RP602x Series

1.5 A PWM/VFM Buck-Boost DC/DC Converter with Synchronous Rectifier

No. EA-353-240419

OVERVIEW

The RP602x is a 6.5 V (Max. rating) buck-boost DC/DC converter with synchronous rectifier. This device is ideally suited for industrial or OA equipment that require constant voltage even when low-input voltage (Min. 2.3 V). Since operating with switching frequency of 2.6 MHz, this device can realize a high-speed response with a small coil and maintain a high-efficiency at low input voltage.

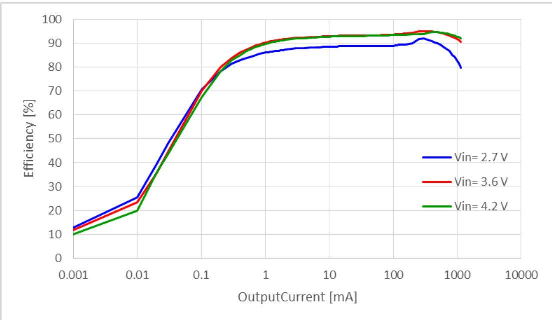
KEY BENEFITS

- **Realize a high-efficiency at low input voltage.**
- **Provide output voltage of 2.7 to 4.2 V corresponding to input voltage of 2.3 to 5.5 V.**

KEYSPECIFICATIONS

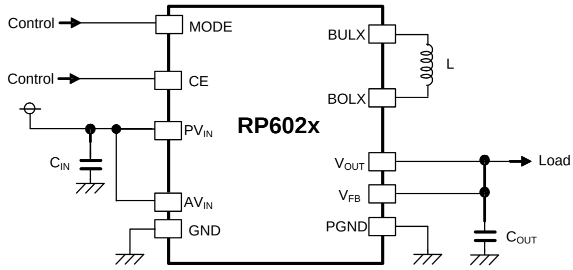
- Input Voltage Range:2.3 V to 5.5 V
- Output Voltage Range:2.7 V to 4.2 V (0.1V step)
- Output Voltage Accuracy :±1.5%
- Line Regulation: Typ. 0.5%, PWM mode
- Load Regulation: Typ. 0.1%, (I_{OUT} = 0 to 500 mA, PWM mode)
- Maximum Output Current: Typ. 1.5 A, (PVIN = 3 V, VOUT = 3.3 V)
- Maximum Burst Current: Typ. 2.7 A, (PVIN=3 V, VOUT=3.3 V, Duty=10%, t=2.0 ms)
- Overcurrent Limit Protection: Typ. 4.2 A
- Oscillator Frequency: Typ. 2.6 MHz
- Built-in Driver ON Resistance: Typ. Pch. 80 mΩ, Nch. 80 mΩ
- Operating Quiescent Current: Typ. 27.5 µA, (VFM mode, Non-switching)
- UVLO Detector Threshold: Typ. 2.0 V
- Soft-start Time: Typ. 1.0 ms
- Thermal Shutdown Temperature:Typ.150°C
- Protection Feature: Overvoltage, Overcurrent

TYPICAL CHARACTERISTICS



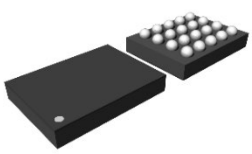
Efficiency Characterisitcs (RP602Z330x, MODE = H)

TYPICAL APPLICATION



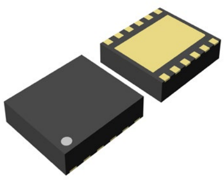
PACKAGE

RP602Z



WLCSP-20-P1
2.305 mm x 1.700 mm

RP602K



DFN(PL)2730-12
2.7mm × 3.0mm

OPTIONAL FUNCTION

The following functions are user-selectable options.

Code	Auto-discharge Function	Latch Protection	Reset Protection
A/E	Yes	Yes	No
B/F	No	Yes	No
C/G	Yes	No	Yes
D/H	No	No	Yes

APPLICATIONS

- Power source for portable equipment such as laptops, PDAs, DSCs, cellular phones, and smartphones
- Power source for Li-ion battery-used equipment

SELECTION GUIDE

Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
RP602Zxxx$-E2-F	WLCSP-20-P1	5,000 pcs	Yes	Yes
RP602Kxxx#-TR	DFN(PL)2730-12	5,000 pcs	Yes	Yes

xxx: Specify the set output voltage (V_{SET}) within the range of 2.7 V to 4.2 V in 0.1 V [1] steps.

$: Specify the combination of the auto-discharge option and the protection function option.

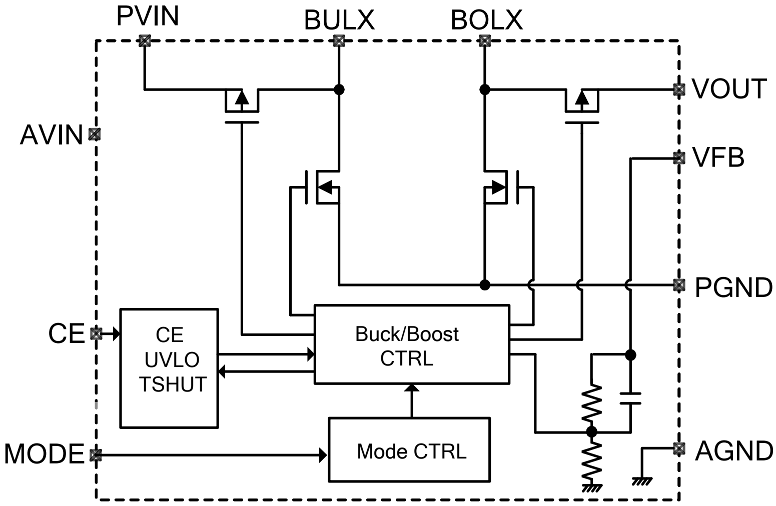
Symbol	Auto-discharge Function	Latch-type Protection	Reset-type Protection	Short-circuit Protection
A	Yes	Yes	No	Yes
B	No	Yes	No	Yes
C	Yes	No	Yes	Yes
D	No	No	Yes	Yes

#: Specify the combination of the auto-discharge option and the protection function option.

Symbol	Auto-discharge Function	Latch-type Protection	Reset-type Protection	Short-circuit Protection
E	Yes	Yes	No	Yes
F	No	Yes	No	Yes
G	Yes	No	Yes	Yes
H	No	No	Yes	Yes

[1] 0.05 V step is also available as a custom code.

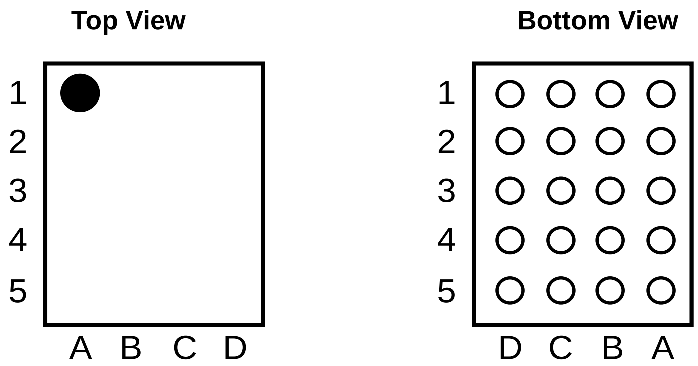
BLOCK DIAGRAM



RP602x Block Diagram

PIN DESCRIPTION

RP602Z Pin Description



WLCSP-20-P1 Pin Configuration

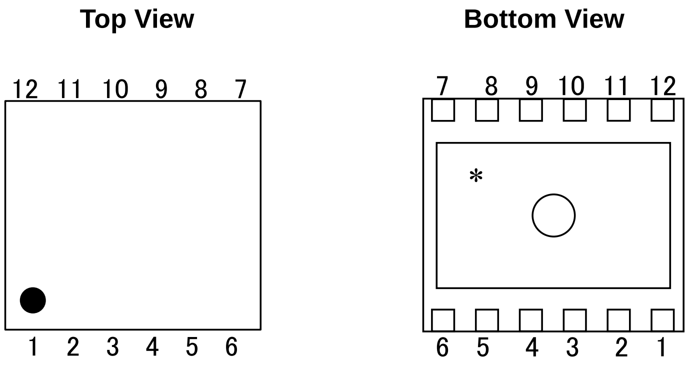
Pin No.	Symbol	Pin Description
A5, B5, C5	VOUT (1)	Output Voltage Pin
A4, B4, C4	BOLX (1)	Boost Switching Output Pin
A3, B3, C3	PGND (2)	Power GND Pin
A2, B2, C2	BULX (1)	Buck Switching Output Pin
A1, B1, C1	PVIN (1)	Power Input Voltage Pin
D1	AVIN (1)	Analog Power Input Voltage Pin
D2	CE	Chip Enable Pin, Active-high
D3	MODE	Mode Control Pin, Forced PWM Control: L, PWM/VFM Auto Switching Control: H
D4	AGND (2)	Analog GND Pin
D5	VFB	Output Voltage Feedback Pin

Pin Truth Table

CE Pin	MODE Pin (3)	Operation
L	-	OFF
H	H	PWM/ VFM Auto Switching Control Mode
	L	Forced PWM Control Mode

(1) The pin numbers sharing the same pin symbol must be connected together: A4, B4, and C4 of the BOLX pin, A2, B2, and C2 of the BULX pin, A5, B5, and C5 of the VOUT pin. D1 of the AVIN pin and A1, B1, and C1 of the PVIN pin must be connected together.
(2) D4 of the AGND pin and A3, B3, and C3 of the PGND pin must be connected to the ground.
(3) The logic to the MODE pin should not be changed while CE = “H”.

RP602K Pin Description



DFN(PL)2730-12 Pin Configuration

Pin No.	Symbol	Pin Description
1	AVIN [1]	Analog Power Input Voltage Pin
2	CE	Chip Enable Pin, Active-high
3	MODE	Mode Control Pin, Forced PWM Control: L, PWM/VFM Auto Switching Control: H
4	NC	No Connection
5	AGND [2]	Analog GND Pin
6	VFB	Output Voltage Feedback Pin
7	VOUT	Output Voltage Pin
8	BOLX	Boost Switching Output Pin
9,10	PGND [2]	Power GND Pin
11	BULX	Buck Switching Output Pin
12	PVIN [1]	Power Input Voltage Pin

∗ The tab on the bottom of the package must be connected to the ground plane on the board to enhance thermal performance.

Pin Truth Table

CE Pin	MODE Pin [3]	Operation
L	-	OFF
H	H	PWM/ VFM Auto Switching Control Mode
	L	Forced PWM Control Mode

(1) The AVIN pin and the PVIN pin must be connected together.
(2) The AGND pin and the PGND pin must be connected to the ground.
(3) The logic to the MODE pin should not be changed while CE = “H”.

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings (AGND = PGND = 0 V)

Symbol	Item		Rating	Unit
V_{IN}	AVIN/ PVIN Pin Voltage		−0.3 to 6.5	V
V_{BULX}	BULX Pin Voltage		−0.3 to V_{IN} + 0.3	V
V_{BOLX}	BOLX Pin Voltage		−0.3 to V_{OUT} + 0.3	V
V_{CE}	CE Pin Voltage		−0.3 to 6.5	V
V_{MODE}	MODE Pin Voltage		−0.3 to 6.5	V
V_{OUT}	VOUT Pin Voltage		−0.3 to 6.5	V
V_{FB}	VFB Pin Voltage		−0.3 to 6.5	V
I_{LX}	BULX/ BOLX Pin Output Current		4.2	A
P_D	Power Dissipation [1]	WLCSP-20-P1 (JEDEC STD.51-9)	1400	mW
		DFN(PL)2730-12 (JEDEC STD.51-7)	3100	
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 life time and safety for both device and system using the device in the field.
The functional operation at or over these absolute maximum ratings are not assured.

RECOMMENDED OPERATING CONDITIONS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	2.3 to 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.

