RICOH

R1200x SERIES

STEP-UP DC/DC CONVERTER FOR OLED BACK LIGHT with SHUTDOWN FUNCTION

NO.EA-192-130502

OUTLINE

R1200x series are CMOS-based control type step-up DC/DC converter with low supply current ICs. Each of these ICs consists of a Nch MOSFET, NPN transistor, an oscillator, 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), and a soft start circuit. As the external components, an inductor, resistances or capacitors are necessary to make a constant output voltage of step-up DC/DC converter with the R1200x. At standby mode, the NPN transistor can separate the output from the input. During the situation of that, there are two versions. R1200xxxxA: the output of V_{OUT} is generated to 0V by the low resistance (with the auto discharge function). R1200xxxxB does not generate the output of V_{OUT} (without the auto discharge function).

The soft-start time (Typ. 1.5ms) and the maximum duty cycle (Typ. 91%) are set internally. For the protection functions of R1200x series are the current limit function of the L_X peak current, the OVP function for detection the over voltage of output and the UVLO function for protective miss-operation by the low voltage. (The threshold of OVP is selectable from 17V, 19V or 21V.)

Since the packages for these ICs are DFN1616-6, DFN(PLP)1820-6, SOT-23-6 and WLCSP-6-P1 (Non-promotion), therefore high density mounting of the ICs on boards is possible.

FEATURES

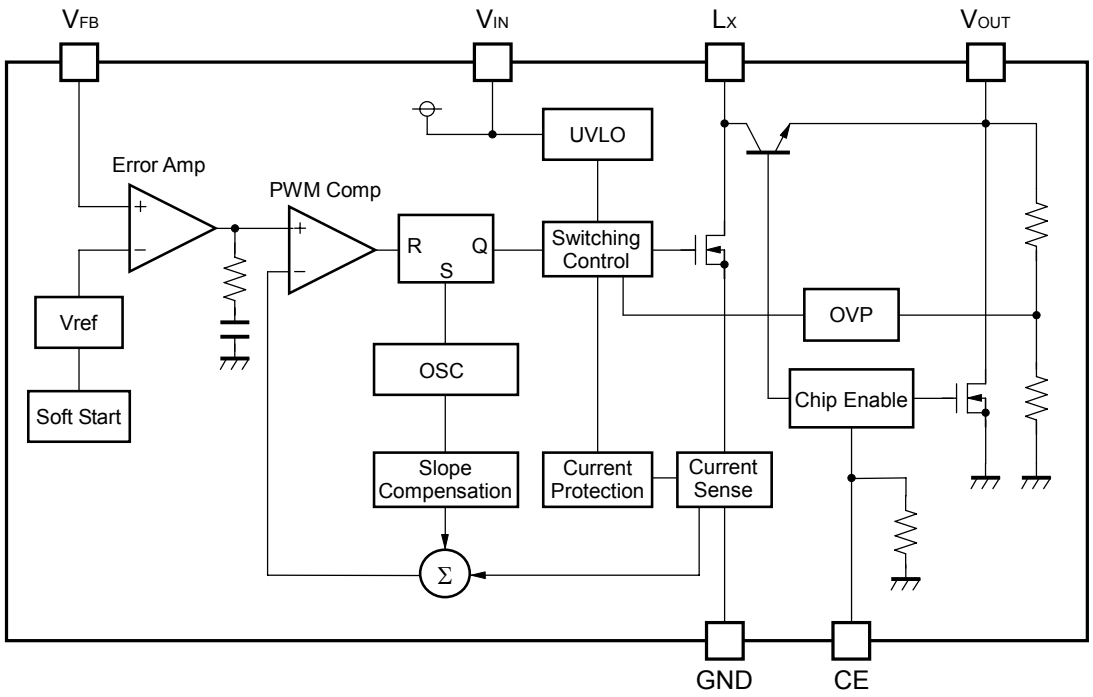
- Supply Current ..... Typ. 500μA
- Standby Current ..... Max. 3μA
- Input Voltage Range ..... 2.3V to 5.5V
- Feedback Voltage ..... 1.0V (Externally adjustable)
- Feedback Voltage Accuracy ..... ±1.5%
- Temperature-Drift Coefficient of Feedback Voltage ..... ±150ppm/°C
- Oscillator Frequency ..... Typ. 1.2MHz
- Maximum Duty Cycle ..... Typ. 91%
- Switch ON Resistance ..... Typ. 1.35Ω
- UVLO Detector Threshold ..... Typ. 2.0V
- Soft-start Time ..... Typ. 1.5ms
- Lx Current Limit Protection ..... Typ. 700mA
- OVP Detector Threshold 17V, 19V, 21V
- Switching Control ..... PWM
- Built-in a rectifier NPN transistor, at standby mode, complete shutdown is possible.
- Built-in Auto discharge function ..... A version
- Packages ..... DFN1616-6, DFN(PLP)1820-6, SOT-23-6, WLCSP-6-P1 (Non-promotion)
- Ceramic capacitors are recommended 1μF

APPLICATION

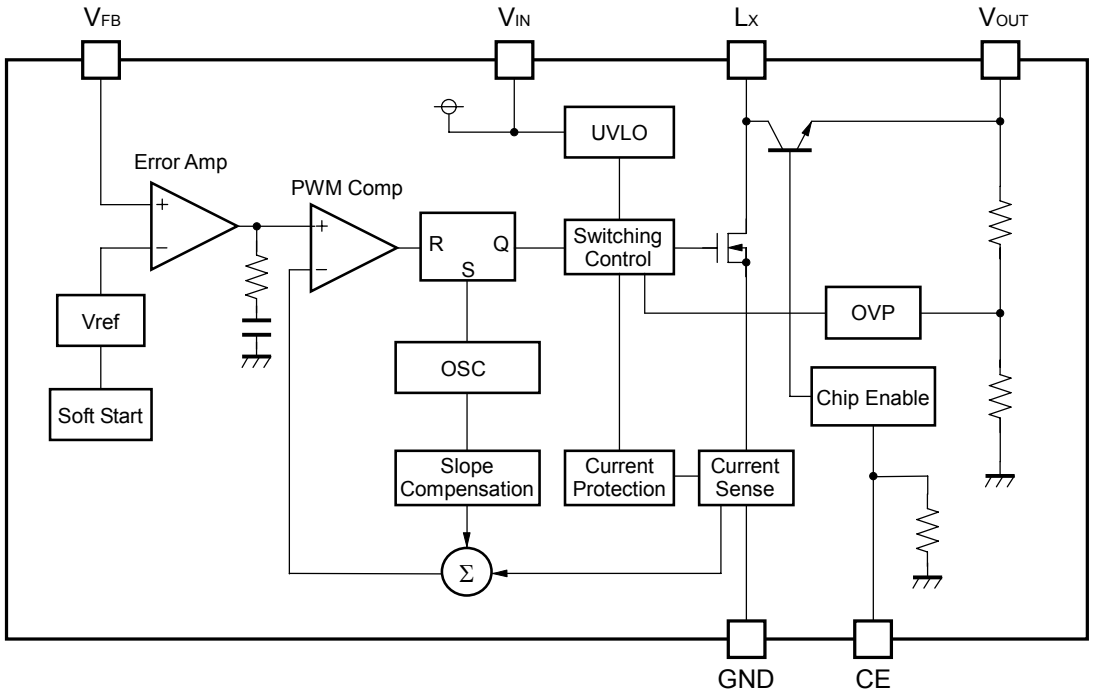
- OLED power supply for portable equipment
- White LED Backlight for portable equipment

