
Step-up DC/DC converter for White LED Backlight

NO.EA-006-1025

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, an under voltage lockout circuit (UVLO), an over-voltage protection circuit (OVP), and so on. 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 6 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 resistance is small and efficiency is good. Maximum duty cycle is internally fixed, Typ. 91%. 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 SOT23-6 and very tiny PLP1820-6.

FEATURES

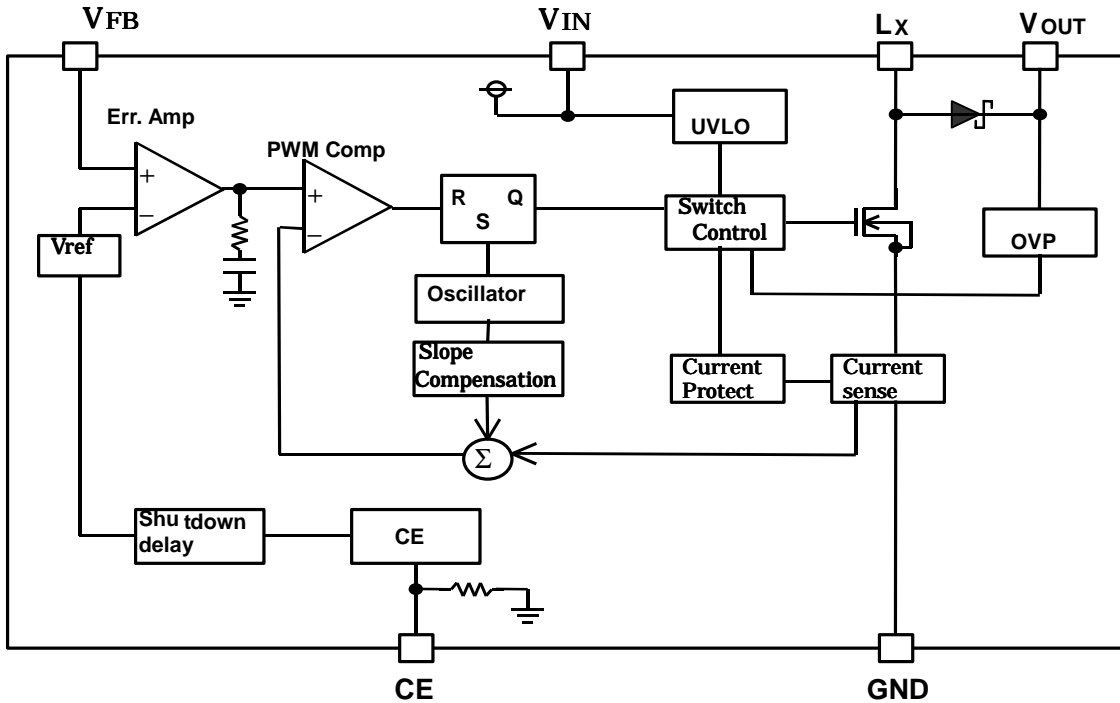
- Operating voltage 1.8V to 5.5V
- Built-in 400mA, 1.5Ω, 20V Nch MOSFET (R1218XXX1A)
- Built-in 400mA, 1.5Ω, 29V Nch MOSFET (R1218XXX2A)
- High Frequency PWM control Oscillator Frequency 1.2MHz
- Maximum Duty Cycle Typ. 91%
- Low Feedback Voltage Typ. 0.2V
- UVLO Threshold Voltage Typ. 1.6V (Hysteresis Typ. 0.1V)
- Lx Current limit Protection Typ. 700mA
- Over Voltage Protection (OVP) Threshold Typ. 9.5V(R1218X02XA)
..... Typ. 14.0V(R1218X03XA)
..... Typ. 18.5V(R1218X04XA)
..... Typ. 23.0V(R1218X052A)
..... Typ. 27.5V(R1218X062A)
- LED dimming controlby external PWM signal (Frequency 500Hz to 5kHz) to CE pin
.....by feedback voltage and filtered PWM signal (high frequency)
- Packages SOT23-6 or PLP1820-6

APPLICATION

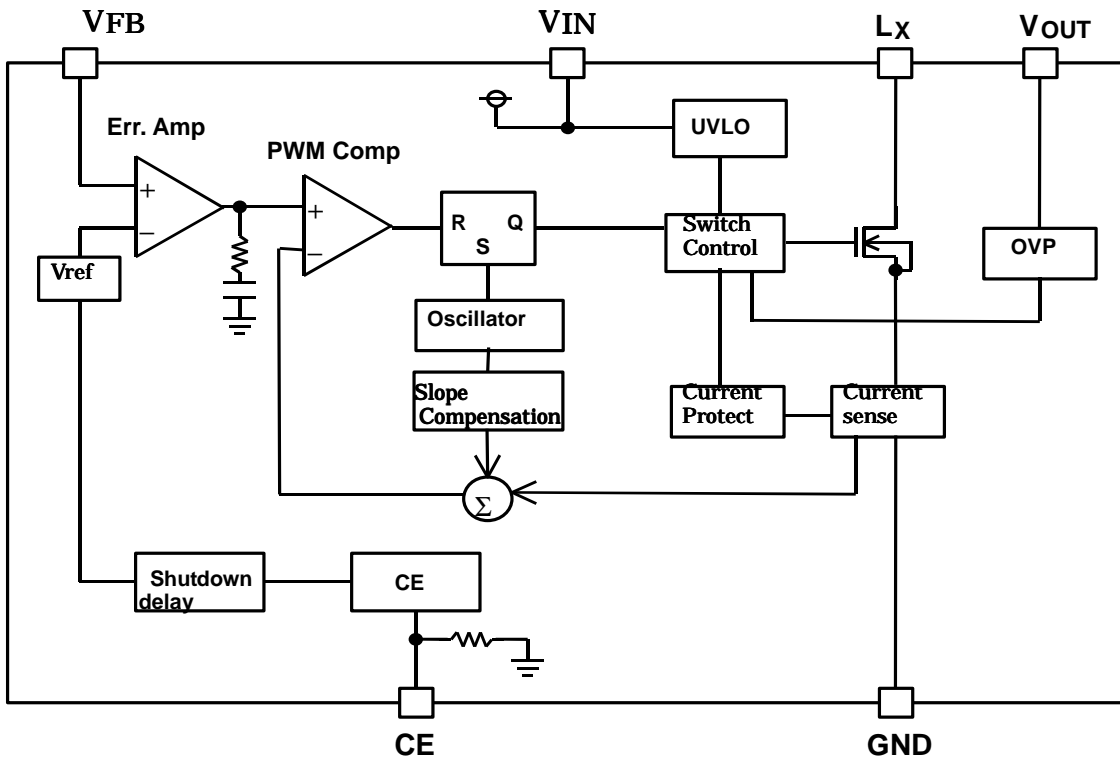
- White LED Backlight for portable equipment