[1] Refer to *POWER DISSIPATION* for detailed information.

ELECTRICAL CHARACTERISTICS

Open-loop Measurement GND = 0 V, unless otherwise noted.

RP602Z Electrical Characteristics (Ta = 25°C)

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
I_{DD}	Power Current	V_{IN} = 5.5 V, V_{OUT} = 4.2 V	V_{MODE} = 5.5V		27.5	60	µA
			V_{MODE} = 0 V		1000	1400	
$I_{STANDBY}$	Standby Current	V_{IN} = 5.5 V, V_{CE} = 0 V			0.1	5.0	µA
V_{OUT}	Output Voltage	V_{IN} = 3.6 V		x0.985		x1.015	V
ΔV_{OUT} /ΔTa	Output Voltage Temperature Coefficient	−40°C ≤ Ta ≤ 85°C			±50		ppm/ °C
V_{OVP}	OVP Detection Voltage	V_{IN} = 3.6 V , Rising		4.5	5.0	5.5	V
	OVP Release Voltage	V_{IN} = 3.6 V , Falling		4.3	4.8	5.3	V
f_{OSC}	Switching Frequency	V_{IN} = 3.6 V		2.4	2.6	2.9	MHz
I_{LIMHS}	BULX Current Limit (1)	V_{IN} = 3.6 V		3.7	4.2		A
R_{ON}	High & Low Switch On-resistance	V_{IN} = 3.6 V			80		mΩ
R_{DIS}	On-resistance of Discharge Tr. (RP602ZxxxA/C)	V_{IN} = 3.6 V, V_{CE} = 0 V			80		Ω
I_{FBH}	V_{FB} Input Current, High	V_{IN} = 5.5 V, V_{CE} = 0 V V_{FB} = 5.5V				1	µA
I_{FBL}	V_{FB} Input Current, Low	V_{IN} = 5.5 V, V_{CE} = 0 V V_{FB} = 0V				1	µA
V_H	CE / MODE Pins Input Voltage, High	V_{IN} = 5.5 V		1.0			V
V_L	CE / MODE Pins Input Voltage, Low	V_{IN} = 2.3 V				0.4	V
I_H	CE / MODE Pins Input Current, High	V_{IN} = V_{CE} = 5.5 V		−1	0	1	µA
I_L	CE / MODE Pins Input Current, Low	V_{IN} = 5.5 V, V_{CE} = 0 V		−1	0	1	µA
V_{UVLO1}	UVLO Detection Voltage	V_{IN} = Falling		1.83	2.00		V
V_{UVLO2}	UVLO Release Voltage	V_{IN} = Rising			2.05	2.25	V
T_{TSD}	Thermal Shutdown Threshold Temperature	Tj, Rising			150		°C
T_{TSR}		Tj, Falling			110		°C
t_{START}	Soft-start Time	V_{IN} = 3.6 V			1		ms
t_{PROT}	Protection Delay Time (RP602ZxxxA/B/C/D)	V_{IN} = 3.6 V			1.6		ms
t_{RST}	Reset Protection Delay Time (RP602ZxxxC/D)	V_{IN} = 3.6 V			12		ms

All test items listed under *ELECTRICAL CHARACTERISTICS* are done under the pulse load condition (Tj ≈ Ta = 25°C).

(1) BULX Current Limit vary according to the switching duty ratio.

Open-loop Measurement GND = 0 V, unless otherwise noted.

RP602K Electrical Characteristics (Ta = 25°C)

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
I_{DD}	Power Current	V_{IN} = 5.5 V, V_{OUT} = 4.2 V,	V_{MODE} = 5.5 V		27.5	60	µA
			V_{MODE} = 0 V		1000	1400	
$I_{STANDBY}$	Standby Current	V_{IN} = 5.5 V, V_{CE} = 0 V			0.1	5.0	µA
V_{OUT}	Output Voltage	V_{IN} = 3.6 V		x0.985		x1.015	V
$\Delta V_{OUT}/\Delta Ta$	Output Voltage Temperature Coefficient	−40°C ≤ Ta ≤ 85°C			±50		ppm/°C
V_{OVP}	OVP Detection Voltage	V_{IN} = 3.6 V , Rising		4.5	5.0	5.5	V
	OVP release Voltage	V_{IN} = 3.6 V , Falling		4.3	4.8	5.3	V
f_{OSC}	Switching Frequency	V_{IN} = 3.6 V		2.4	2.6	2.9	MHz
I_{LIMHS}	BULX Current Limit (1)	V_{IN} = 3.6 V		3.7	4.2		A
R_{ON}	High & Low Switch On-resistance	V_{IN} = 3.6 V			120		mΩ
R_{DIS}	On-resistance of Discharge Tr. (RP602KxxxE/G)	V_{IN} = 3.6 V, V_{CE} = 0 V			80		Ω
I_{FBH}	V_{FB} Input Current, High	V_{IN} = 5.5 V, V_{CE} = 0 V V_{FB} = 5.5V				1	µA
I_{FBL}	V_{FB} Input Current, Low	V_{IN} = 5.5 V, V_{CE} = 0 V V_{FB} = 0V				1	µA
V_H	CE / MODE Pins Input Voltage, High	V_{IN} = 5.5 V		1.0			V
V_L	CE / MODE Pins Input Voltage, Low	V_{IN} = 2.3 V				0.4	V
I_H	CE / MODE Pins Input Current, High	V_{IN} = V_{CE} = 5.5 V		−1	0	1	µA
I_L	CE / MODE Pins Input Current, Low	V_{IN} = 5.5 V, V_{CE} = 0 V		−1	0	1	µA
V_{UVLO1}	UVLO Detection Voltage	V_{IN} = Falling		1.83	2.00		V
V_{UVLO2}	UVLO Release Voltage	V_{IN} = Rising			2.05	2.25	V
T_{TSD}	Thermal Shutdown Threshold Temperature	Tj, Rising			150		°C
T_{TSR}		Tj, Falling			110		°C
t_{START}	Soft-start Time	V_{IN} = 3.6 V			1		ms
t_{PROT}	Protection Delay Time (RP602KxxxE/F/G/H)	V_{IN} = 3.6 V			1.6		ms
t_{RST}	Reset Protection Delay Time (RP602KxxxG/H)	V_{IN} = 3.6 V			12		ms

All test items listed under *ELECTRICAL CHARACTERISTICS* are done under the pulse load condition (Tj ≈ Ta = 25°C).

(1) BULX Current Limit vary according to the switching duty ratio.

Product-specific Electrical Characteristics (Ta = 25°C)

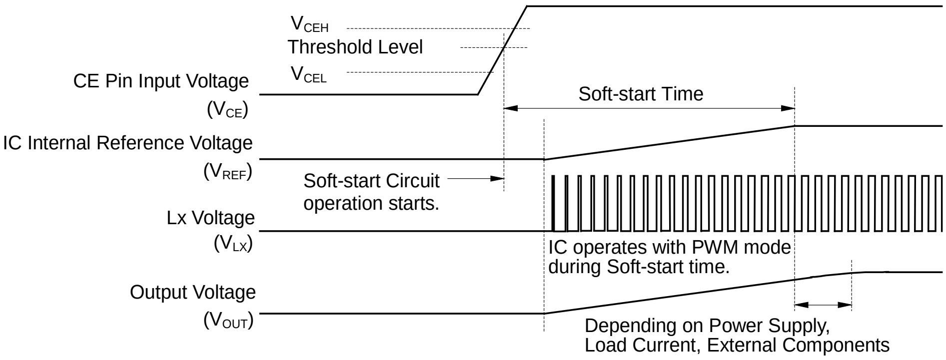
Product Name	V_{OUT} (V)		
	Min.	Typ.	Max.
RP602x270x	2.660	2.700	2.740
RP602x280x	2.758	2.800	2.842
RP602x290x	2.857	2.900	2.943
RP602x300x	2.955	3.000	3.045
RP602x310x	3.054	3.100	3.146
RP602x320x	3.152	3.200	3.248
RP602x330x	3.251	3.300	3.349
RP602x340x	3.349	3.400	3.451
RP602x350x	3.448	3.500	3.552
RP602x360x	3.546	3.600	3.654
RP602x370x	3.645	3.700	3.755
RP602x380x	3.743	3.800	3.857
RP602x390x	3.842	3.900	3.958
RP602x400x	3.940	4.000	4.060
RP602x410x	4.039	4.100	4.161
RP602x420x	4.137	4.200	4.263

THEORY OF OPERATION

Soft-start Time

Starting-up with CE Pin

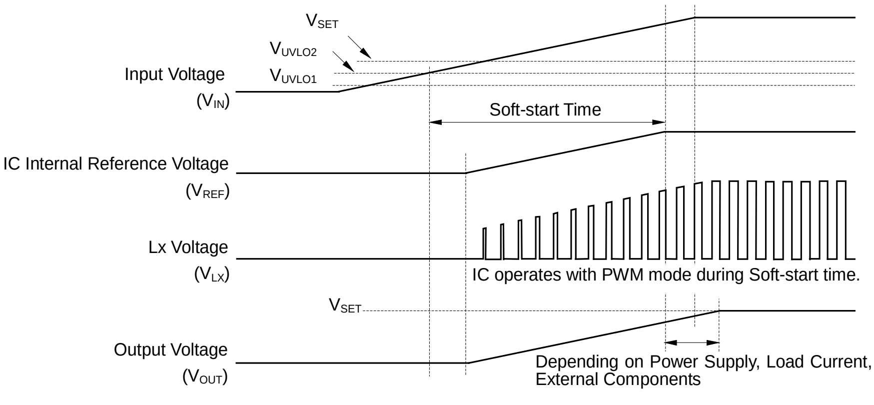
The IC starts to operate when the CE pin voltage (V_{CE}) exceeds the threshold voltage. The threshold voltage is preset between CE "High" input voltage (V_{CEH}) and CE "Low" input voltage (V_{CEL}). After the start-up of the IC, soft-start circuit starts to operate. Then, after a certain period of time, the reference voltage (V_{REF}) in the IC gradually increases up to the specified value. Soft-start time (t_{START}) starts when soft-start circuit is activated, and ends when the reference voltage reaches the specified voltage. Soft start time is not always equal to the turn-on speed of the DC/DC converter. Note that the turn-on speed could be affected by the power supply capacity, the output current, the inductance value and the C_{OUT} value.



Timing Chart: Starting-up with CE Pin

Starting-up with Power Supply

After the power-on, when V_{IN} exceeds the UVLO release voltage (V_{UVLO2}), the IC starts to operate. Then, soft-start circuit starts to operate and after a certain period of time, V_{REF} gradually increases up to the specified value. Soft-start time starts when soft-start circuit is activated, and ends when V_{REF} reaches the specified voltage. Note that the turn-on speed of V_{OUT} could be affected by the power supply capacity, the output current, the inductance value, the C_{OUT} value and the turn-on speed of V_{IN} determined by C_{IN}.



Timing Chart: Starting-up with Power Supply

Undervoltage Lockout (UVLO) Circuit

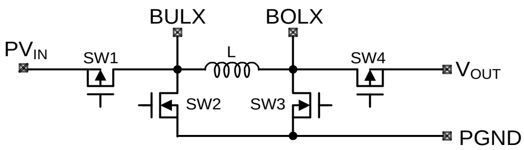
If the V_{IN} becomes lower than the UVLO detection voltage (V_{UVLO1}), the UVLO circuit starts to operate, V_{REF} stops, and P-channel and N-channel built-in switch transistors turn "OFF". As a result, V_{OUT} drops according to the C_{OUT} capacitance value and the load. To restart the operation, V_{IN} needs to be higher than V_{UVLO2}.

Overvoltage Protection (OVP) Circuit

If the V_{OUT} becomes higher than the OVP detection voltage (V_{OVP}), the OVP circuit starts to operate, P-channel and N-channel built-in switch transistors turn "OFF". As a result, V_{OUT} drops according to the C_{OUT} capacitance value and the load.

