Step-up DC/DC converter for White LED Backlight

No. EA-166-180316

OUTLINE

The R1218x Series are PWM control type step-up DC/DC converter ICs with low supply current.
The R1218x is fully dedicated to drive White LED with constant current. Each of these ICs consists of an NMOS FET, an oscillator, a PWM comparator, a voltage reference unit, an error amplifier, a current limit circuit, an under voltage lockout circuit (UVLO), an over-voltage protection circuit (OVP).
The R1218x can drive white LEDs with high efficiency with low supply current. A diode is built-in the R1218xxx1A, therefore it is possible to drive up to 4LEDs without an external diode. The R1218xxx2A, an external diode is necessary, however, up to 7 serial LEDs can be driven with the R1218xxx2A.
Constant current can be set with an external resistance value. Dimming control is possible by PWM signal for CE pin. Feedback voltage is 0.2V, therefore power loss by current setting resistor is small and efficiency is good. Maximum duty cycle is internally fixed, Typ. 91% to 92%. LEDs can be driven from low voltage. Protection circuits are the current limit of Lx peak current, the over voltage limit of output, and the under voltage lockout function.
Packages are standard SOT-23-6 and very tiny DFN(PLP)1820-6.

FEATURES

- Input voltage... 1.8V to 5.5V
- Built-in 400mA, 1.5Ω, 20V Nch MOSFET and diode (R1218xxx1A)
- Built-in 400mA, 1.5Ω, 33V Nch MOSFET (R1218xxx2A)
- Oscillator Frequency (PWM control)............. 1.2MHz
- Maximum Duty Cycle .... Typ. 91% to 92%
- Feedback Voltage .... Typ. 0.2V
- UVLO Threshold Voltage .... Typ. 1.6V (Hysteresis Typ. 0.1V)
- Lx Current limit Protection............................. Typ. 700mA
- Over Voltage Protection (OVP) Threshold.... Typ. 9.5V (R1218x021A)
  Typ. 14.0V (R1218x031A)
  Typ. 18.5V (R1218x041A)
  Typ. 23.0V (R1218x052A)
  Typ. 27.5V (R1218x062A)
  Typ. 31.5V (R1218x072A)
- LED dimming control.................................... by external PWM signal (Frequency 200Hz to 5kHz) to CE pin
  by feedback voltage and filtered PWM signal (high frequency)
- Packages .... DFN(PLP)1820-6, SOT-23-6

APPLICATIONS

- White LED Backlight for portable equipment

SELECTION GUIDE

The OVP threshold, the built-in diode, and the package for the ICs can be selected at the user's request.

Selection Guide

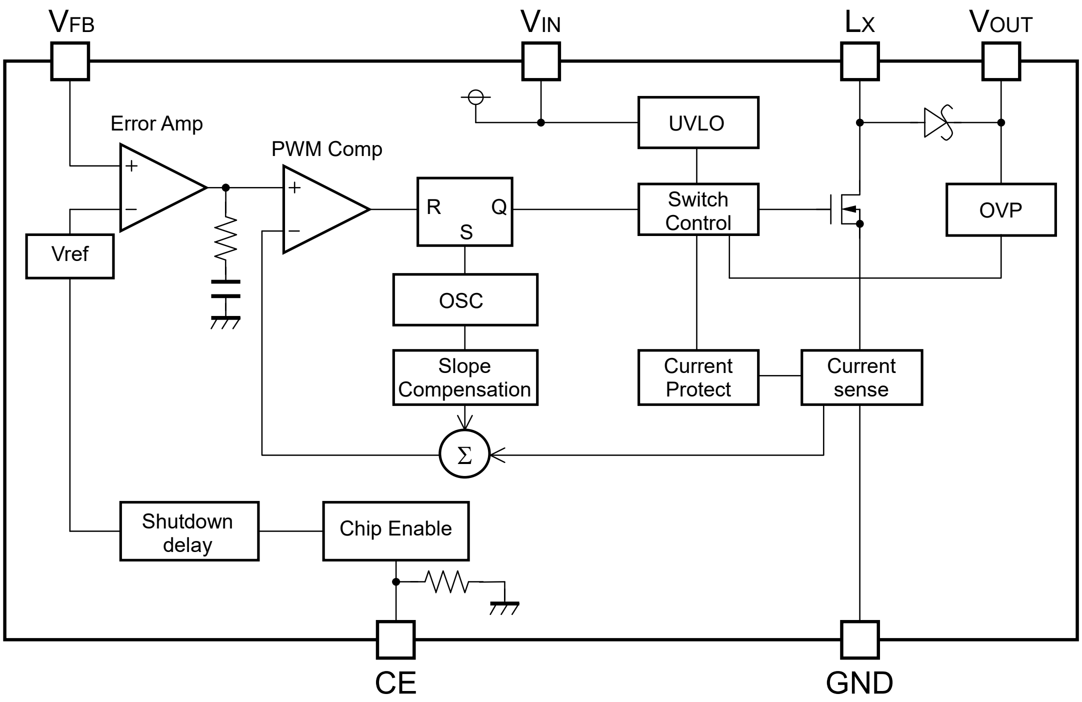
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1218Kxxxx-TR	DFN(PLP)1820-6	5,000 pcs	Yes	Yes
R1218Nxxxx-TR-FE	SOT-23-6	3,000 pcs	Yes	Yes

xxxx: The combination of the OVP threshold and with/without of built-in diode can be designated.

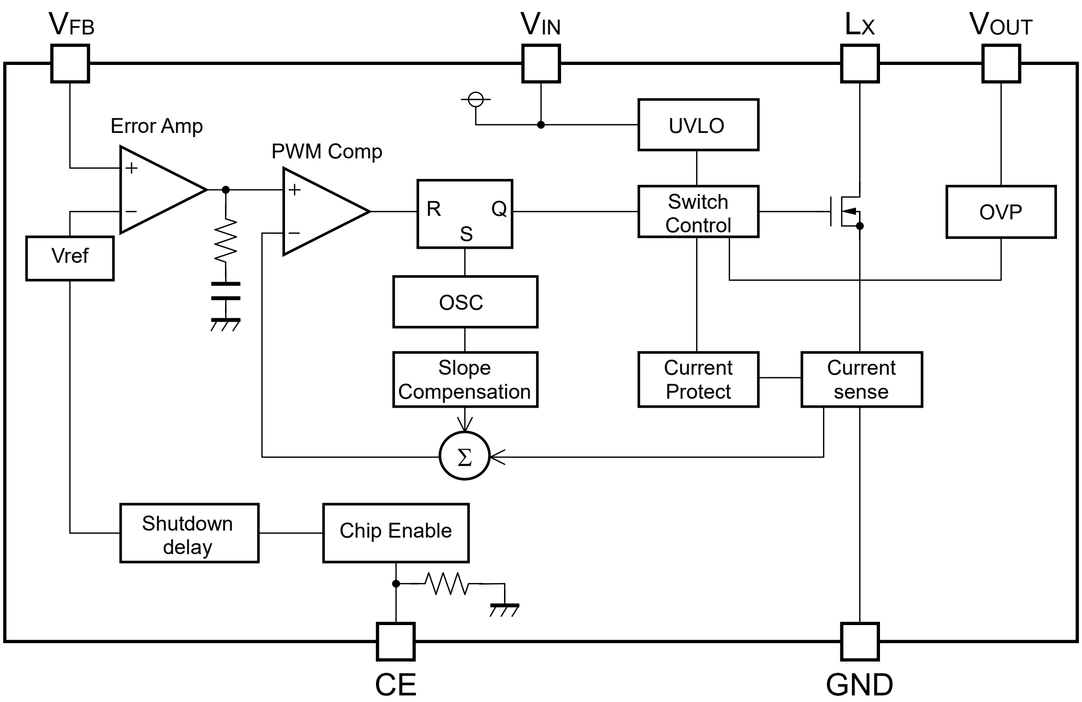
Code	OVP Threshold	Built-in Diode
021A	9.5 V	Yes
031A	14.0 V	Yes
041A	18.5 V	Yes
052A	23.0 V	No
062A	27.5 V	No
072A	31.5 V	No

BLOCK DIAGRAMS

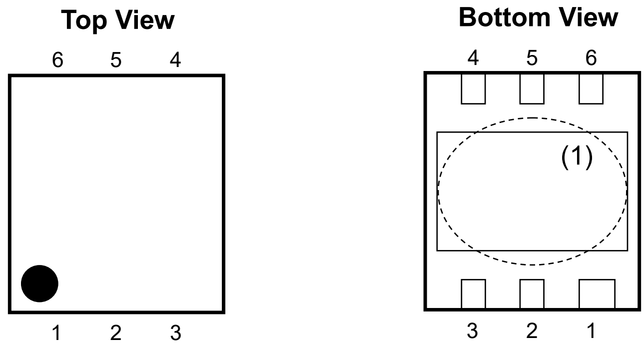
R1218xxx1A



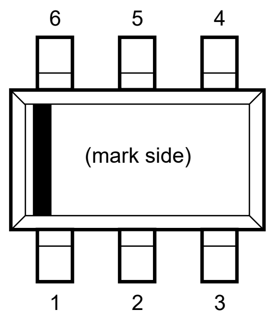
R1218xxx2A



PIN DESCRIPTIONS



DFN(PLP)1820-6 Pin Configuration



SOT-23-6 Pin Configuration

DFN(PLP)1820-6 Pin Description

Pin No	Symbol	Pin Description
1	CE	Chip Enable Pin ("H" Active)
2	V_{FB}	Feedback Pin
3	Lx	Switching Pin (Open Drain Output)
4	GND	Ground Pin
5	V_{IN}	Power Supply Input Pin
6	V_{OUT}	Output Pin

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5	GND	Ground Pin
6	V_{FB}	Feedback Pin

(1) Tab is GND level (They are connected to the reverse side of this IC). The tab is better to be connected to the GND, but leaving it open is also acceptable.