BLOCK DIAGRAMS

• R1218XXX1A



• R1218XXX2A



SELECTION GUIDE

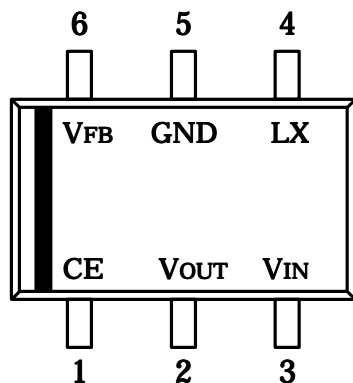
The OVP threshold voltage and the package for the ICs can be selected at the user's request. The selection can be available by designating the part number as shown below;

R1218xxxxx-xx ←Part Number
 ↑ ↑ ↑
 a b c

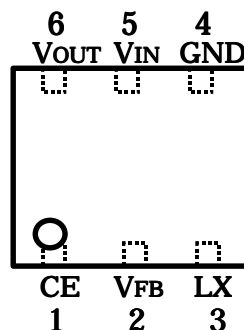
Code	Descriptions
a	Designation of the package N: SOT23-6 K: PLP1820-6
b	Designation of OVP threshold and with/without of built-in diode 021A: 9.5V with built-in diode 031A: 14.0V with built-in diode 041A: 18.5V with built-in diode 052A: 23.0V without built-in diode 062A: 27.5V without built-in diode
c	Taping type (SOT23-6: TR-F, PLP1820-6: TR)

PIN CONFIGURATIONS

- SOT23-6



- PLP1820-6



PIN DESCRIPTION

- SOT23-6

Pin No	Symbol	Pin Description
1	CE	Chip Enable Pin
2	VOUT	Output Voltage
3	VIN	Power Supply Input Pin
4	Lx	Switching Pin (Open Drain Output)
5	GND	Ground Pin
6	VFB	Feedback Pin

R1218X

• PLP1820-6

Pin No	Symbol	Pin Description
1	CE	Chip Enable Pin
2	VFB	Feedback Pin
3	Lx	Switching Pin (Open Drain Output)
4	GND	Ground Pin
5	VIN	Power Supply Input Pin
6	VOUT	Output Voltage

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating		Unit
VIN	VIN Pin Voltage	6.5		V
VCE	CE Pin Voltage	-0.3 to VIN+0.3		V
VFB	VFB Pin Voltage	-0.3 to VIN+0.3		V
VOUT	VOUT Pin Voltage	R1218XXX1A	-0.3 to 22.0	V
		R1218XXX2A	-0.3 to 32.0	
VLX	Lx Pin Voltage	R1218XXX1A	-0.3 to 22.0	V
		R1218XXX2A	-0.3 to 32.0	
ILX	Lx Pin Current	1000		mA
PD	Power Dissipation	R1218NXXXA suspended in air	250	mW
		R1218KXXXA*Note1	880	
Topt	Operating Temperature Range	-40 to +85		°C
Tstg	Storage Temperature Range	-55 to 125		°C

(*Note 1) Mounted on board. Conditions: Board material: FR4 Board Dimensions: 40*40*1.6(mm), Double layer, Wiring Ratio=50%(Both sides), Thermal via: 0.54mm*30pcs, Wind velocity: 0m/s

ELECTRICAL CHARACTERISTICS

• Common

(Topt=25°C)

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
VIN	Operating Input Voltage		1.8		5.5	V
IIN	Supply Current	VIN=5.5V, VFB=0V, Lx at no load		0.5	1.0	mA
ISTB	Standby Current	VIN=5.5V, VCE=0V		0.0	3.0	μA
VUVLO1	UVLO Detector Threshold	VIN falling	1.5	1.6	1.7	V
VUVLO2	UVLO Released Voltage	VIN rising		VUVLO1+0.1	1.8	V
VCEH	CE "H" Input Voltage	VIN=5.5V	1.5			V
VCEL	CE "L" Input Voltage	VIN=1.8V			0.5	V
RCE	CE Pull Down Resistance	VIN=3.6V	600	1200	1600	kΩ
Tshudn	CE Shutdown Delay	VIN=3.6V		10		ms

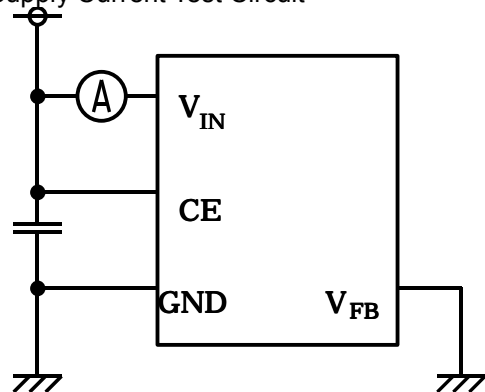
Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit	
VFB	VFB Voltage Tolerance	V _{IN} =3.6V	0.19	0.20	0.21	V	
$\Delta V_{FB}/\Delta T$	VFB Voltage Temperature Coefficient	V _{IN} =3.6V, -40°C≤T _{opt} ≤85°C		±150		ppm/°C	
I _{FB}	VFB Input Current	V _{IN} =5.5V, V _{FB} =0V or 5.5V	-0.1		0.1	μA	
R _{ON}	Switch On Resistance	V _{IN} =3.6V, I _{SW} =100mA		1.5		Ω	
I _{OFF}	Switch Leakage Current	R1218XXX1A V _{LX} =20V		0.0	3.0	μA	
		R1218XXX2A V _{LX} =29V		0.0	3.0	μA	
I _{LIM}	Switch Current Limit	V _{IN} =3.6V	400	700	1000	mA	
f _{OSC}	Oscillator Frequency	V _{IN} =3.6V, V _{OUT} =V _{FB} =0V	1000	1200	1400	kHz	
Maxduty	Maximum Duty Cycle	V _{IN} =3.6V, V _{OUT} =V _{FB} =0V	86	91		%	
VOVP1	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	V
			R1218X041A	17.0	18.5	20.0	V
			R1218X052A	21.5	23.0	24.5	V
			R1218X062A	26.0	27.5	29.0	V
VOVP2	OVP Released Voltage	V _{IN} =3.6V V _{OUT} falling	R1218X021A		VOVP1-0.5		V
			R1218X031A		VOVP1-0.75		V
			R1218X041A		VOVP1-1.0		V
			R1218X052A		VOVP1-1.25		V
			R1218X062A		VOVP1-1.5		V

