RICOH RP120Z001D

Low Input / Output 1.5 A LDO Regulator

No.EA-585-210825

OVERVIEW

The RP120Z001D is a very low dropout LDO which operates from input voltage as low as 0.768 V (@V_{SET} = 0.6 V, V_{BIAS} = 3.3 V, I_{OUT} = 1.5 A). The LDO uses an internal low on-resistance (67 mΩ @V_{SET} = 0.6 V, V_{BIAS} = 3.3 V, I_{OUT} = 1 A) NMOS transistor as the driver. The VBIAS pin provides the higher supply necessary for the LDO circuitry while the output current comes directly from the VIN input for high efficiency regulation.

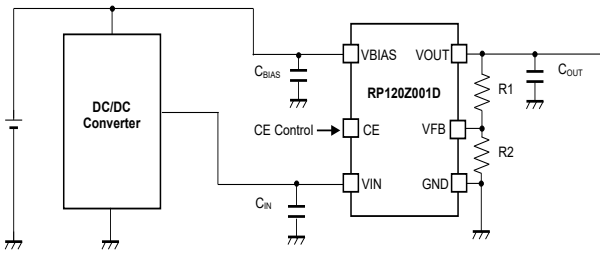
KEY BENEFITS

- High PSRR, high output current, and fast response characteristics.
- Suitable for sensitive sensors, high-quality audio, and RF devices.
- Very small WLCSP package (1.2 mm x 0.8 mm x 0.29 mm).

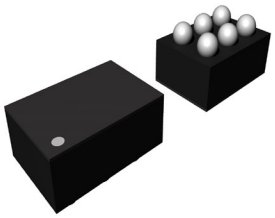
KEY SPECIFICATIONS

- Input Voltage Range :
  V_{IN} = V_{SET} + V_{DIFF} to V_{BIAS}
  (Ex. Min. 0.768 V @V_{SET} = 0.6 V, V_{BIAS} = 3.3 V, I_{OUT} = 1.5 A)
  V_{BIAS} = 2.4 V to 5.5 V
- External setting range of output voltage: 0.6 V to 3.6 V
- Output Current: I_{OUTMAX} = 1.5 A
- Supply Current: Typ. 35 µA
- Output Noise: Typ. 50 µVrms (V_{SET} = 0.6 V)
- Power Supply Ripple Rejection:
  Typ. 90 dB (f = 1 kHz, Ripple in V_{IN})
  Typ. 60 dB (f = 100 kHz, Ripple in V_{IN})
- Dropout Voltage: Typ. 67 mV
  (I_{OUT} = 1 A, V_{SET} = 0.6 V, V_{BIAS} = 3.3 V)
- Inrush Current Limit: Typ. 600 mA
- Short Circuit Current Protection: Typ. 600 mA
- Thermal Shutdown: Typ. 165 °C
- Ceramic Capacitor: C_{OUT} 4.7 µF

TYPICAL APPLICATION



PACKAGE (unit: mm)



WLCSP-6-P11
1.2 x 0.8 x 0.29

APPLICATIONS

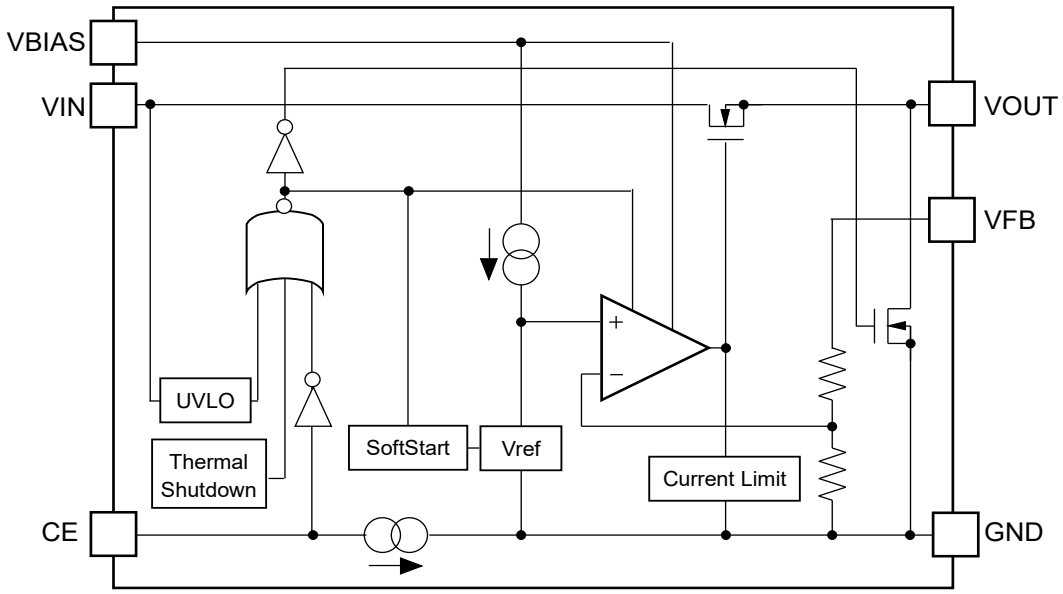
- Portable communication devices, battery-powered devices, camera, video, audio.
- Communication devices such as RF modules, clock generation devices such as VCOs and PLLs.
- Constant voltage source for analog circuits of FPGA and SoC.

