

R1211D(SON-6) is the discontinued product.



R1211x Series

PWM Step-Up DC/DC Controller

NO.EA-088-241115

OUTLINE

The R1211x is a CMOS-based PWM step-up DC/DC converter controller with low supply current. The R1211x consists of an oscillator, a PWM control circuit, a reference voltage unit, an error amplifier, a reference current unit, a protection circuit, and an under voltage lockout (UVLO) circuit. A low ripple and high efficiency step-up DC/DC converter can be configured by only adding few external components, such as an inductor, a diode, a power MOSFET, divider resistors, and capacitors. The R1211x002B/D has a built-in phase compensation, while the R1211x002A/C can set a phase compensation externally. The R1211x002B/D has stand-by mode. The max duty cycle is internally fixed at 90% typically. A soft-start function is built-in, and a soft-starting time is set at 9 ms typically (R1211x002A/B, 700 kHz) or 10.5 ms typically (R1211xC/D, 300 kHz). The R1211x has a latch-type protection circuit, which latches the external driver in off-state if the maximum duty cycle continues for a specified time after soft-starting time. The protection delay time can be set with an external capacitor. To release the protection, turn the power off and back on (power source voltage lower than UVLO detector threshold) or make the device into standby mode and back to active mode using the CE pin.

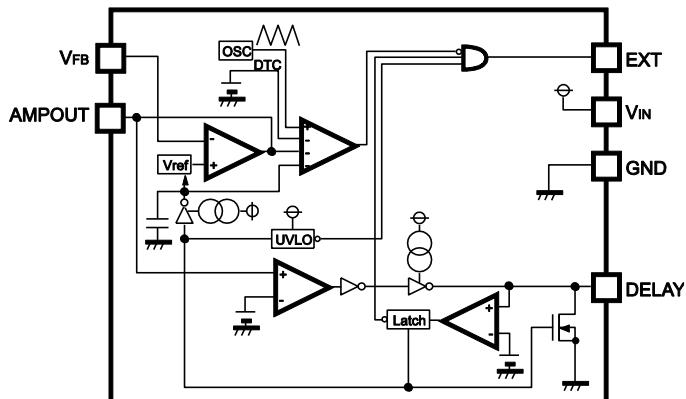
FEATURES

- Input Voltage Range 2.5 V to 6.0 V
- Oscillator Frequency (PWM Control) 300 kHz, 700 kHz
- Maximum Duty Cycle Typ. 90%
- Standby Current Typ. 0 μ A (R1211x002B/D)
- Feedback Voltage 1.0 V
- Feedback Voltage Accuracy $\pm 1.5\%$
- UVLO Threshold Level Typ. 2.2 V (Hysteresis Typ. 0.13 V)
- Feedback Voltage Temperature Coefficient ± 150 ppm/ $^{\circ}$ C
- Built-in Latch-type Protection Circuit Protection delay time can be set with an external capacitor
- Packages SON-6, SOT-23-6W

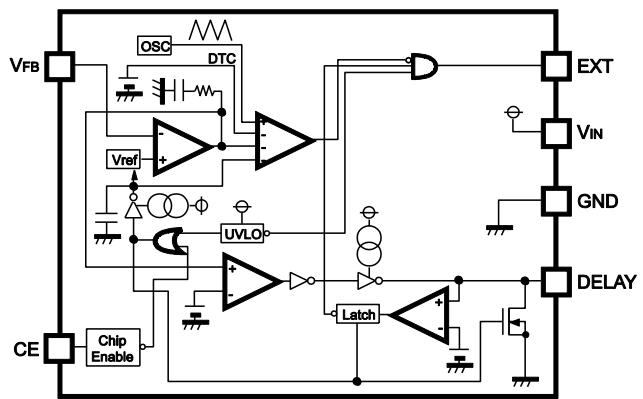
APPLICATIONS

- Constant Voltage Power Source for Portable Equipment
- Constant Voltage Power Source for LCD and CCD

BLOCK DIAGRAMS



R1211x002A/C Block Diagram



R1211x002B/D Block Diagram

SELECTION GUIDE

In the R1211x, the oscillator frequency, the optional function, and the package type are user-selectable options.

Selection Guide

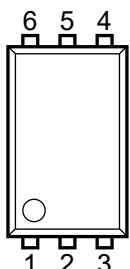
Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1211D002x-TR-FE	SON-6	3,000 pcs	Yes	Yes
R1211N002x-TR-FE	SOT-23-6W	3,000 pcs	Yes	Yes

x: Designation of Oscillator Frequency and Optional Function

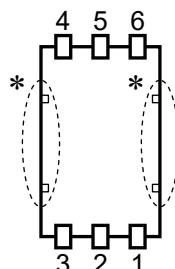
- (A) 700 kHz, with AMPOUT pin (External Phase Compensation Type)
- (B) 700 kHz, with CE pin (Internal Phase Compensation Type, with Standby)
- (C) 300 kHz, with AMPOUT pin (External Phase Compensation Type)
- (D) 300 kHz, with CE pin (Internal Phase Compensation Type, with Standby)

PIN CONFIGURATIONS

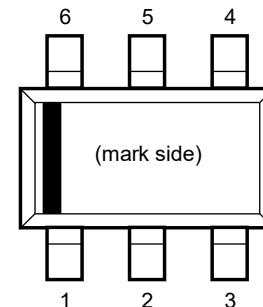
Top View



Bottom View



SON-6 Pin Configuration



SOT-23-6W Pin Configuration

PIN DESCRIPTIONS

Pin Descriptions

Symbol	Pin No				Pin Description	
	R1211x002A/C		R1211x002B/D			
	SON-6	SOT-23-6W	SON-6	SOT-23-6W		
DELAY	1	1	1	1	Pin for External Capacitor (for Setting Output Delay Time of Protection)	
GND	2	5	2	5	Ground Pin	
EXT	3	6	3	6	External FET Drive Pin (CMOS Output)	
V _{IN}	4	4	4	4	Power Supply Pin	
V _{FB}	5	3	5	3	Feedback Pin for Monitoring Output Voltage	
AMPOUT	6	2	-	-	Amplifier Output Pin	
CE	-	-	6	2	Chip Enable Pin ("H" Active)	

* Tab suspension leads in the  parts have GND level. (They are connected to the reverse side of this IC.)

Do not connect to other wires or land patterns.

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings		(GND = 0 V)	
Symbol	Item	Rating	Unit
V_{IN}	V_{IN} Pin Voltage	6.5	V
V_{EXT}	EXT Pin Output Voltage	$-0.3 \sim V_{IN}+0.3$	V
V_{DLY}	DELAY Pin Voltage	$-0.3 \sim V_{IN}+0.3$	V
V_{AMP}	AMPOUT Pin Voltage	$-0.3 \sim V_{IN}+0.3$	V
V_{CE}	CE Pin Input Voltage	$-0.3 \sim V_{IN}+0.3$	V
V_{FB}	V_{FB} Pin Voltage	$-0.3 \sim V_{IN}+0.3$	V
I_{AMP}	AMPOUT Pin Current	± 10	mA
I_{EXT}	EXT Pin Inductor Drive Output Current	± 50	mA
P_D	Power Dissipation (Standard Land Pattern)*	SOT-23-6W	430
		SON-6	500
T_{opt}	Operating Temperature Range	$-40 \sim +85$	°C
T_{stg}	Storage Temperature Range	$-55 \sim +125$	°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

R1211x002A Electrical Characteristics

(Topt = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V _{IN}	Operating Input Voltage		2.5		6.0	V
V _{FB}	Feedback Voltage	V _{IN} =3.3V	0.985	1.000	1.015	V
ΔV _{FB} / ΔT _{opt}	V _{FB} Voltage Temperature Coefficient	-40°C ≤ Topt ≤ 85°C		±150		ppm/° C
I _{FB}	V _{FB} Input Current	V _{IN} =6V, V _{FB} =0V or 6V	-0.1		0.1	μA
f _{osc}	Oscillator Frequency	V _{IN} =3.3V, V _{DLY} =V _{FB} =0V	595	700	805	kHz
Δf _{osc} / ΔT _{opt}	Oscillator Frequency Temperature Coefficient	-40°C ≤ Topt ≤ 85°C		±1.4		kHz/°C
I _{DD1}	Supply Current 1	V _{IN} =6V, V _{DLY} =V _{FB} =0V, EXT at no load		600	900	μA
maxdty	Maximum Duty Cycle	V _{IN} =3.3V, EXT "H" side	82	90	94	%
R _{EXTH}	EXT "H" ON Resistance	V _{IN} =3.3V, I _{EXT} =-20mA		5	10	Ω
R _{EXTL}	EXT "L" ON Resistance	V _{IN} =3.3V, I _{EXT} =20mA		3	6	Ω
I _{DLY1}	Delay Pin Charge Current	V _{IN} =3.3V, V _{DLY} =V _{FB} =0V	2.5	5.0	7.5	μA
I _{DLY2}	Delay Pin Discharge Current	V _{IN} =V _{FB} =2.5V, V _{DLY} =0.1V	2.5	5.5	9.0	mA
V _{DLY}	Delay Pin Detector Threshold	V _{IN} =3.3V, V _{FB} =0V, V _{DLY} =0V→2V	0.95	1.00	1.05	V
T _{START}	Soft-start Time	V _{IN} =3.3V at 90% of rising edge	4.5	9.0	13.5	ms
V _{UVLO}	UVLO Detector Threshold	V _{IN} =2.5V→2V, V _{DLY} =V _{FB} =0V	2.1	2.2	2.3	V
V _{HYS}	UVLO Detector Hysteresis	V _{IN} =2V→2.5V, V _{DLY} =V _{FB} =0V	0.08	0.13	0.18	V
I _{AMP1}	AMP "H" Output Current	V _{IN} =3.3V, V _{AMP} =1V, V _{FB} =0.9V	0.45	0.90	1.50	mA
I _{AMP2}	AMP "L" Output Current	V _{IN} =3.3V, V _{AMP} =1V, V _{FB} =1.1V	30	60	90	μA

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

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R1211x

NO.EA-088-241115

R1211x002B Electrical Characteristics

(Topt = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	
V _{IN}	Operating Input Voltage		2.5		6.0	V	
V _{FB}	Feedback Voltage	V _{IN} =3.3V	0.985	1.000	1.015	V	
ΔV _{FB} / ΔTopt	V _{FB} Voltage Temperature Coefficient	-40°C ≤ Topt ≤ 85°C		±150		ppm/° C	
I _{FB}	VFB Input Current	V _{IN} =6V, V _{FB} =0V or 6V	-0.1		0.1	μA	
f _{osc}	Oscillator Frequency	V _{IN} =3.3V, V _{DLY} =V _{FB} =0V	595	700	805	kHz	
Δf _{osc} / ΔTopt	Oscillator Frequency Temperature Coefficient	-40°C ≤ Topt ≤ 85°C		±1.4		kHz/°C	
I _{DD1}	Supply Current 1	V _{IN} =6V, V _{DLY} =V _{FB} =0V, EXT at no load		600	900	μA	
maxdty	Maximum Duty Cycle	V _{IN} =3.3V, EXT "H" side	82	90	94	%	
R _{EXTH}	EXT "H" ON Resistance	V _{IN} =3.3V, I _{EXT} =-20mA		5	10	Ω	
R _{EXTL}	EXT "L" ON Resistance	V _{IN} =3.3V, I _{EXT} =20mA		3	6	Ω	
I _{DLY1}	Delay Pin Charge Current	V _{IN} =3.3V, V _{DLY} =V _{FB} =0V	2.5	5.0	7.5	μA	
I _{DLY2}	Delay Pin Discharge Current	V _{IN} =V _{FB} =2.5V, V _{DLY} =0.1V	2.5	5.5	9.0	mA	
V _{DLY}	Delay Pin Detector Threshold	V _{IN} =3.3V, V _{FB} =0V, V _{DLY} =0V→2V		0.95	1.00	1.05	V
T _{START}	Soft-start Time	V _{IN} =3.3V	4.5	9.0	13.5	ms	
V _{UVLO}	UVLO Detector Threshold	V _{IN} =2.5V→2V, V _{DLY} =V _{FB} =0V	2.1	2.2	2.3	V	
V _{HYS}	UVLO Detector Hysteresis	V _{IN} =2V→2.5V, V _{DLY} =V _{FB} =0V	0.08	0.13	0.18	V	
I _{STB}	Standby Current	V _{IN} =6V, V _{CE} =0V		0	1	μA	
I _{CEH}	CE "H" Input Current	V _{IN} =6V, V _{CE} =6V	-0.5		0.5	μA	
I _{CEL}	CE "L" Input Current	V _{IN} =6V, V _{CE} =0V	-0.5		0.5	μA	
V _{CEH}	CE "H" Input Voltage	V _{IN} =6V, V _{CE} =0V→6V	1.5			V	
V _{CEL}	CE "L" Input Voltage	V _{IN} =2.5V, V _{CE} =2V→0V			0.3	V	