• R1218XXX1A

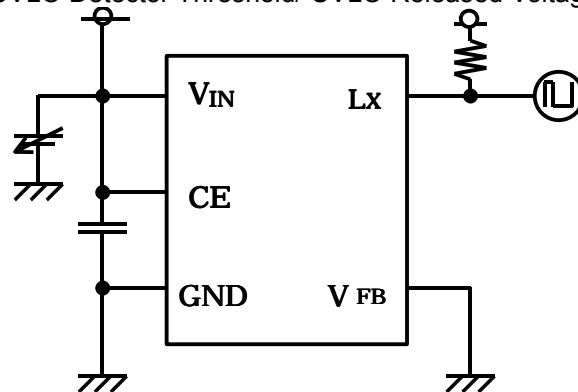
Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V _F	Diode Forward Voltage	I _{DIODE} =100mA		0.8		V
I _R	Diode Leakage Current	V _{OUT} =20V, V _{LX} =0V		10		μA

TEST CIRCUITS

Supply Current Test Circuit

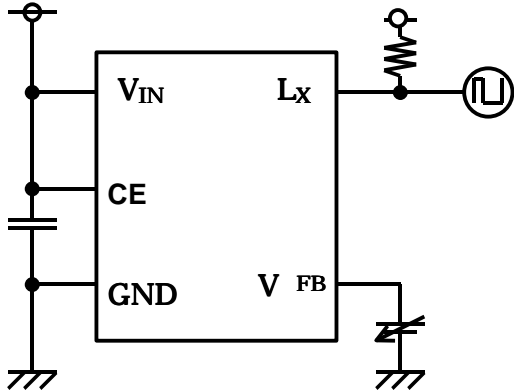


UVLO Detector Threshold/ UVLO Released Voltage

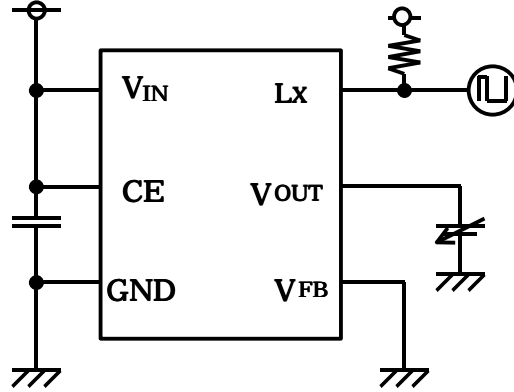


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VFB Voltage, Oscillator Frequency, Maximum Duty Test Circuit

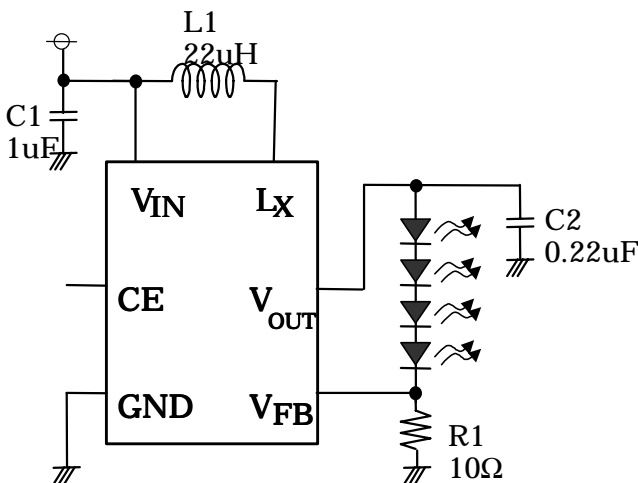


OVP Detector Threshold, OVP Released Voltage Test Circuit

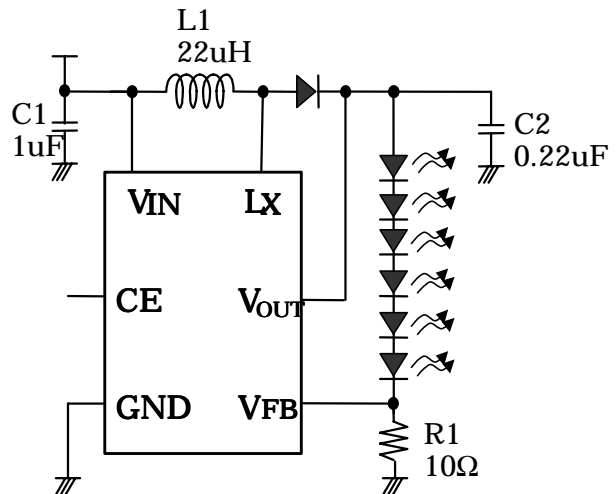


TYPICAL APPLICATIONS

R1218X041A



R1218X062A



• LED Current setting

LED current can be set with feedback resistor(R1)

$$I_{LED} = V_{FB} / R1$$

• 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 200Hz to 5kHz 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.

(2) Dimming control by DC voltage

LED dimming control is also possible by using the DC voltage to VFB pin. LED current is adjustable by DC voltage and resistors, R1 and R2 in the figure 4.

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

(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 (VH) and "L" level (VL) of PWM signal and resistors, R1, R2, R3, and R4 in the figure5. 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.

$$I_{LEDMIN} = (0.2 - R2 * (VH - 0.2)) / (R3 + R4) / R1$$

$$I_{LEDMAX} = (0.2 - R2 * (VL - 0.2)) / (R3 + R4) / R1$$

For example, supposed that the PWM signal level is set as 2.5V/0V, to adjust the LED current range from 0mA to 20mA by the duty cycle, our recommendation external components values are, R1=10Ω, R2=5.1kΩ, R3=51kΩ, R4=5.1kΩ 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 40kHz, 0.1μF or more capacitor is our recommendation value as C3.

Figure 3. Dimming control by CE pin input

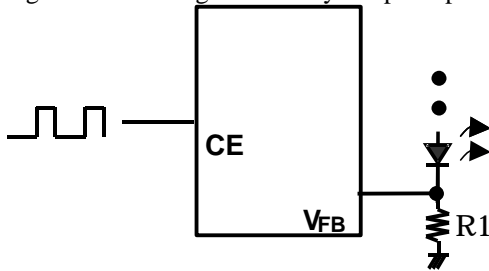


Figure 4. Dimming control by DC voltage

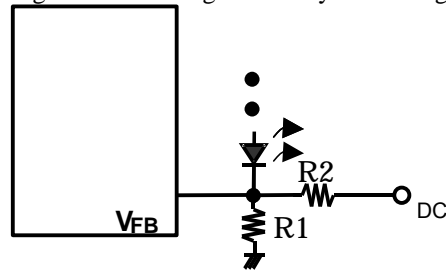
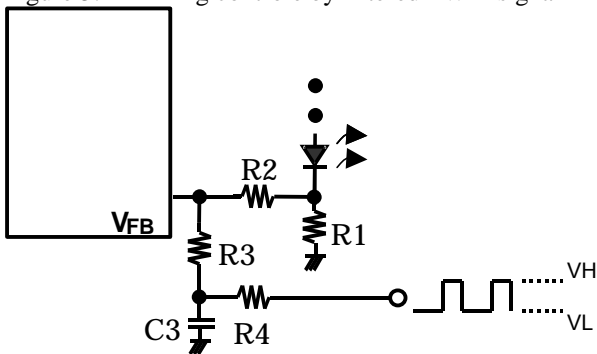


Figure 5. Dimming control by filtered PWM signal



• Selection of Inductors

The peak current of the inductor at normal mode can be calculated as next formula:

$$I_{Lpeak} = 1.25 \times I_{LED} \times V_{OUT} / V_{IN} + 0.5 \times V_{IN} \times (V_{OUT} - V_{IN}) / (L \times V_{OUT} \times f_{OSC})$$

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. For example, for 4 serial LED drive from $V_{IN}=3.6V$, recommendation value of the inductor is 10μH or more.