Overcurrent Protection Circuit

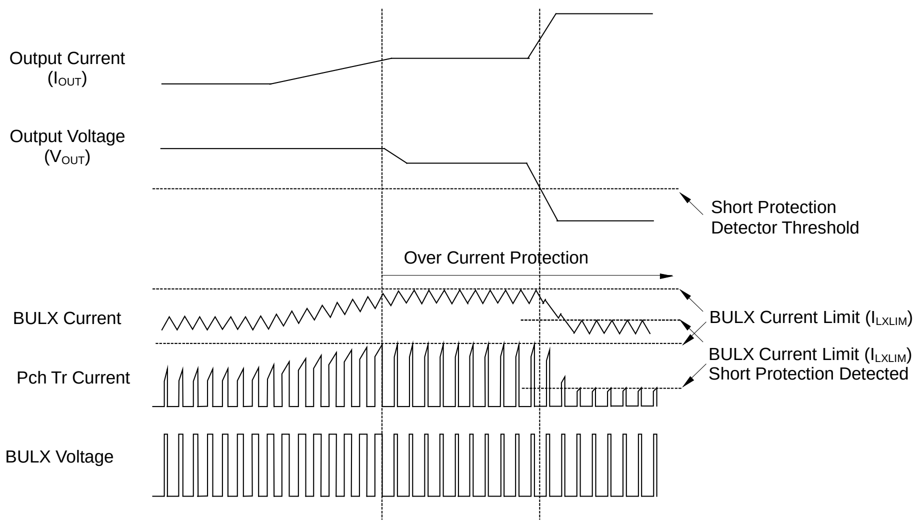
Overcurrent protection circuit supervises the inductor peak current (the peak current flowing through Pch Tr (SW1) in each switching cycle, and if the current exceeds the BULX current limit (I_{LXLIM}), it turns off Pch Tr (SW1). I_{LXLIM} of the RP602x is set to Typ.4200 mA.



Simplified Diagram of Output Switches

Short Protection Circuit

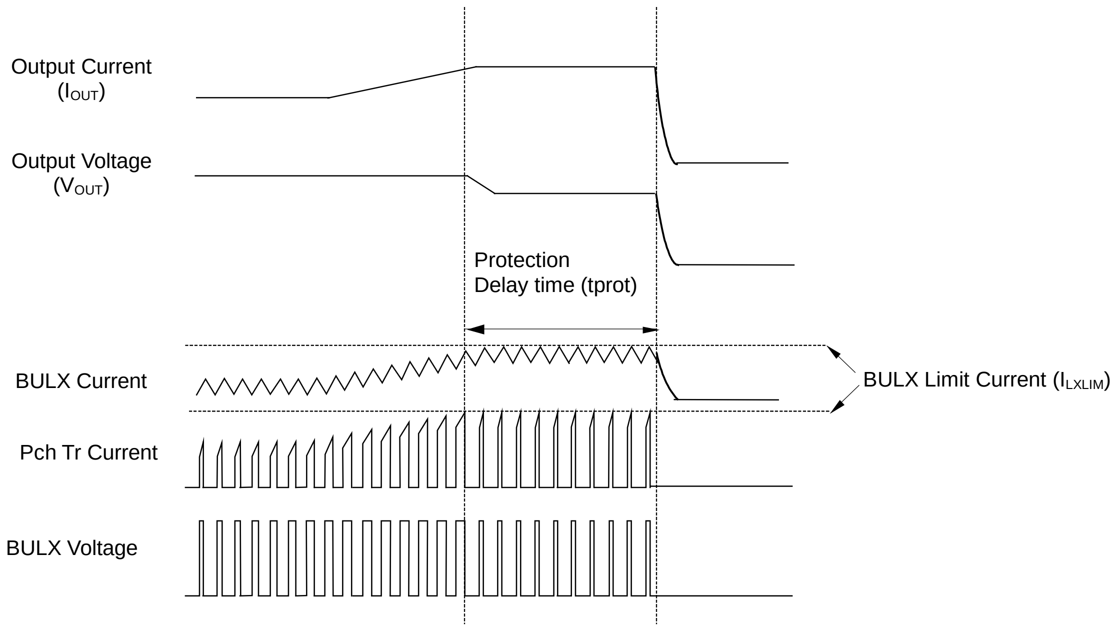
If the V_{OUT} becomes lower than a certain threshold, the BULX current limit is reduced.



Timing Chart: Overcurrent Protection Circuit & Short Protection Circuit

Latch Type Protection Circuit: RP602xxxxA/B/E/F

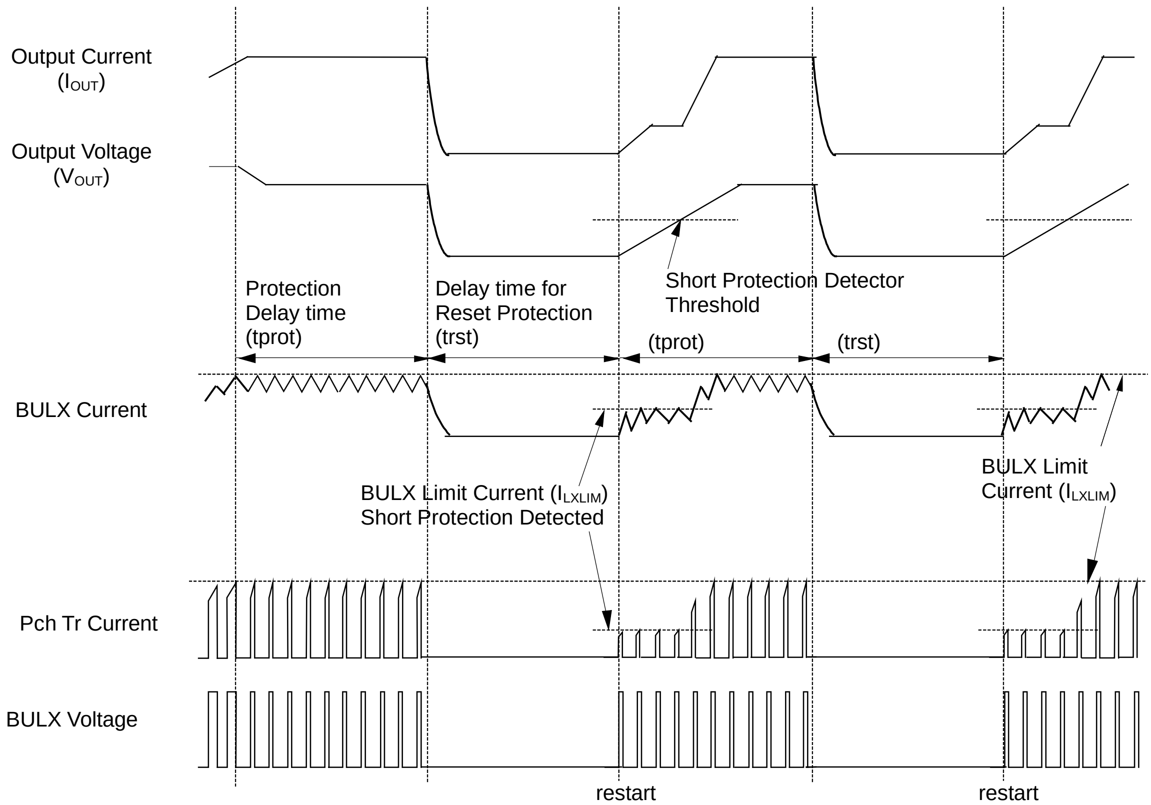
The latch type protection circuit latches the built-in drivers of SW1, SW2, SW3 and SW4 off to stop the operation of the device if the overcurrent state continues more than the protection delay time (t_{PROT}).
To release the latch-type protection, reset the device by switching the CE pin from High to Low or making the input voltage (V_{IN}) lower than the UVLO detection voltage (V_{UVLO1}).



Timing Chart: RP602xxxxA/B/E/F Latch Protection Circuit

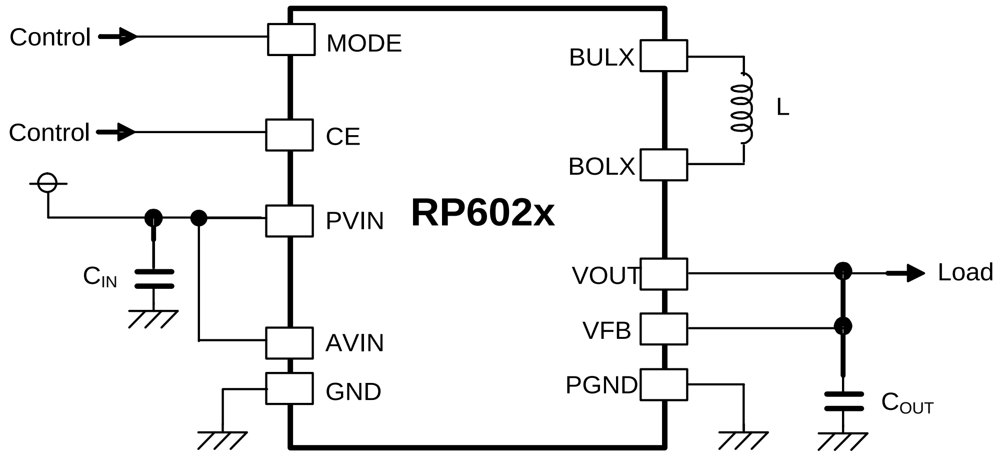
Reset Type Protection Circuit: RP602xxxxC/D/G/H

When the overcurrent state continues more than the protection delay time (t_{PROT}), the reset type protection circuit operates and switching stops. The built-in drivers of SW1, SW2, SW3 and SW4 turn off and restarts after the reset protection delay time (t_{RST}). When the overcurrent state is released, the operation is automatically released and returns to normal operation.



Timing Chart: RP602xxxxC/D/G/H Reset Protection Circuit

APPLICATION INFORMATION



RP602x Typical Application Circuit

Recommended External Components

Symbol	Description
C_{IN} (1)	10 µF, Ceramic, GRM188R60J106ME47, Murata
C_{OUT} (2)	22 µF x 2, Ceramic, GRM188R60J226MEA0, Murata
L	1.0 µH, Inductor, DFE201610P- 1R0M, TOKO 1.0 µH, Inductor, XAL4020- 102ME, Coilcraft

Technical Notes on External Components Selection

- Use ceramic capacitors having a low equivalent series resistance (ESR). C_{OUT} should be paralleled with another C_{OUT}. When selecting the capacitors, consider the bias characteristics and input/ output voltage.
- When the built-in switches are turned off, the inductor may generate a spike-shaped high voltage. Use the high-breakdown voltage capacitor (C_{OUT}) which output voltage is 1.5 times or more than the set output voltage.
- Use an inductor that has a low DC resistance, has an enough tolerable current and is less likely to cause magnetic saturation. If the inductance value is extremely small, the peak current of LX may increase. When the peak current of LX reaches to the LX limit current (I_{LXLIM}), overcurrent protection circuit starts to operate. When selecting the inductor, consider the peak current of LX pin (I_{LXMAX}). Refer to *Calculation Method of Peak Current of LX Pin (I_{LXMAX}) in Continuous Mode* for details.

(1) Place C_{IN} as close as possible to the PV_{IN} pin.
(2) Place C_{OUT} as close as possible to the V_{OUT} pin.

Calculation Method of Peak Current of LX Pin (I_{LXMAX}) in Continuous Mode

The peak current of LX pin (I_{LXMAX}) can be calculated as follows, in the case of an ideal buck converter operating in steady conditions, using the components listed in *Recommended External Components* of *APPLICATION INFORMATION*.

Ripple Current P-P value is described as I_{RP}, ON resistance of Pch. Tr. is described as R_{ONP}, ON resistance of Nch. Tr. is described as R_{ONN}, and DC resistor of the inductor is described as R_L.

First, when Pch. Tr. is “ON”, the following equation is satisfied.