SELECTION GUIDE

SELECTION GUIDE

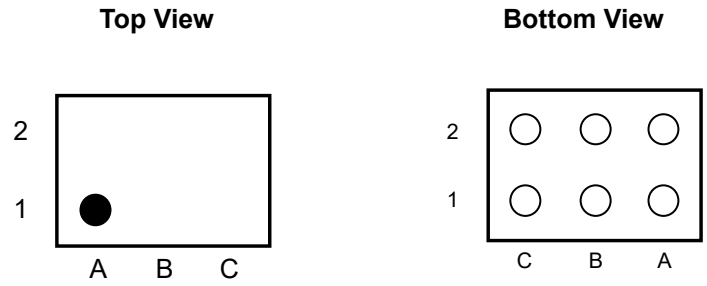
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
RP120Z001D-E2-F	WLCSP-6-P11	5,000 pcs	YES	YES

BLOCK DIAGRAM



RP120Z001D Block Diagram

PIN DESCRIPTIONS



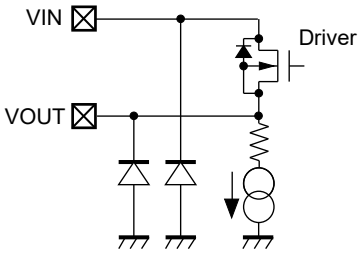
WLCSP-6-P11 Pin Configuration

RP120Z(WLCSP-6-P11) Pin Description

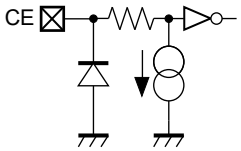
Symbol	Pin No.	I/O	Description
VOUT	A1	O	Output voltage pin. The VOUT pin supplies power to the load. A minimum output capacitance shown in “Phase Compensation” section is required to ensure stability. See the “Phase Compensation“ section for more information on output capacitance.
VFB	B1	I	Output Feedback Pin This is the input to the error amplifier. The output voltage typically set be connecting VFB pin to a resistor divider from VOUT pin to GND.
GND	C1	-	Ground pin of the internal circuit.
VIN	A2	I	Power supply pin of the NMOS driver. Input Supply Voltage. Output load current is supplied directly from VIN. The VIN pin should be locally bypassed to GND.
CE	B2	I	Chip Enable Pin. Logic "High" input : LDO is active, Logic “Low” input: the LDO into shutdown. This pin is pulled down internally.
VBIAS	C2	I	Analog Power Supply Pin Must be connected to an external supply voltage. The VBIAS pin should be locally bypassed to GND.

Please refer to “*TYPICAL APPLICATION CIRCUITN*“ or “*OPERATION*“ for details.