BLOCK DIAGRAMS

R1200xxxxA



R1200xxxxB



SELECTION GUIDE

The OVP threshold voltage, auto discharge function, and the package for the ICs can be selected at the user's request.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1200Zxxx∗-E2-F	WLCSP-6-P1 (Non-promotion)	5,000 pcs	Yes	Yes
R1200Lxxx∗-TR	DFN1616-6	5,000 pcs	Yes	Yes
R1200Kxxx∗-TR	DFN(PLP)1820-6	5,000 pcs	Yes	Yes
R1200Nxxx∗-TR-FE	SOT-23-6	3,000 pcs	Yes	Yes

xxx : Designation of OVP detector threshold
(001) 17V threshold of OVP
(002) 19V threshold of OVP
(003) 21V threshold of OVP

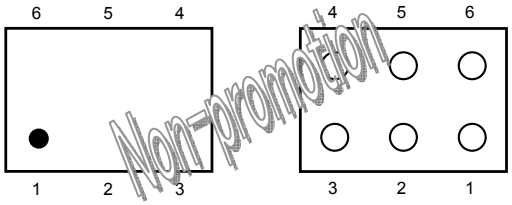
∗ : The auto discharge function at off state are options as follows.
(A) with auto discharge function at off state
(B) without auto discharge function at off state

The products scheduled to be discontinued : "Non-promotion"

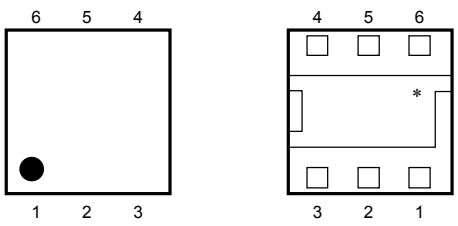
These products will be discontinued in the future. We advise you to select other products.

PIN CONFIGURATIONS

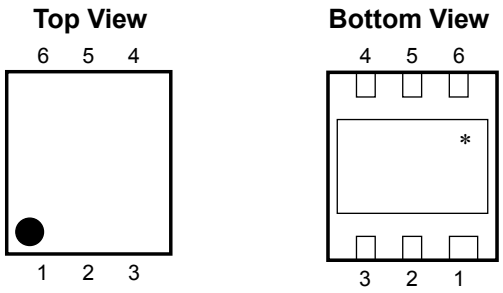
● **WLCSP-6-P1**



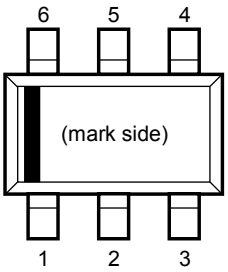
● **DFN1616-6**



● **DFN(PLP)1820-6**



● **SOT-23-6**



PIN DESCRIPTIONS

● **WLCSP-6-P1 (Non-promotion)**

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

● **DFN1616-6, DFN(PLP)1820-6**

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_{DD}	Input Pin
6	V_{OUT}	Output Pin

∗) 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.

- **SOT-23-6**

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

ABSOLUTE MAXIMUM RATINGS

GND=0V

Symbol	Item	Rating	Unit
V_{IN}	V_{IN} Pin Voltage	−0.3 to 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	−0.3 to 25.0	V
V_{LX}	Lx Pin Voltage	−0.3 to 25.0	V
I_{LX}	Lx Pin Current	1000	mA
P_D	Power Dissipation (WLCSP-6-P1) (Non-promotion)*	633	mW
	Power Dissipation (DFN1616-6)*	640	
	Power Dissipation (DFN(PLP)1820-6)*	880	
	Power Dissipation (SOT-23-6)*	420	
Topt	Operating Temperature Range	−40 to 85	°C
Tstg	Storage Temperature Range	−55 to 125	°C

∗) For Power Dissipation, please refer to PACKAGE INFORMATION.

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.