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings (GND = 0 V)

Symbol	Item			Rating	Unit
V_{IN}	V_{IN} Pin Voltage			6.5	V
V_{CE}	CE Pin Voltage			−0.3 to V_{IN} + 0.3	V
V_{FB}	V_{FB} Pin Voltage			−0.3 to V_{IN} + 0.3	V
V_{OUT}	V_{OUT} Pin Voltage		R1218xxx1A	−0.3 to 22	V
			R1218xxx2A	−0.3 to 34	
V_{LX}	L_X Pin Voltage		R1218xxx1A	−0.3 to 22	V
			R1218xxx2A	−0.3 to 34	
I_{LX}	L_X Pin Current			1000	mA
P_D	Power Dissipation[1]	DFN(PLP)1820-6	JEDEC STD. 51-7 Test Land Pattern	2200	mW
		SOT-23-6	JEDEC STD. 51-7 Test Land Pattern	660	
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 the permanent damages and may degrade the life time and safety for both device and system using the device in the field.
The functional operation at or over these absolute maximum ratings is not assured.

RECOMMENDED OPERATING CONDITIONS

Recommended Operating Conditions

Symbol	Item	Rating	Unit
V_{IN}	Operating Input Voltage	1.8 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 when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

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

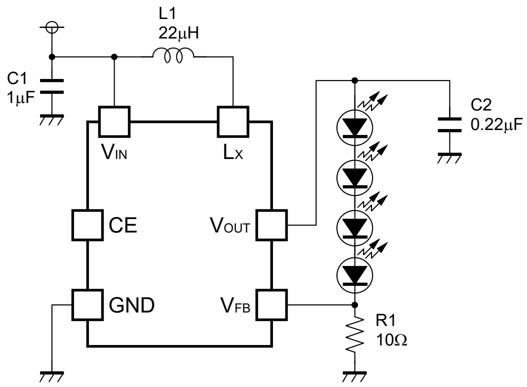
ELECTRICAL CHARACTERISTICS

R1218xxxxA Electrical Characteristics (Ta = 25°C)

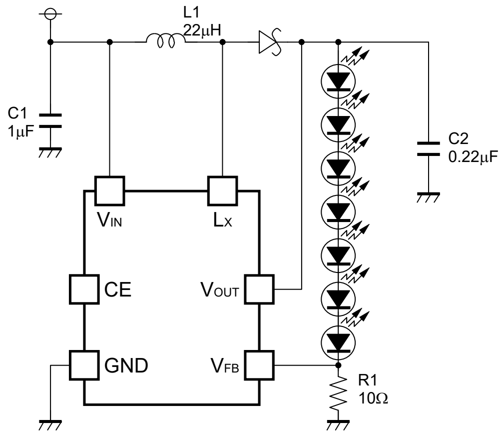
Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
I_{DD}	Supply Current	V_{IN} = 5.5 V, V_{FB} = 0 V, Lx at no load			0.5	1.0	mA
Istandby	Standby Current	V_{IN} = 5.5 V, V_{CE} = 0 V			0	3.0	μA
V_{UVLO1}	UVLO Detector Threshold	V_{IN} falling		1.5	1.6	1.7	V
V_{UVLO2}	UVLO Released Voltage	V_{IN} rising			V_{UVLO1} + 0.1	1.8	V
V_{CEH}	CE Input Voltage "H"	V_{IN} = 5.5 V		1.5			V
V_{CEL}	CE Input Voltage "L"	V_{IN} = 1.8 V				0.5	V
R_{CE}	CE Pull Down Resistance	V_{IN} = 3.6 V		600	1200	2200	kΩ
tshtdn	CE Shutdown Delay Time	V_{IN} = 3.6 V			10		ms
V_{FB}	V_{FB} Voltage	V_{IN} = 3.6 V		0.19	0.20	0.21	V
$\Delta V_{FB}/\Delta Ta$	V_{FB} Voltage Temperature Coefficient	V_{IN} = 3.6 V, −40°C ≤ Ta ≤ 85°C			±150		ppm /°C
I_{FB}	V_{FB} Input Current	V_{IN} = 5.5 V, V_{FB} = 0 V or 5.5 V		–0.1		0.1	μA
R_{ON}	Switch On Resistance	V_{IN} = 3.6 V, I_{SW} = 100 mA			1.5		Ω
I_{LXleak}	Switch Leakage Current	R1218xxx1A	V_{LX} = 20 V		0	3.0	μA
		R1218xxx2A	V_{LX} = 33 V		0	3.0	μA
I_{LXlim}	Switch Current Limit	V_{IN} = 3.6 V		400	700	1000	mA
Vf	Diode Forward Voltage	R1218xxx1A	I_{DIODE} = 100 mA		0.8		V
$I_{DIODEleak}$	Diode Leakage Current	R1218xxx1A	V_{OUT} = 20 V, V_{LX} = 0 V		10		μA
fosc	Oscillator Frequency	V_{IN} = 3.6V, V_{OUT} = V_{FB} = 0V		1.0	1.2	1.4	MHz
Maxduty	Maximum Duty Cycle	V_{IN} = 3.6V, V_{OUT} = V_{FB} = 0 V	R1218x072A	86	92		%
			Others	86	91		
V_{OVP1}	OVP Detector Threshold	V_{IN} = 3.6V, V_{OUT} rising	R1218x021A	8.5	9.5	10.5	V
			R1218x031A	13.0	14.0	15.0	
			R1218x041A	17.0	18.5	20.0	
			R1218x052A	21.5	23.0	24.5	
			R1218x062A	26.0	27.5	29.0	
			R1218x072A	30.0	31.5	33.0	
V_{OVP2}	OVP Released Voltage	V_{IN} = 3.6V, V_{OUT} falling	R1218x021A		V_{OVP1} - 0.5		V
			R1218x031A		V_{OVP1} - 0.75		
			R1218x041A		V_{OVP1} - 1.0		
			R1218x052A		V_{OVP1} - 1.25		
			R1218x062A		V_{OVP1} - 1.5		
			R1218x072A		V_{OVP1} - 1.75		

APPLICATION INFORMATION

● Typical Application Circuit



R1218x041A



R1218x072A

● Selection of Inductors

The peak current of the inductor at normal mode can be estimated as the next formula when the efficiency is 80%.

$IL_{max} = 1.25 \times I_{OUT} \times V_{OUT} / V_{IN} + 0.5 \times V_{IN} \times (V_{OUT} - V_{IN}) / (L_X\ V_{OUT} \times fosc)$

When the start-up or dimming control by CE pin, transient current flows, the peak current must be equal or less than the current limit of the IC. The peak current should not beyond the rating current of the inductor. The recommended inductance value is 10 µH -22 µH.

Table 1 Peak current value in each condition

Condition				
V_{IN} (V)	V_{OUT} (V)	I_{OUT} (mA)	L (µH)	IL_{max} (mA)
3	14	20	10	215
3	14	20	22	160
3	21	20	10	280
3	21	20	22	225

Table 2 Recommended inductors

L (µH)	Part No.	Rated Current (mA)	Size (mm)
10	LQH32CN100K53	450	3.2 x 2.5 x 1.55
10	LQH2MC100K02	225	2.0 x 1.6 x 0.9
10	VLF3010A-100	490	2.8 x 2.6 x 0.9
10	VLS252010-100	520	2.5 x 2.0 x 1.0
22	LQH32CN220K53	250	3.2 x 2.5 x 1.55
22	LQH2MC220K02	185	2.0 x 1.6 x 0.9
22	VLF3010A-220	330	2.8 x 2.6 x 0.9

- **Selection of Capacitors**

Set 1 µF or more value bypass capacitor C1 between V_{IN} pin and GND pin as close as possible.
Set 0.22 µF or more capacitor C2 between V_{OUT} and GND pin.
Note the V_{OUT} that depends on LED used, and select the rating of V_{OUT} or more.

- **Selection of SBD (Schottky Barrier Diode)**

Select the diode with low V_F such as Schottky type with low reverse current I_R, and with low capacitance.

