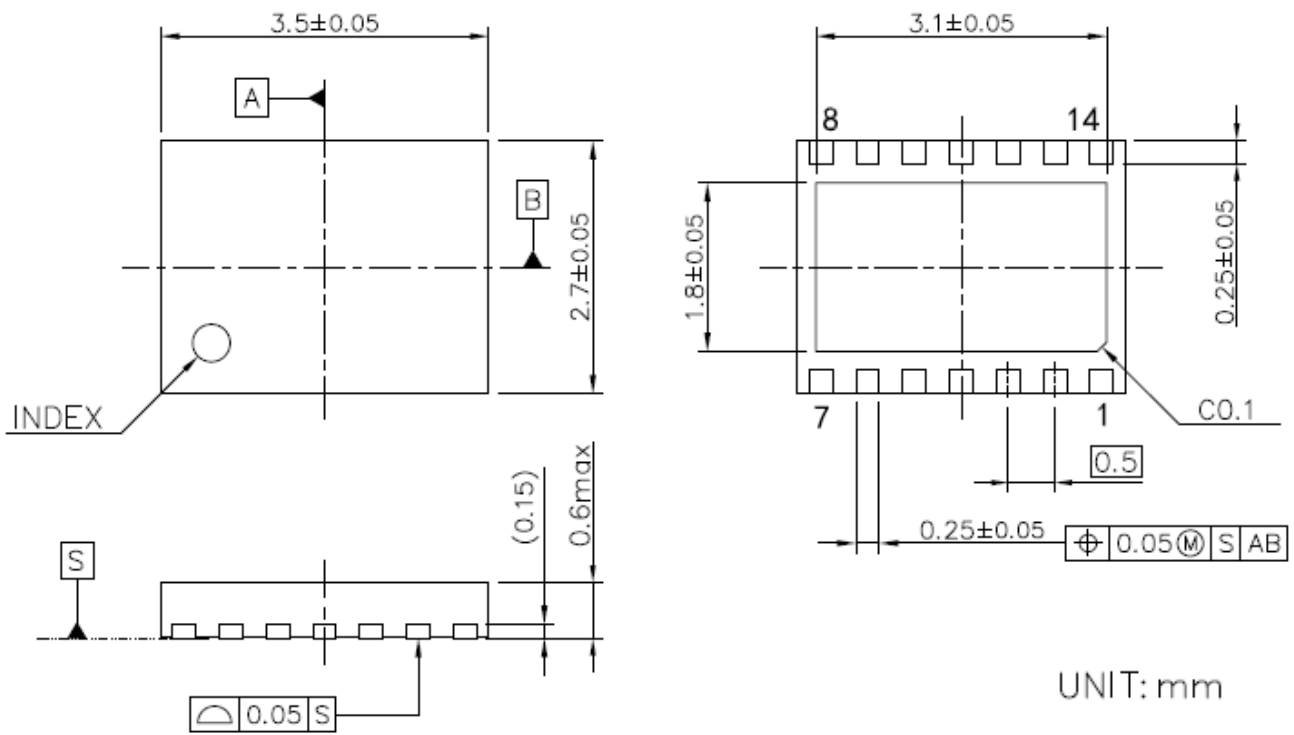
ψjt: Junction-to-Top Thermal Characterization Parameter



**Power Dissipation vs. Ambient Temperature**



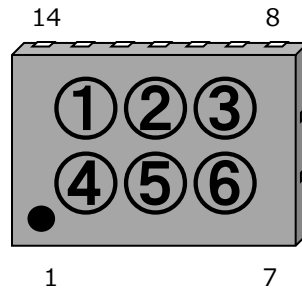
**Measurement Board Pattern**



**DFN2735-14 Package Dimensions**

①②③④ : Product Code ... Refer to *Part Marking List*

⑤⑥ : Lot Number ... Alphanumeric Serial Number



**R1810L (DFN2735-14) Part Markings**

**NOTICE**

There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact our sales or distributor before attempting to use AOI.

**R1810L Part Marking List**

Product Name	①②③④	Product Name	①②③④	Product Name	①②③④	Product Name	①②③④
R1810L003A	G V 0 0	R1810L003B	G W 0 0				
R1810L005A	G V 0 2	R1810L005B	G W 0 2	R1810L005C	G X 0 0	R1810L005D	G Y 0 0
R1810L006A	G V 0 3	R1810L006B	G W 0 3	R1810L006C	G X 0 1	R1810L006D	G Y 0 1
R1810L007A	G V 0 4	R1810L007B	G W 0 4	R1810L007C	G X 0 2	R1810L007D	G Y 0 2
R1810L013A	G V 0 5	R1810L013B	G W 0 5				
R1810L015A	G V 2 3						
R1810L016A	G V 0 6						
R1810L017A	G V 0 7	R1810L017B	G W 0 6	R1810L017C	G X 0 3		
R1810L018A	G V 0 8	R1810L018B	G W 0 7	R1810L018C	G X 0 4		
R1810L019A	G V 0 9	R1810L019B	G W 0 8	R1810L019C	G X 0 5	R1810L019D	G Y 0 3
R1810L022A	G V 1 0	R1810L022B	G W 0 9				
R1810L023A	G V 1 1	R1810L023B	G W 1 0				
R1810L024A	G V 1 2	R1810L024B	G W 1 1				
R1810L025A	G V 1 3	R1810L025B	G W 1 2				
R1810L026A	G V 1 4	R1810L026B	G W 1 3				
R1810L027A	G V 1 5	R1810L027B	G W 1 4				
R1810L028A	G V 1 6	R1810L028B	G W 1 5				
R1810L029A	G V 1 7	R1810L029B	G W 1 6				
R1810L030A	G V 1 8	R1810L030B	G W 1 7				
R1810L031A	G V 1 9	R1810L031B	G W 1 8				
R1810L032A	G V 2 0	R1810L032B	G W 1 9				
R1810L033A	G V 2 1	R1810L033B	G W 2 0				
R1810L034A	G V 2 2	R1810L034B	G W 2 1				



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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  - Aerospace Equipment
  - Equipment Used in the Deep Sea
  - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
  - Life Maintenance Medical Equipment
  - Fire Alarms / Intruder Detectors
  - Vehicle Control Equipment (automotive, airplane, railroad, ship, etc.)
  - Various Safety Devices
  - Traffic control system
  - Combustion equipment

In case your company desires to use this product for any applications other than general electronic equipment mentioned above, make sure to contact our company in advance. Note that the important requirements mentioned in this section are not applicable to cases where operation requirements such as application conditions are confirmed by our company in writing after consultation with your company.

6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, fire containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. The products have been designed and tested to function within controlled environmental conditions. Do not use products under conditions that deviate from methods or applications specified in this datasheet. Failure to employ the products in the proper applications can lead to deterioration, destruction or failure of the products. We shall not be responsible for any bodily injury, fires or accident, property damage or any consequential damages resulting from misuse or misapplication of the products.
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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