ELECTRICAL CHARACTERISTICS

- **R1200x**

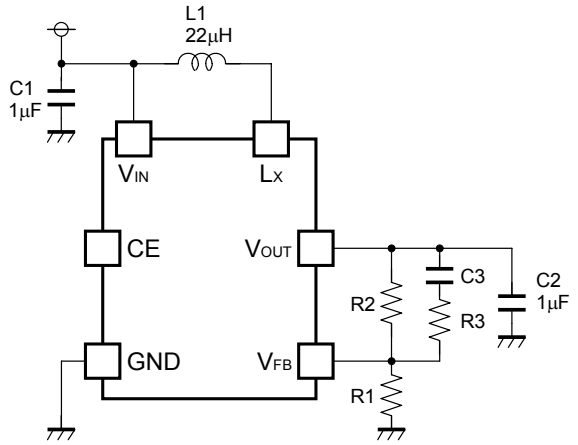
Topt=25°C

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
V_{IN}	Operating Input Voltage			2.3		5.5	V
I_{DD}	Supply Current	V_{IN}=5.5V, V_{FB}=0V, Lx at no load			0.5	1.0	mA
Istandby	Standby Current	V_{IN}=5.5V, V_{CE}=0V			0	3.0	μA
V_{UVLO1}	UVLO Detector Threshold	V_{IN} falling		1.9	2.0	2.1	V
V_{UVLO2}	UVLO Released Voltage	V_{IN} rising			V_{UVLO1} +0.10	2.25	V
V_{CEH}	CE Input Voltage "H"	V_{IN}=5.5V		1.5			V
V_{CEL}	CE Input Voltage "L"	V_{IN}=2.3V				0.5	V
R_{CE}	CE Pull Down Resistance	V_{IN}=3.6V		600	1200	2200	kΩ
V_{FB}	V_{FB} Voltage Accuracy	V_{IN}=3.6V		0.985	1.0	1.015	V
$\Delta V_{FB}/\Delta Topt$	V_{FB} Voltage Temperature Coefficient	V_{IN}=3.6V, −40°C ≤ Topt ≤ 85°C			±150		ppm /°C
I_{FB}	V_{FB} Input Current	V_{IN}=5.5V, V_{FB}=0V or 5.5V		−0.1		0.1	μA
tstart	Soft-start Time	V_{IN}=3.6V			1.5		ms
R_{ON}	Switch ON Resistance	V_{IN}=3.6V, I_{SW}=100mA			1.35		Ω
I_{LXleak}	Switch Leakage Current				0	3.0	μA
I_{LXlim}	Switch Current Limit	V_{IN}=3.6V		400	700	1000	mA
V_{NPN}	NPN V_{CE} Voltage	I_{NPN}=100mA			0.8		V
$I_{NPNOFF1}$	NPN Leakage Current 1	V_{OUT}=23V				10	μA
$I_{NPNOFF2}$	NPN Leakage Current 2	V_{OUT}=0V, V_{LX}=5.5V				3.0	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}=0V		86	91		%
V_{OVP1}	OVP Detector Threshold	V_{IN}=3.6V, V_{OUT} rising	R1200x001x	16	17	18	V
			R1200x002x	18	19	20	
			R1200x003x	20	21	22	
V_{OVP2}	OVP Released Voltage	V_{IN}=3.6V, V_{OUT} falling			V_{OVP1} −1.1		V
I_{DISCHG}	V_{OUT} Discharge Current	V_{IN}=3.6V, V_{OUT}=0.1V	R1200xxxxA		0.7		mA
I_{VOUT}	OVP Sense Current	V_{IN}=3.6V, V_{OUT}=23V			6.0		μA

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

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.

TYPICAL APPLICATIONS



Symbol	Parts Recommendation
L1	22μH LQH32CN220K53L (Murata)
C1	1μF
C2	1μF GRM21BR11E105K (Murata)
C3	220pF
R1, R2	For V_{OUT} setting
R3	2kΩ

● **The Method of Output Voltage Setting**

・The output voltage can be calculated with divider resistors (R1 and R2) values as the following formula:

$$\text{Output Voltage} = V_{FB} \times (R1 + R2) / R1$$

・The total value of R1 and R2 should be equal or less than 300kΩ. Make the V_{IN} and GND line sufficient. The large current flows through the V_{IN} and GND line due to the switching. If this impedance (V_{IN} and GND line) is high, the internal voltage of the IC may shift by the switching current, and the operating may become unstable. Moreover, when the built-in L_X switch is turn OFF, the spike noise caused by the inductor may be generated. As a result of this, recommendation voltage rating of capacitor (C2) value is equal 1.5 times larger or more than the setting output voltage.

● **Shutdown**

・At standby mode, the output is completely separated from the input and shutdown by the NPN transistor of internal IC. However, the leakage current is generated when the L_X pin voltage is equal or more than V_{IN} pin voltage at standby mode.

・R1200xxxxA (with auto discharge function): In the term of standby mode, the switch is turned ON between V_{OUT} to GND and the V_{OUT} capacitor is discharged.

・R1200xxxxB (without auto discharge function): The built-in switch for discharge does not turn on, but the OVP sense resistors between V_{OUT} and GND exists as same as A version.

・However, the both version (A/B) has the OVP sense resistance (4 to 5MΩ) between V_{OUT} and GND (refer to OVP sense current (I_{VOUT}) on ELECTRICAL CHARACTERISTICS table) and the current flows through from V_{OUT} to GND.

● **Selection of external components**

・The recommendation of capacitor value for C1 is in the range from 1μF to 4.7μF. Connect C1 with a capacitance value between V_{IN} and GND pin, and as close as possible to the pins.

・Connect a capacitor in the range from 1μF to 4.7μF between V_{OUT} and GND pins.

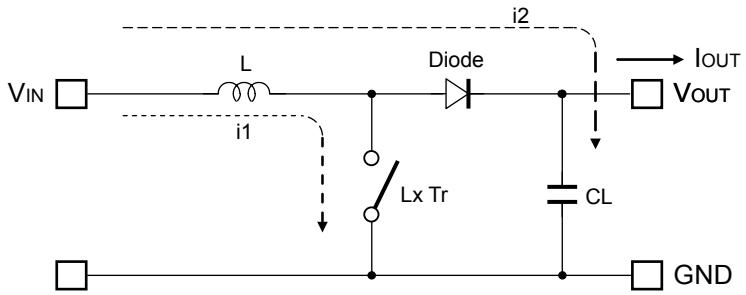
・The recommendation of inductance value is in the range from 4.7μH - 22μH. Choose an inductor of which the DC resistance is small enough and the permissible current is large enough and be hard for magnetic saturation. If the inductance value is too small, at the maximum load the peak current may be large and reach the current limit of L_X. (Refer to the item of the operation of the DC/DC converter and output current.)

・If the spike noise of V_{OUT} may be large, the spike noise may be picked into V_{FB} pin and make the operation unstable. In this case, use a R3 of the resistance value in the range from 1kΩ to 5kΩ to reduce a noise level of V_{FB}.

∗ The performance of power source circuits using these ICs extremely depends upon the peripheral circuits. Pay attention in the selection of the peripheral circuits. In particular, design the peripheral circuits in a way that the values such as voltage, current, and power of each component, PCB patterns and the IC do not exceed their respected rated values.