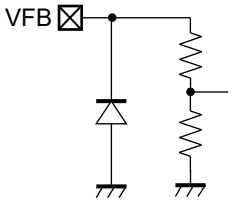
Internal Equivalent Circuit Diagram of Pin



Internal equivalent circuit diagram of VIN and VOUT pin



Internal equivalent circuit diagram of CE pin



Internal equivalent circuit diagram of VFB pin

ABSOLUTE MAXIMUM RATINGS

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Ratings	Unit
V_{BIAS}	Analog Power Supply Voltage	−0.3 to 6.5	V
V_{IN}	NMOS driver power input voltage	−0.3 to V_{BIAS} + 0.3 ≤ 6.5	V
V_{CE}	Input Voltage (CE pin)	−0.3 to 6.5	V
V_{OUT}	Output Voltage	−0.3 to V_{IN} + 0.3 ≤ 6.5	V
V_{FB}	VFB pin Voltage	−0.3 to V_{OUT} + 0.3 ≤ 6.5	V
P_D	Power Dissipation	Refer to Appendix *"POWER DISSIPATION"*	
Tj	Junction Temperature Range	−40 to 125	°C
Tstg	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.

ELECTROSTATIC DISCHARGE(ESD) RATINGS

Symbol	Conditions	Ratings	Unit
V_{HBM}	HBM C=100pF、R=1.5kΩ	±2000	V
V_{CDM}	CDM	±1000	

Electrostatic Discharge Ratings
The electrostatic discharge test is done based on JESD47. In the HBM method, ESD is applied using the power supply pin and GND pin as reference pins.

RECOMMENDED OPERATING CONDITIONS

RECOMMENDED OPERATING CONDITIONS

Symbol	Item	Ratings	Unit
V_{BIAS}	Input Voltage	2.4 to 5.5 (V_{SET} < 0.9) V_{SET} + 1.5V to 5.5 (V_{SET} ≥ 0.9)	V
V_{IN}		V_{SET} + V_{DIF} to V_{BIAS} (Max. 5.5)	V
Ta	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 ratings 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

V_{BIAS} = V_{CE} = 3.6V, V_{IN} = 1.1V, I_{OUT} = 1mA, C_{BIAS} = C_{IN} = 1.0µF, C_{OUT} = 4.7µF
unless otherwise specified.

The specifications surrounded by [ ] are guaranteed by design engineering at −40°C ≤ Ta ≤ 85°C.

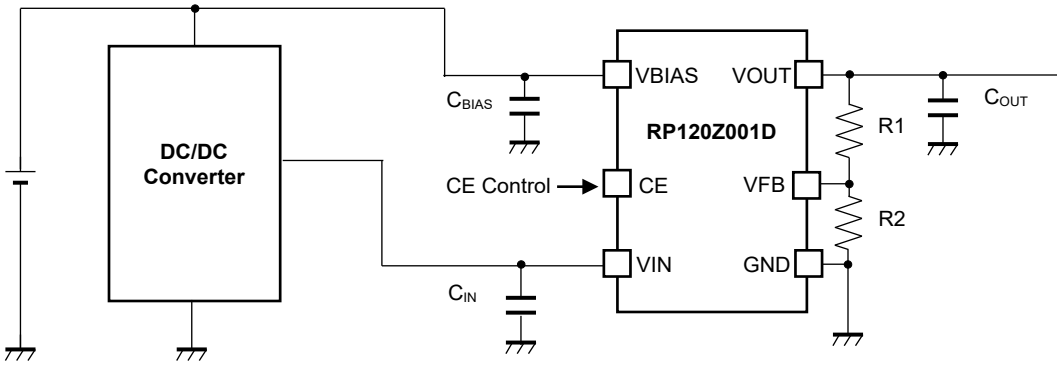
RP120Z001D (Ta = 25°C)