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

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R1211x

NO.EA-088-241115

R1211x002C Electrical Characteristics

(Topt = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	
V _{IN}	Operating Input Voltage		2.5		6.0	V	
V _{FB}	V _{FB} Voltage Tolerance	V _{IN} =3.3V	0.985	1.000	1.015	V	
ΔV _{FB} / Δ Topt	V _{FB} Voltage Temperature Coefficient	-40°C ≤ Topt ≤ 85°C		±150		ppm/° C	
I _{FB}	V _{FB} Input Current	V _{IN} =6V, V _{FB} =0V or 6V	-0.1		0.1	μA	
f _{osc}	Oscillator Frequency	V _{IN} =3.3V, V _{DLY} =V _{FB} =0V	240	300	360	kHz	
Δf _{osc} / Δ Topt	Oscillator Frequency Temperature Coefficient	-40°C ≤ Topt ≤ 85°C		±0.6		kHz/°C	
I _{DD1}	Supply Current 1	V _{IN} =6V, V _{DLY} =V _{FB} =0V, EXT at no load		300	500	μA	
maxdty	Maximum Duty Cycle	V _{IN} =3.3V, EXT "H" side	82	90	94	%	
R _{EXTH}	EXT "H" ON Resistance	V _{IN} =3.3V, I _{EXT} =-20mA		5	10	Ω	
R _{EXTL}	EXT "L" ON Resistance	V _{IN} =3.3V, I _{EXT} =20mA		3	6	Ω	
I _{DLY1}	Delay Pin Charge Current	V _{IN} =3.3V, V _{DLY} =V _{FB} =0V	2.0	4.5	7.0	μA	
I _{DLY2}	Delay Pin Discharge Current	V _{IN} =V _{FB} =2.5V, V _{DLY} =0.1V	2.5	5.5	9.0	mA	
V _{DLY}	Delay Pin Detector Threshold	V _{IN} =3.3V, V _{FB} =0V, V _{DLY} =0V→2V		0.95	1.00	1.05	V
T _{START}	Soft-start Time	V _{IN} =3.3V	5.0	10.5	16.0	ms	
V _{UVLO}	UVLO Detector Threshold	V _{IN} =2.5V→2V, V _{DLY} =V _{FB} =0V	2.1	2.2	2.3	V	
V _{HYS}	UVLO Detector Hysteresis	V _{IN} =2V→2.5V, V _{DLY} =V _{FB} =0V	0.08	0.13	0.18	V	
I _{AMP1}	AMP "H" Output Current	V _{IN} =3.3V, V _{AMP} =1V, V _{FB} =0.9V	0.45	0.90	1.50	mA	
I _{AMP2}	AMP "L" Output Current	V _{IN} =3.3V, V _{AMP} =1V, V _{FB} =1.1V	25	50	75	μA	

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

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R1211x

NO.EA-088-241115

R1211x002D Electrical Characteristics

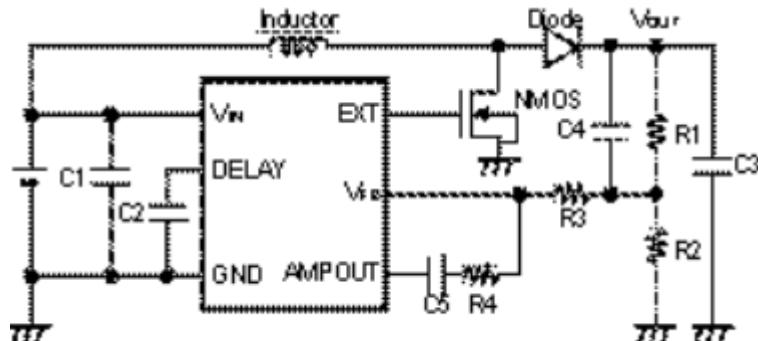
(Topt = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	
V _{IN}	Operating Input Voltage		2.5		6.0	V	
V _{FB}	V _{FB} Voltage Tolerance	V _{IN} =3.3V	0.985	1.000	1.015	V	
ΔV _{FB} / Δ Topt	V _{FB} Voltage Temperature Coefficient	-40°C ≤ Topt ≤ 85°C		±150		ppm/° C	
I _{FB}	V _{FB} Input Current	V _{IN} =6V, V _{FB} =0V or 6V	-0.1		0.1	μA	
f _{osc}	Oscillator Frequency	V _{IN} =3.3V, V _{DLY} =V _{FB} =0V	240	300	360	kHz	
Δf _{osc} / Δ Topt	Oscillator Frequency Temperature Coefficient	-40°C ≤ Topt ≤ 85°C		±0.6		kHz/°C	
I _{DD1}	Supply Current 1	V _{IN} =6V, V _{DLY} =V _{FB} =0V, EXT at no load		300	500	μA	
maxdty	Maximum Duty Cycle	V _{IN} =3.3V, EXT "H" side	82	90	94	%	
R _{EXTH}	EXT "H" ON Resistance	V _{IN} =3.3V, I _{EXT} =-20mA		5	10	Ω	
R _{EXTL}	EXT "L" ON Resistance	V _{IN} =3.3V, I _{EXT} =20mA		3	6	Ω	
I _{DLY1}	Delay Pin Charge Current	V _{IN} =3.3V, V _{DLY} =V _{FB} =0V	2.0	4.5	7.0	μA	
I _{DLY2}	Delay Pin Discharge Current	V _{IN} =V _{FB} =2.5V, V _{DLY} =0.1V	2.5	5.5	9.0	mA	
V _{DLY}	Delay Pin Detector Threshold	V _{IN} =3.3V, V _{FB} =0V, V _{DLY} =0V→2V		0.95	1.00	1.05	V
T _{START}	Soft-start Time	V _{IN} =3.3V		5.0	10.5	16.0	ms
V _{UVLO}	UVLO Detector Threshold	V _{IN} =2.5V→2V, V _{DLY} =V _{FB} =0V		2.1	2.2	2.3	V
V _{HYS}	UVLO Detector Hysteresis	V _{IN} =2V→2.5V, V _{DLY} =V _{FB} =0V		0.08	0.13	0.18	V
I _{STB}	Standby Current	V _{IN} =6V, V _{CE} =0V		0	1	μA	
I _{CEH}	CE "H" Input Current	V _{IN} =6V, V _{CE} =6V	-0.5		0.5	μA	
I _{CEL}	CE "L" Input Current	V _{IN} =6V, V _{CE} =0V	-0.5		0.5	μA	
V _{CEH}	CE "H" Input Voltage	V _{IN} =6V, V _{CE} =0V→6V	1.5			V	
V _{CEL}	CE "L" Input Voltage	V _{IN} =2.5V, V _{CE} =2V→0V			0.3	V	

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

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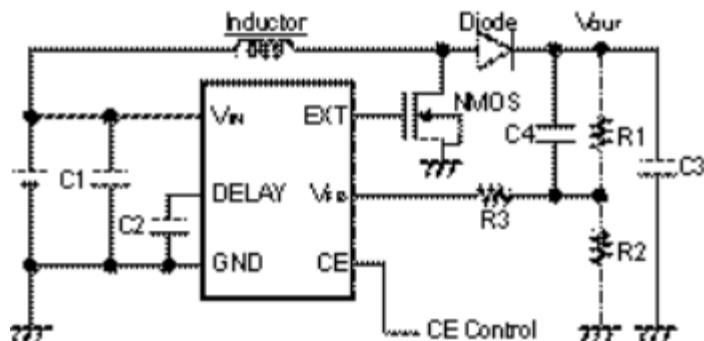
TYPICAL APPLICATIONS AND TECHNICAL NOTES



R1211x002A/R1211x002C Typical Application

NMOS: IRF7601 (International Rectifier)
Inductor: VLF504012MT-100M (TDK: 10 μ H) R1211x002A
VLF504012MT-220M (TDK: 22 μ H) R1211x002C
Diode: CRS10I30A (TOSHIBA)

C1: 4.7 μ F (Ceramic) R1: Output Voltage Setting Resistor 1
C2: 0.22 μ F (Ceramic) R2: Output Voltage Setting Resistor 2
C3: 10 μ F (Ceramic) R3: 30 k Ω
C4: 680 pF (Ceramic) R4: 30 k Ω
C5: 2200 pF (Ceramic)



R1211x002B/R1211x002D Typical Application

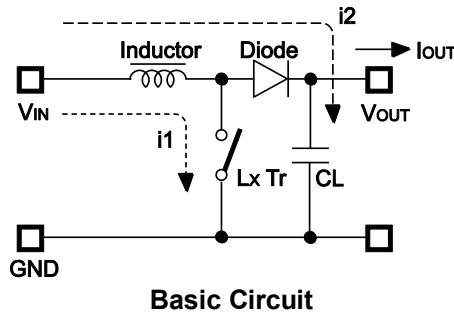
NMOS: IRF7601 (International Rectifier)
Inductor: VLF504012MT-100M (TDK: 10 μ H) R1211x002B
VLF504012MT-220M (TDK: 22 μ H) R1211x002D
Diode: CRS10I30A (TOSHIBA)
C1: 4.7 μ F (Ceramic) R1: Output Voltage Setting Resistor 1
C2: 0.22 μ F (Ceramic) R2: Output Voltage Setting Resistor 2
C3: 10 μ F (Ceramic) R3: 30 k Ω
C4: 680 pF (Ceramic)

[Note] These example circuits may be applied to the output voltage requirement is 15 V or less. If the output voltage requirement is 15 V or more, ratings of NMOS and diode as shown above is over the limit, therefore, choose other external components.