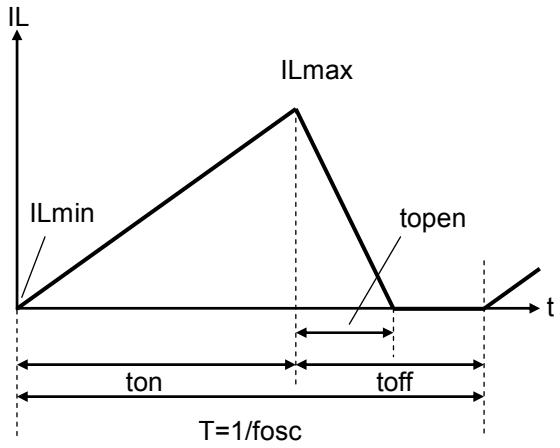
OPERATION OF STEP-UP DC/DC CONVERTER AND OUTPUT CURRENT

<Basic Circuit>

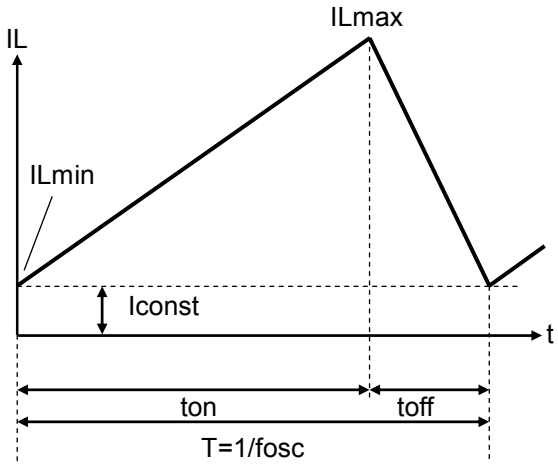


<Current through L>

Discontinuous mode



Continuous mode



There are two operation modes of the step-up PWM control-DC/DC converter. That is the continuous mode and discontinuous mode by the continuousness inductor.

When the transistor turns ON, the voltage of inductor L becomes equal to V_{IN} voltage. The increase value of inductor current (i1) will be

$$\Delta i1 = V_{IN} \times t_{on} / L \quad \text{..... Formula 1}$$

As the step-up circuit, during the OFF time (when the transistor turns OFF) the voltage is continually supply from the power supply. The decrease value of inductor current (i2) will be

$$\Delta i2 = (V_{OUT} - V_{IN}) \times t_{open} / L \quad \text{..... Formula 2}$$

At the PWM control-method, the inductor current become continuously when $t_{open}=t_{off}$, the DC/DC converter operate as the continuous mode.

In the continuous mode, the variation of current of i1 and i2 is same at regular condition.

$$V_{IN} \times ton / L = (V_{OUT} - V_{IN}) \times toff / L \quad \text{Formula 3}$$

The duty at continuous mode will be

$$duty\ (\%) = ton / (ton + toff) = (V_{OUT} - V_{IN}) / V_{OUT} \quad \text{Formula 4}$$

The average value of inductor current (i1) when $t_{open}=t_{off}$ will be

$$i1\ (Ave.) = V_{IN} \times ton / (2 \times L) \quad \text{Formula 5}$$

If the input power is equal to the output power, it becomes the continuous mode if the I_{OUT} value is larger than the value will be calculated by following formula.

$$I_{OUT} = V_{IN}^2 \times ton / (2 \times L \times V_{OUT}) \quad \text{Formula 6}$$

The peak current (I_{Lmax}) of inductor will be

$$I_{Lmax} = I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times ton / (2 \times L)$$

$$I_{Lmax} = I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times T \times (V_{OUT} - V_{IN}) / (2 \times L \times V_{OUT}) \quad \text{Formula 7}$$

The peak current value is larger than the I_{OUT} value. In case of this, selecting the condition of the input and the output and the external components by considering of ILmax value.

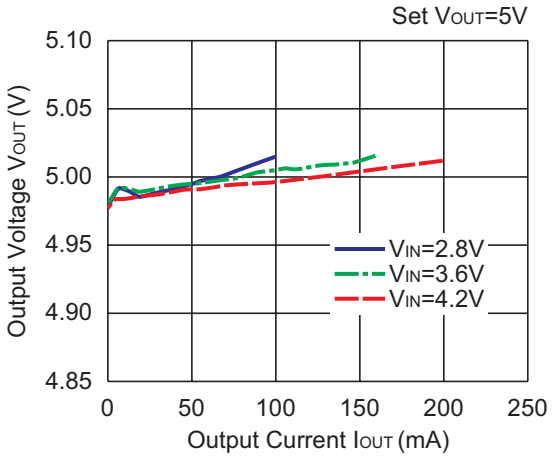
The explanation above is based on the ideal calculation, and the loss caused by L_X switch and the external components are not included.

The actual maximum output current will be between 50% and 80% by the above calculations. Especially, when the IL is large or V_{IN} is low, the loss of V_{IN} is generated with on resistance of the switch.

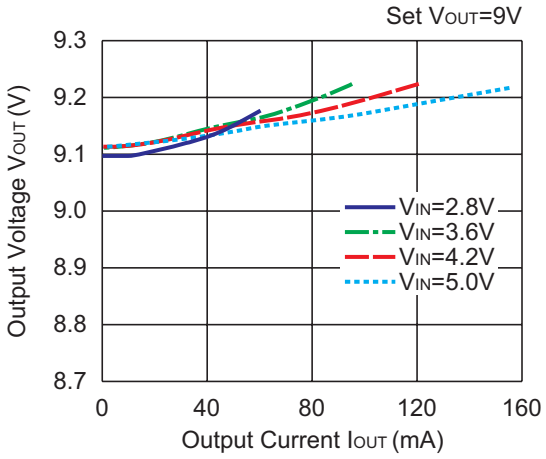
TYPICAL CHARACTERISTICS

1) Output Voltage vs. Output Current (L=22µH)