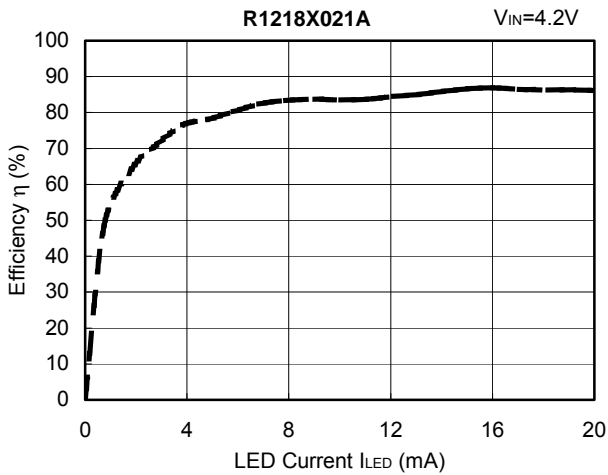
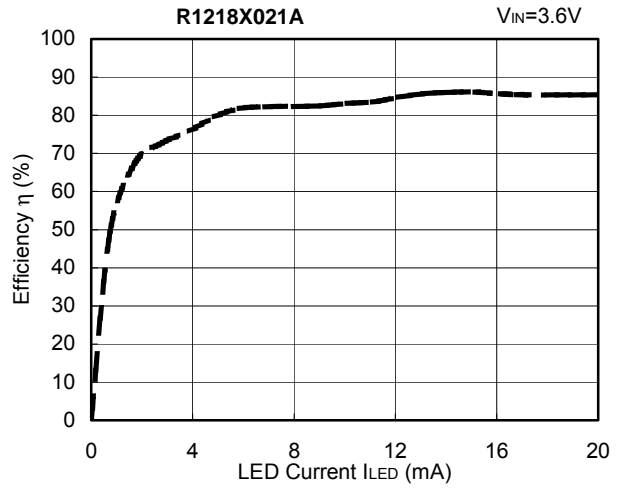
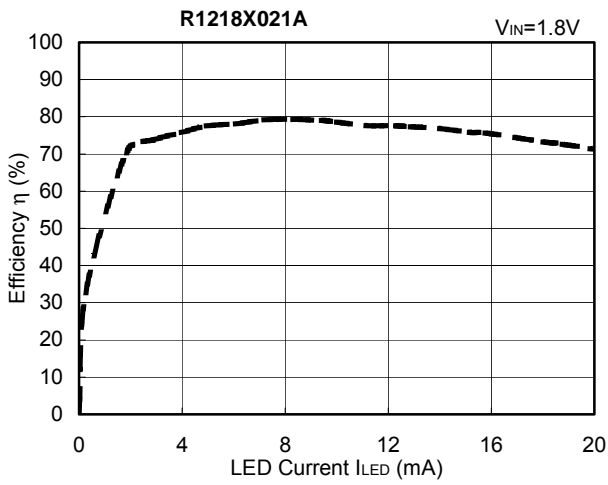
• Selection of Capacitors

Set 1μF or more value bypass capacitor between VIN pin and the GND like C1 as in the figure above as close as possible to the IC.

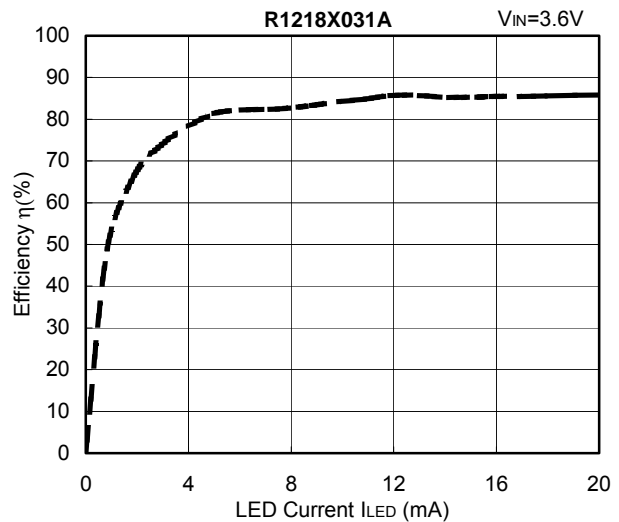
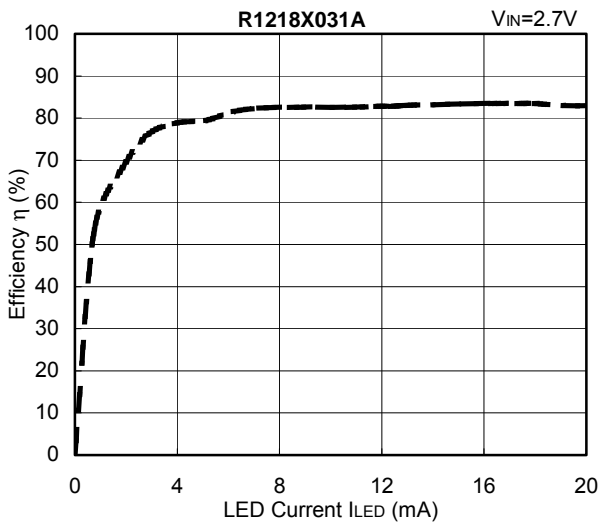
Set 0.22μF or more capacitor between VOUT and the GND like C2 as in the figure above.