$V_{IN} = V_{OUT} + (R_{ONP} + R_L) \times I_{OUT} + L \times I_{RP} / t_{ON}$ .... Equation 1

Second, when Pch. Tr. is "OFF" (Nch. Tr. is "ON"), the following equation is satisfied.

$L \times I_{RP} / t_{OFF} = R_{ONN} \times I_{OUT} + V_{OUT} + R_L \times I_{OUT}$ .... Equation 2

Put Equation 2 into Equation 1 to solve ON duty of Pch. Tr. ($D_{ON} = t_{ON} / (t_{OFF} + t_{ON})$):

$D_{ON} = (V_{OUT} + R_{ONN} \times I_{OUT} + R_L \times I_{OUT}) / (V_{IN} + R_{ONN} \times I_{OUT} - R_{ONP} \times I_{OUT})$ .... Equation 3

Ripple Current is described as follows:

$I_{RP} = (V_{IN} - V_{OUT} - R_{ONP} \times I_{OUT} - R_L \times I_{OUT}) \times D_{ON} / fosc / L$ .... Equation 4

Peak current that flows through L, and LX Tr. is described as follows:

$I_{LX}max = I_{OUT} + I_{RP} / 2$ .... Equation 5

The peak current of LX pin (I_{LXMAX}) can be calculated as follows, in the case of an ideal boost converter operating in steady conditions, using the components listed in *Recommended External Components* of *APPLICATION INFORMATION*.

Ripple Current P-P value is described as I_{RP}, Average inductor current is described as I_{LX}, ON resistance of Pch. Tr. and ON resistance of Nch. Tr. is described as R_{ONP} and R_{ONN} respectively, and DC resistor of the inductor is described as R_L.

First, when Nch. Tr. is “ON”, the following equation is satisfied.

$L \times I_{RP} / t_{ON} = V_{IN} - (R_L + R_{ONN}) \times I_{LX}$ .... Equation 6

Second, when Nch. Tr. is "OFF" (Pch. Tr. is "ON"), the following equation is satisfied.

$L \times I_{RP} / t_{OFF} = V_{OUT} + (R_L + R_{ONP}) \times I_{LX} - V_{IN}$ .... Equation 7

Put Equation 7 into Equation 6 to solve ON duty of Nch. Tr. ($D_{ON} = t_{ON} / (t_{OFF} + t\ t_{ON})$):

$D_{ON} = (V_{OUT} - V_{IN} + R_L \times I_{LX} + R_{ONP} \times I_{LX}) / (V_{OUT} + R_{ONP} \times I_{LX} - R_{ONN} \times I_{LX})$ .... Equation 8

Ripple Current is described as follows:

$I_{RP} = (V_{IN} - R_L \times I_{LX} - R_{ONN} \times I_{LX}) \times D_{ON} / f_{OSC} / L$ .... Equation 9

Peak current that flows through L (I_{LMAX}), and LX Tr. is described as follows:

$I_{LXMAX} = I_{LX} + I_{RP} / 2$ .... Equation 10

Also, the average peak current (I_{OUT} and D_{ON}) in the boost circuit is described as follows:

$I_{LX} = I_{OUT} / (1 - D_{ON})$ .... Equation 11

TECHNICAL NOTES

The performance of a power source circuit using this device is highly dependent on a peripheral circuit. A peripheral component or the device mounted on PCB should not exceed a rated voltage, a rated current or a rated power. When designing a peripheral circuit, please be fully aware of the following points.

- Place the bypass capacitor (C_{IIN}) between the PVIN pin and the GND pin with shortest-distance wiring.
- Place the output capacitor (C_{OUT}) between the V_{OUT} pin and the GND pin with shortest-distance wiring. Connect GND of C_{OUT} to the GND pin with shortest-distance wiring.
- Make the GND plane wide.
- Ensure the PVIN and GND lines are firmly connected. A large switching current flows through the PVIN, GND, inductor, BOLX, BULX and V_{OUT} lines. If their impedance is too high, noise pickup or unstable operation may result.
- Connect the BOLX pin and the inductor and the BULX pin with shortest-distance wiring.

PCB LAYOUT CONSIDERATIONS

Current Paths on PCB

Figure 1 and Figure 2 show the current pathways of step-up circuit when NMOSFET is turned on. Figure 3 and Figure 4 show the current pathways of step-down circuit when PMOSFET is turned on.

The currents flow in the directions of blue or green arrows. The parasitic components, such as impedance, inductance or capacitance, formed in the pathways indicated by the red arrows affect the stability of the system and become the cause of noise. Reduce the parasitic components as much as possible. The current pathways should be made by short and thick wirings.

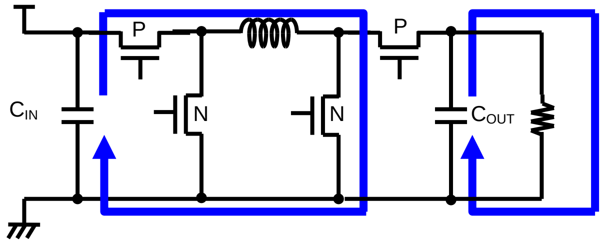


Figure 1. NMOSFET-ON (Step-up)

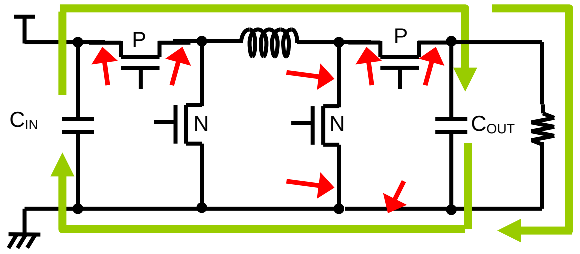


Figure 2. PMOSFET-ON (Step-up)

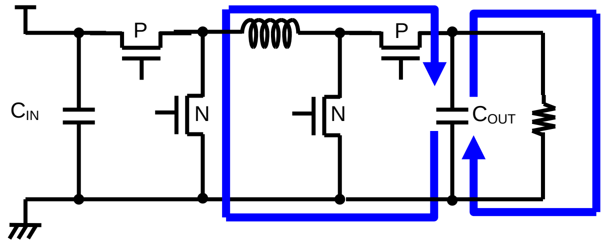


Figure 3. NMOSFET-ON (Step-down)

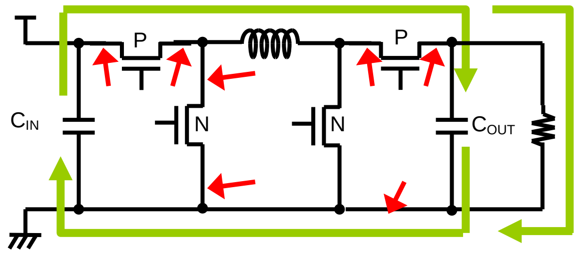
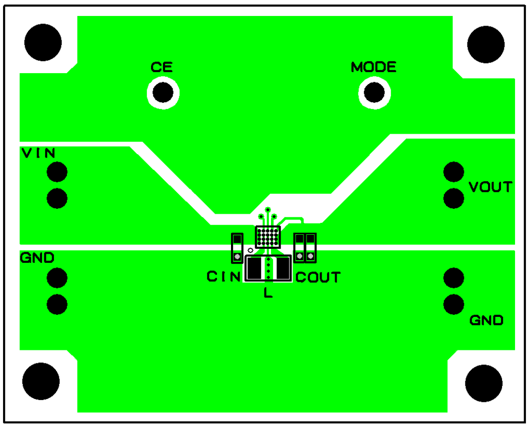


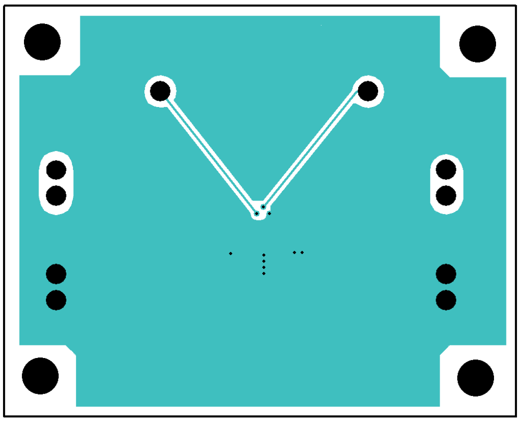
Figure 4. PMOSFET-ON (Step-down)

PCB LAYOUT

Top Layer

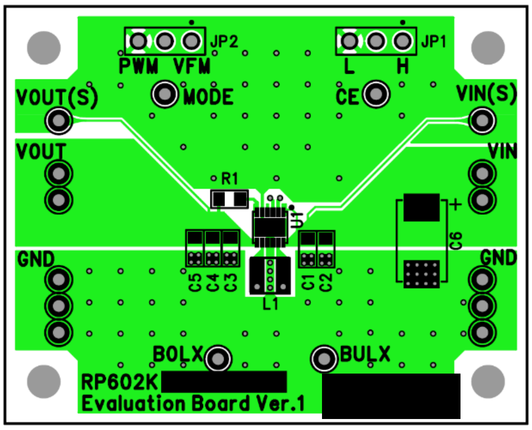


Bottom Layer

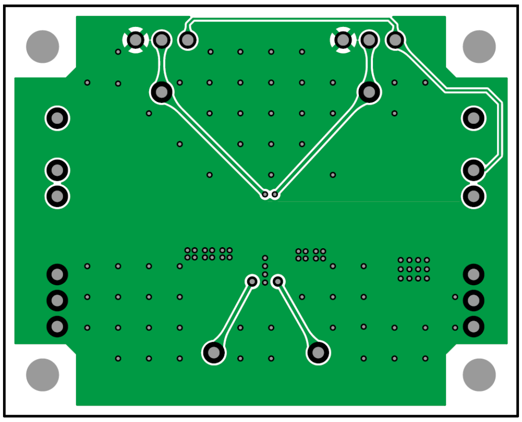


RP602x [PKG: WLCSP-20-P1]　PCB Layout

Top Layer



Bottom Layer



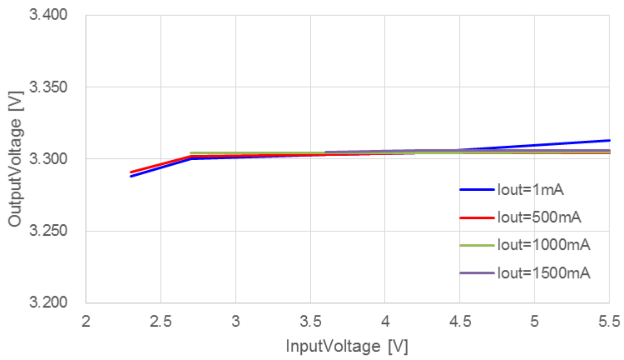
RP602x [PKG: DFN(PL)2730-12]　PCB Layer

TYPICAL CHARACTERISTICS

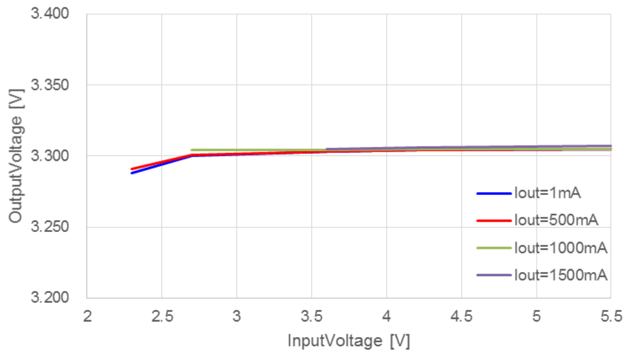
Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