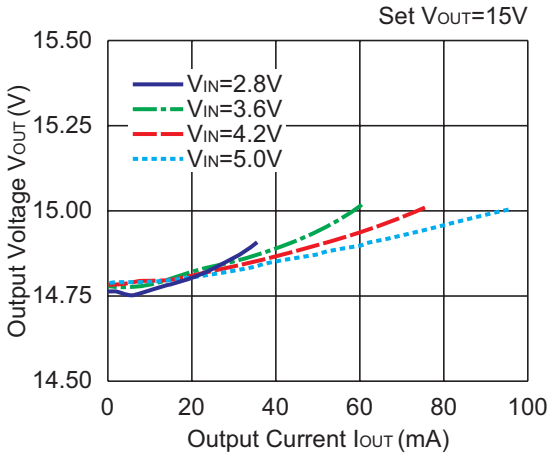
R1200x



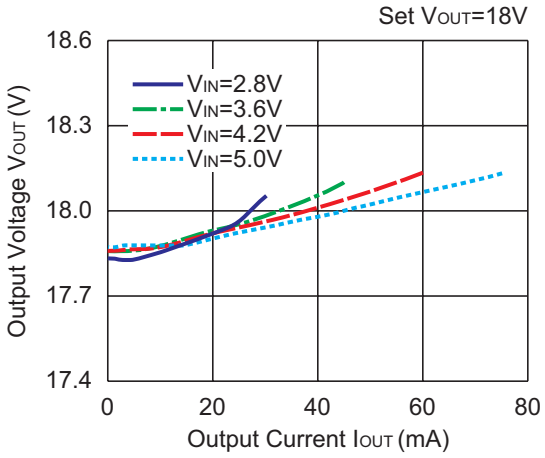
R1200x



R1200x

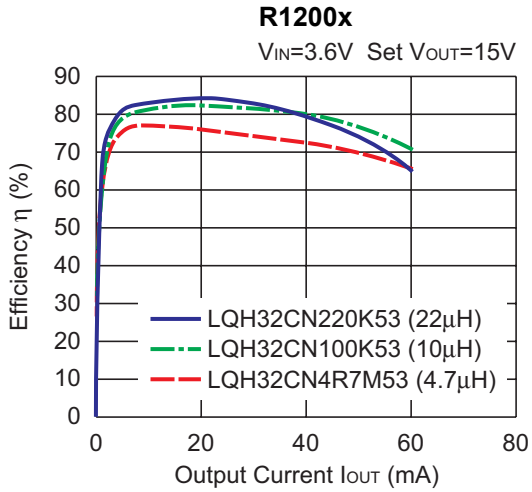


R1200x

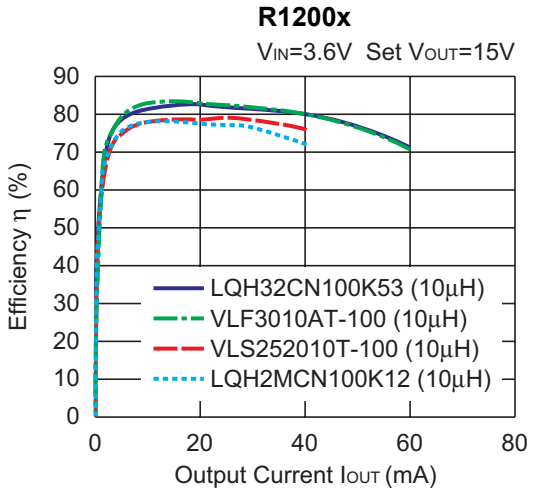


2) Efficiency vs. Output Current

R1200x



R1200x



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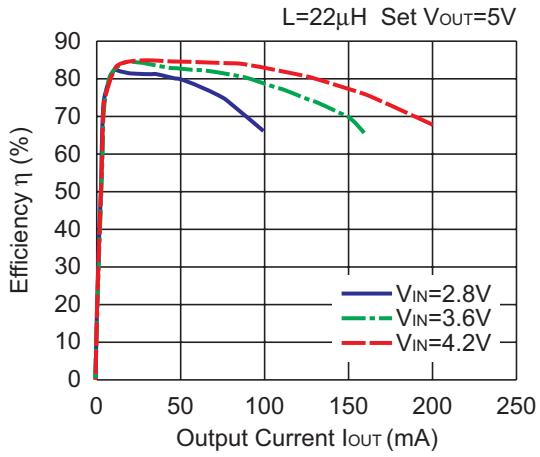

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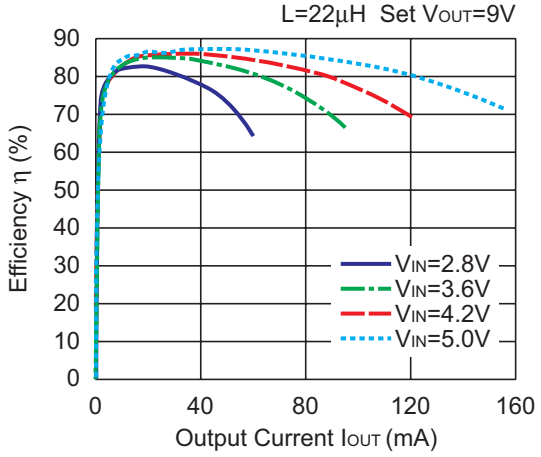

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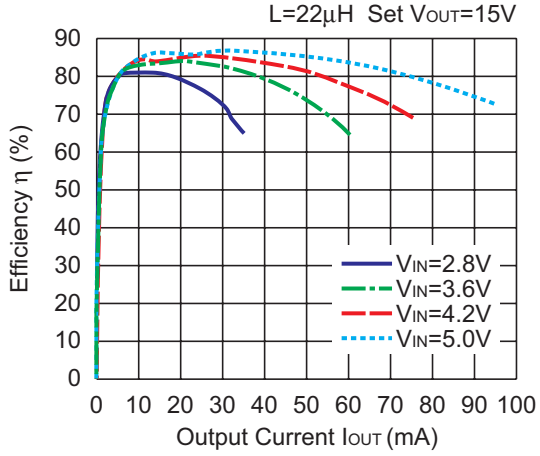

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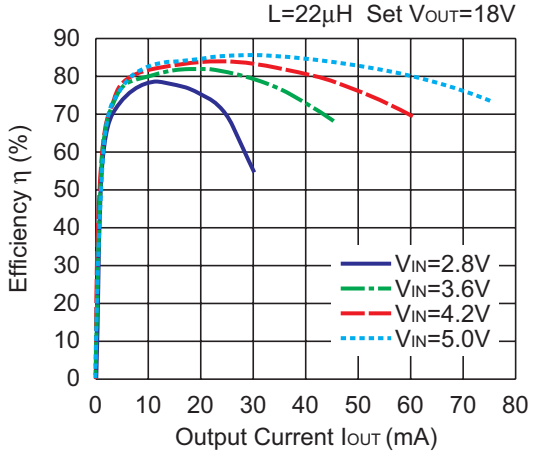
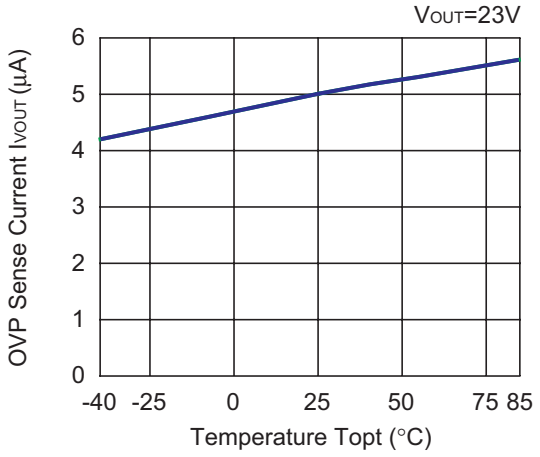