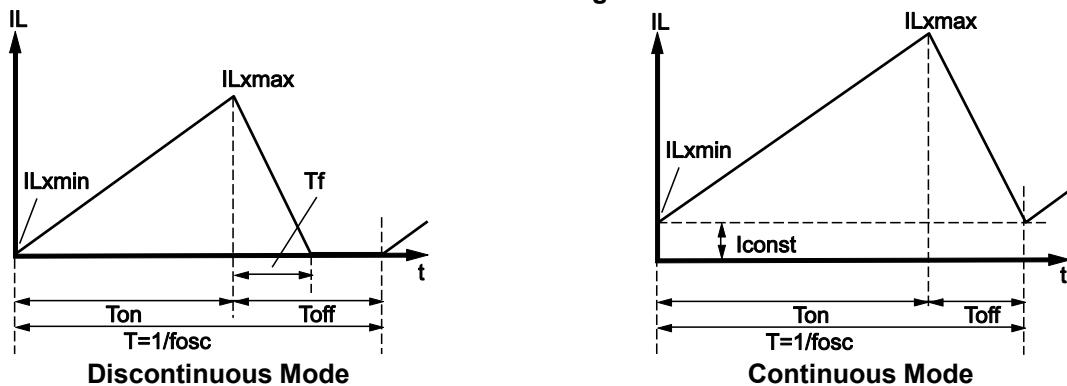
- Use a 1 μ F or more capacitance value of bypass capacitor between VIN pin and GND, C1 as shown in the typical applications above.
- In terms of the capacitor for setting delay time of the latch protection, C2 as shown in typical applications of the previous page, connect between Delay pin and GND pin of the IC with the minimum wiring distance.
- Connect a 1 μ F or more value of capacitor between VOUT and GND, C3 as shown in typical applications of the previous page. (Recommended value is from 10 μ F to 22 μ F.) If the operation of the composed DC/DC converter may be unstable, use a tantalum type capacitor instead of ceramic type.
- Connect a capacitor between VOUT and the dividing point, C4 as shown in typical applications of the previous page. The capacitance value of C4 depends on divider resistors for output voltage setting. Typical value is between 100 pF and 1000 pF.
- The output voltage can be set with divider resistors for voltage setting, R1 and R2 as shown in typical applications of the previous page. Refer to the next formula.
Output Voltage = $V_{FB} \times (R1 + R2) / R2$
 $R1 + R2 = 100 \text{ k}\Omega$ is recommended range of resistances.
- The operation of latch protection circuit is as follows: When the IC detects maximum duty cycle, charge to an external capacitor, C2 of DELAY pin starts. And maximum duty cycle continues and the voltage of DELAY pin reaches delay voltage detector threshold, V_{DLY} , outputs "L" to EXT pin and turns off the external power MOSFET. To release the latch protection operation, make the IC be standby mode with CE pin and make it active in terms of R1211x002B/D version. Otherwise, restart with power on.
- The delay time of latch protection can be calculated with C2, V_{DLY} , and Delay Pin Charge Current, I_{DLY1} , as in the next formula.
 $t = C2 \times V_{DLY} / I_{DLY1}$
Once after the maximum duty is detected and released before delay time, charge to the capacitor is halt and delay pin outputs "L".
- As for R1211x002A/C version, the values and positioning of C4, C5, R3, and R4 shown in the above diagram are just an example combination. These are for making phase compensation. If the spike noise of VOUT may be large, the spike noise may be picked into VFB pin and make the operation unstable. In this case, a resistor R3, shown in typical applications of the previous page. The recommended resistance value of R3 is in the range from 10 $\text{k}\Omega$ to 50 $\text{k}\Omega$. Then, noise level will be decreased.
- As for R1211x002B/D version, EXT pin outputs GND level at standby mode.
- Select the Power MOSFET, the diode, and the inductor within ratings (Voltage, Current, Power) of this IC. Choose the power MOSFET with low threshold voltage depending on Input Voltage to be able to turn on the FET completely. Choose the diode with low VF such as Shottky type with low reverse current IR, and with fast switching speed. When an external transistor is switching, spike voltage may be generated caused by an inductor, therefore recommended voltage tolerance of capacitor connected to VOUT is three times of setting voltage or more.

* The performance of power circuit with using this IC depends on external components. Choose the most suitable components for your application.

OUTPUT CURRENT AND SELECTION OF EXTERNAL COMPONENTS



Circuit through L



There are two modes, or discontinuous mode and continuous mode for the PWM step-up switching regulator depending on the continuous characteristic of inductor current.

During on time of the transistor, when the voltage added on to the inductor is described as V_{IN} , the current is $V_{IN} \times t / L$. Therefore, the electric power, P_{ON} , which is supplied with input side, can be described as in next formula.

$$P_{ON} = \int_0^{T_{on}} V_{IN}^2 \times t/L dt \quad \text{..... Formula 1}$$

With the step-up circuit, electric power is supplied from power source also during off time. In this case, input current is described as $(V_{OUT} - V_{IN}) \times t / L$, therefore electric power, P_{OFF} is described as in next formula.

$$P_{OFF} = \int_0^{T_{off}} V_{IN} \times (V_{OUT} - V_{IN}) \times t/L dt \quad \text{..... Formula 2}$$

In this formula, T_f means the time of which the energy saved in the inductance is being emitted. Thus average electric power, P_{AV} is described as in the next formula.

$$P_{AV} = 1/(T_{on} + T_{off}) \times \left\{ \int_0^{T_{on}} V_{IN}^2 \times t/L dt + \int_0^{T_{off}} V_{IN} \times (V_{OUT} - V_{IN}) \times t/L dt \right\} \quad \text{..... Formula 3}$$

In PWM control, when $T_f = T_{off}$ is true, the inductor current becomes continuous, then the operation of switching regulator becomes continuous mode.

In the continuous mode, the deviation of the current is equal between on time and off time.

$$V_{IN} \times T_{ON}/L = (V_{OUT} - V_{IN}) \times T_{off}/L \quad \text{..... Formula 4}$$

Further, the electric power, P_{AV} is equal to output electric power, $V_{OUT} \times I_{OUT}$, thus,

$$I_{OUT} = f_{osc} \times V_{IN}^2 \times T_{ON}^2 / \{2 \times L \times (V_{OUT} - V_{IN})\} = V_{IN}^2 \times T_{ON} / (2 \times L \times V_{OUT}) \quad \text{..... Formula 5}$$

When I_{OUT} becomes more than formula 5, the current flows through the inductor, then the mode becomes continuous. The continuous current through the inductor is described as I_{const} , then,

$$I_{OUT} = f_{osc} \times V_{IN}^2 \times T_{ON}^2 / \{2 \times L \times (V_{OUT} - V_{IN})\} + V_{IN} \times I_{const} / V_{OUT} \quad \text{..... Formula 6}$$

In this moment, the peak current, IL_{xmax} flowing through the inductor and the driver Tr. is described as follows:

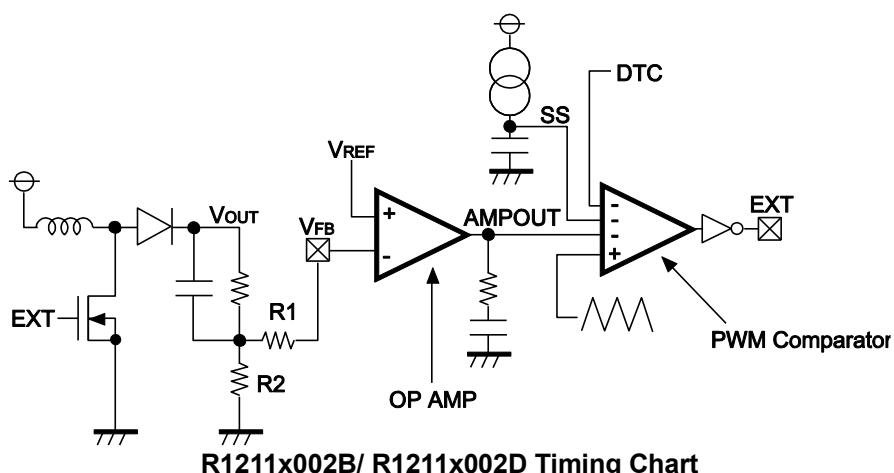
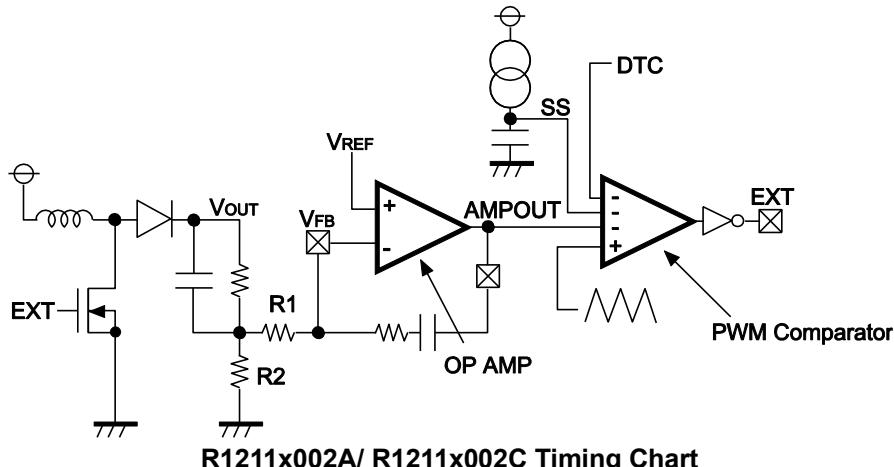
$$IL_{xmax} = I_{const} + V_{IN} \times T_{ON}/L \quad \text{..... Formula 7}$$

With the formula 4 and 6, IL_{xmax} is,

$$IL_{xmax} = V_{OUT}/V_{IN} \times I_{OUT} + V_{IN} \times T_{ON}/(2 \times L) \quad \text{..... Formula 8}$$

Therefore, peak current is more than I_{OUT} . Considering the value of IL_{xmax} , the condition of input and output, and external components should be selected. In the formula 7, peak current IL_{xmax} at discontinuous mode can be calculated. Put $I_{const} = 0$ in the formula. The explanation above is based on the ideal calculation, and the loss caused by Lx switch and external components is not included. The actual maximum output current is between 50% and 80% of the calculation. Especially, when the IL_x is large, or V_{IN} is low, the loss of V_{IN} is generated with the on resistance of the switch. As for V_{OUT} , V_f (as much as 0.3 V) of the diode should be considered.

TIMING CHART



Soft-start Operation

Soft-start operation is starting from power-on as follows:

(Step1)

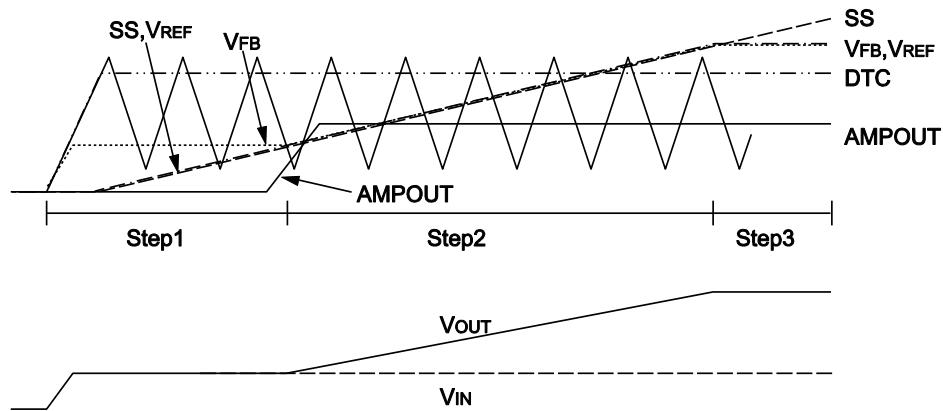
The voltage level of SS is rising gradually by constant current circuit of the IC and a capacitor. V_{REF} level which is input to OP AMP is also gradually rising. V_{OUT} is rising up to input voltage level just after the power-on, therefore, V_{FB} voltage is rising up to the setting voltage with input voltage and the ratio of R1 and R2. AMPOUT is at "L", and switching does not start.

(Step2)

When the voltage level of SS becomes the setting voltage with the ratio of R1 and R2 or more, switching operation starts. V_{REF} level gradually increases together with SS level. V_{OUT} is also rising with balancing V_{REF} and V_{FB} . Duty cycle depends on the lowest level among AMPOUT, SS, and DTC of the 4 input terminals in the PWM comparator.

(Step3)

When SS reaches 1 V, soft-start operation finishes. V_{REF} becomes constant voltage (= 1 V). Then the switching operation becomes normal mode.