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_{FB}	Feedback pin Output Voltage	Ta = 25°C		0.591	0.6	0.609	V
		−40°C ≤ Ta ≤ 85°C		[0.582]	0.6	[0.618]	
I_{BIAS}	VBIAS Pin Supply Current	I_{OUT} = 0mA			35	[50]	µA
I_{IN}	VIN Pin Supply Current	I_{OUT} = 0mA			1.5	[2.8]	µA
I_{STBB}	VBIAS pin Standby Current	V_{BIAS} = 5.5V , V_{CE} = 0V			0	0.2	µA
I_{STBI}	VIN pin Standby Current	V_{BIAS} = 5.5V , V_{CE} = 0V			0	0.2	µA
I_{CEH}	CE Pin Input Current ”H”	V_{BIAS} = V_{CE} = 5.5V			0.25	[0.6]	µA
ΔV_{OUT} /ΔI_{OUT}	Load Regulation	1mA ≤ I_{OUT} ≤ 1.5A		[-1.7]	0.1	[1.7]	%
ΔV_{OUT} /ΔV_{IN}	V_{IN} Line Regulation	V_{SET} + 0.1V ≤ V_{IN} ≤ 3.6V		[-0.25]		[0.25]	%/V
ΔV_{OUT} /ΔV_{BIAS}	V_{BIAS} Line Regulation	V_{SET} + 1.5V ≤ V_{BIAS} ≤ 5.5V		[-0.25]		[0.25]	%/V
R_{DISTR}	Auto-discharge NMOS On-resistance	V_{CE} = 0V			50		Ω
V_{CEH}	CE Pin Input Voltage ”H”			[0.9]		[5.5]	V
V_{CEL}	CE Pin Input Voltage ”L”			[0]		[0.4]	V
V_{DIF}	Dropout Voltage	V_{SET} = 0.6V, V_{BIAS} = 3.3V	I_{OUT} = 1.0A		0.067	[0.115]	V
			I_{OUT} = 1.5A		0.102	[0.168]	
t_{SS}	Soft Start Time (1)			[100]	185	[320]	µs
I_{SC}	Short-circuit Current	V_{OUT}= 0V			0.6		A
$I_{LIMRISE}$	Limit Current at Start-up	V_{OUT}= 0V			0.6		A
V_{UVLOF}	UVLO Detection Voltage	V_{BIAS} = V_{CE} = 3.6V, V_{IN} Falling		[0.26]	0.3	[0.34]	V
V_{UVLOR}	UVLO Release Voltage	V_{BIAS} = V_{CE} = 3.6V, V_{IN} Rising		[0.36]	0.4	[0.44]	V

All test items listed under Electrical Characteristics are done with short-circuiting VOUT pin and VFB pin, and under the pulse load condition (Tj ≈ Ta = 25°C).

(1) It is specified based on the measurement result of the time when the VOUT pin voltage rises from 10% to 90%, and converted it to 100% time by calculation.

TYPICAL APPLICATION CIRCUIT



RP120Z001D (Adjustable Output Type) Typical Application Circuit

The output voltage is set by the ratio of two external resistors as shown above.

Output Voltage Setting Range : 0.6V to 3.6V
V_{FB} = 0.6V (Typ.)

The set output voltage (V_{SET}) is as follows.

$$V_{SET} = V_{FB} \times ((R1 + R2) / R2)$$

More precisely, the current in R1 is the current in R2 plus the internal current through the resistance (R_{IC}) between VFB pin and GND. The value of the R_{IC} is Typ.2.7MΩ, therefore, $V_{FB} \times R1/R_{IC}$ makes an error.
If R1 << R_{IC}, the error can be reduced.
Use a resistance value, R2 of 20kΩ or less for V_{SET} <1.3V and 10kΩ or less for V_{SET} ≥ 1.3V.

External Components

V_{IN}, V_{BIAS} pins should be locally bypassed to GND to make their impedance low. If their impedance is high, making unexpected noise or unstable operation may result. A capacitor (C_{BIAS}) between VBIAS pin and GND and another capacitor (C_{IN}) between VIN pin and GND should be 1uF or more each.
It is desirable to choose X7R and X5R ceramic capacitors (voltage rating should be more than twice as much as input), which have good temperature characteristics of ESR, ESL, and capacitance.

Phase Compensation

The RP120Z is designed to be stable with an output capacitor for phase compensation with whole range of the output load current. An output capacitor of minimum 4.7μF (V_{SET} ≤ 2.0V), or minimum 10μF (V_{SET}> 2.0V) or greater value of C_{OUT} is recommended to ensure stability. Note that bypass capacitors used to decouple individual components powered by the more stable characteristics and are more suitable for use as the output capacitor.
The X7R type has better stability across temperature, while the X5R is less expensive and is available in higher values.

Set Output Voltage (V_{SET})	Effective Capacity
0.6V ≤ V_{SET} < 1.2V	Min. 2.7μF
1.2V ≤ V_{SET} ≤ 2.0V	Min. 2.4μF
2.0V < V_{SET} ≤ 3.6V	Min. 6.0μF

OPERATION

Chip Enable Function

Input "High" to CE pin, the RP120Z is active. Input "Low" to CE pin, the RP120Z is into shutdown.
Regardless of the state of V_{IN} and V_{BIAS} voltage, a voltage can be forced to CE pin.
The CE pin is pulled down inside the IC with a constant current of Typ.0.25μA, therefore, when the CE pin is left floating, the RP120Z goes into shutdown state. CE pin must be tied to a valid logic level (such as V_{BIAS}) if not used.