Table 3 Recommended components

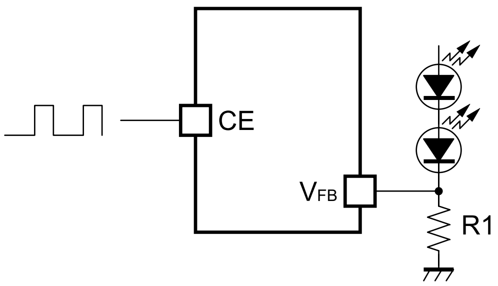
	Rated voltage (V)	Part No.
C1	6.3	CM105B105K06
C2	25	GRM21BR11E224
	50	GRM21BR71H224
D1	30	CRS10I30A
	30	RSX051VA-30

- **LED Current setting**

LED current can be set with feedback resistor (R1)
$I_{LED} = 0.2 / R1$

- **LED Dimming Control, Softstart**

(1) LED dimming control by PWM signal to CE pin
LED dimming control is possible by forcing PWM signal to CE pin.
When the power-on or start up with CE pin, softstart function works, however, after that, if the CE pin is set as "L" and set CE pin "H" again during the shutdown delay time, softstart function is disabled and starts up fast to normal mode, therefore 200 Hz to 5 kHz PWM signal is standard. By the CE pin input, LED turns on and off. Average LED current varies depending on the duty cycle of CE input. Too high frequency PWM signal is not effective because of its delay.

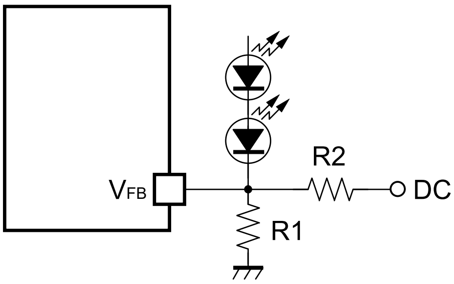


Dimming control by CE pin input

(2) Dimming control by DC voltage

LED dimming control is also possible by using the DC voltage to V_{FB} pin. LED current is adjustable by DC voltage and resistors, R1 and R2 in the following figure.

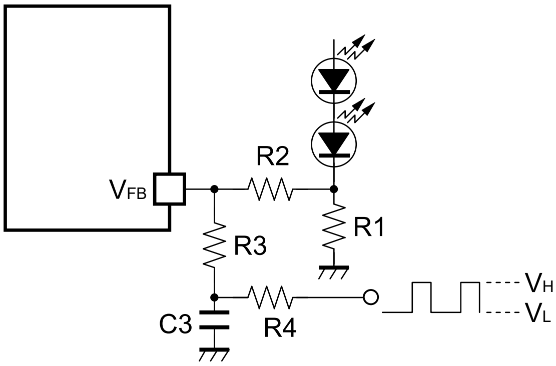
I_{LED} = 0.2/R1 - (DC - 0.2)/R2



Dimming control by DC voltage

(3) Dimming control by feedback voltage and filtered PWM signal

LED dimming control is also possible by using the feedback voltage and filtered PWM signal.
LED current is adjustable according to the "H" level (V_H) and "L" level (V_L) of PWM signal and resistors, R1, R2, R3, and R4 in the following figure.



Dimming control by filtered PWM signal

Duty = 0% to 100% PWM signal duty cycle can be used up to the maximum LED current and minimum LED current as in the next formulas.

I_{LEDMIN} = {0.2 - R2 x (V_H - 0.2) / (R3 + R4)} / R1
I_{LEDMAX} = {0.2 - R2 x (V_L - 0.2) / (R3 + R4)} / R1

For example, supposed that the PWM signal level is set as 2.5 V/0 V, to adjust the LED current range from 0 mA to 20 mA by the duty cycle, our recommendation external components values are, R1 = 10 Ω, R2 = 5.1 kΩ, R3 = 51 kΩ, R4 = 5.1 kΩ or around.

C3 should be set large enough to regard the PWM signal as adjustable DC voltage by the filter. In this method, higher frequency control than the frequency against the CE pin can be used for dimming control. For example, if the frequency is 40 kHz, 0.1 μF or more capacitor is our recommendation value as C3.

TECHNICAL NOTES

●Current path on PCB

The current paths in an application circuit are shown in Fig. 1 and 2.
A current flows through the paths shown in Fig. 1 at the time of MOSFET-ON, and shown in Fig. 2 at the time of MOSFET-OFF. In the paths pointed with red arrows in Fig. 2, current flows just in MOSFET-ON period or just in MOSFET-OFF period. Parasitic impedance/inductance and the capacitance of these paths influence stability of the system and cause noise outbreak. So please minimize this side effect. In addition, please shorten the wiring of other current paths shown in Fig. 1 and 2 except for the paths of LED load.

●Layout Guide for PCB

- Please shorten the wiring of the input capacitor (C1) between VIN pin and GND pin of IC. The GND pin should be connected to the strong GND plane.
- The area of LX land pattern should be smaller.
- In the case of internal diode version, please put output capacitor (C2) close to the VOUT pin.
- In the case of external diode, the wiring between L_X pin and inductor and diode should be short and please put output capacitor(C2) close to the cathode of diode.
- Please make the GND side of output capacitor (C2) close to the GND pin of IC.

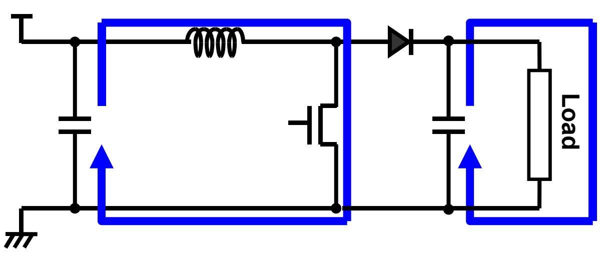


Fig. 1 MOSFET-ON

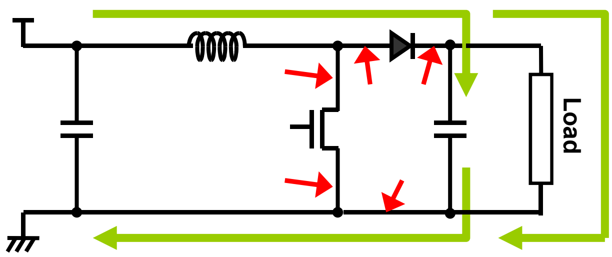


Fig. 2 MOSFET-OFF

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●PCB Layout

- PKG: DFN(PLP)1820-6 pin

R1218Kxx1A

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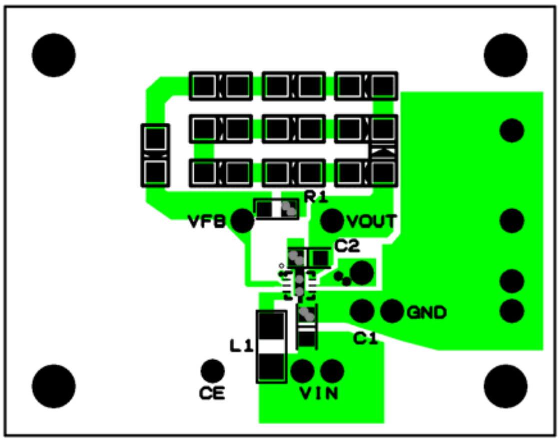
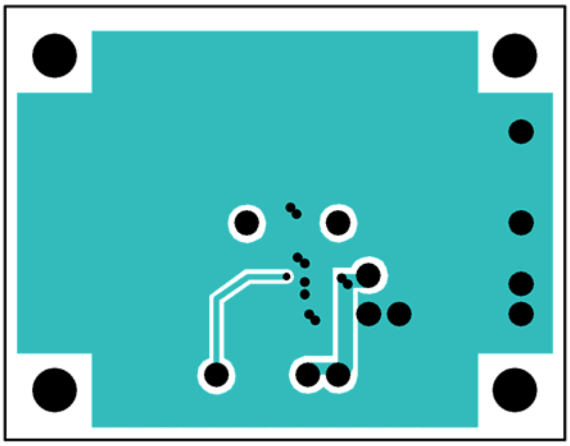
<tr><td>
</td><td></td></tr>
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R1218Kxx2A

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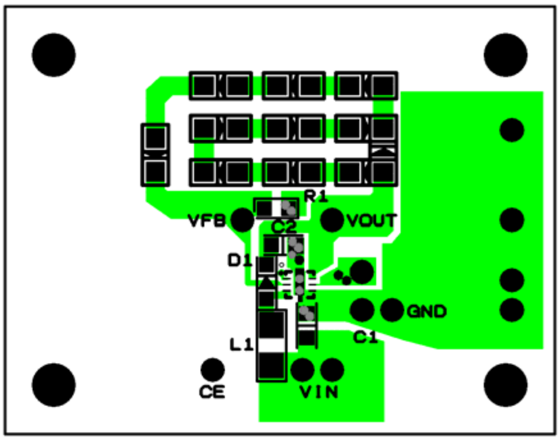
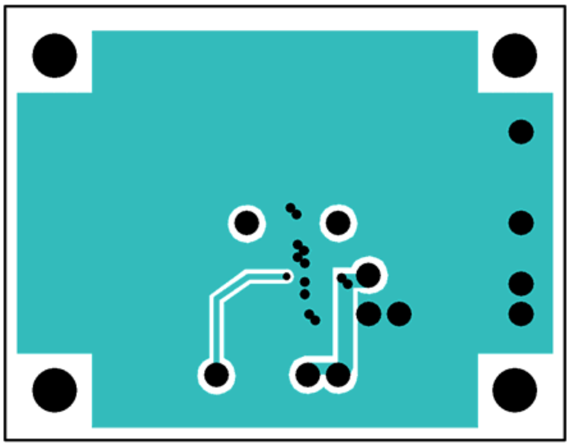
<tr><td>
</td><td></td></tr>
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- PKG: SOT-23-6 pin