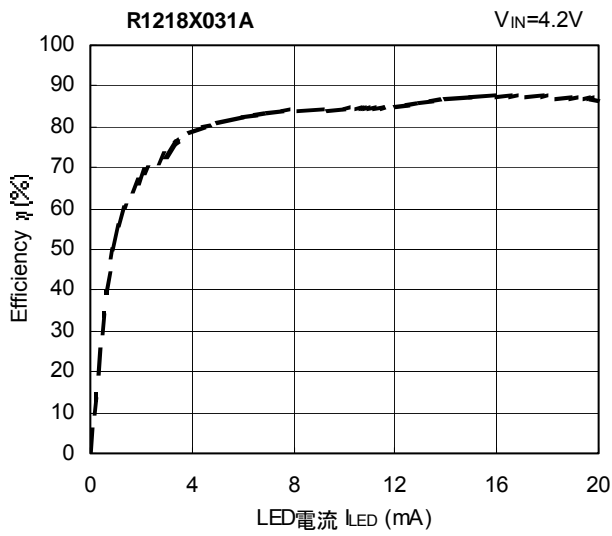
TYPICAL CHARACTERISTICS

1) Efficiency vs. I_{LED} (2LED) L: LQH32CN220 T_{opt}=25°C

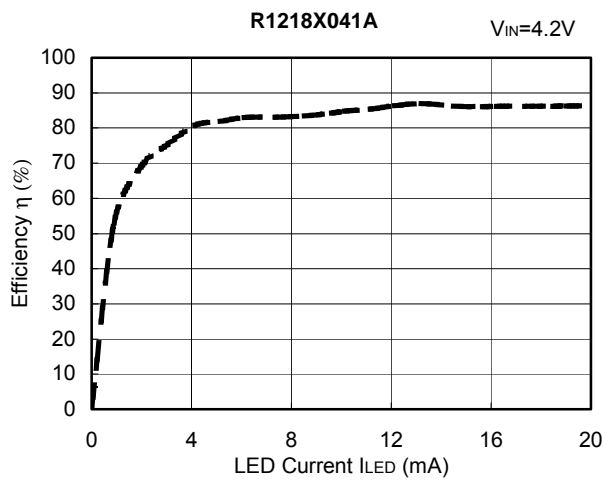
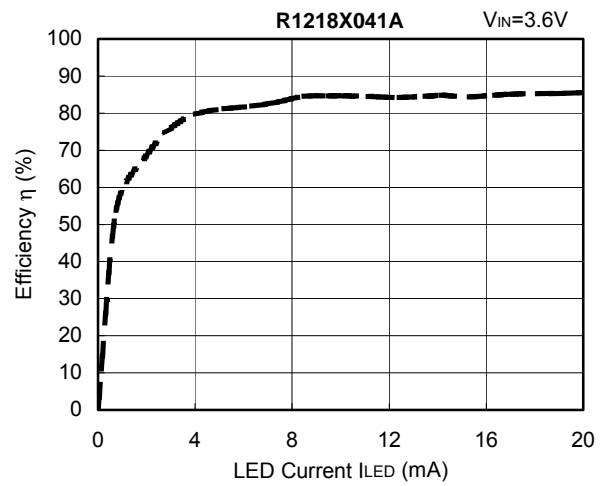
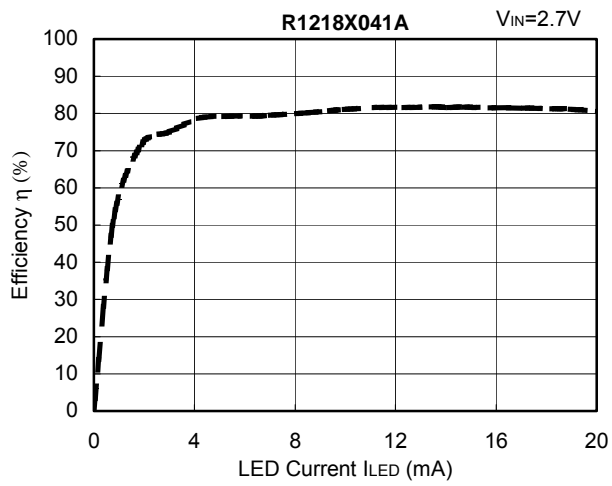


2. Efficiency vs. I_{LED} (3LED) L: LQH32CN220, T_{opt}=25°C

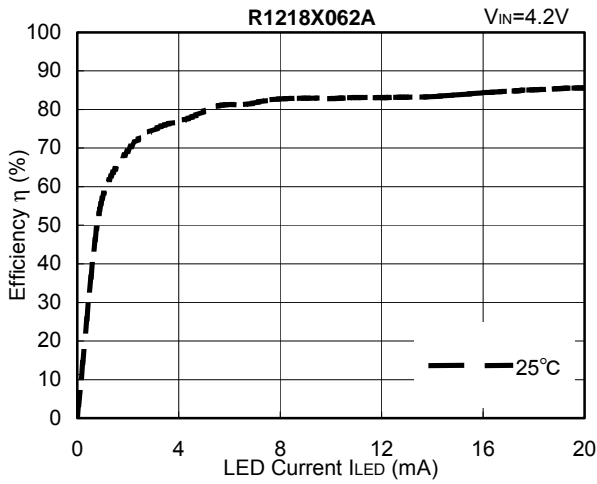
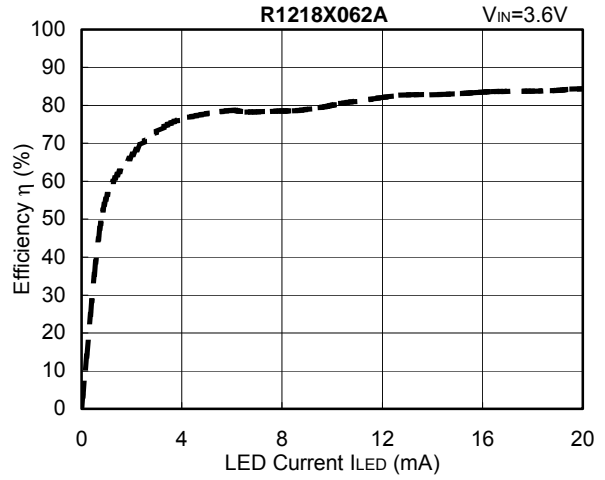
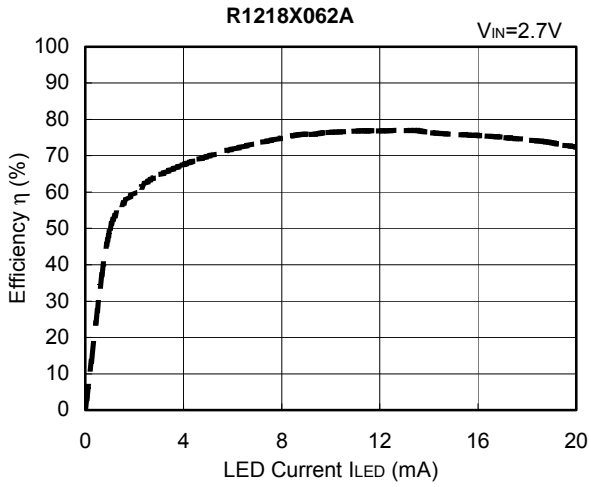