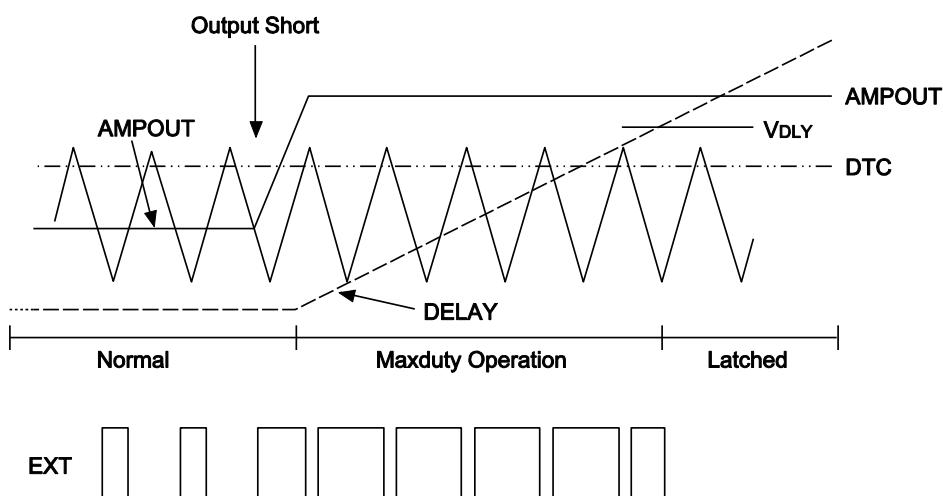


Latch Protection Operation

The operation of Latch protection circuit is as follows: When AMPOUT becomes "H" and the IC detects maximum duty cycle, charge to an external capacitor, C2 of DELAY pin starts. And maximum duty cycle continues and the voltage of DELAY pin reaches delay voltage detector threshold, V_{DLY} , outputs "L" to EXT pin and turns off the external power MOSFET. To release the latch protection operation, make the IC be standby mode with CE pin and make it active in terms of R1211x002B/D version. Otherwise, make supply voltage down to UVLO detector threshold or lower, and make it rise up to the normal input voltage. During the soft-start time, if the duty cycle may be the maximum, protection circuit does not work and DELAY pin is fixed at GND level. The delay time of latch protection can be calculated with C2, V_{DLY} , and Delay Pin Charge Current, I_{DLY1} , as in the next formula.

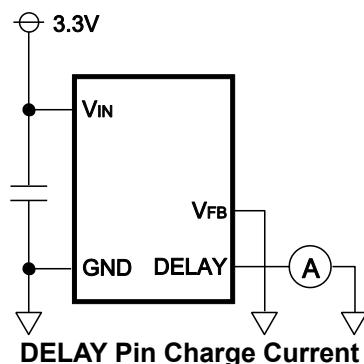
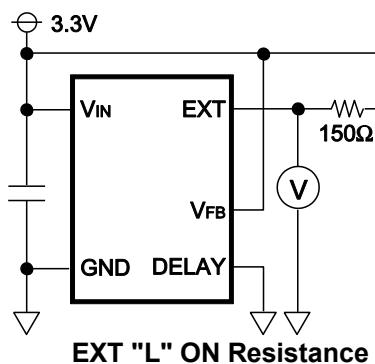
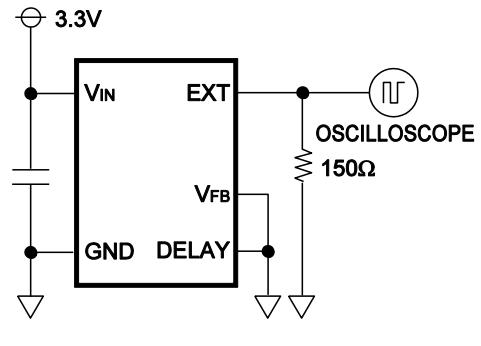
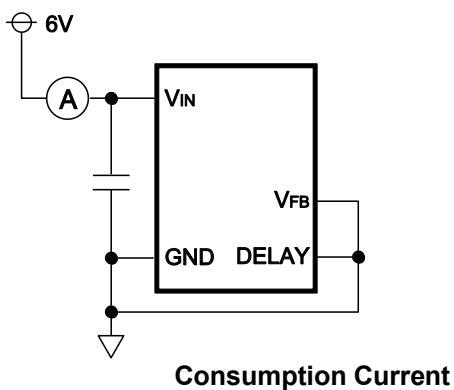
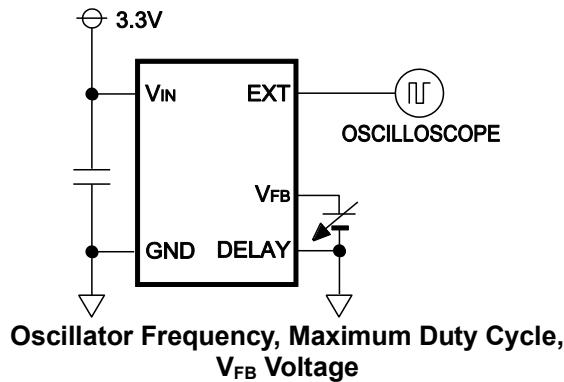
$$t = C2 \times V_{DLY} / I_{DLY1}$$

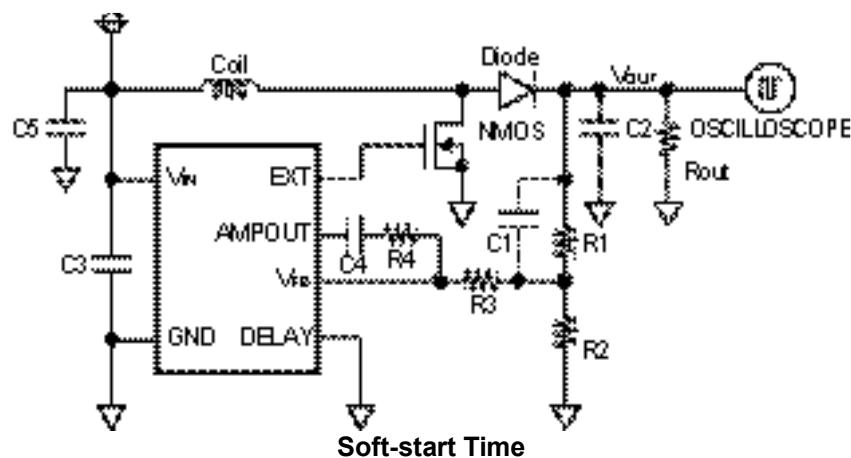
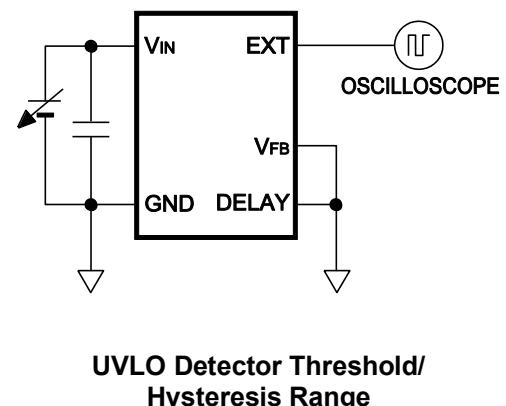
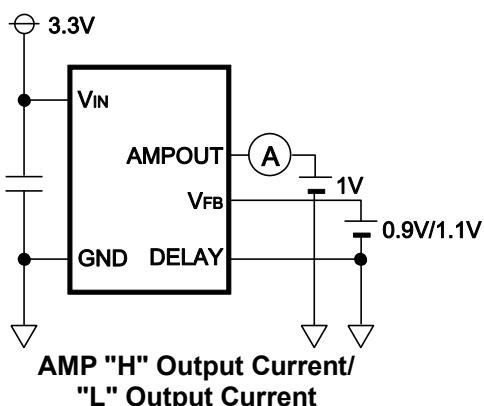
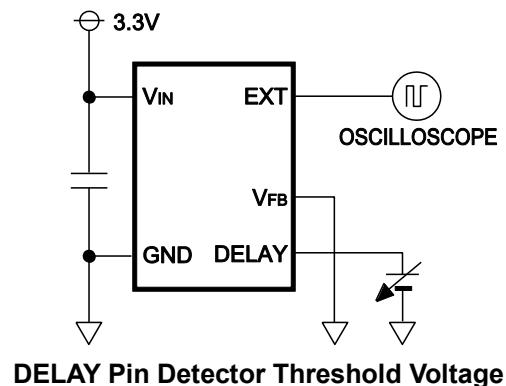
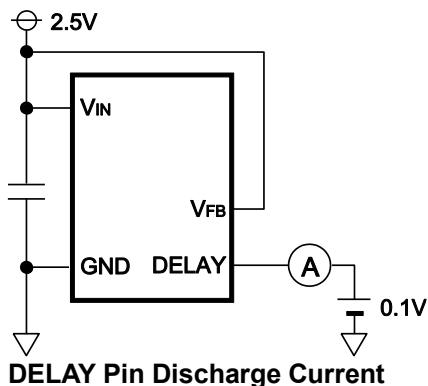
Once after the maximum duty is detected and released before delay time, charge to the capacitor is halt and delay pin outputs "L".



TEST CIRCUITS

R1211x002A/ R1211x002C Test Circuits





<Components>

R1: 90 kΩ

C1: 680 pF (Ceramic)

R2: 10 kΩ

C2: 22 µF (Tantalum) + 2.2 µF (Ceramic)

R3: 30 kΩ

C3: 2.2 µF (Ceramic) + 68 µF (Tantalum)

R4: 30 kΩ

C4: 2200 pF (Ceramic)

Rout: 1 kΩ/ 330 Ω

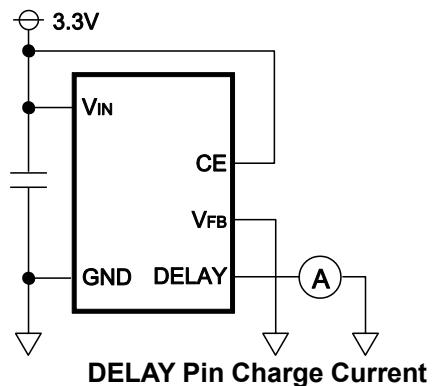
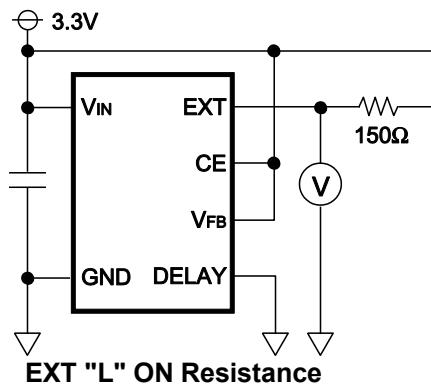
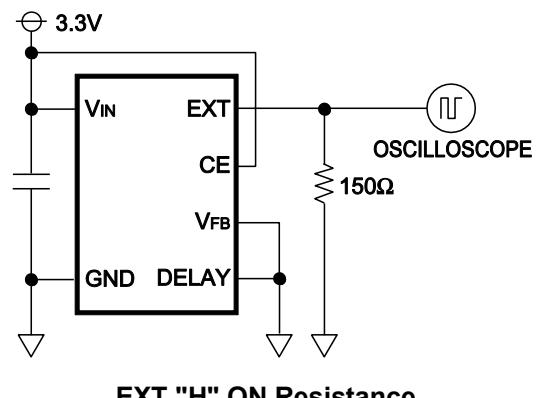
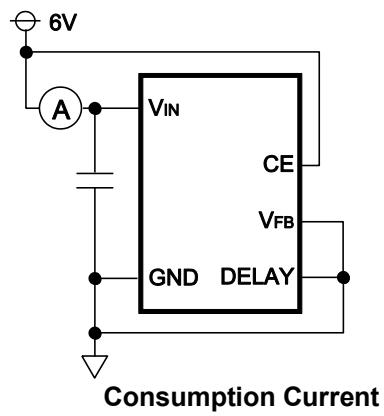
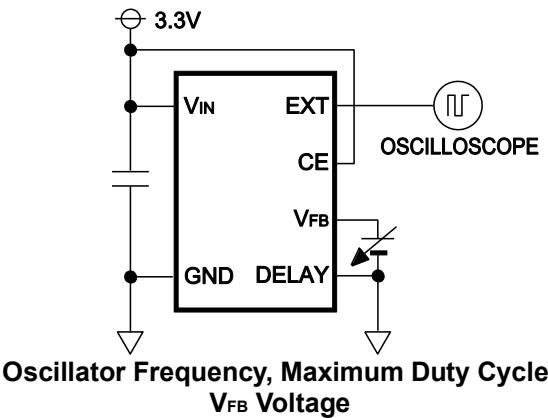
C5: 22 µF (Tantalum)