1) Input Voltage vs. Output Voltage

RP602Z330x, MODE = H

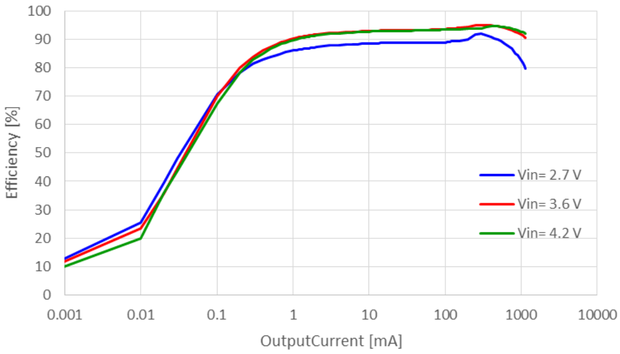


RP602Z330x, MODE = L

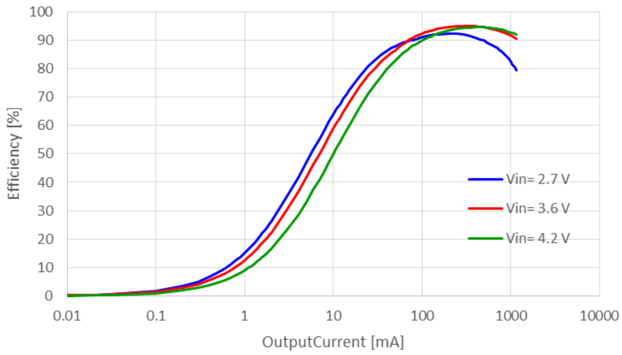


2) Output Current vs. Efficiency (for Different Input Voltages)

RP602Z330x, MODE = H

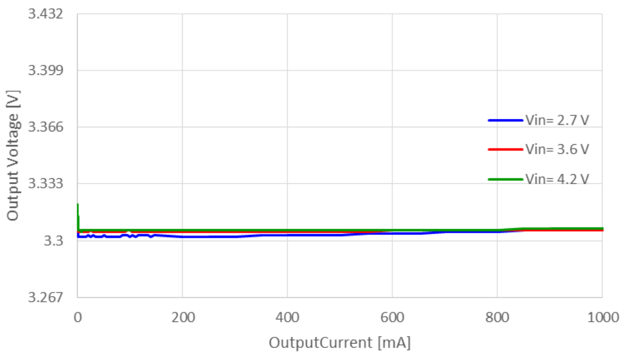


RP602Z330x, MODE = L

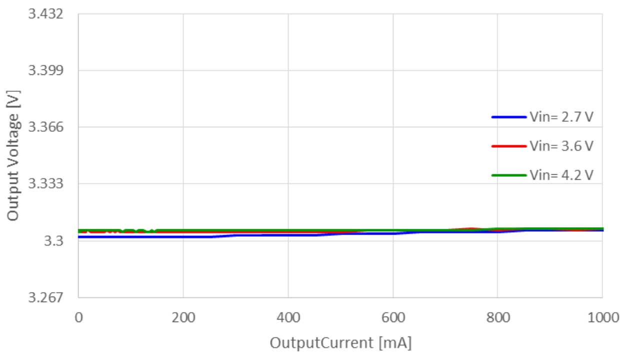


3) Output Current vs. Output Voltage

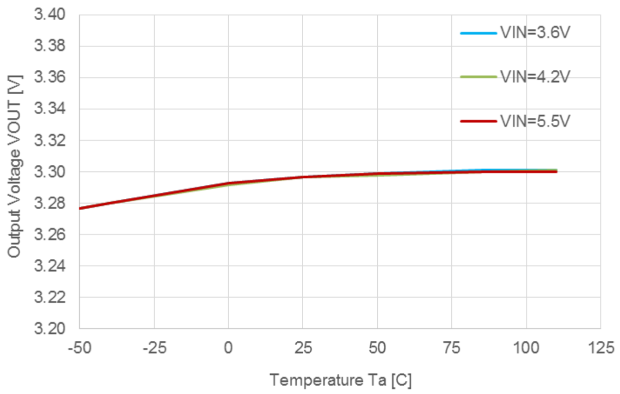
RP602Z330x, MODE = H



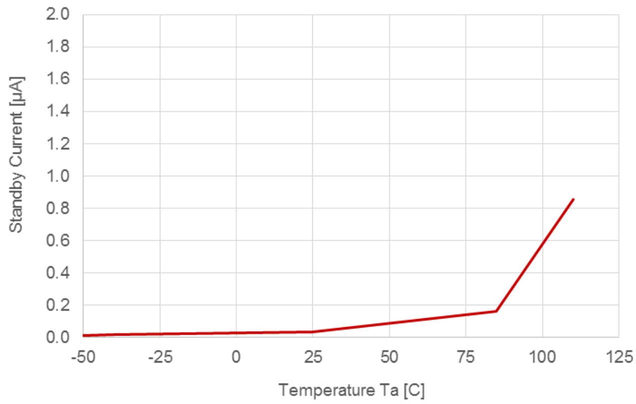
RP602Z330x, MODE = L



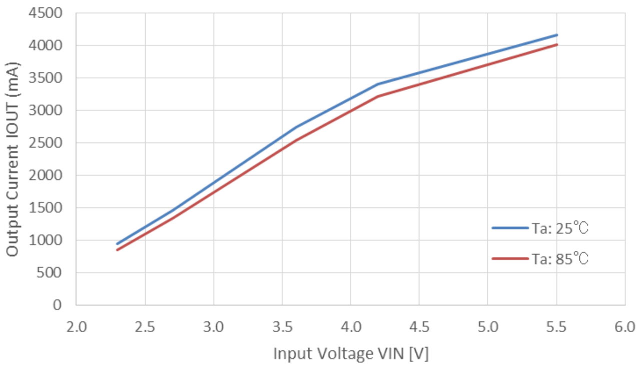
4) Temperature vs. Output Voltage
RP602Z330x



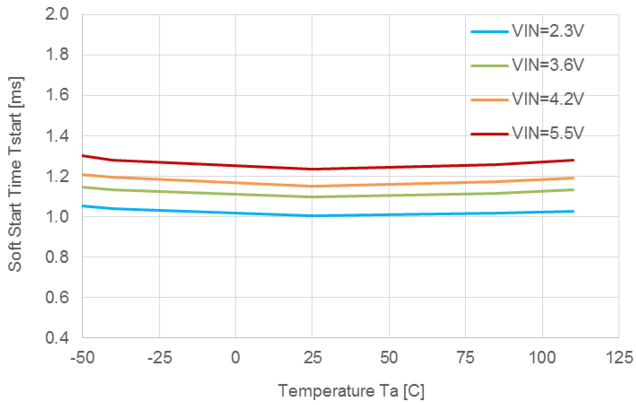
5) Temperature vs. Standby Current
RP602Z330x, V_{IN} = 5.5 V



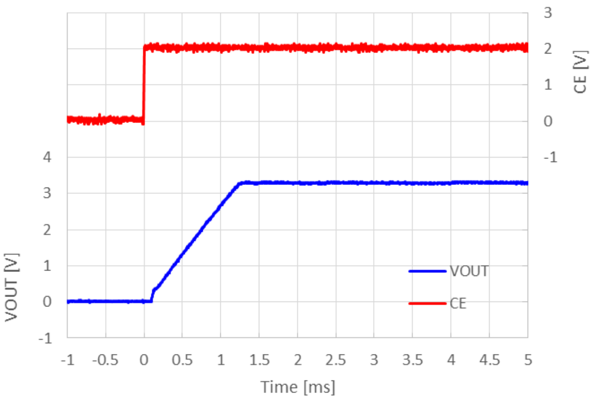
6) Input Voltage vs. Output Current
RP602Z330x, MODE = L



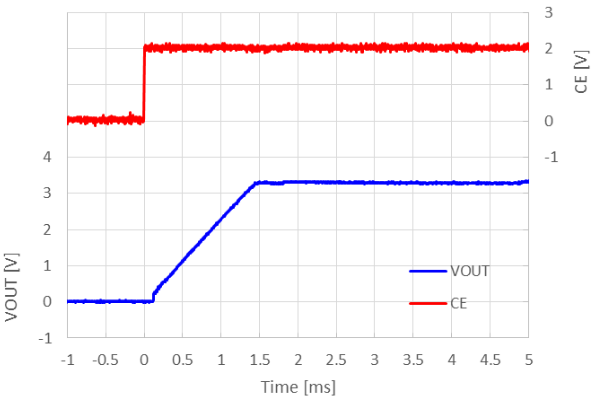
7) Temperature vs. Soft-start Time
RP602Z330x



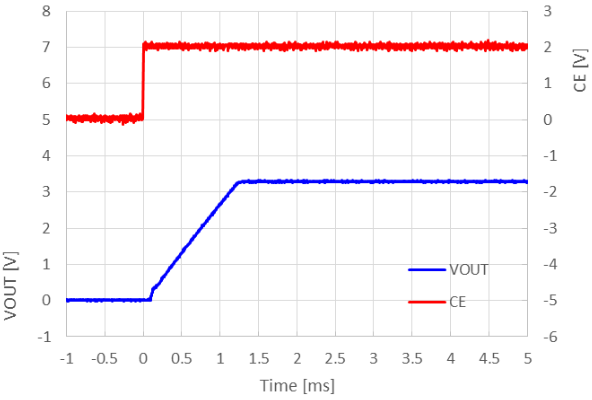
8) CE Start-up Waveform
RP602Z330x, V_{IN} = 3.6 V, MODE = H
I_{OUT} = 0 mA



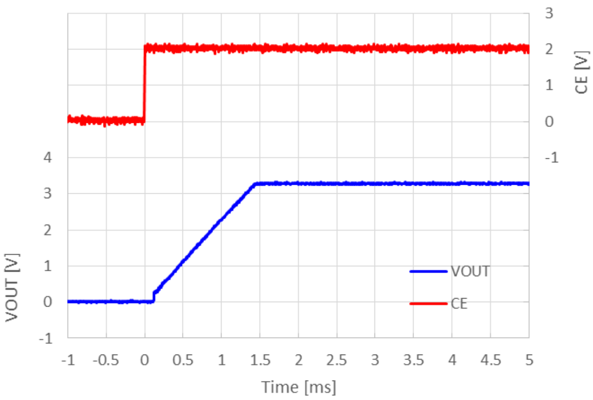
RP602Z330x, V_{IN} = 5.5 V, MODE = H
I_{OUT} = 0 mA



RP602Z330x, V_{IN} = 3.6 V, MODE = L
I_{OUT} = 0 mA

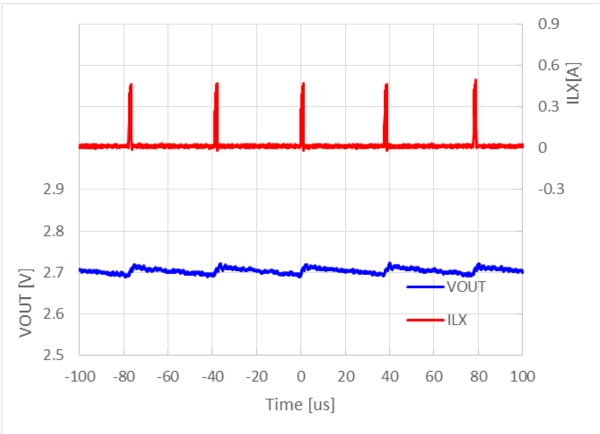


RP602Z330x, V_{IN} = 5.5 V, MODE = L
I_{OUT} = 0 mA

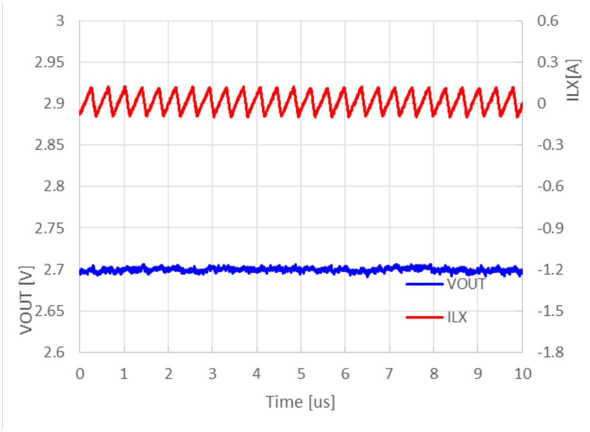


9) V_{OUT} Waveform

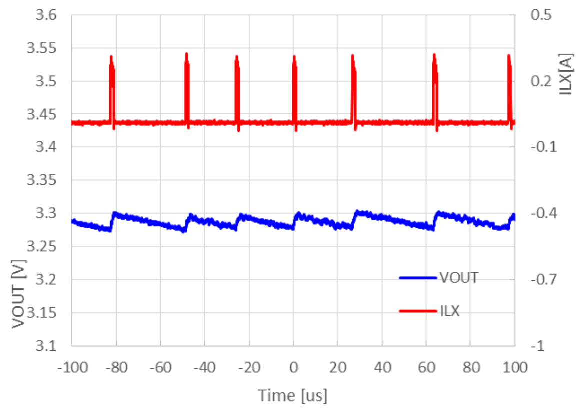
RP602Z270x, V_{IN} = 3.6 V, MODE = H
I_{OUT} = 10 mA