UVLO (Undervoltage Lock Out) Function

An undervoltage lockout comparator (UVLO) is activated while CE pin is “High”.
The UVLO comparator senses V_{IN} pin voltage to ensure that the V_{IN} supply for the LDO is greater than UVLO released voltage (V_{UVLOR}, Typ. 0.4V) before enabling the LDO. If V_{IN} is below the UVLO threshold (V_{UVLOF}, Typ. 0.3V), the UVLO shuts down the LDO, and V_{OUT} is pulled to GND through the external divider and internal auto discharge transistor for Off state. After UVLO is released, the LDO starts up with soft-start.

Thermal Shutdown Function

The RP120Z has internal thermal limiting designed to protect the device during momentary overload conditions. For continuous normal conditions, the maximum junction temperature rating of 125°C must not be exceeded. At higher temperatures, or in cases where internal power dissipation cause excessive self heating on-chip, the thermal shutdown circuitry will shut down LDO when the junction temperature exceeds Typ. 165°C, the RP120Z will reenable once the junction temperature drops back to thermal shutdown released threshold (Typ. 125°C), the IC will restart with the soft start operation.

Auto Discharge

When turning off, the V_{OUT} voltage quickly pulled down to near 0V by discharging electric charge stored in output capacitor through the MOSFET connected between the VOUT pin and GND.
The auto discharge function is enabled when CE pin = ”Low”, thermal shutdown detection, or UVLO detection. This function is effective when V_{BIAS} is the minimum operating voltage or higher. The on-resistance of the MOSFET is Typ.50Ω.

Soft Start / Inrush Current Limit

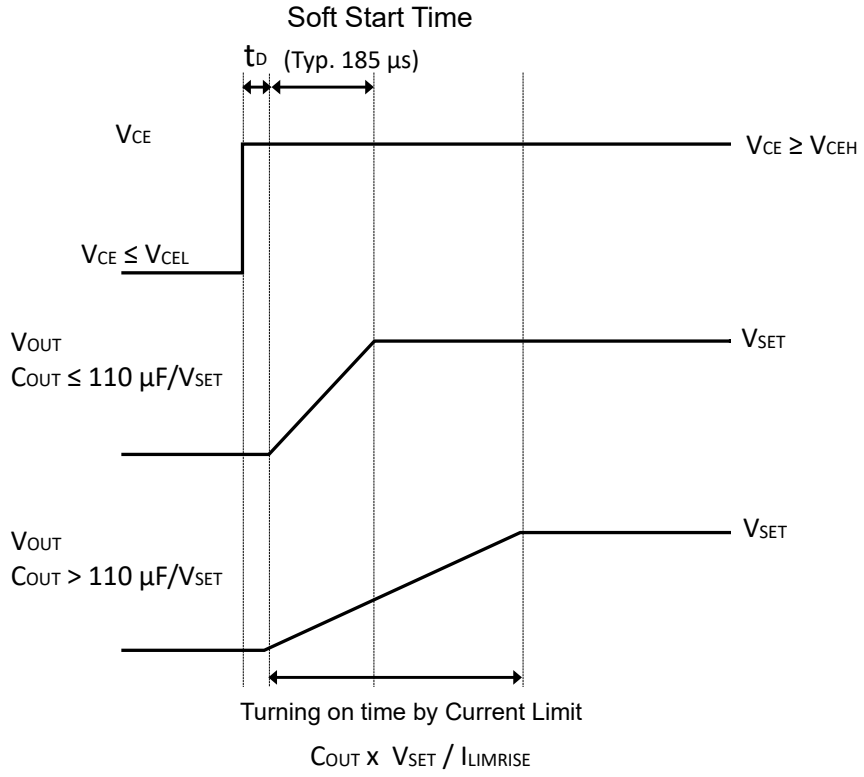
The RP120Z includes a soft-start feature to prevent excessive inrush current flow at V_{IN} during start-up. When the LDO is enabled, the soft-start circuitry gradually increases the internal reference voltage of LDO over a period of approximately 185µs.
In addition, the RP120Z limits the inrush current up to Typ. 600mA during startup.