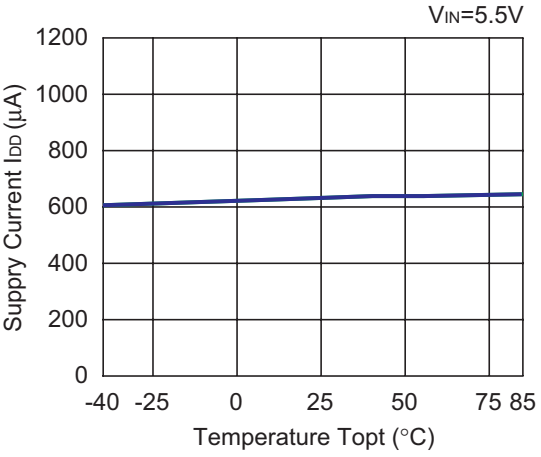
3) OVP Sense Current vs. Temperature

R1200x



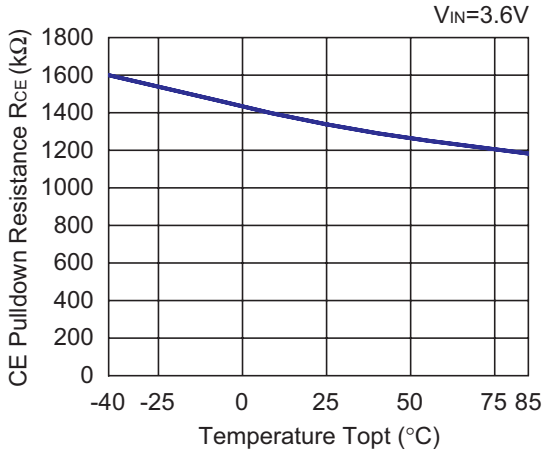
4) Supply Current vs. Temperature

R1200x



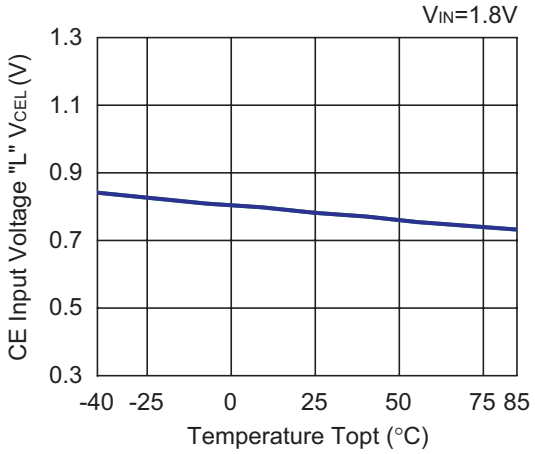
5) CE Pulldown Resistance vs. Temperature

R1200x



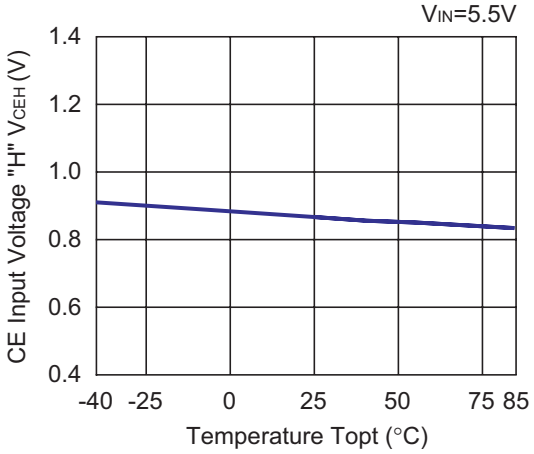
6) CE Input Voltage "L" vs. Temperature

R1200x



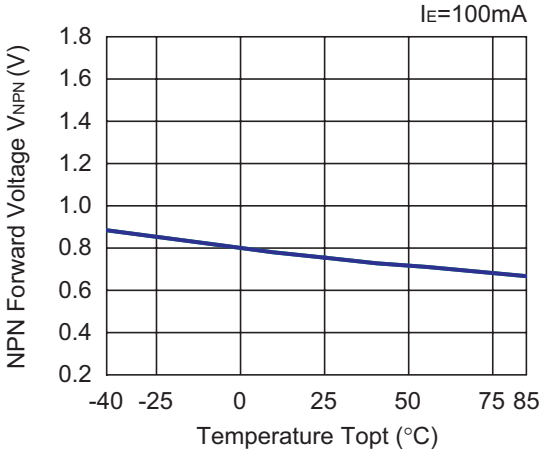
7) CE Input Voltage "H" vs. Temperature

R1200x



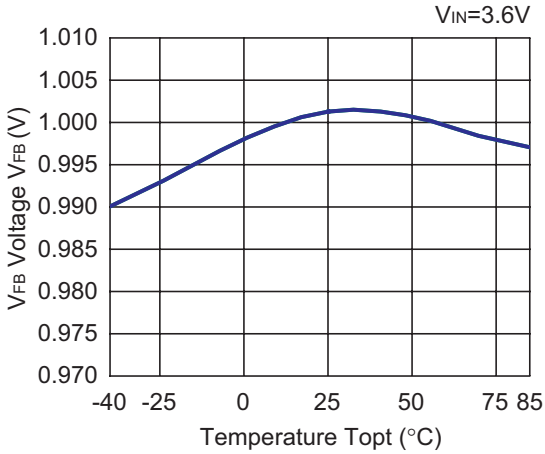
8) NPN V_{CE} Voltage vs. Temperature

R1200x



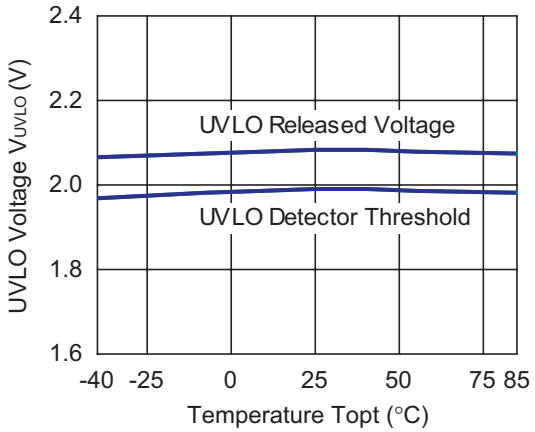
9) V_{FB} Voltage vs. Temperature

R1200x



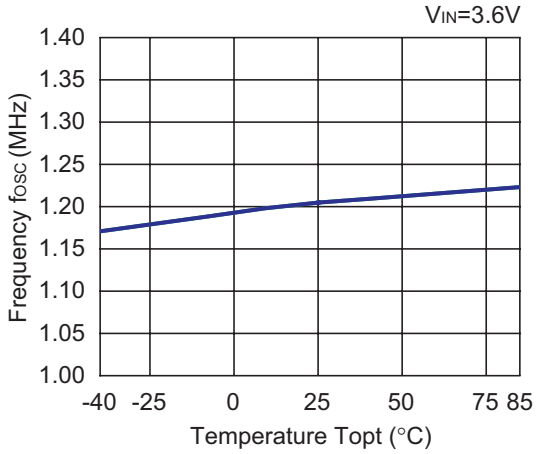
10) UVLO Detect / Released Voltage vs. Temperature