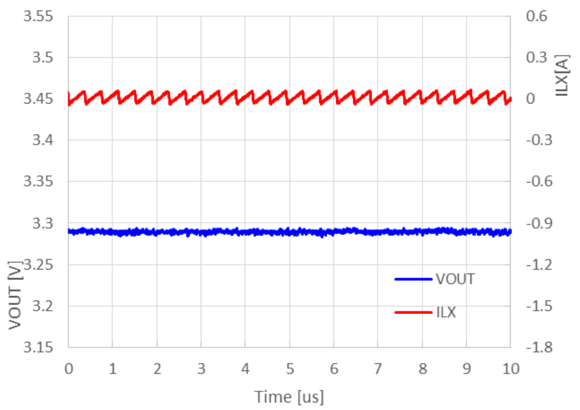
RP602Z270x, V_{IN} = 3.6 V, MODE = L
I_{OUT} = 0 mA



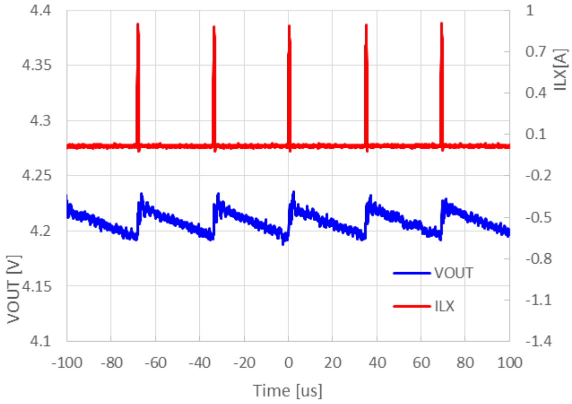
RP602Z330x, V_{IN} = 3.6 V, MODE = H
I_{OUT} = 10 mA



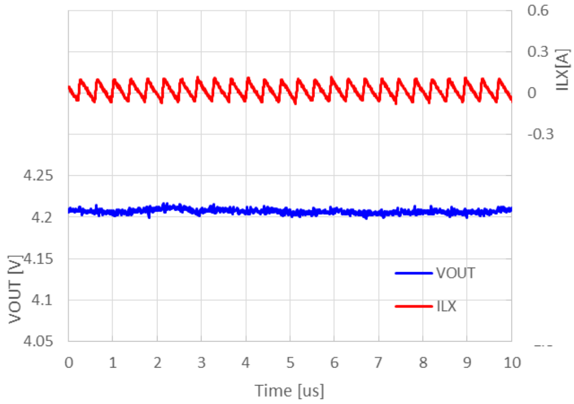
RP602Z330x, V_{IN} = 3.6 V, MODE = L
I_{OUT} = 0 mA



RP602Z420x, V_{IN} = 3.6 V, MODE = H
I_{OUT} = 10 mA

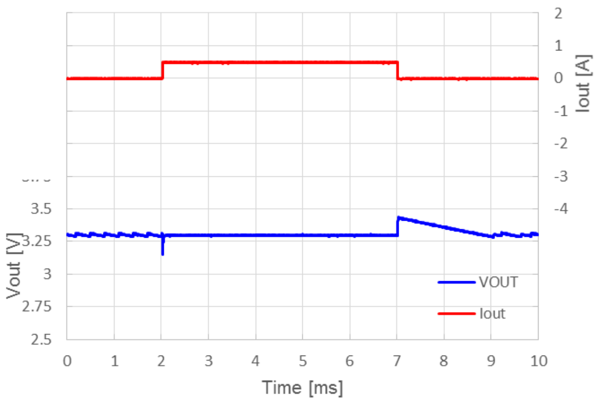


RP602Z420x, V_{IN} = 3.6 V, MODE = L
I_{OUT} = 0 mA

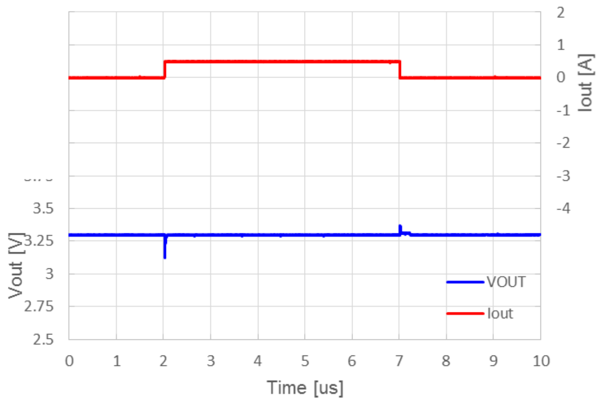


10) Load Transient Response Waveform

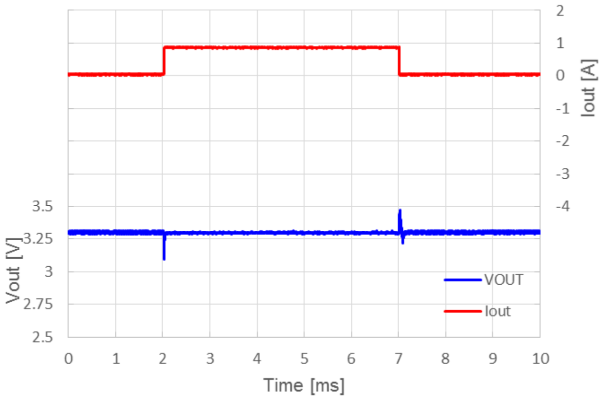
RP602Z330x, V_{IN} = 3.6 V, MODE = H
I_{OUT} = 1 mA ←→ 500 mA



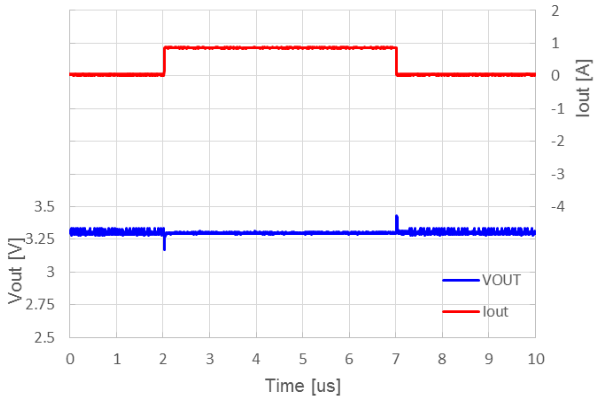
RP602Z330x, V_{IN} = 3.6 V, MODE = L
I_{OUT} = 1 mA ←→ 500 mA



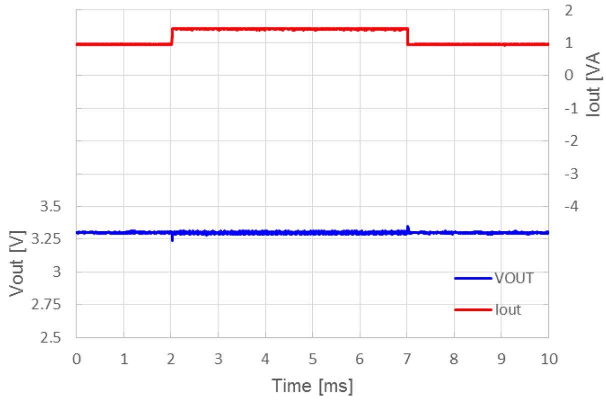
RP602Z330x, V_{IN} = 3.6 V, MODE = H
I_{OUT} = 50 mA ←→ 900 mA



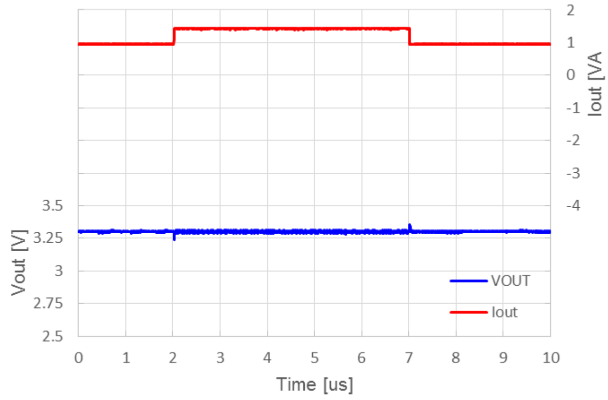
RP602Z330x, V_{IN} = 3.6 V, MODE = L
I_{OUT} = 50 mA ←→ 900 mA



RP602Z330x, V_{IN} = 3.6 V, MODE = H
I_{OUT} = 1000 mA ←→ 1500 mA

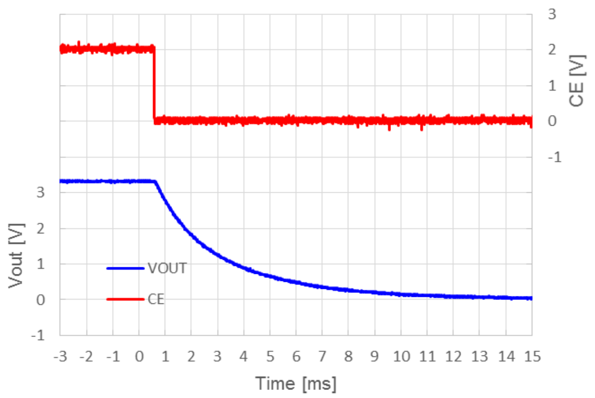


RP602Z330x, V_{IN} = 3.6 V, MODE = L
I_{OUT} = 1000 mA ←→ 1500 mA

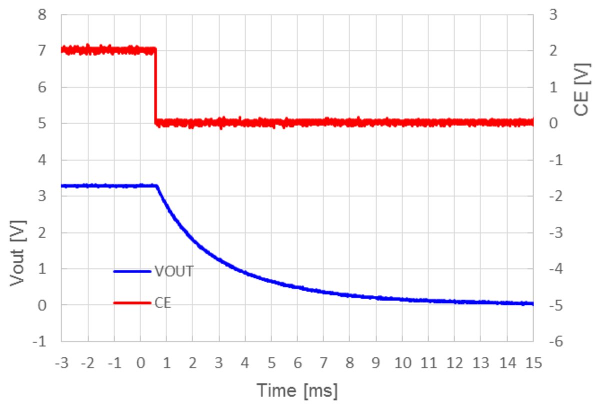


11) CE Turn off Waveform

RP602Z330x, V_{IN} = 3.6 V, MODE = H
I_{OUT} = 0 mA

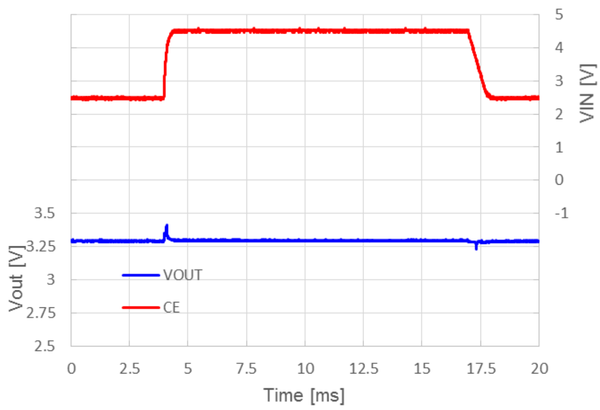


RP602Z330x, V_{IN} = 3.6 V, MODE = L
I_{OUT} = 0 mA

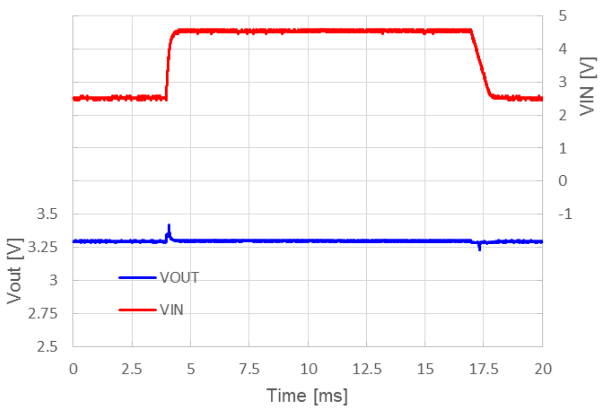


12) Input Transient Response Waveform

RP602Z330x, MODE = H
I_{OUT} = 500 mA, V_{IN} = 2.5 V ←→ 4.5 V



RP602Z330x, MODE = L
I_{OUT} = 500 mA, V_{IN} = 2.5 V ←→ 4.5 V



Ver. B

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-9.