The inrush current depends on the capacitance value of C_{OUT}. Connecting a large load and the inrush current value may exceed the threshold of Typ. 600mA during startup, the slew rate is further limited and extended start-up time. If an effective capacitance value of the C_{OUT} is larger than about 110µF / V_{SET} is used, the output voltage ramp up time is determined by the inrush current limit value and C_{OUT} value.

The output turning on time (t_{ON}) can be calculated from the following equation:

$t_{ON} = t_D + C_{OUT} \times V_{SET} / I_{LIMRISE}$
t_D : Delay Time at Start-up 60µs
V_{SET} : Set Output Voltage
$I_{LIMRISE}$: Current Limit at Start-up Typ. 600mA

If the load current (I_{LOAD}) exists other than the charge current to C_{OUT} during start-up, the start-up time is extended. The load current over $I_{LIMRISE}$ may interfere charging of C_{OUT} and the output does not rise up.



TECHNICAL NOTES

Constraints of the voltage value and the sequence of V_{BIAS} and V_{IN}

V_{IN} voltage must be applied below V_{BIAS} voltage since a forward current flows through the parasitic diode in the IC. $V_{BIAS} \geq V_{IN}$ should be true even when they turn on and off. At startup, supply V_{IN} and V_{BIAS} at the same time, or supply V_{IN} after V_{BIAS}. When turning off the supply voltage of V_{IN} and V_{BIAS}, turn them off at the same time, or turn off V_{IN} before V_{BIAS}.

Thermal Shutdown

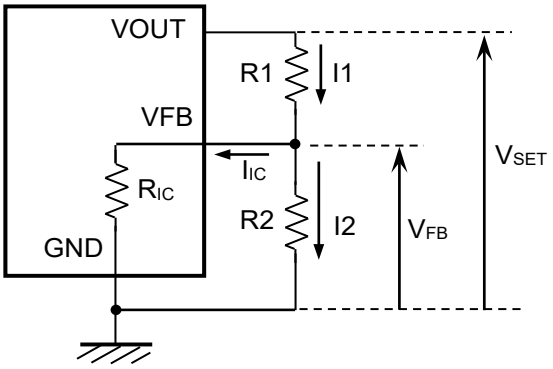
The thermal shutdown function prevents the IC from fuming and firing but does not ensure the IC's reliability or keep the IC below the absolute maximum ratings. The thermal shutdown function does not operate against the heat generated by abnormal IC operation such as latch-up and overvoltage.
The thermal shutdown function operates in a state over the absolute maximum ratings, and should not be used for a system design.

APPLICATION INFORMATION

Adjustable Output Voltage

The output voltage is set by the ratio of two external resistors (R1, R2).

The device servos the output to maintain the VFB pin voltage at 0.6V(referenced to ground). The output voltage (V_{SET}) can be calculated using the formula below.



$I1 = I_{IC} + I2$ ..... (1)

$I2 = V_{FB} / R2$ ..... (2)

(1)、(2)

$I1 = I_{IC} + V_{FB} / R2$ ..... (3)

$V_{SET} = V_{FB} + R1 \times I1$ ..... (4)

I1 can be substituted by formula (3)

$V_{SET} = V_{FB} + R1 \times (I_{IC} + V_{FB} / R2)$

$= V_{FB} \times (1 + R1 / R2) + R1 \times I_{IC}$ ..... (5)

$R1 \times I_{IC}$ in the above formula (5) is the error.

$I_{IC} = V_{FB} / R_{IC}$ ..... (6)

Thus,

$R1 \times I_{IC} = R1 \times V_{FB} / R_{IC}$

$= V_{FB} \times R1 / R_{IC}$ ..... (7)

If $R1 << R_{IC}$, the error can be minimized.

If the error is ignored, the output voltage is calculated by the next formula.

$V_{SET} = V_{FB} \times ((R1 + R2) / R2)$ ..... (8)

R_{IC} of RP120Z is Typ.2.7MΩ (Ta=25°C, guaranteed by design value).

The accuracy of the output voltage is determined by the V_{FB} accuracy and resistance accuracy.