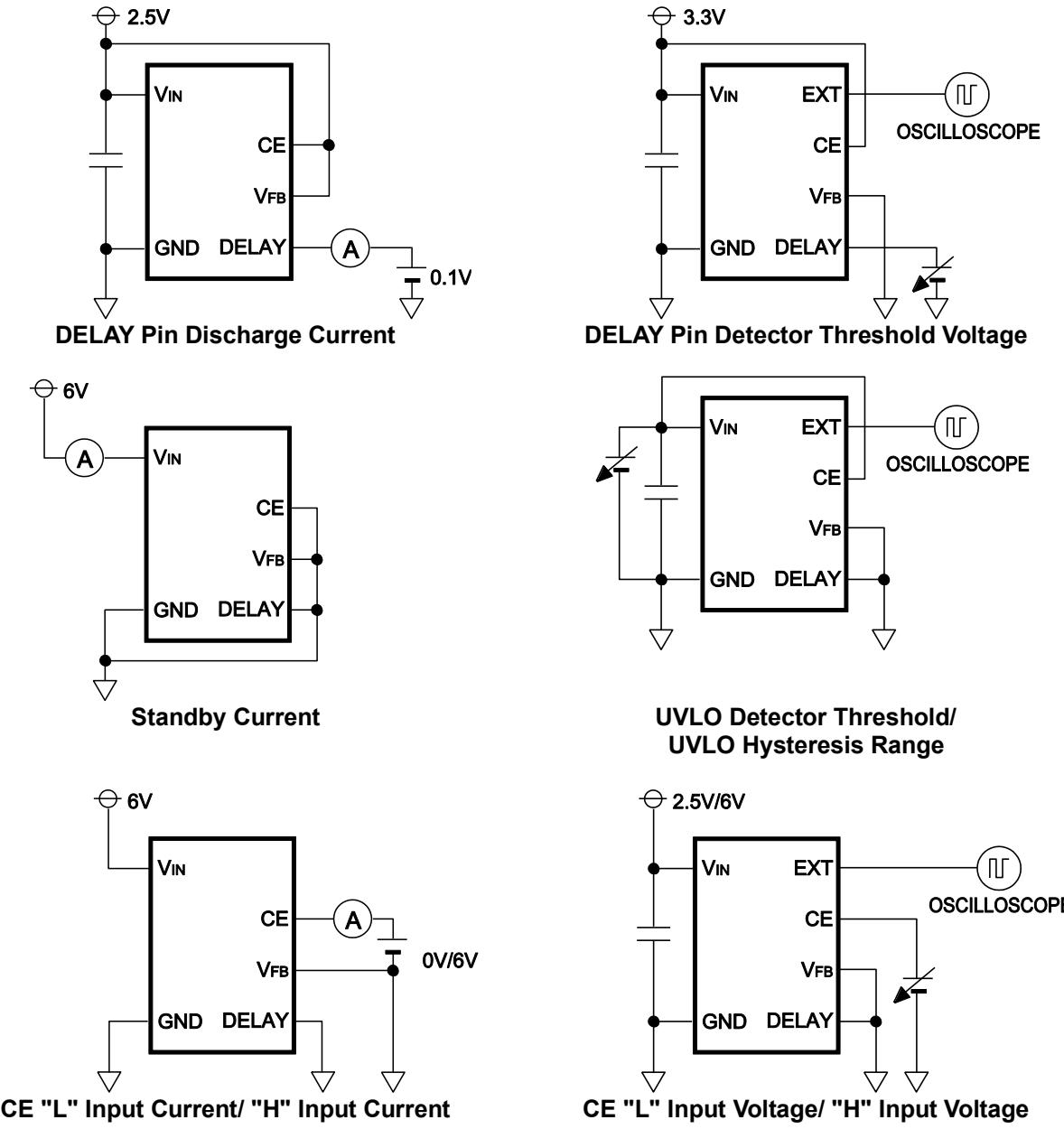
Coil: VLF504012MT-220M (TDK: 22 µH)

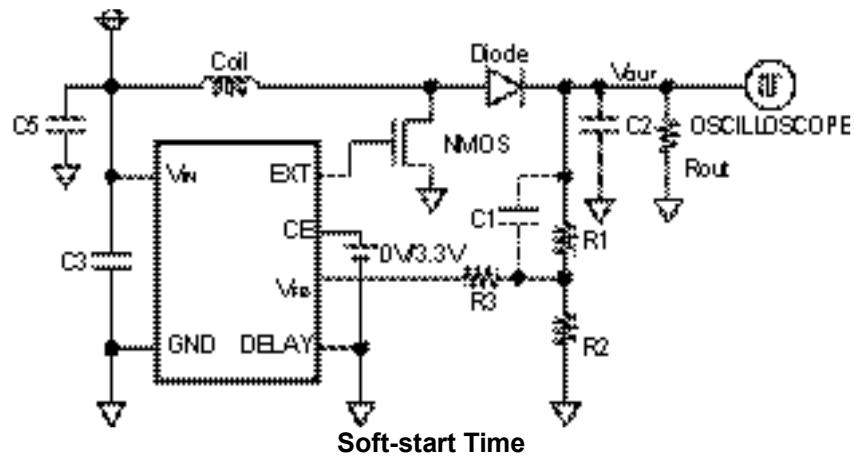
Diode: CRS10130A (TOSHIBA)

NMOS: IRF7601 (International Rectifier)

R1211x002B/ R1211x002D Test Circuits







<Components>

R1: 90 kΩ

C1: 680 pF (Ceramic)

R2: 10 kΩ

C2: 22 µF (Tantalum) + 2.2 µF (Ceramic)

R3: 30 kΩ

C3: 2.2 µF (Ceramic) + 68 µF (Tantalum)

Rout: 1 kΩ/ 330 Ω

C5: 22 µF (Tantalum)

Coil: VLF504012MT-220M (TDK: 22 µH)

Diode: CRS10I30A (TOSHIBA)

NMOS: IRF7601 (International Rectifier)

R1211D(SON-6) is the discontinued product.

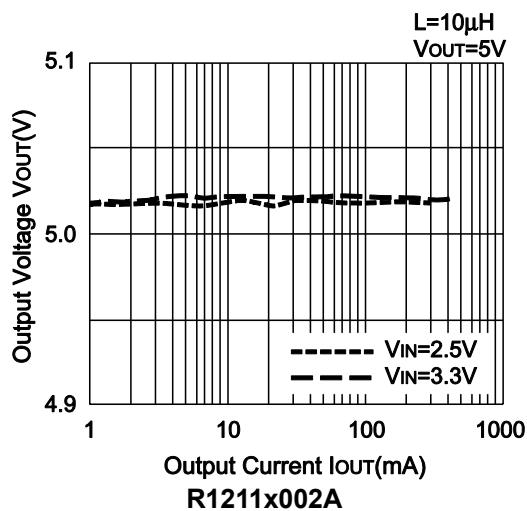
R1211x

NO.EA-088-241115

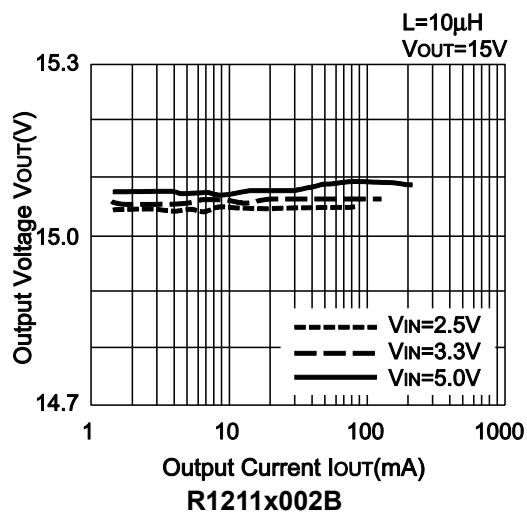
TYPICAL CHARACTERISTICS

1) Output Voltage vs. Output Current

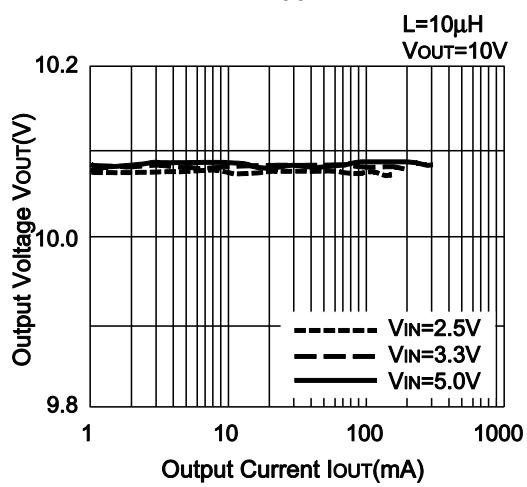
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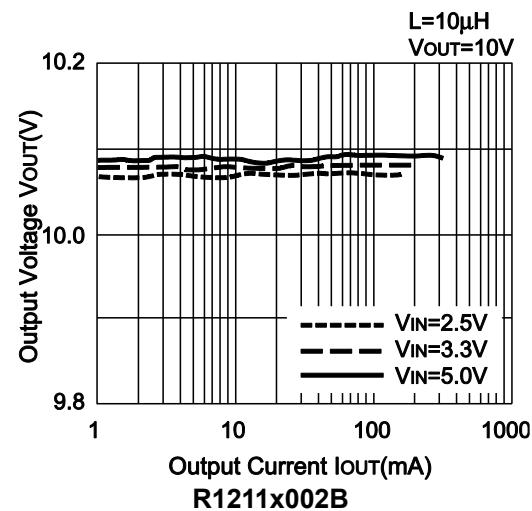
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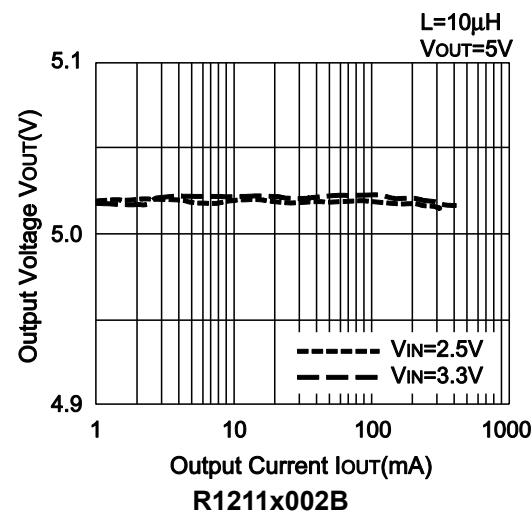
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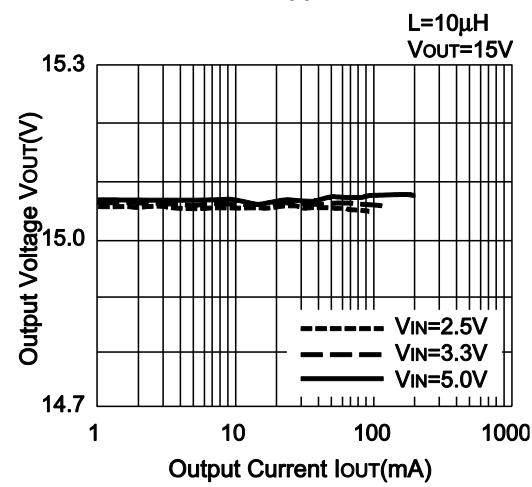
R1211x002A



R1211x002B



R1211x002B

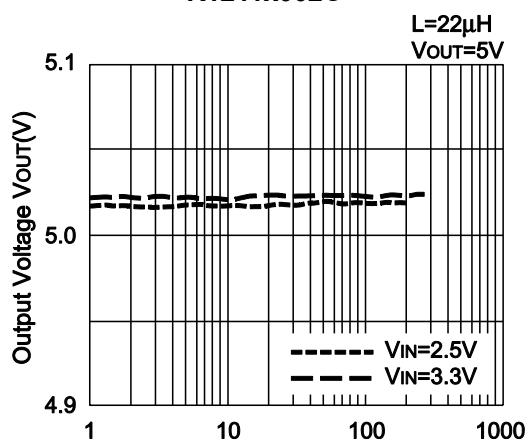


R1211D(SON-6) is the discontinued product.