R1218Nxx1A

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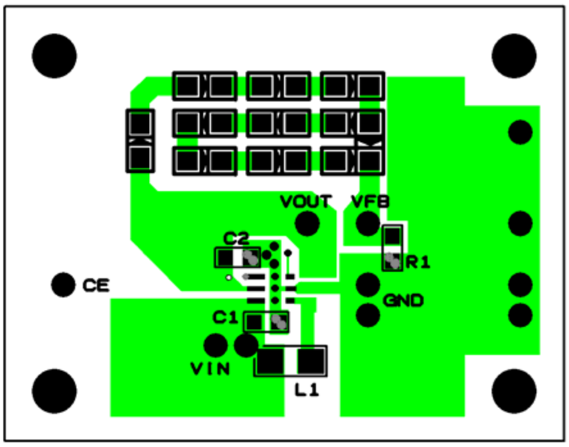
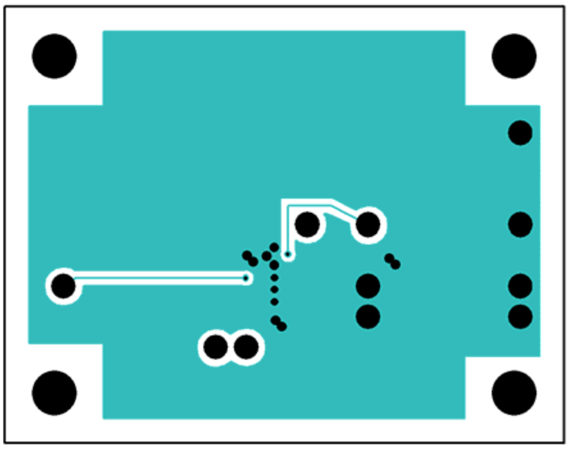
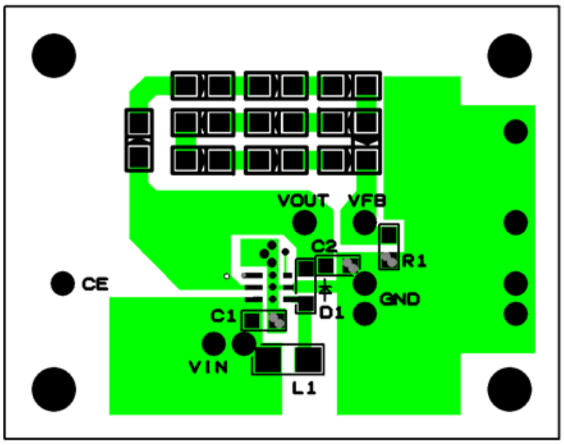
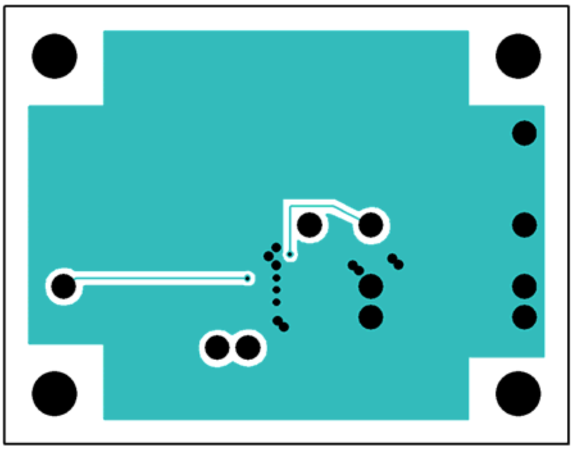
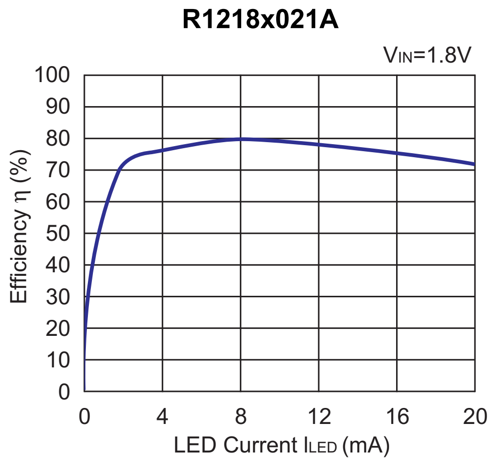
	

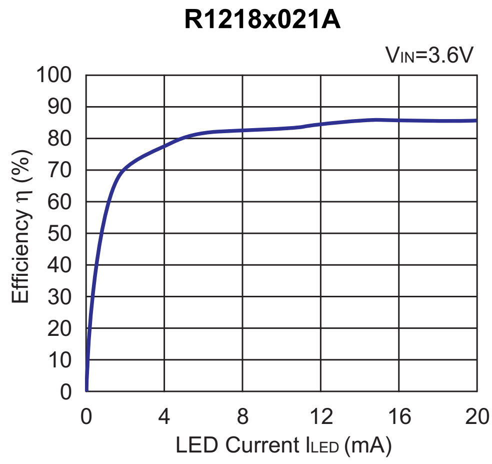
R1218Nxx2A

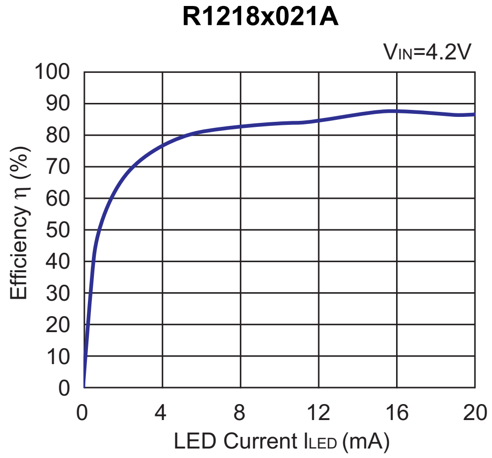
Topside	Backside
	

TYPICAL CHARACTERISTICS

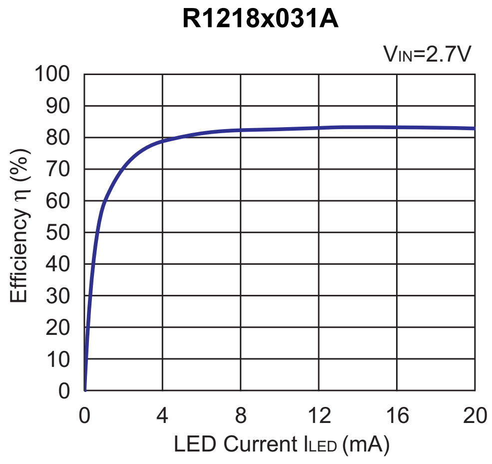
1) Efficiency vs. LED Current (2 LED) L: LQH32CN220 (Ta = 25°C)

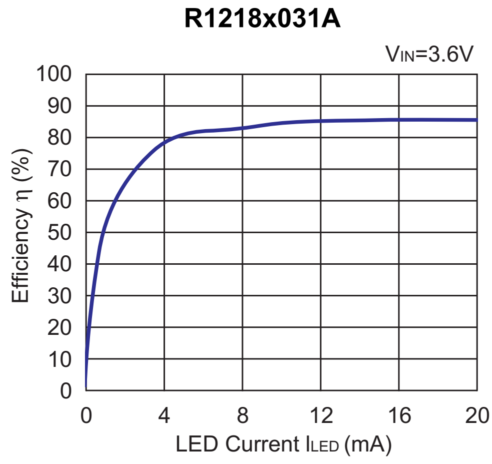






2) Efficiency vs. LED Current (3 LED) L: LQH32CN220 (Ta = 25°C)





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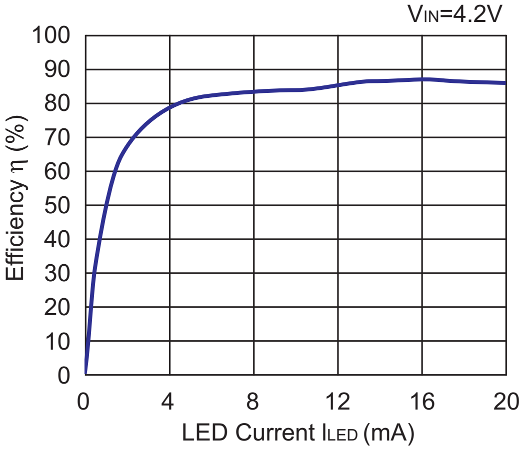
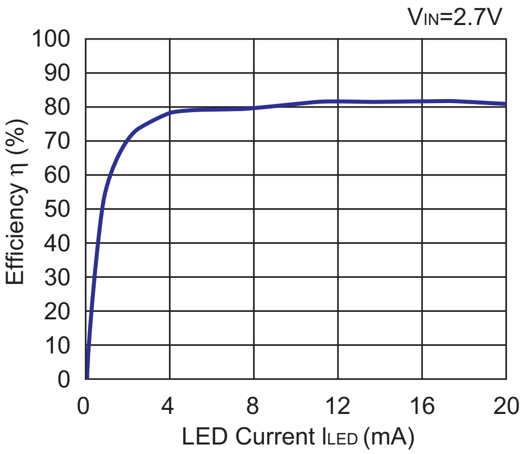
R1218x031A