The current calculated by V_{SET} / (R1 + R2) flows between the VOUT pin and GND.

V_{FB} of RP120Z001D is typically 0.6V.

Recommended output voltage setting range: 0.6V ≤ V_{SET} ≤ 3.6V

V_{FB} accuracy: 0.6V ± 18mV (guaranteed by design in all temperature range).

Use a resistance value, R2 of 20kΩ or less for V_{SET} <1.3V and 10kΩ or less for V_{SET} ≥ 1.3V.

Reference Resistance Value Table

Set Output Voltage [V]	R1 [kΩ]	R2 [kΩ]
0.6	Short	Open
0.7	3.3	20
0.8	6.6	20
0.9	9.9	20
1.05	14.9	20
1.1	16.5	20
1.2	19.9	20
1.3	11.6	10
1.5	14.9	10
1.8	19.9	10
2.5	31.6	10
2.8	36.5	10
3.0	39.9	10
3.3	44.8	10
3.6	49.8	10

PD-WLCSP-6-P11-(85125)-JE-A

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

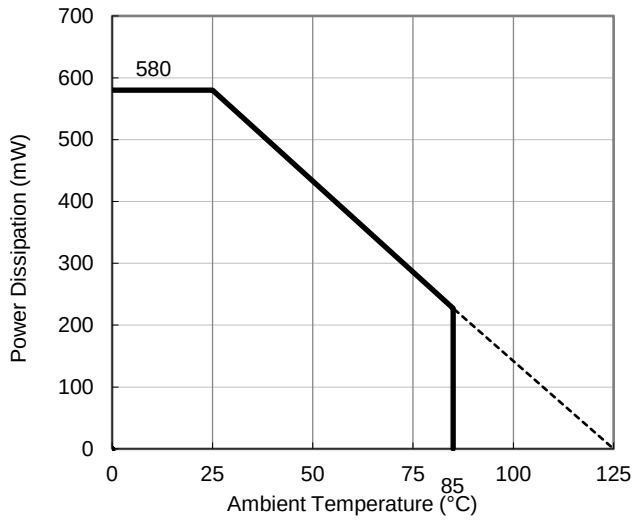
Measurement Conditions

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 x 114.3 mm x 1.6 mm
Copper Ratio	Outer Layer (First Layer): Less than 10% Inner Layers (Second and Third Layers): 74.2 x 74.2mm 100% Outer Layer (Fourth Layer): Less than 10%

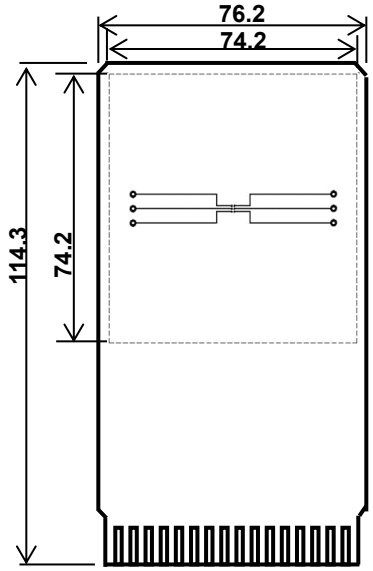
Measurement Result (Ta = 25°C, Tjmax = 125°C)

Item	Measurement Result
Power Dissipation	580 mW
Thermal Resistance (θja)	θja = 170°C/W