3. Efficiency vs. I_{LED} (4 LED) L: LQH32CN220, T_{opt}=25°C

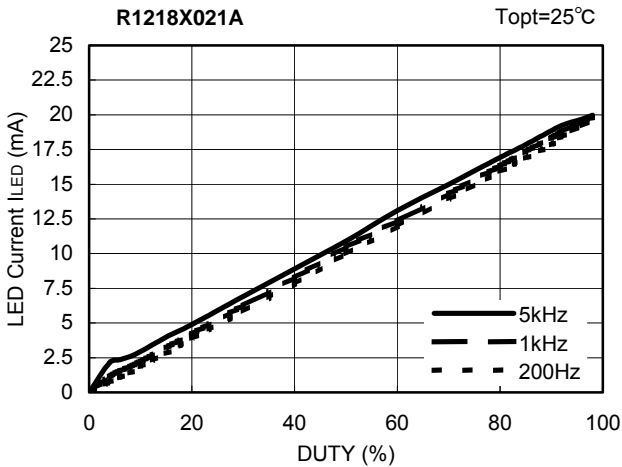


4. Efficiency vs. I_{LED} (6LED) L: LQH32CN220, Diode: CRS02

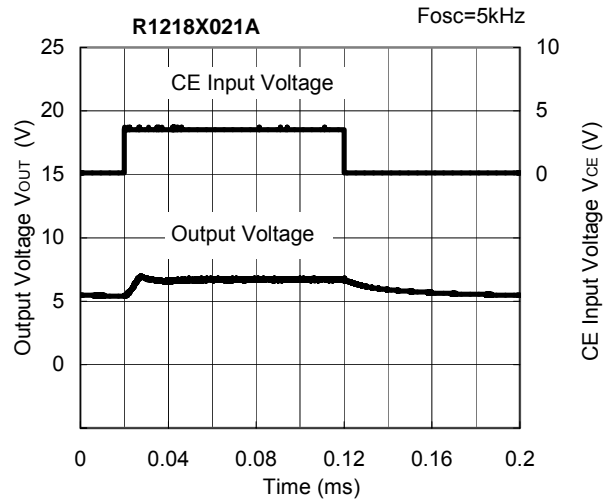
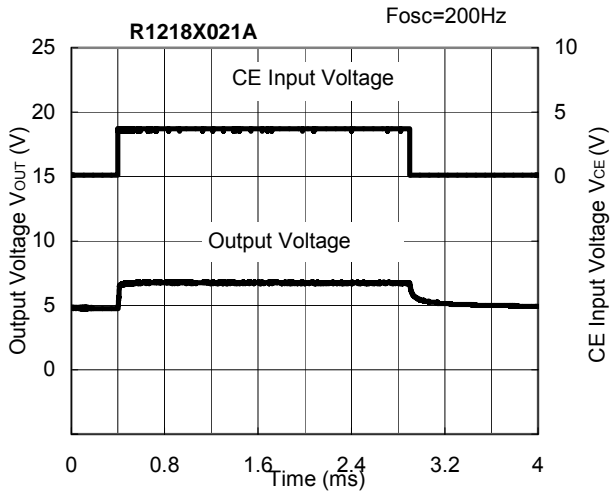


5. PWM Dimming Control (2 LED) $V_{IN}=3.6V$, $R_1=10\Omega$

5-1. Duty vs. LED current

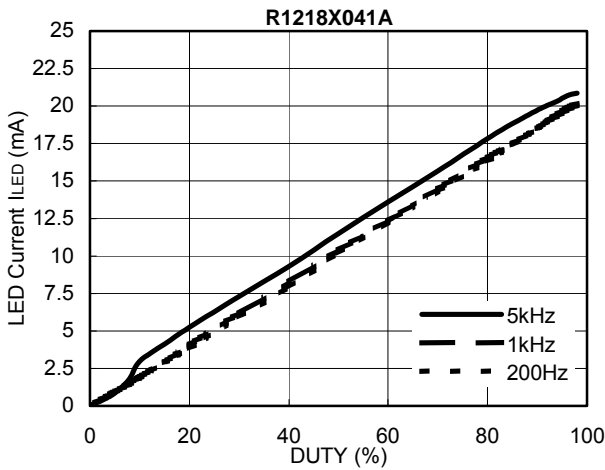


5-2. Output Voltage Waveform (Topt=25°C)

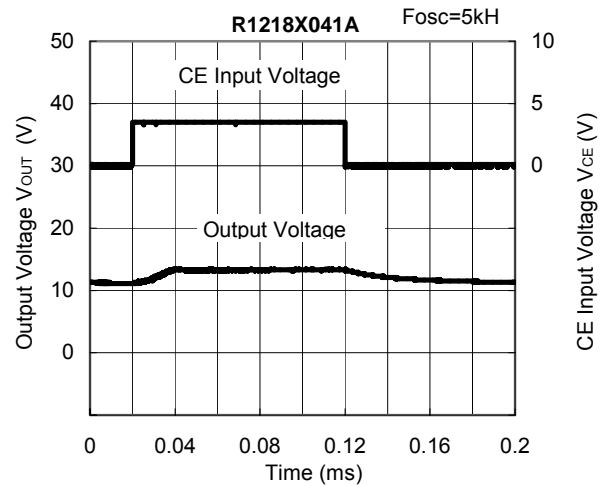
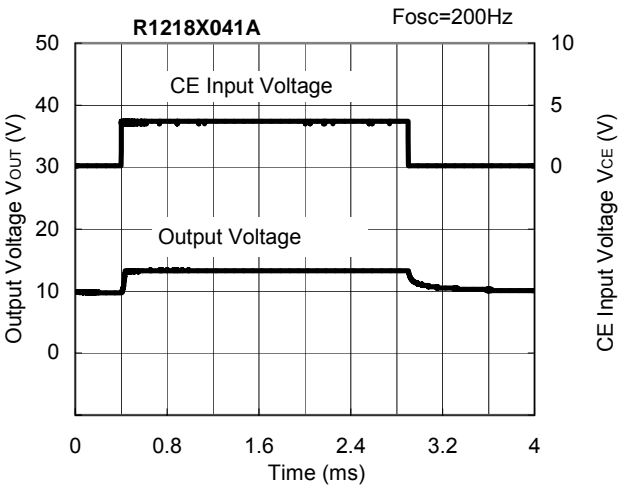


6. PWM Dimming Control (4 LED) VIN=3.6V, R1=10Ω

6-1. Duty vs. LED Current (Topt=25°C)