3) Efficiency vs. LED Current (4 LED) L: LQH32CN220 (Ta = 25°C)

R1218x041A



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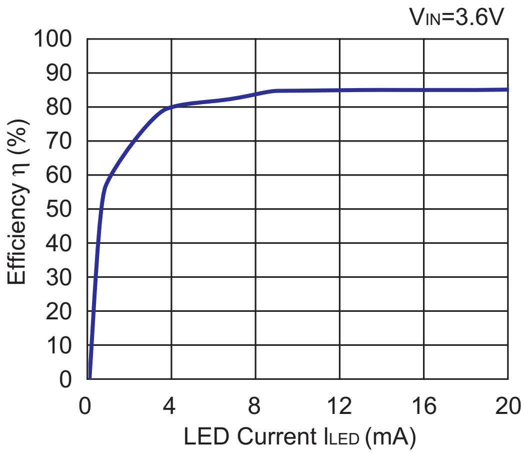

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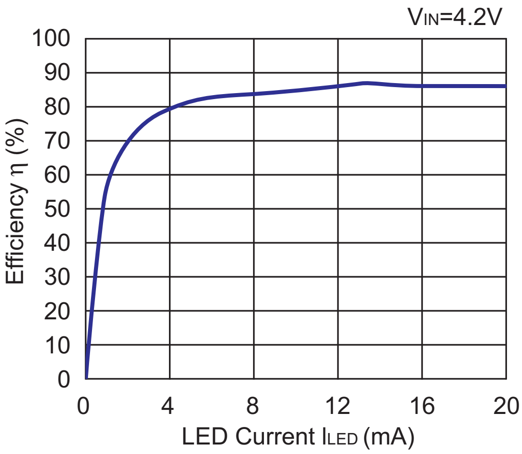
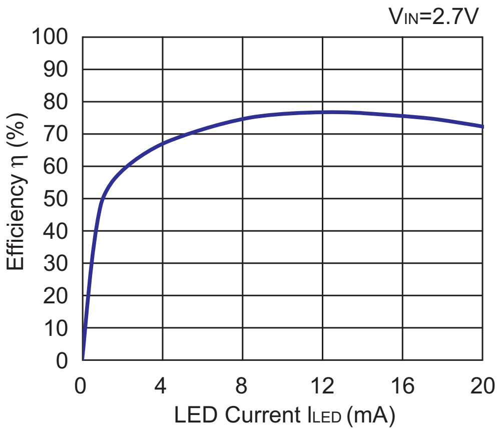
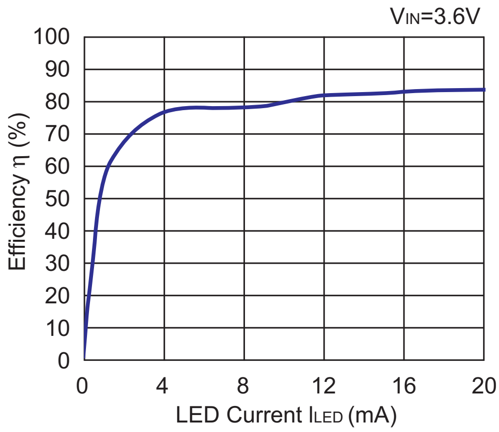


4) Efficiency vs. LED Current (6 LED) L: LQH32CN220, Diode: CRS02 (Ta = 25°C)

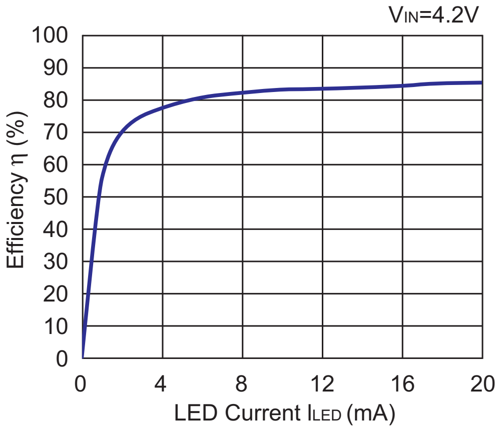
R1218x062A



R1218x062A

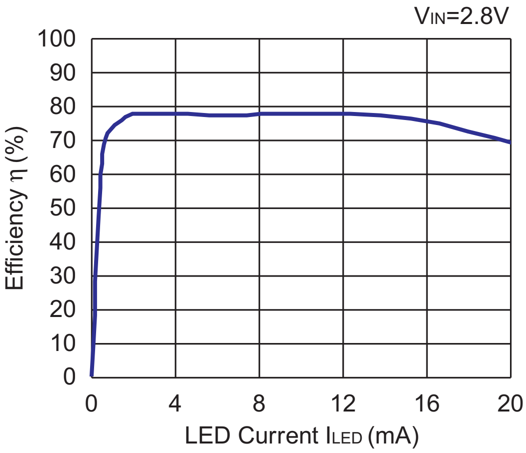


R1218x062A

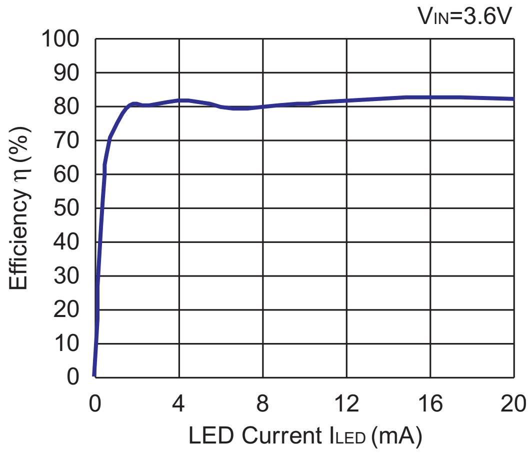


5) Efficiency vs. LED Current (7 LED) L: LQH32CN220, Diode: CRS02 (Ta = 25°C)

R1218x072A



R1218x072A



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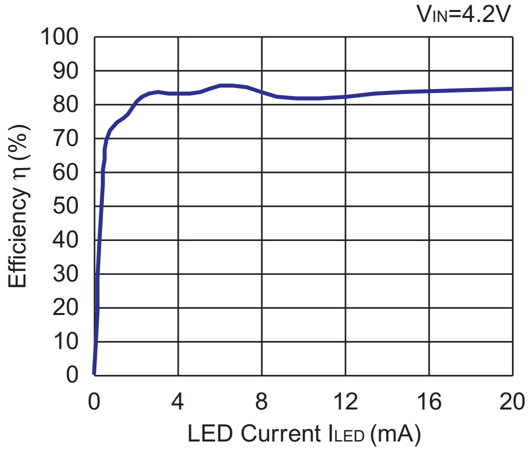
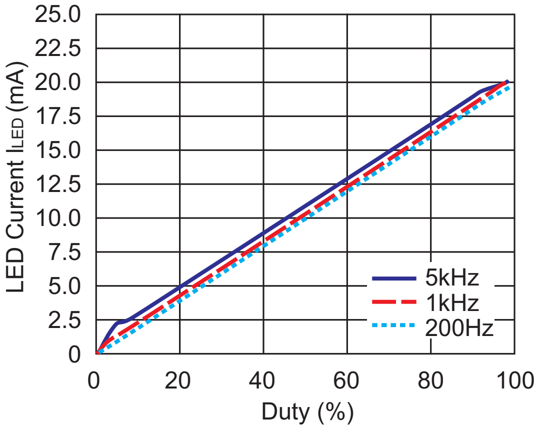


6) PWM Dimming Control (2 LED) V_{IN} = 3.6 V, R1 = 10 Ω

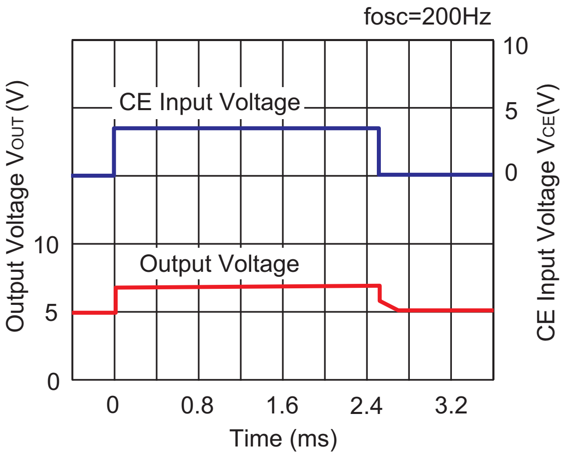
6-1. Duty vs. LED Current (2 LED) (Ta = 25°C)