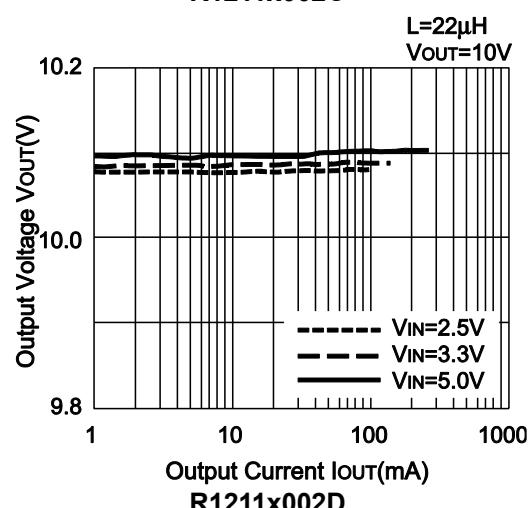
R1211x

NO.EA-088-241115

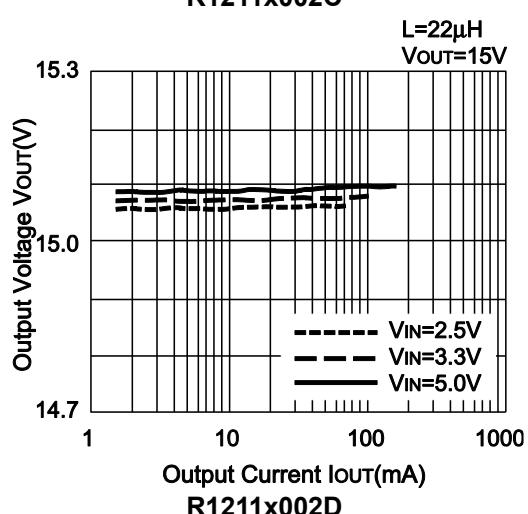
R1211x002C



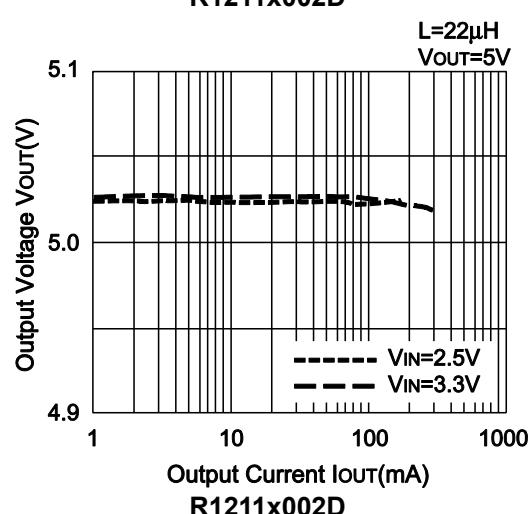
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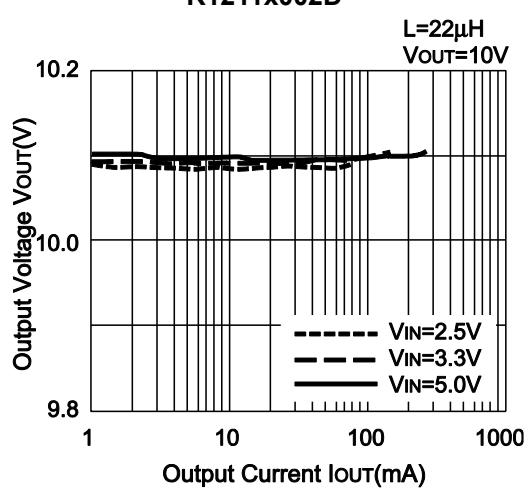
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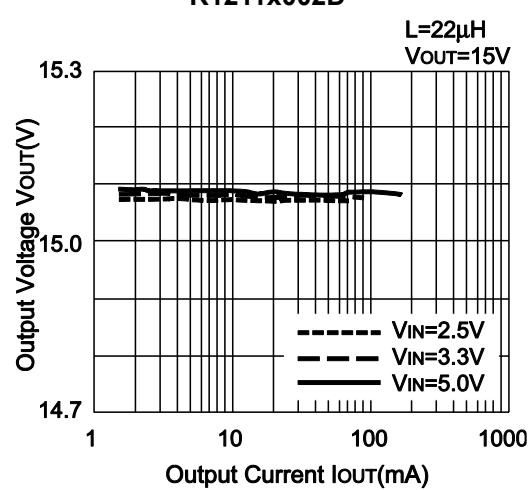
R1211x002D



R1211x002D



R1211x002D



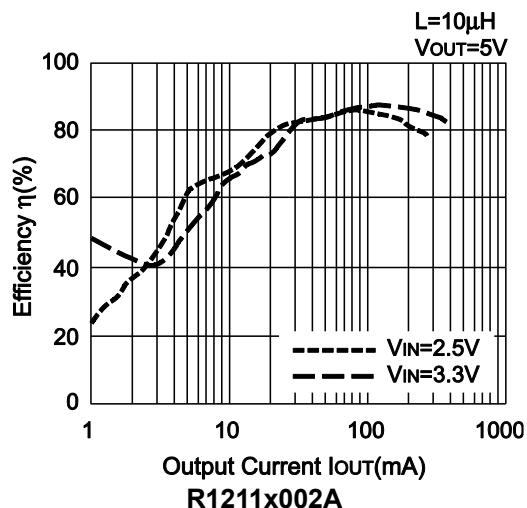
R1211D(SON-6) is the discontinued product.

R1211x

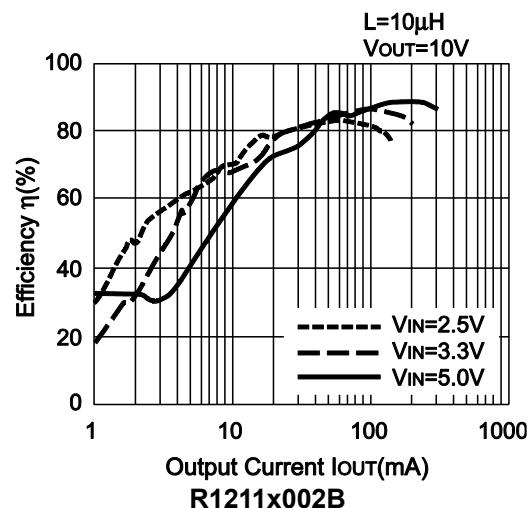
NO.EA-088-241115

2) Efficiency vs. Output Current

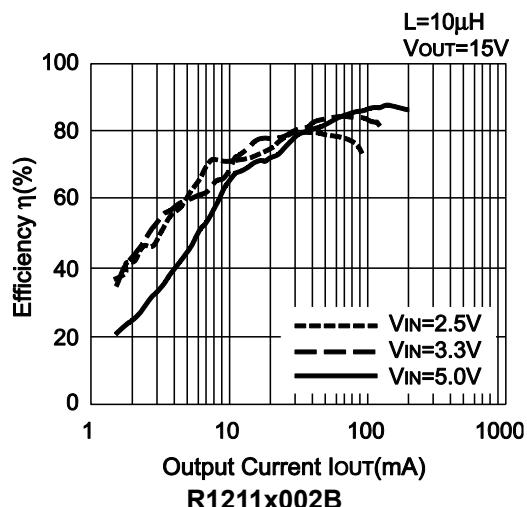
R1211x002A



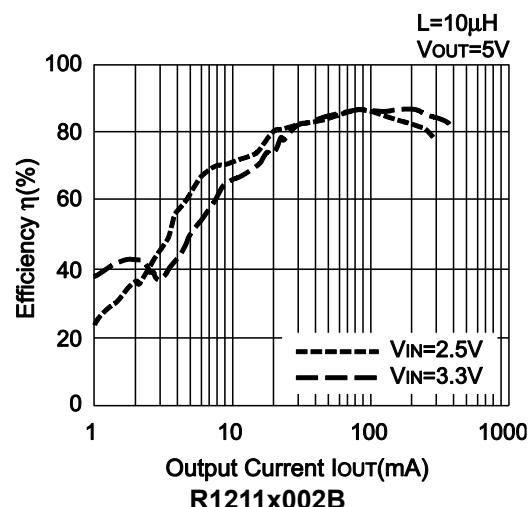
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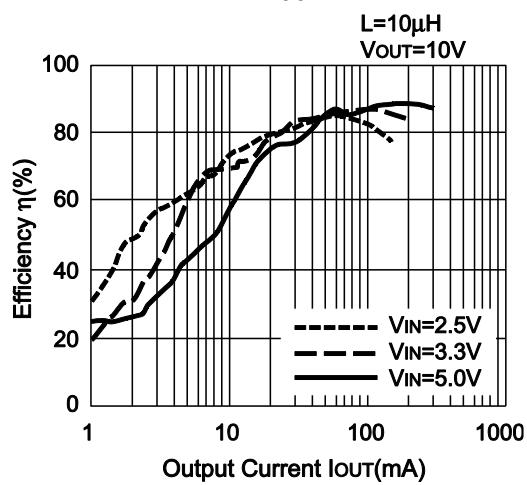
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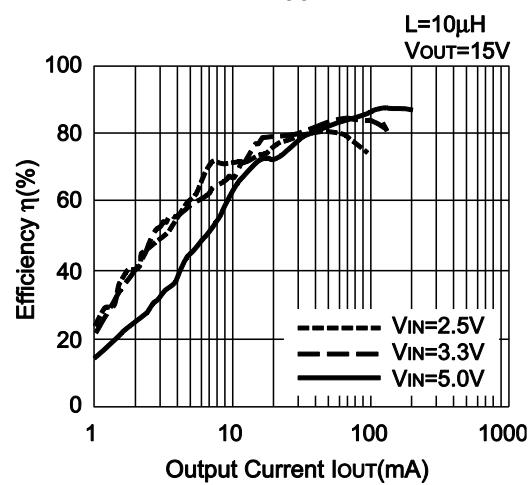
R1211x002B