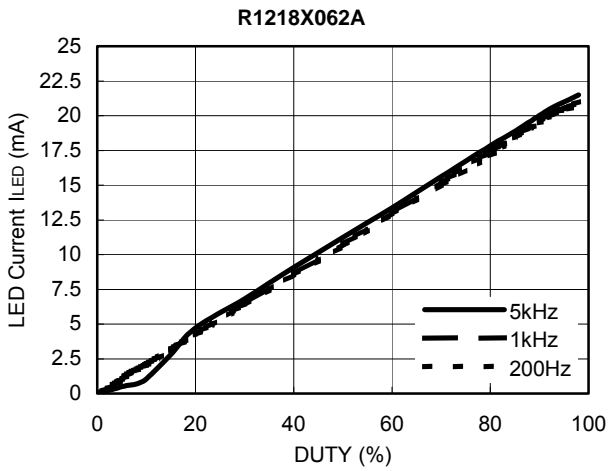
6-2. Output Voltage Waveform



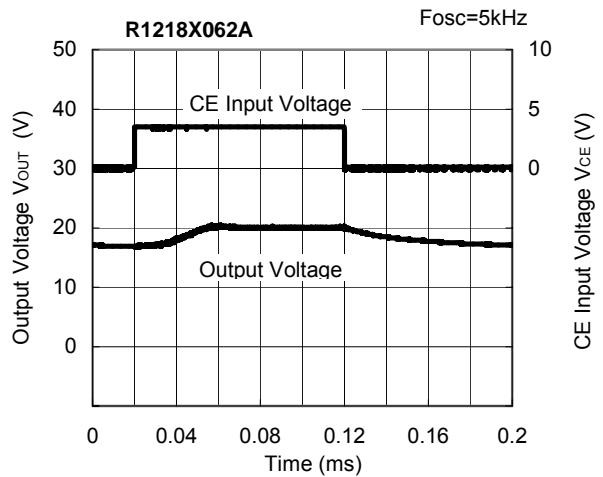
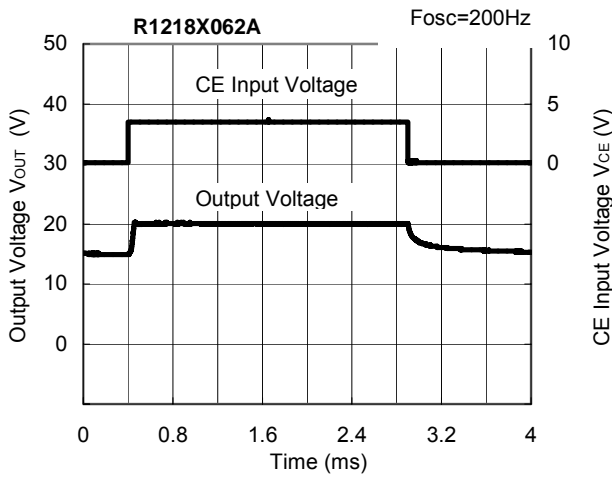
R1218X

7. PWM Dimming Control (6 LED) $V_{IN}=3.6V, R_1=10\Omega$

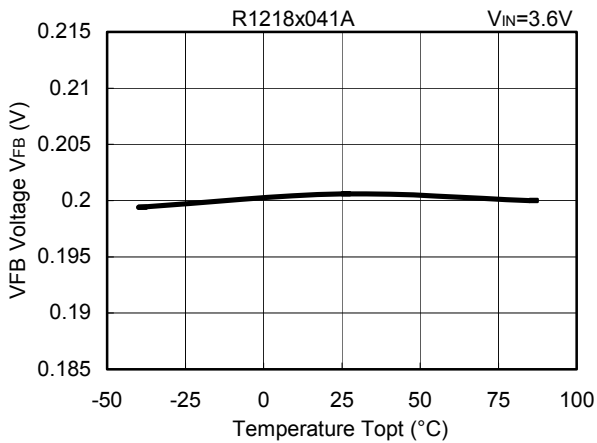
7-1. Duty vs. LED Current ($T_{opt}=25^\circ C$)



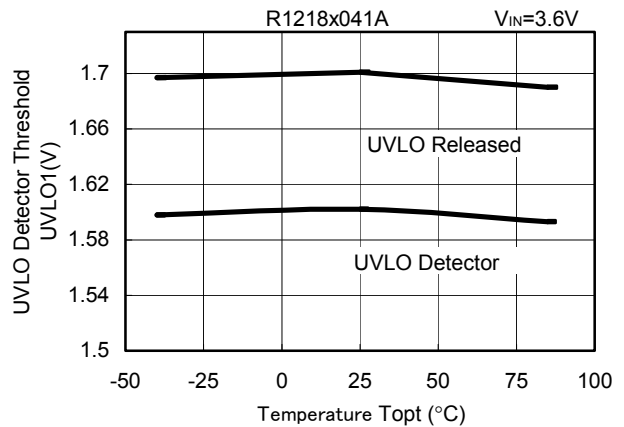
7-2. Output Voltage Waveform ($T_{opt}=25^\circ C$)



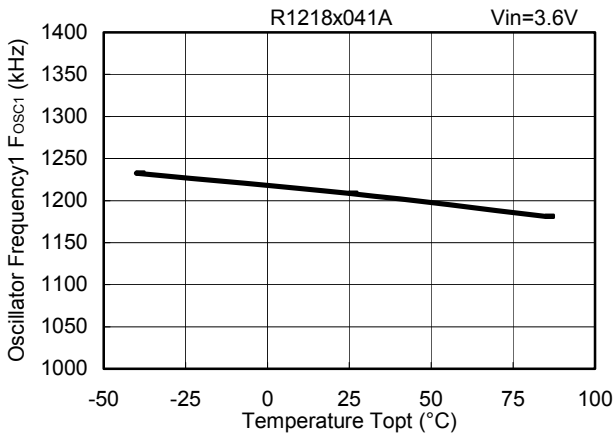
8. VFB Voltage vs. Temperature



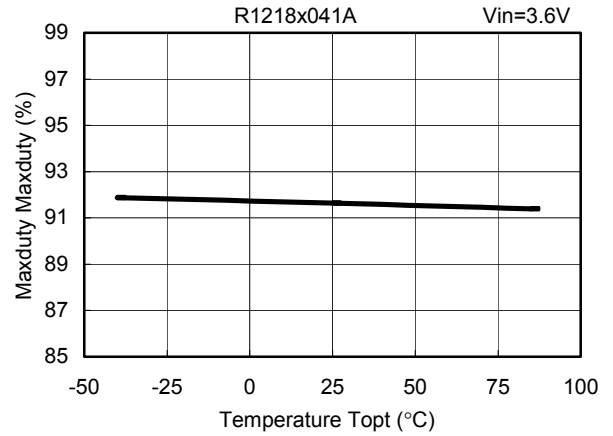
9. UVLO Detector Threshold/Released Voltage vs. Temperature