θja: Junction-to-Ambient Thermal Resistance



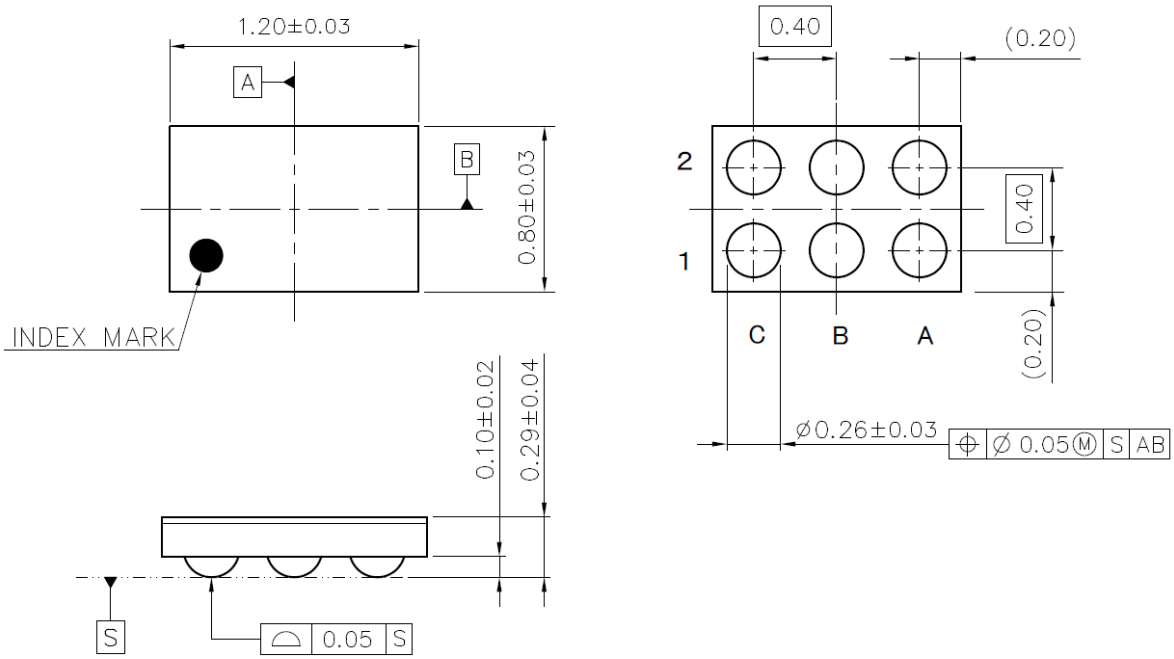
Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

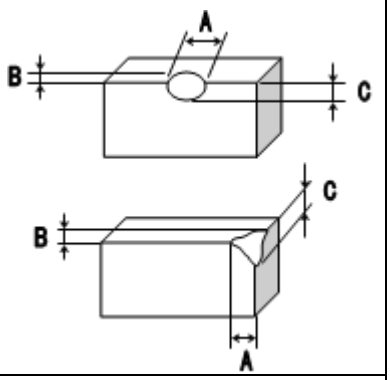
RICOH

DM- WLCSP-6-P11-JE-A



UNIT: mm

WLCSP-6-P11 Package Dimensions

No.	Inspection Items	Inspection Criteria	Figure
1	Package chipping	A≥0.2mm is rejected B≥0.2mm is rejected C≥0.2mm is rejected And, Package chipping to Si surface and to bump is rejected.	
2	Si surface chipping	A≥0.2mm is rejected B≥0.2mm is rejected C≥0.2mm is rejected But, even if A≥0.2mm, B≤0.1mm is acceptable.	
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)	

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 Ricoh 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 prior written consent of Ricoh.
3. Please be sure to take any necessary formalities under relevant laws or regulations before exporting or otherwise taking out of your country the products or the technical information described herein.
4. The technical information described in this document shows typical characteristics of and example application circuits for the products. The release of such information is not to be construed as a warranty of or a grant of license under Ricoh's or any third party's intellectual property rights or any other rights.
5. The products listed in this document are intended and designed for use as general electronic components in standard applications (office equipment, telecommunication equipment, measuring instruments, consumer electronic products, amusement equipment etc.). Those customers intending to use a product in an application requiring extreme quality and reliability, for example, in a highly specific application where the failure or misoperation of the product could result in human injury or death (aircraft, spacevehicle, nuclear reactor control system, traffic control system, automotive and transportation equipment, combustion equipment, safety devices, life support system etc.) should first contact us.
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. Anti-radiation design is not implemented in the products described in this document.
8. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
9. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
10. 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 Ricoh sales or our distributor before attempting to use AOI.
11. Please contact Ricoh sales representatives should you have any questions or comments concerning the products or the technical information.

RoHS Compliant
Halogen Free

Ricoh is committed to reducing the environmental loading materials in electrical devices with a view to contributing to the protection of human health and the environment.
Ricoh has been providing RoHS compliant products since April 1, 2006 and Halogen-free products since April 1, 2012.

RICOH ELECTRONIC DEVICES CO., LTD.

Official website
https://www.n-redc.co.jp/en/
Contact us
https://www.n-redc.co.jp/en/buy/