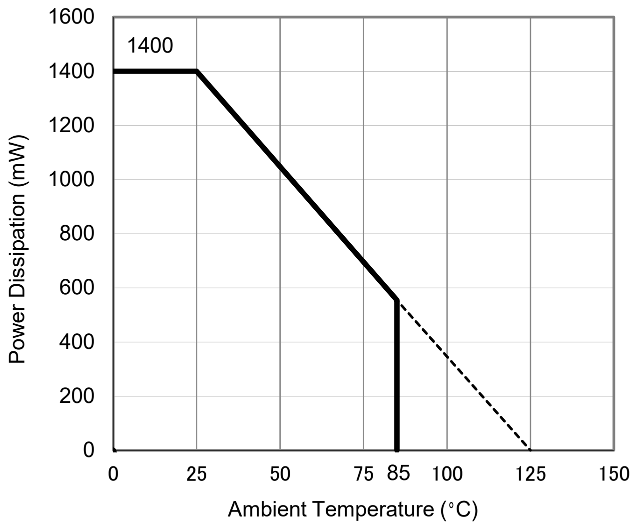
Measurement Conditions

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 Layers (First and Fourth Layers): 60% Inner Layers (Second and Third Layers): 100%

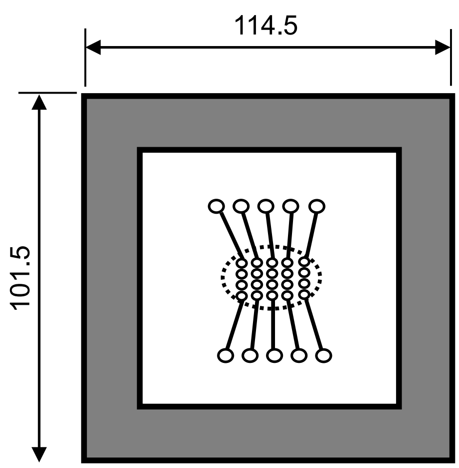
Measurement Result (Ta = 25°C, Tjmax = 125°C)

Item	Measurement Result
Power Dissipation	1400 mW
Thermal Resistance (θja)	θ ja = (125 − 25°C) / 1.4W = 71 °C/W

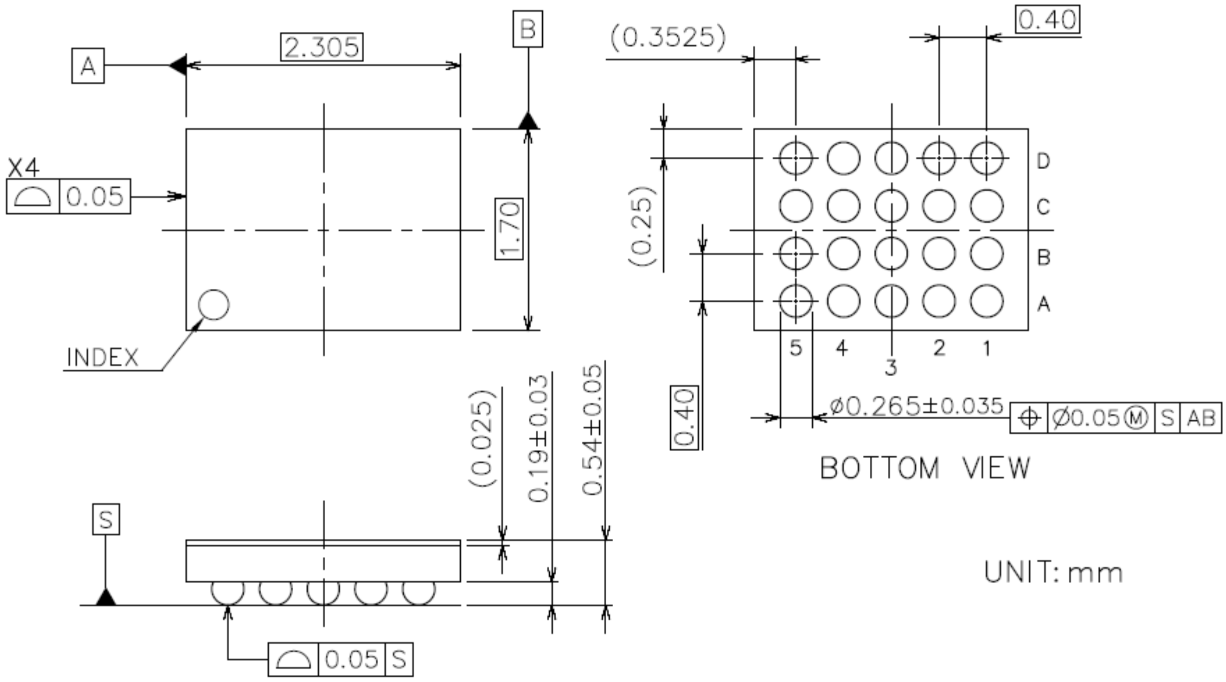
θja: Junction-to-Ambient Thermal Resistance



Power Dissipation vs. Ambient Temperature

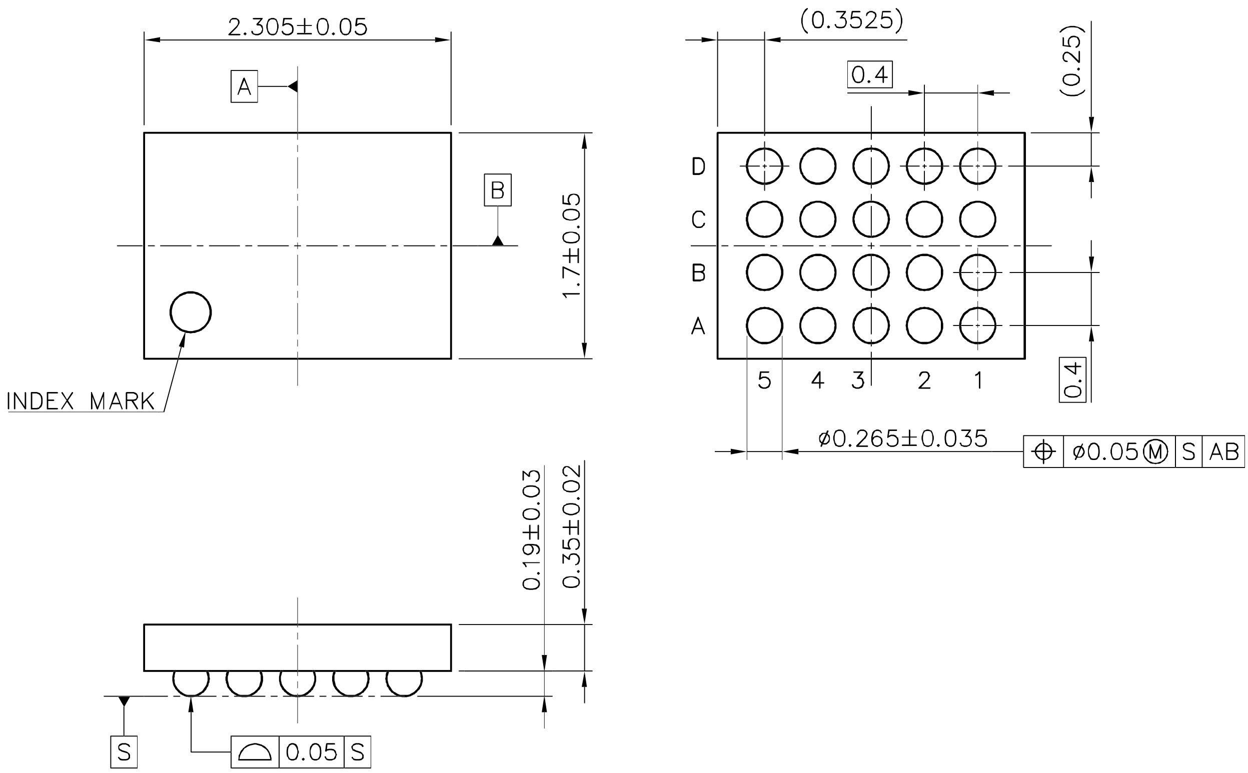


Measurement Board Pattern



WLCSP-20-P1 Package Dimensions (Unit: mm)

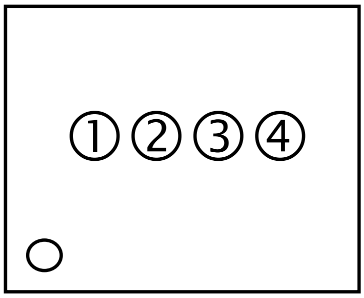
Production will start in 2024



WLCSP-20-P1 Package Dimensions (Unit: mm)

①②: Product Code ··· Refer to *Part Marking List*

③④: Lot Number ··· Alphanumeric Serial Number



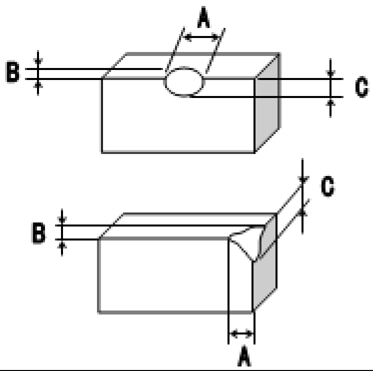
WLCSP-20 Part Markings

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.