R1211x002B



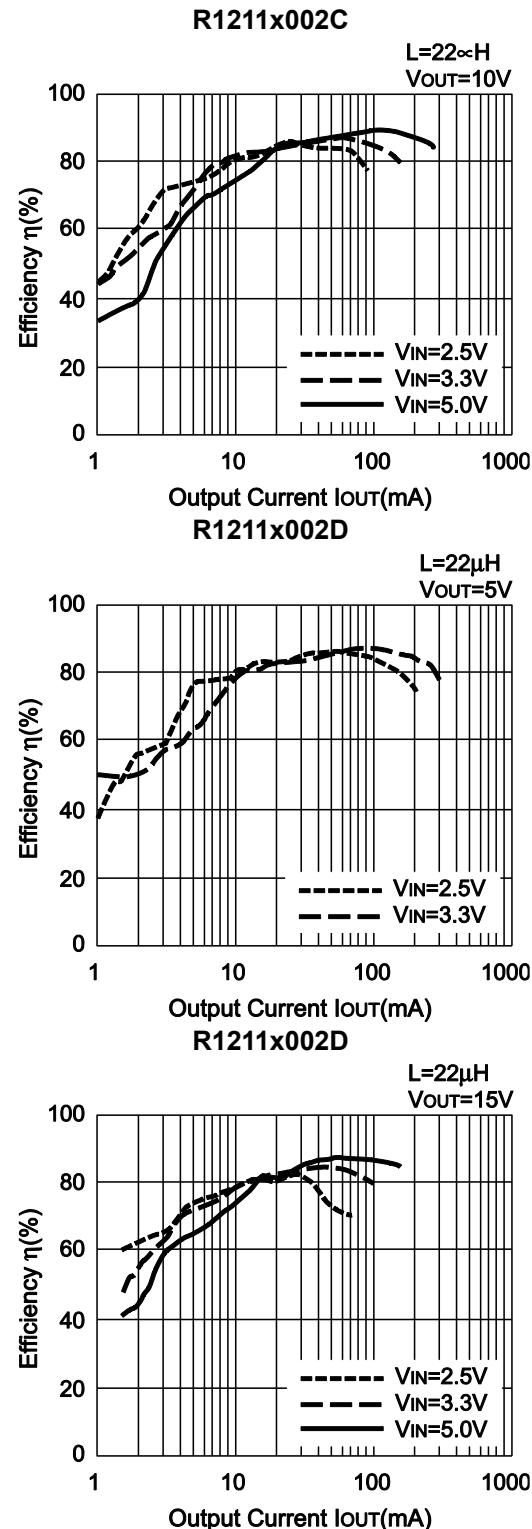
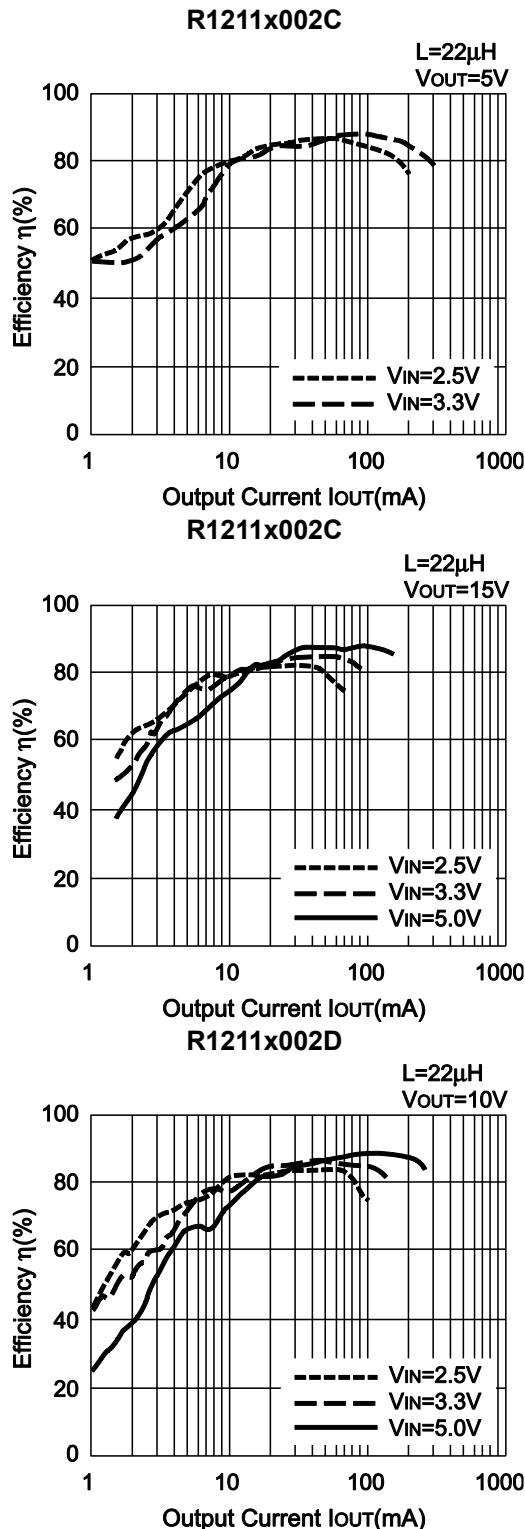
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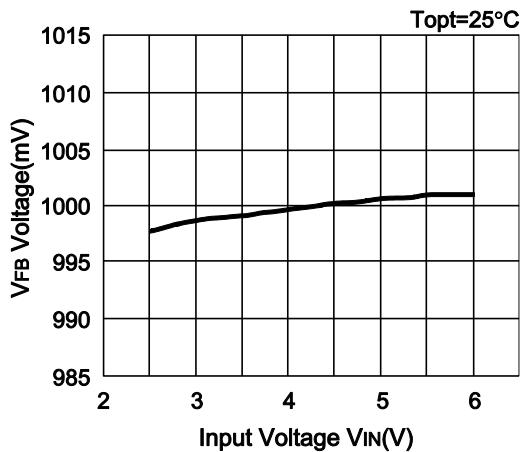
R1211D(SON-6) is the discontinued product.

R1211x

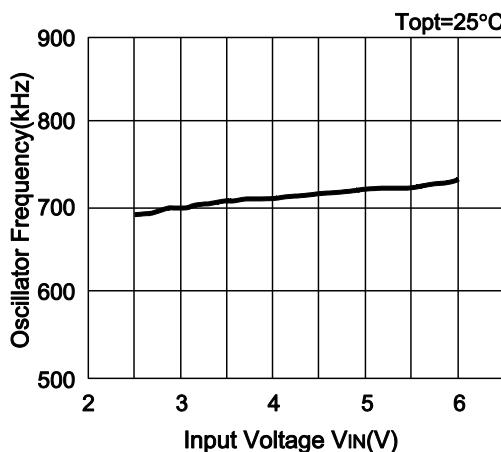
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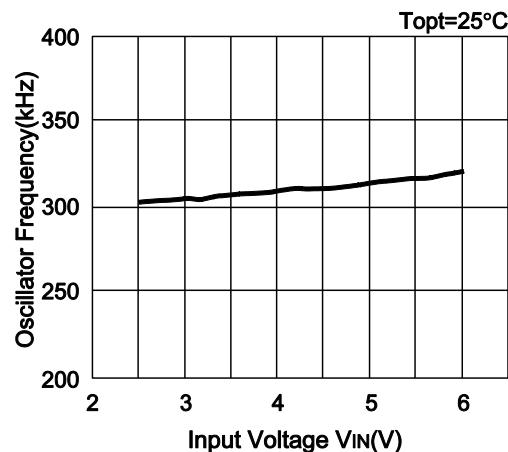
**3) VFB Voltage vs. Input Voltage
R1211x002x**



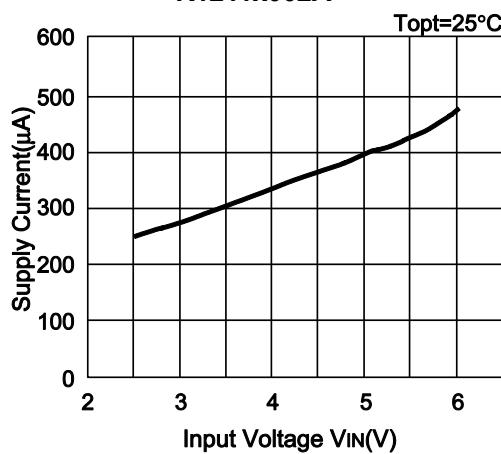
**4) Oscillator Frequency vs. Input Voltage
R1211x002A/B**



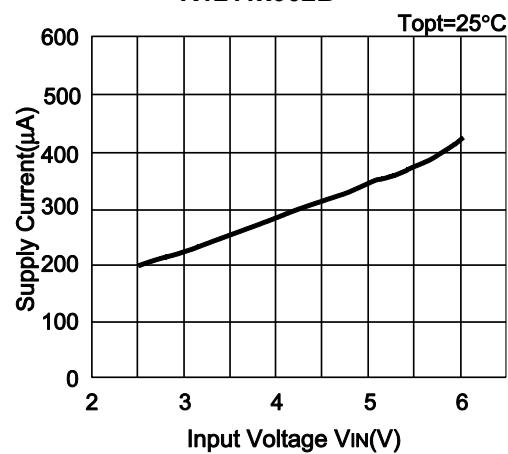
R1211x002C/D



**5) Supply Current vs. Input Voltage
R1211x002A**



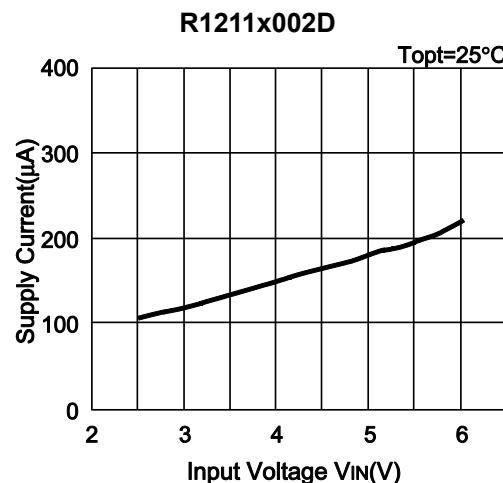
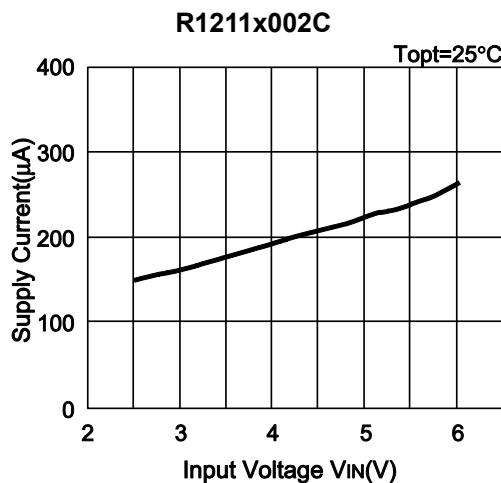
R1211x002B



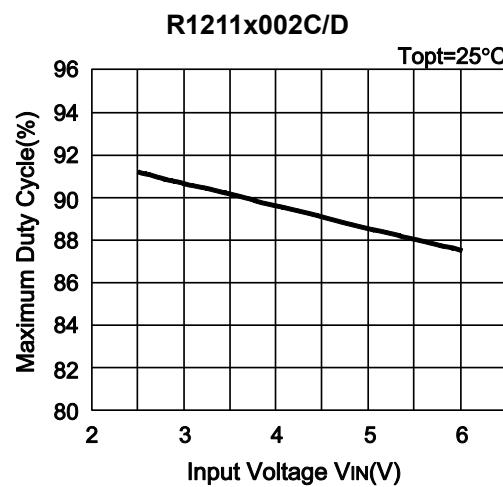
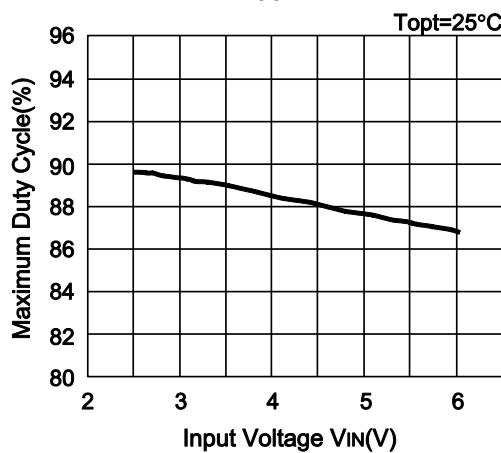
R1211D(SON-6) is the discontinued product.