R1200x



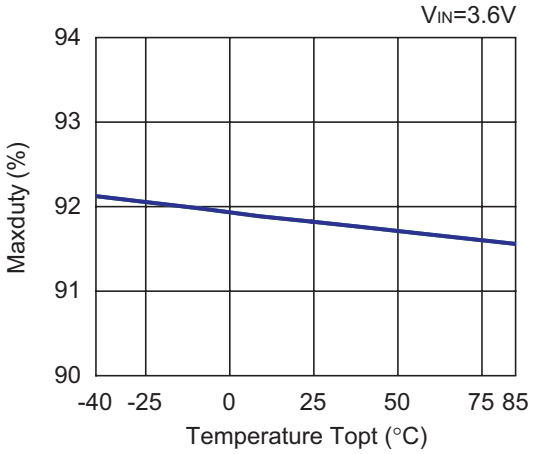
11) Oscillator Frequency vs. Temperature

R1200x



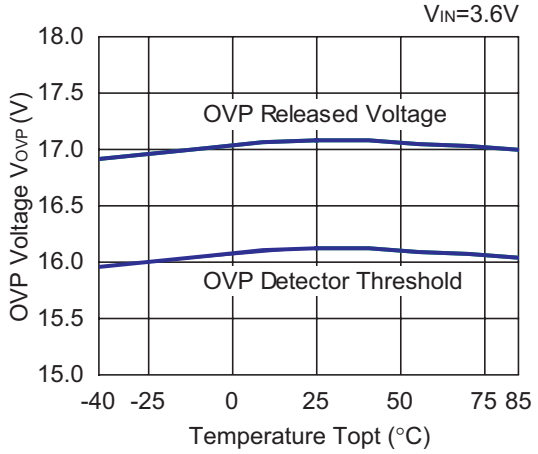
12) Maxduty vs. Temperature

R1200x



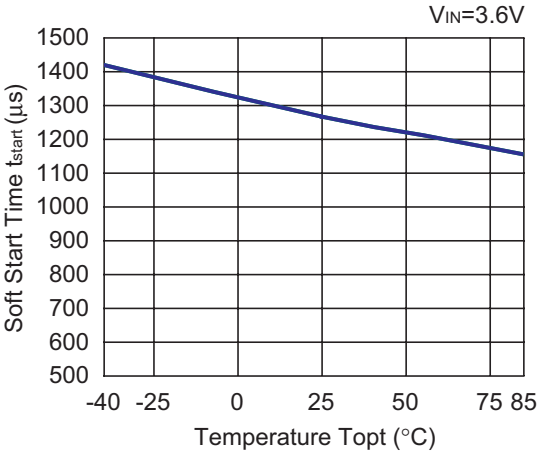
13) OVP Detect / Released Voltage vs. Temperature

R1200x001x



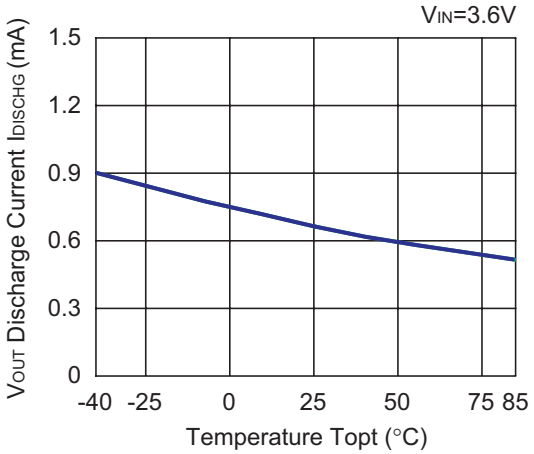
14) Soft-start Time vs. Temperature

R1200x



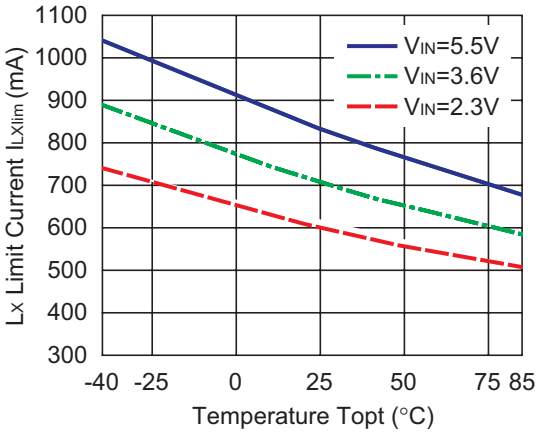
15) VOUT Discharge Current vs. Temperature

R1200x



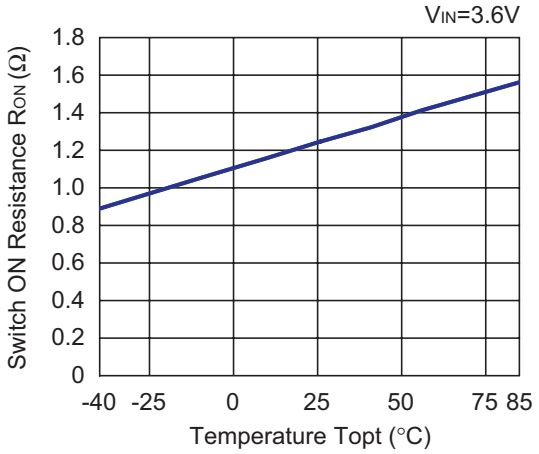
16) Lx Limit Current vs. Temperature

R1200x



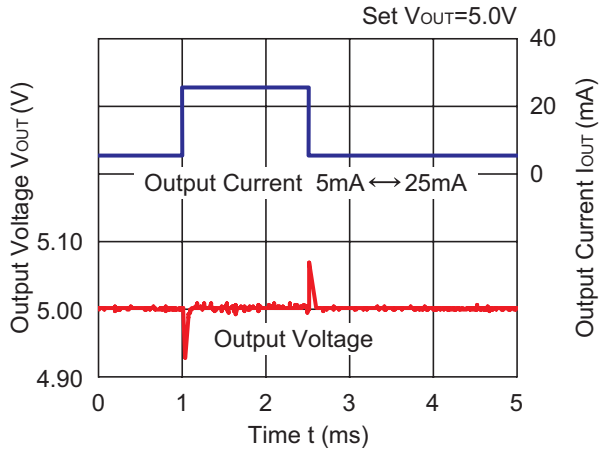
17) Switch ON Resistance vs. Temperature