MK-RP602Z-JE-A

RP602Z Part Marking List

P602ZxxxA		RP602ZxxxB		RP602ZxxxC		RP602ZxxxD	
Product Name	**①②**	**Product Name**	**①②**	**Product Name**	**①②**	**Product Name**	**①②**
RP602Z270A	AA	RP602Z270B	CA	RP602Z270C	EA	RP602Z270D	GA
RP602Z275A	AB	RP602Z275B	CB	RP602Z275C	EB	RP602Z275D	GB
RP602Z280A	AC	RP602Z280B	CC	RP602Z280C	EC	RP602Z280D	GC
RP602Z285A	AD	RP602Z285B	CD	RP602Z285C	ED	RP602Z285D	GD
RP602Z290A	AE	RP602Z290B	CE	RP602Z290C	EE	RP602Z290D	GE
RP602Z295A	AF	RP602Z295B	CF	RP602Z295C	EF	RP602Z295D	GF
RP602Z300A	AG	RP602Z300B	CG	RP602Z300C	EG	RP602Z300D	GG
RP602Z305A	AH	RP602Z305B	CH	RP602Z305C	EH	RP602Z305D	GH
RP602Z310A	AJ	RP602Z310B	CJ	RP602Z310C	EJ	RP602Z310D	GJ
RP602Z315A	AK	RP602Z315B	CK	RP602Z315C	EK	RP602Z315D	GK
RP602Z320A	AL	RP602Z320B	CL	RP602Z320C	EL	RP602Z320D	GL
RP602Z325A	AM	RP602Z325B	CM	RP602Z325C	EM	RP602Z325D	GM
RP602Z330A	AN	RP602Z330B	CN	RP602Z330C	EN	RP602Z330D	GN
RP602Z335A	AP	RP602Z335B	CP	RP602Z335C	EP	RP602Z335D	GP
RP602Z340A	AQ	RP602Z340B	CQ	RP602Z340C	EQ	RP602Z340D	GQ
RP602Z345A	AR	RP602Z345B	CR	RP602Z345C	ER	RP602Z345D	GR
RP602Z350A	AS	RP602Z350B	CS	RP602Z350C	ES	RP602Z350D	GS
RP602Z355A	AT	RP602Z355B	CT	RP602Z355C	ET	RP602Z355D	GT
RP602Z360A	AU	RP602Z360B	CU	RP602Z360C	EU	RP602Z360D	GU
RP602Z365A	AV	RP602Z365B	CV	RP602Z365C	EV	RP602Z365D	GV
RP602Z370A	AW	RP602Z370B	CW	RP602Z370C	EW	RP602Z370D	GW
RP602Z375A	AX	RP602Z375B	CX	RP602Z375C	EX	RP602Z375D	GX
RP602Z380A	AY	RP602Z380B	CY	RP602Z380C	EY	RP602Z380D	GY
RP602Z385A	AZ	RP602Z385B	CZ	RP602Z385C	EZ	RP602Z385D	GZ
RP602Z390A	BA	RP602Z390B	DA	RP602Z390C	FA	RP602Z390D	HA
RP602Z395A	BB	RP602Z395B	DB	RP602Z395C	FB	RP602Z395D	HB
RP602Z400A	BC	RP602Z400B	DC	RP602Z400C	FC	RP602Z400D	HC
RP602Z405A	BD	RP602Z405B	DD	RP602Z405C	FD	RP602Z405D	HD
RP602Z410A	BE	RP602Z410B	DE	RP602Z410C	FE	RP602Z410D	HE
RP602Z415A	BF	RP602Z415B	DF	RP602Z415C	FF	RP602Z415D	HF
RP602Z420A	BG	RP602Z420B	DG	RP602Z420C	FG	RP602Z420D	HG

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)	

PD-DFN(PL)2730-12-(85125)-JE-B

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

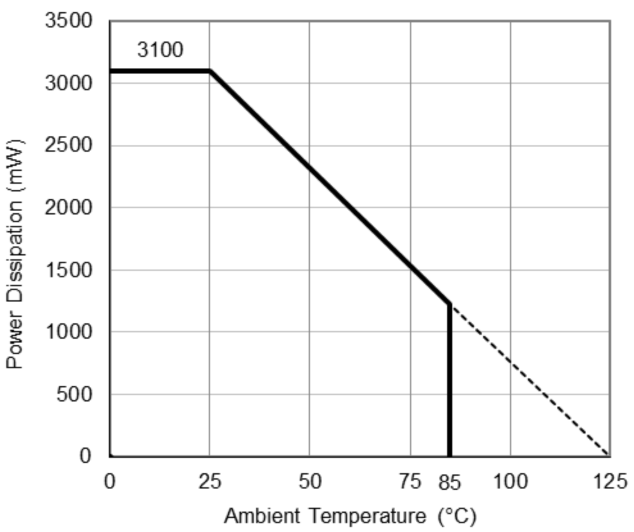
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 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 = 125°C)

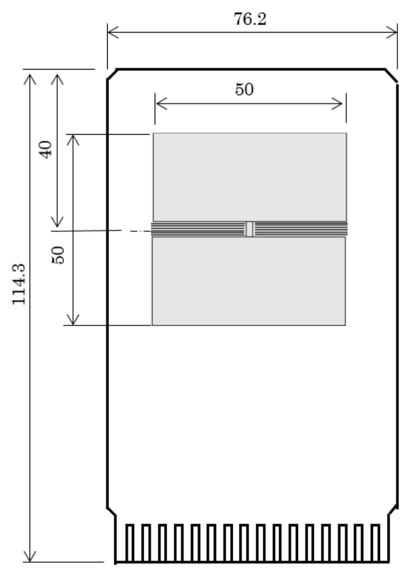
Item	Measurement Result
Power Dissipation	3100 mW
Thermal Resistance (θja)	θja = 32°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 8°C/W

θja: Junction-to-Ambient Thermal Resistance

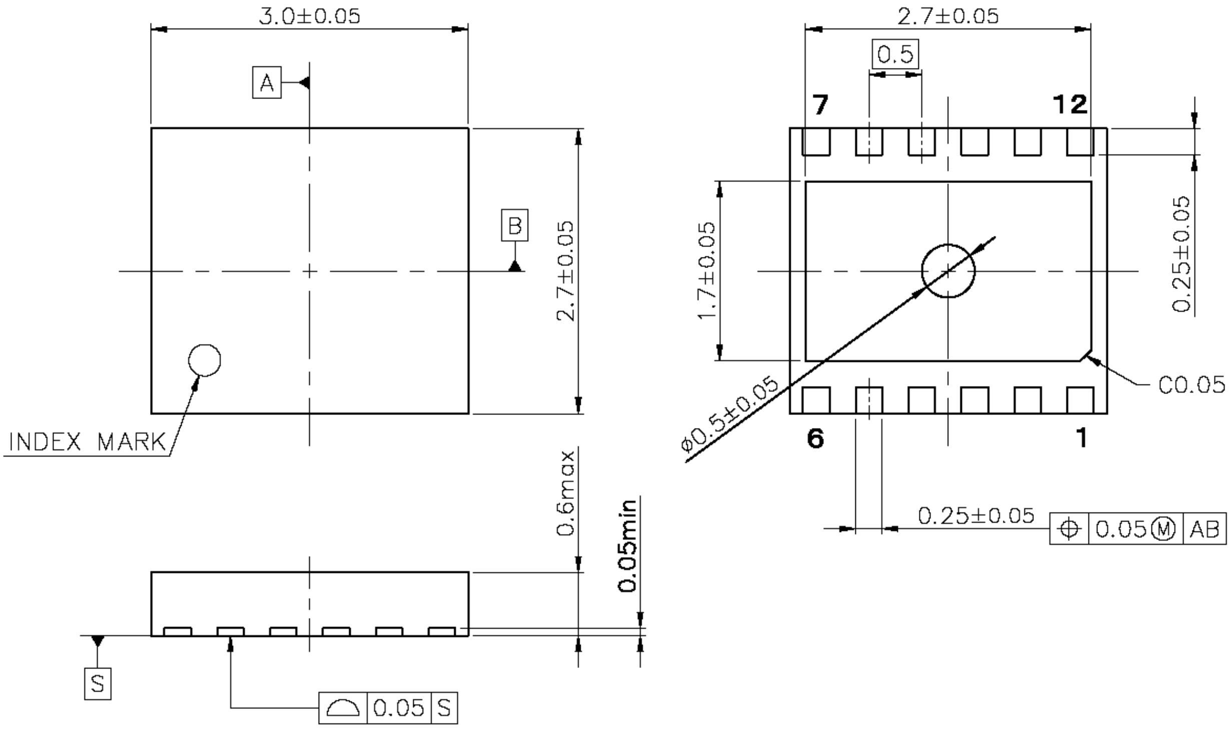
ψjt: Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



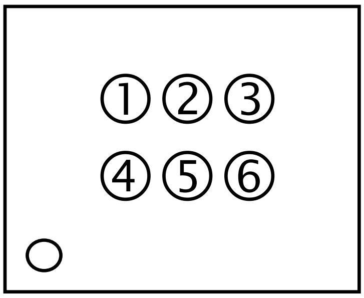
Measurement Board Pattern



DFN(PL)2730-12 Package Dimensions (Unit: mm)

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

⑤⑥: Lot Number ··· Alphanumeric Serial Number



RP602K [DFN(PL)2730-12] 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.

RP602K Part Marking List

P602KxxxA		RP602KxxxB		RP602KxxxC		RP602KxxxD	
Product Name	①②③④	Product Name	①②③④	Product Name	①②③④	Product Name	①②③④
RP602K270E	GA00	RP602K270F	GB00	RP602K270G	GC00	RP602K270H	GD00
RP602K275E	GA01	RP602K275F	GB01	RP602K275G	GC01	RP602K275H	GD01
RP602K280E	GA02	RP602K280F	GB02	RP602K280G	GC02	RP602K280H	GD02
RP602K285E	GA03	RP602K285F	GB03	RP602K285G	GC03	RP602K285H	GD03
RP602K290E	GA04	RP602K290F	GB04	RP602K290G	GC04	RP602K290H	GD04
RP602K295E	GA05	RP602K295F	GB05	RP602K295G	GC05	RP602K295H	GD05
RP602K300E	GA06	RP602K300F	GB06	RP602K300G	GC06	RP602K300H	GD06
RP602K305E	GA07	RP602K305F	GB07	RP602K305G	GC07	RP602K305H	GD07
RP602K310E	GA08	RP602K310F	GB08	RP602K310G	GC08	RP602K310H	GD08
RP602K315E	GA09	RP602K315F	GB09	RP602K315G	GC09	RP602K315H	GD09
RP602K320E	GA10	RP602K320F	GB10	RP602K320G	GC10	RP602K320H	GD10
RP602K325E	GA11	RP602K325F	GB11	RP602K325G	GC11	RP602K325H	GD11
RP602K330E	GA12	RP602K330F	GB12	RP602K330G	GC12	RP602K330H	GD12
RP602K335E	GA13	RP602K335F	GB13	RP602K335G	GC13	RP602K335H	GD13
RP602K340E	GA14	RP602K340F	GB14	RP602K340G	GC14	RP602K340H	GD14
RP602K345E	GA15	RP602K345F	GB15	RP602K345G	GC15	RP602K345H	GD15
RP602K350E	GA16	RP602K350F	GB16	RP602K350G	GC16	RP602K350H	GD16
RP602K355E	GA17	RP602K355F	GB17	RP602K355G	GC17	RP602K355H	GD17
RP602K360E	GA18	RP602K360F	GB18	RP602K360G	GC18	RP602K360H	GD18
RP602K365E	GA19	RP602K365F	GB19	RP602K365G	GC19	RP602K365H	GD19
RP602K370E	GA20	RP602K370F	GB20	RP602K370G	GC20	RP602K370H	GD20
RP602K375E	GA21	RP602K375F	GB21	RP602K375G	GC21	RP602K375H	GD21
RP602K380E	GA22	RP602K380F	GB22	RP602K380G	GC22	RP602K380H	GD22
RP602K385E	GA23	RP602K385F	GB23	RP602K385G	GC23	RP602K385H	GD23
RP602K390E	GA24	RP602K390F	GB24	RP602K390G	GC24	RP602K390H	GD24
RP602K395E	GA25	RP602K395F	GB25	RP602K395G	GC25	RP602K395H	GD25
RP602K400E	GA26	RP602K400F	GB26	RP602K400G	GC26	RP602K400H	GD26
RP602K405E	GA27	RP602K405F	GB27	RP602K405G	GC27	RP602K405H	GD27
RP602K410E	GA28	RP602K410F	GB28	RP602K410G	GC28	RP602K410H	GD28
RP602K415E	GA29	RP602K415F	GB29	RP602K415G	GC29	RP602K415H	GD29
RP602K420E	GA30	RP602K420F	GB30	RP602K420G	GC30	RP602K420H	GD30

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    - Traffic control system
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    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.
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