R1218x021A

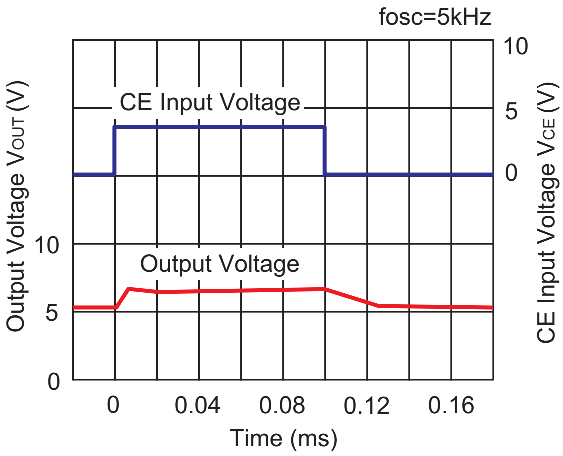


6-2. Output Voltage Waveform (2 LED) (Ta = 25°C)

R1218x021A



R1218x021A

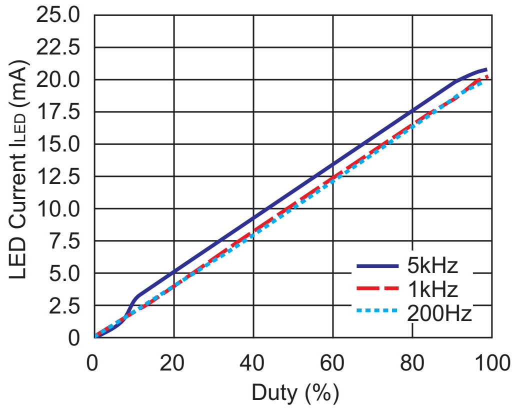


RICOH

7) PWM Dimming Control (4 LED) V_{IN} = 3.6 V, R1 = 10 Ω

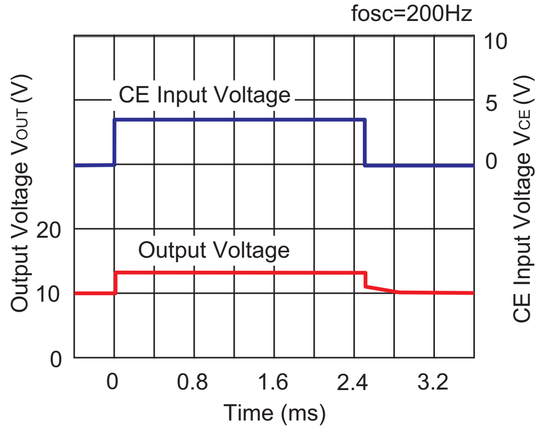
7-1. Duty vs. LED Current (4 LED) (Ta = 25°C)

R1218x041A

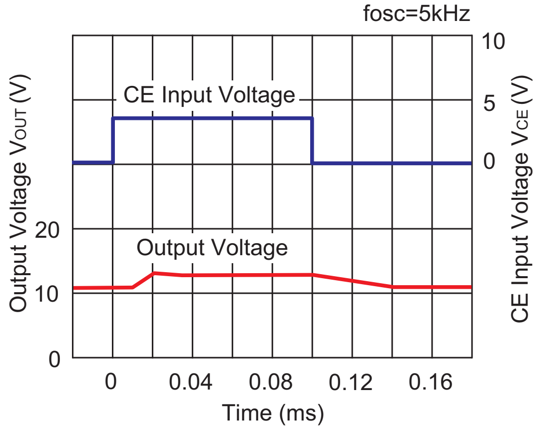


7-2. Output Voltage Waveform (4 LED) (Ta = 25°C)

R1218x041A



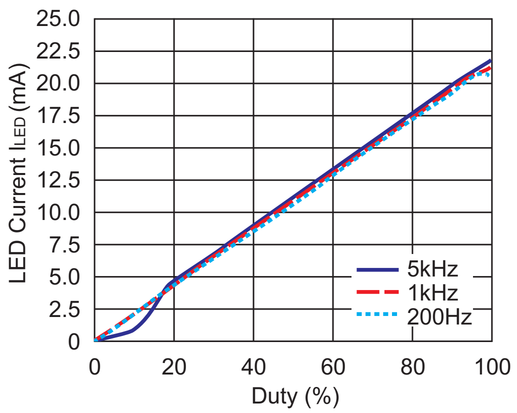
R1218x041A



8) PWM Dimming Control (6 LED) V_{IN} = 3.6 V, R1 = 10 Ω

8-1. Duty vs. LED Current (6 LED) (Ta = 25°C)

R1218x062A



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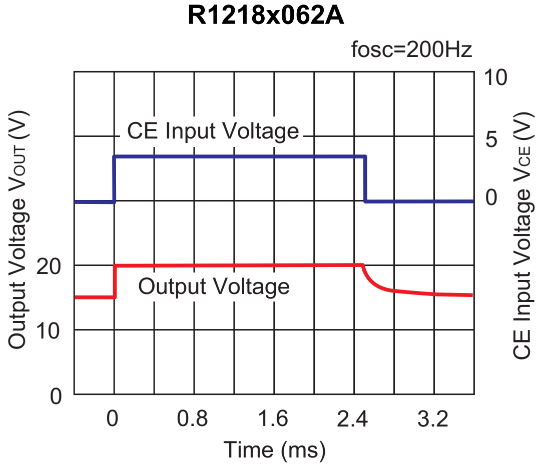
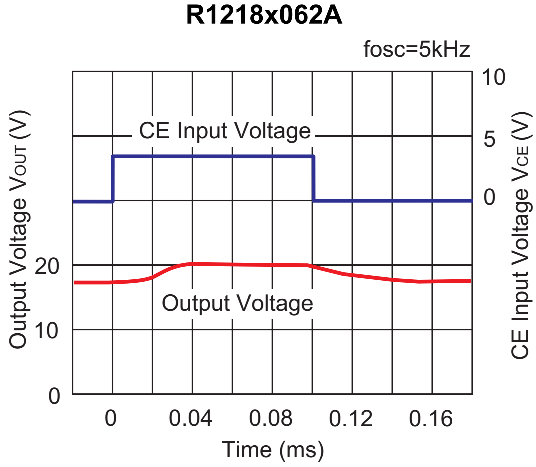
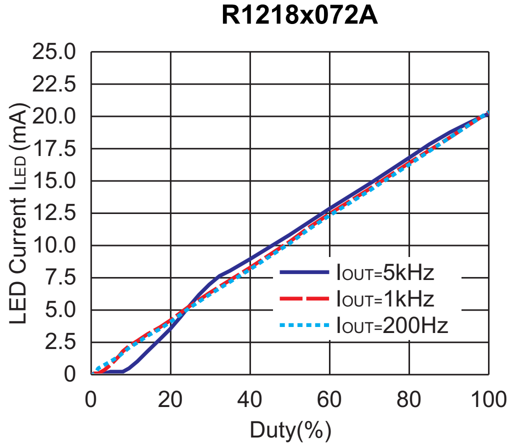
8-2. Output Voltage Waveform (6 LED) (Ta = 25°C)



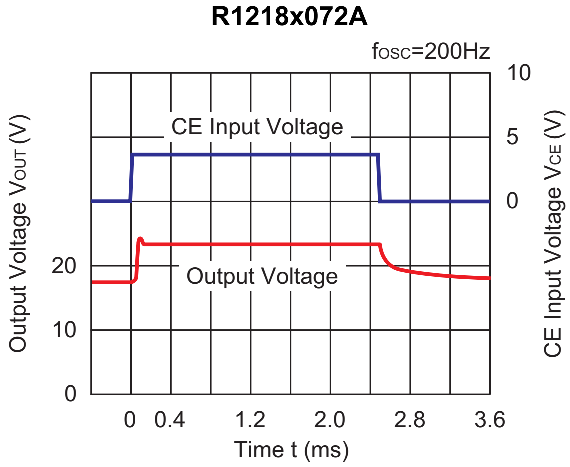


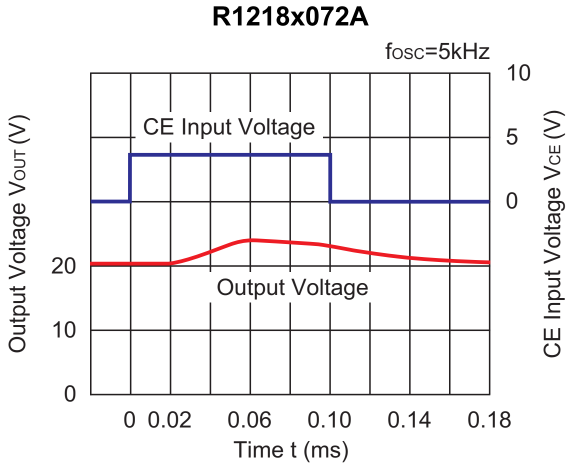
9) PWM Dimming Control (7 LED) V_{IN} = 3.6 V, R1 = 10 Ω

9-1. Duty vs. LED Current (7 LED) (Ta = 25°C)