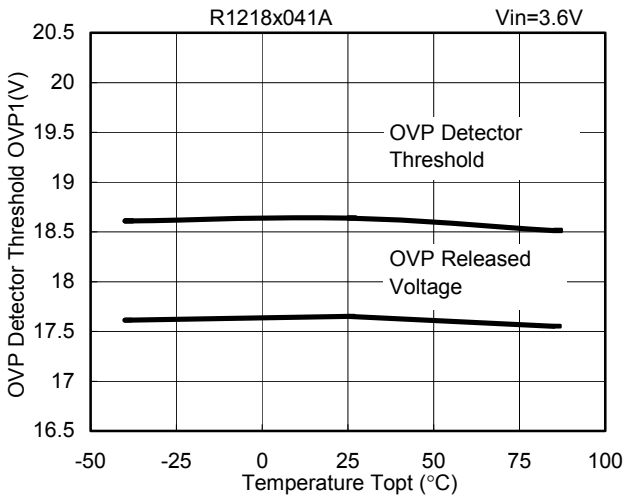
10. Oscillator Frequency vs. Temperature



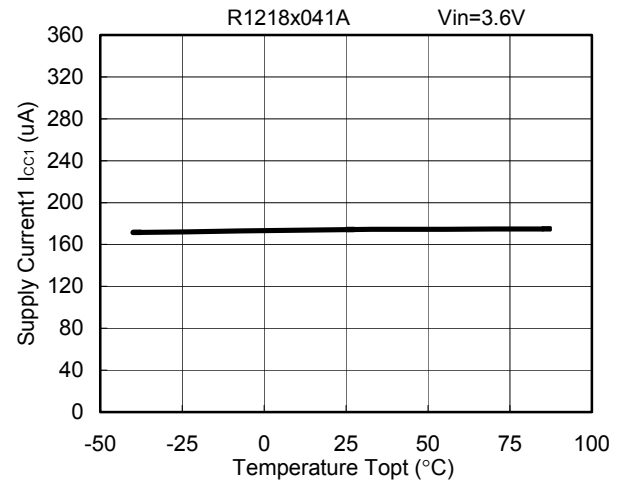
11. Maximum duty cycle vs. Temperature



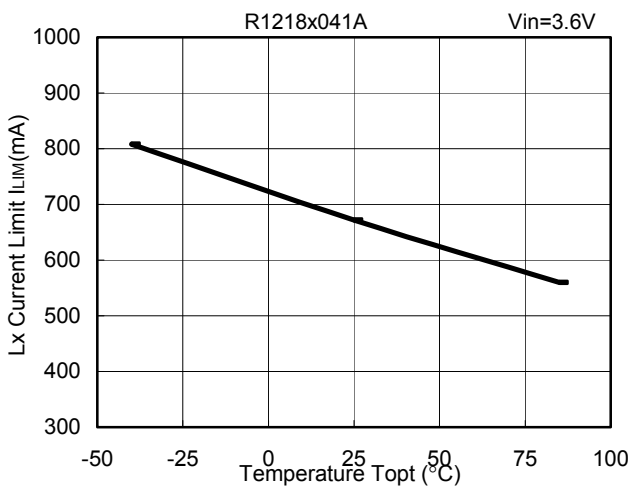
12. OVP Detector Threshold/Released Voltage vs. Temperature



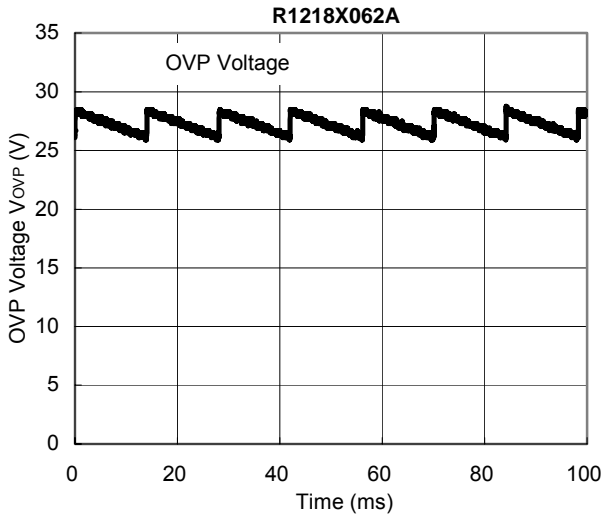
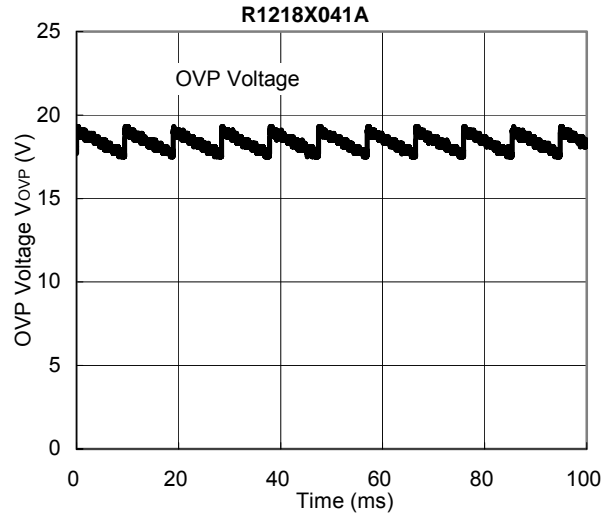
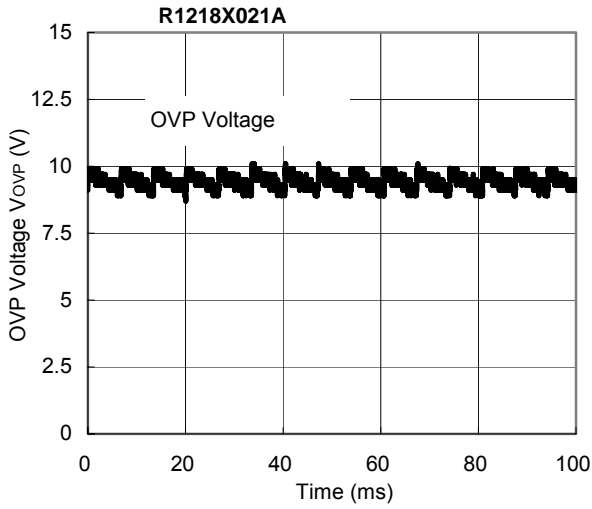
13. Supply Current vs. Temperature



14. LX Current Limit vs. Temperature



15. OVP Transient Response (Topt=25°C)



16. Efficiency dependence on inductors