R1200x

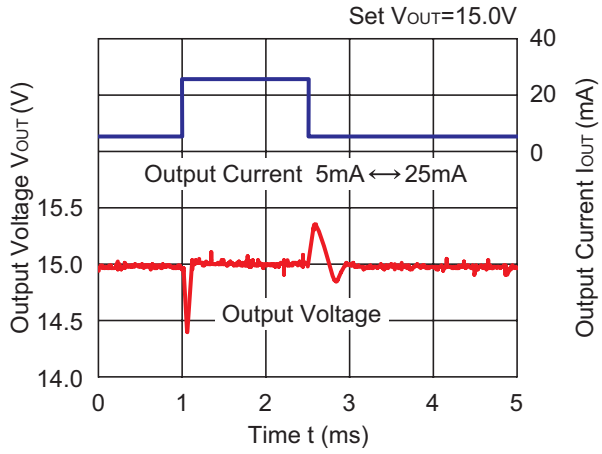


18) Load Transient Response (VIN=3.6V, IOUT=5mA↔25mA, tr=tf=0.5µs)

R1200x

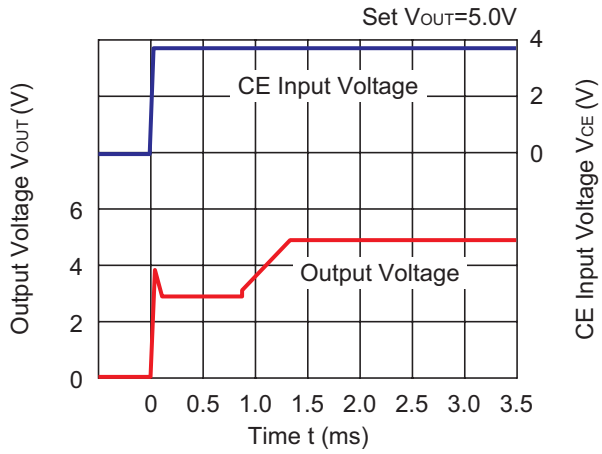


R1200x

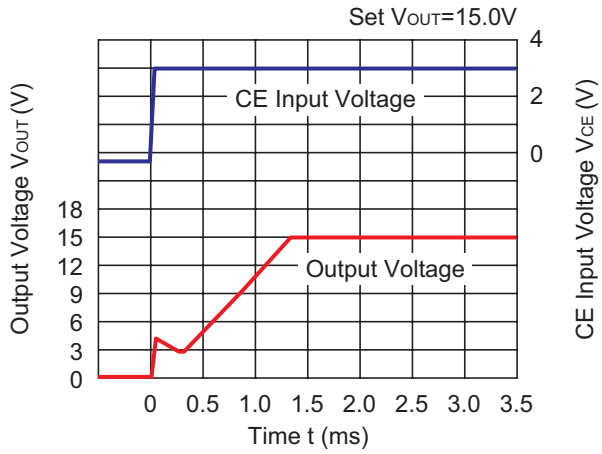


19) Start-up Waveform (VIN=3.6V, IOUT=20mA)

R1200x001A

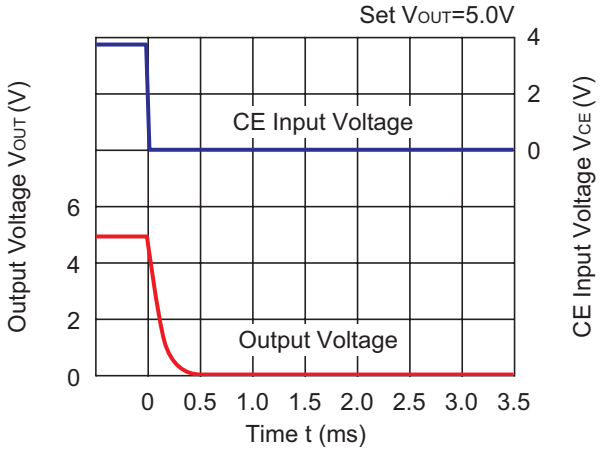


R1200x003A

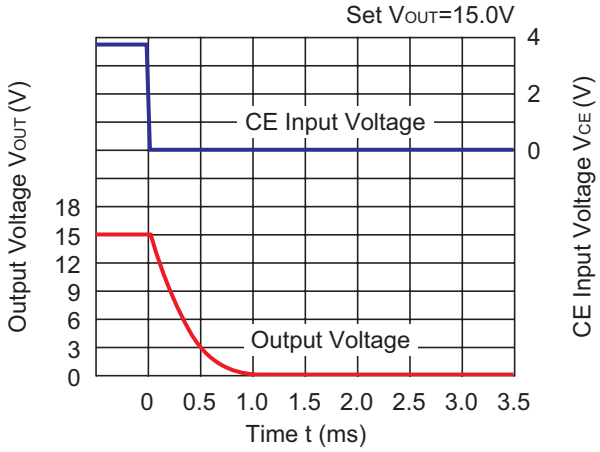


20) Shut-down Waveform (V_{IN}=3.6V, I_{OUT}=20mA)

R1200x001A

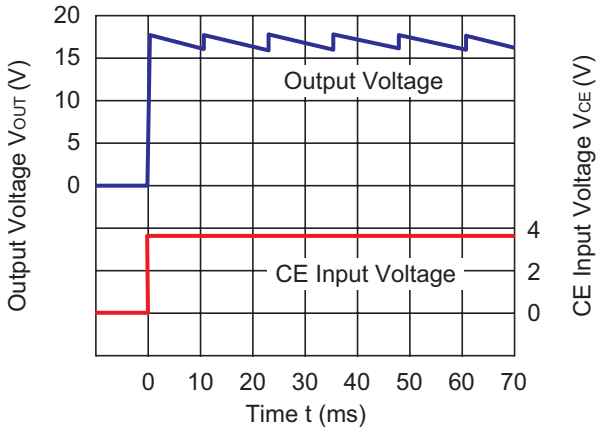


R1200x003A



21) OVP Waveform (V_{FB}=0V)

R1200x001A



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