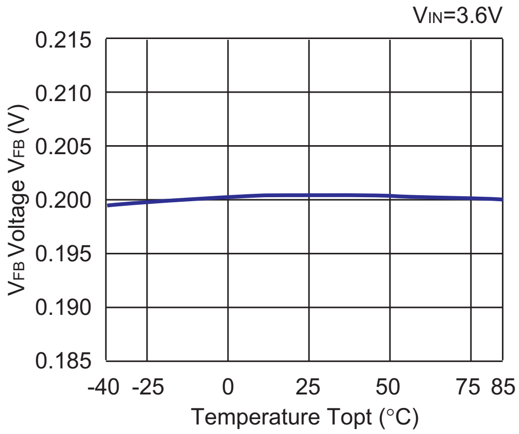
9-2. Output Voltage Waveform (7 LED) (Ta = 25°C)





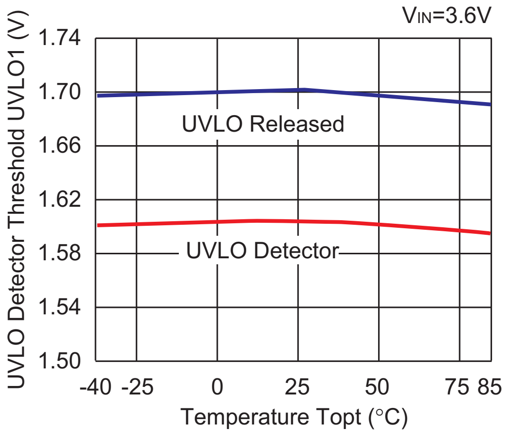
10) V_{FB} Voltage vs. Temperature

R1218x041A



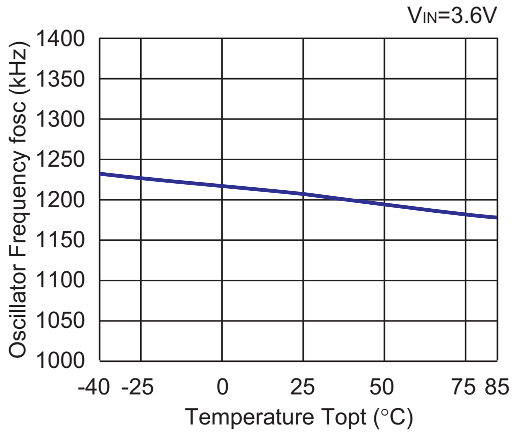
11) UVLO Detector Threshold/Released Voltage vs. Temperature

R1218x041A



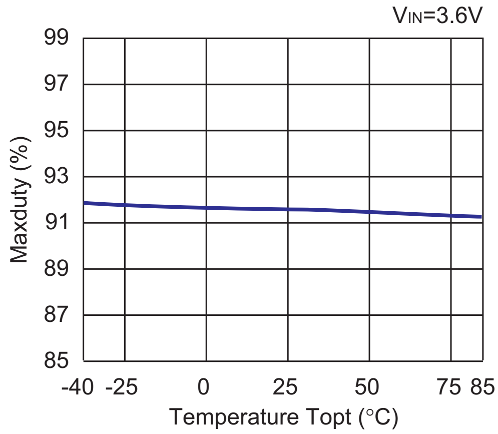
12) Oscillator Frequency vs. Temperature

R1218x041A



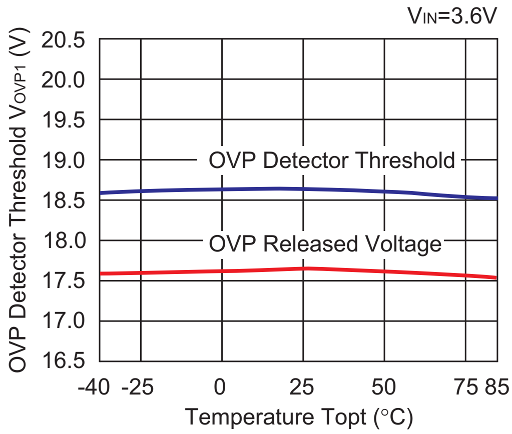
13) Maximum duty cycle vs. Temperature

R1218x041A



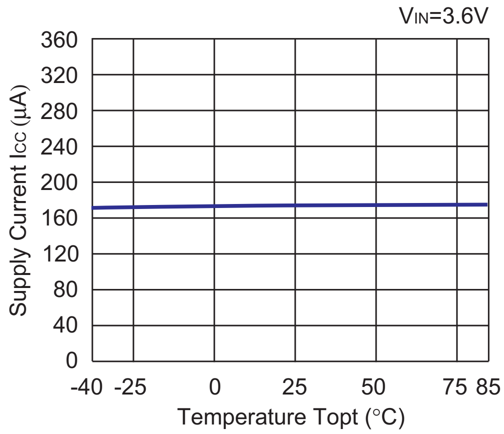
14) OVP Detector Threshold/Released Voltage vs. Temperature

R1218x041A

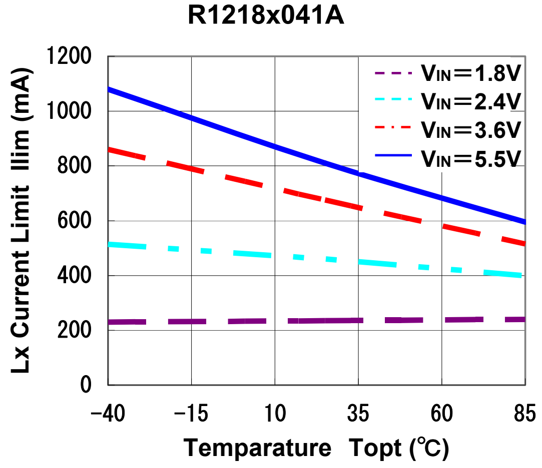


15) Supply Current vs. Temperature

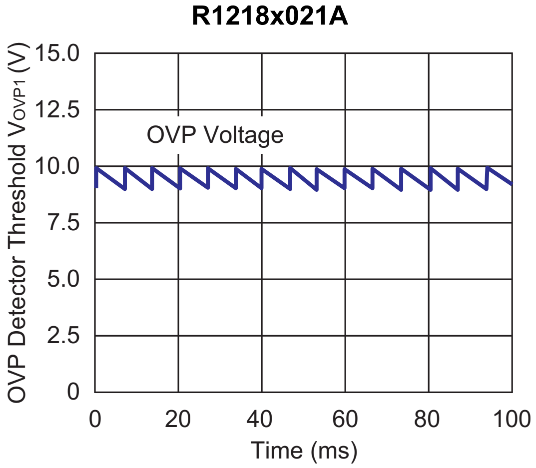
R1218x041A

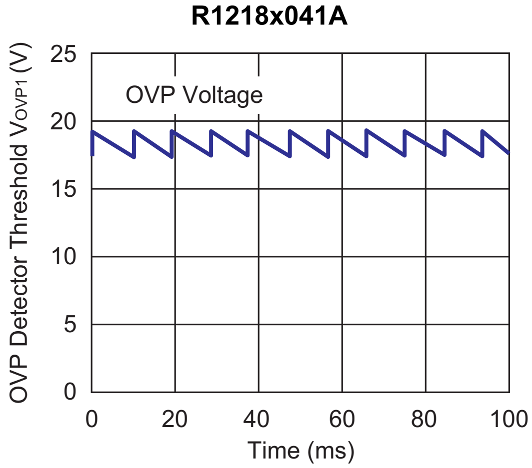


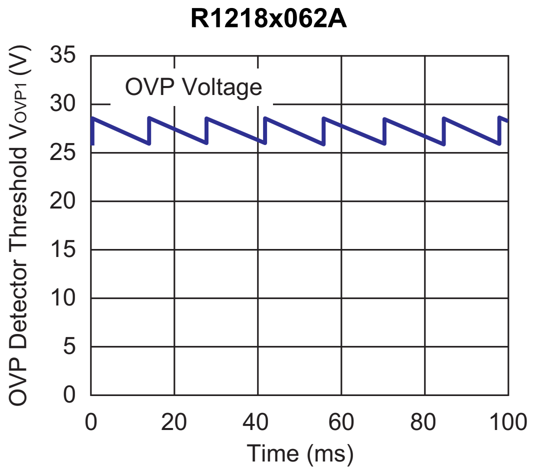
16) LX Current Limit vs. Temperature



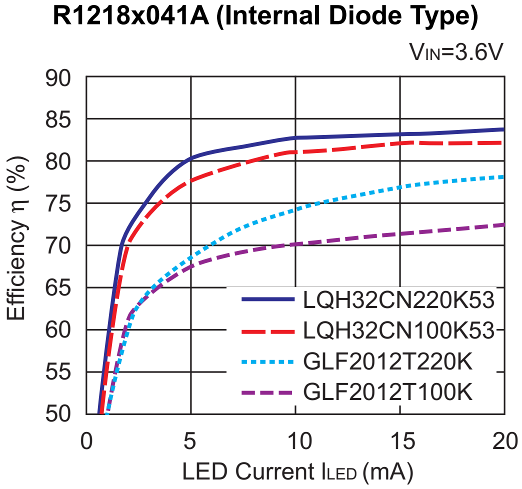
17) OVP Transient Response (Ta = 25°C)







18) Efficiency dependence on inductors (4 LED)



The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

Measurement Conditions

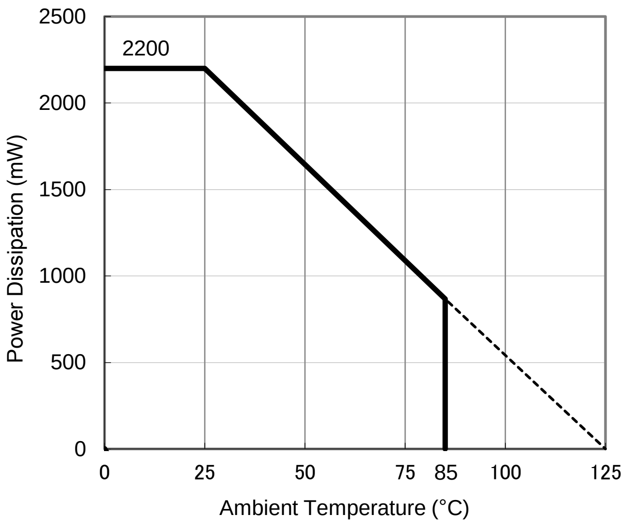
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	ϕ 0.2 mm × 34 pcs

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

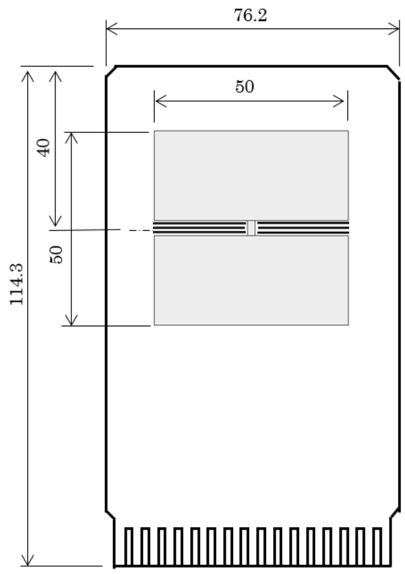
Item	Measurement Result
Power Dissipation	2200 mW
Thermal Resistance (θja)	θja = 45°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 18°C/W

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter



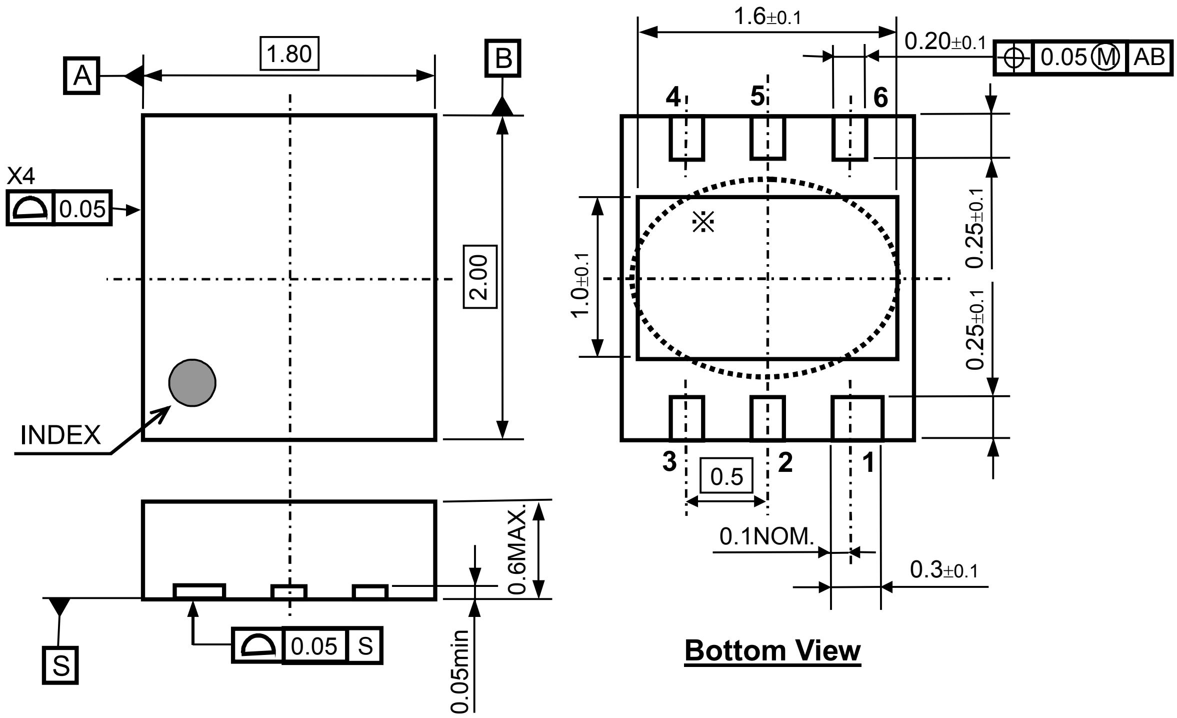
Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

RICOH

Ver. A



DFN(PLP)1820-6 Package Dimensions (Unit: mm)

∗ The tab on the bottom of the package is substrate level (GND). It is recommended that the tab be connected to the ground plane on the board, or otherwise be left floating.

Ver. 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. 51-7.

Measurement Conditions

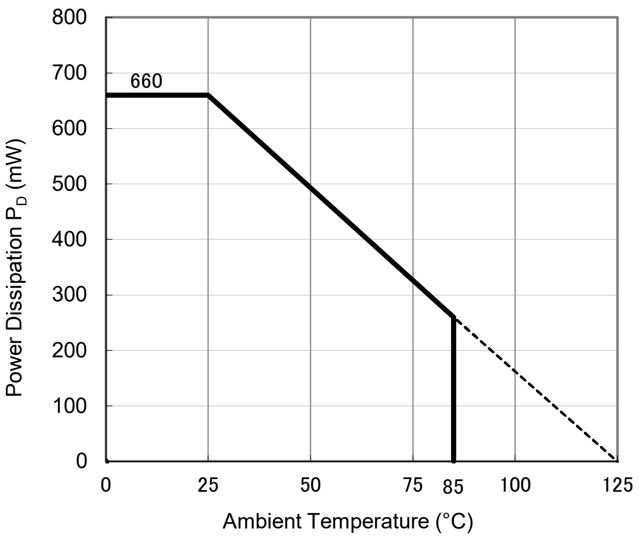
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	ϕ 0.3 mm × 7 pcs

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

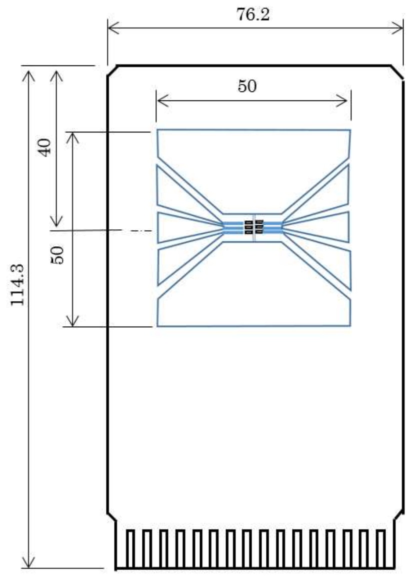
Item	Measurement Result
Power Dissipation	660 mW
Thermal Resistance (θja)	θja = 150°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 51°C/W

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter



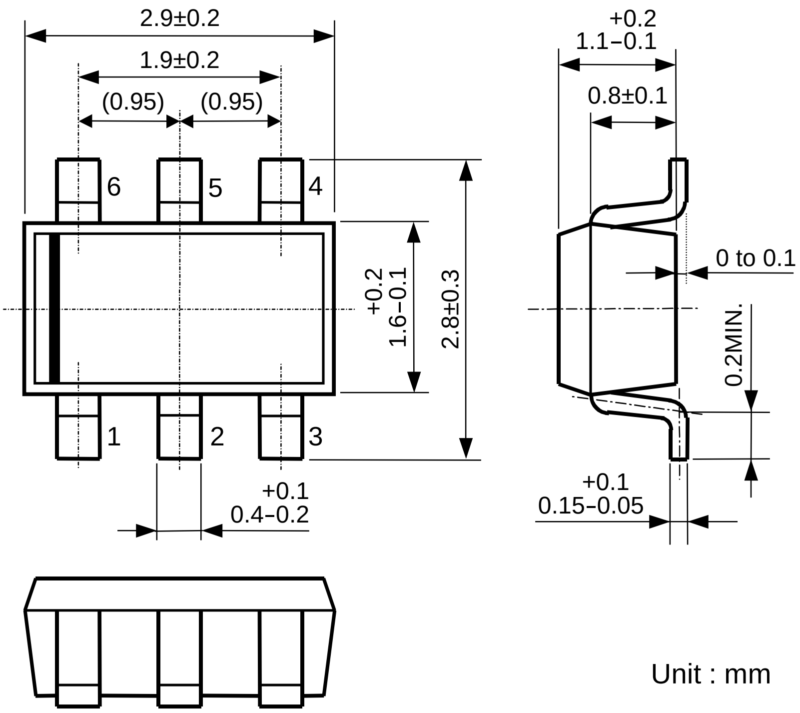
Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

RICOH

Ver. A



SOT-23-6 Package Dimensions

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