R1211x

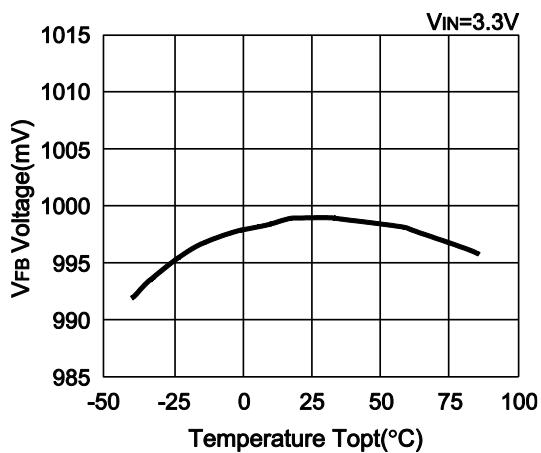
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6) Maximum Duty Cycle vs. Input Voltage
R1211x002A/B



7) VFB Voltage vs. Temperature
R1211x002x



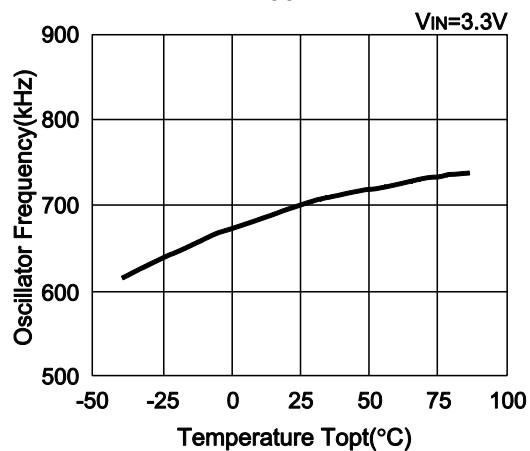
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R1211x

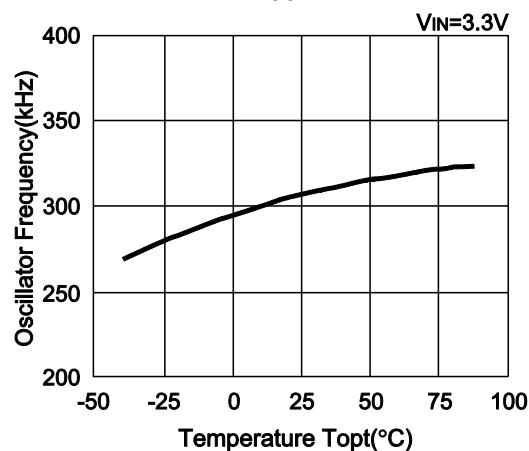
NO.EA-088-241115

8) Oscillator Frequency vs. Temperature

R1211x002A/B

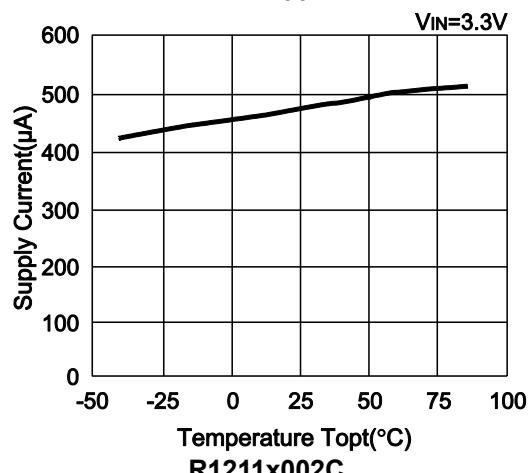


R1211x002C/D

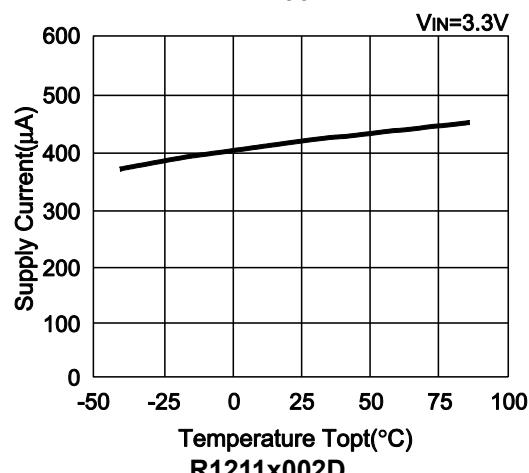


9) Supply Current vs. Temperature

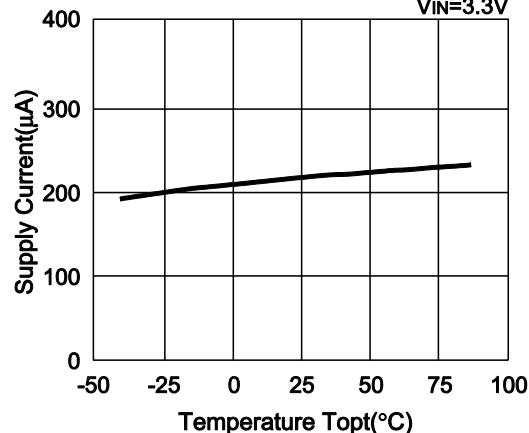
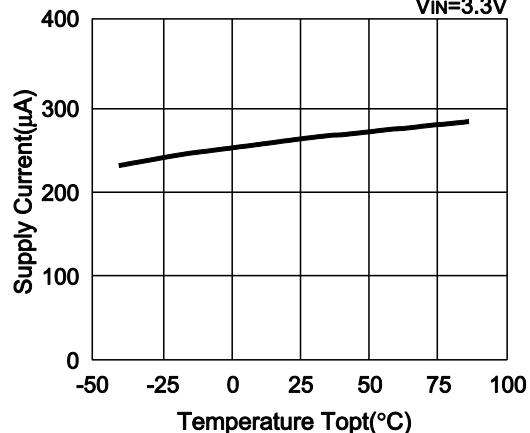
R1211x002A



R1211x002B



R1211x002C

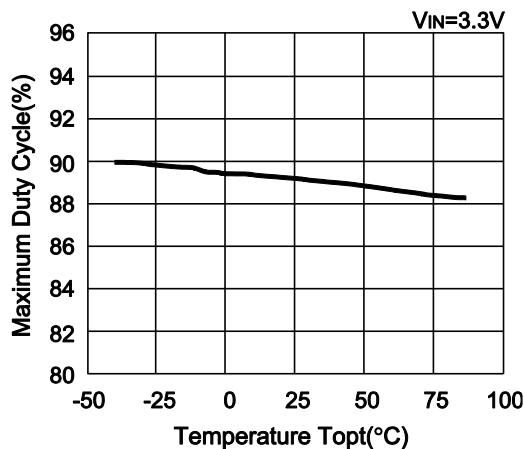


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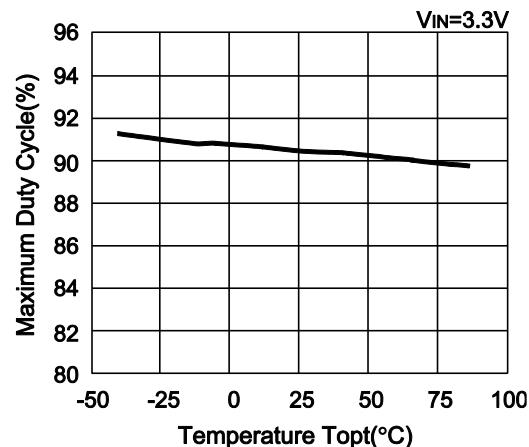
R1211x

NO.EA-088-241115

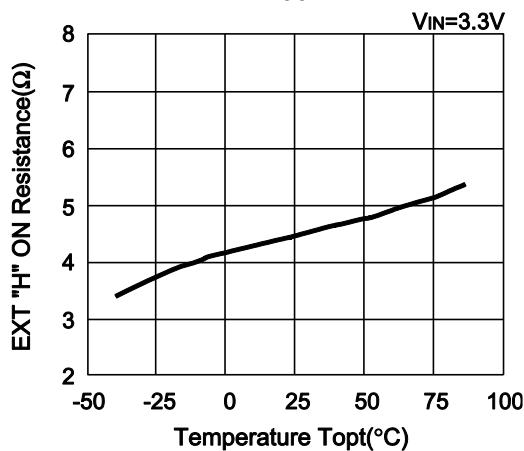
10) Maximum Duty Cycle vs. Temperature
R1211x002A/B



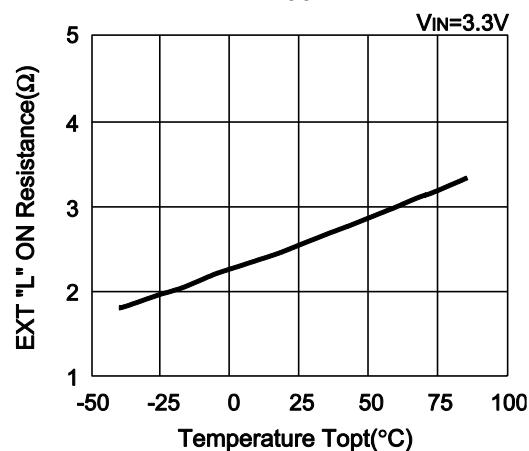
R1211x002C/D



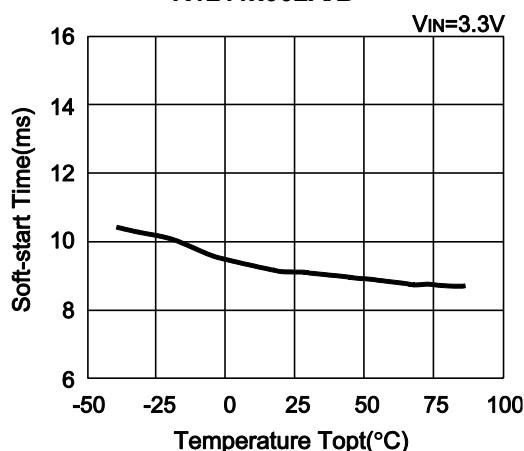
11) EXT "H" On Resistance vs. Temperature
R1211x002x



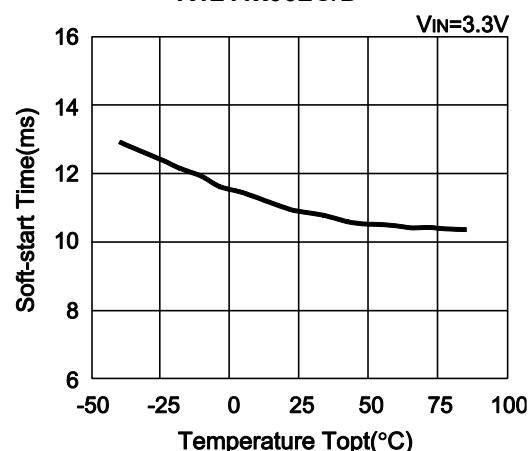
12) EXT "L" On Resistance vs. Temperature
R1211x002x



13) Soft-start Time vs. Temperature
R1211x002A/B



R1211x002C/D

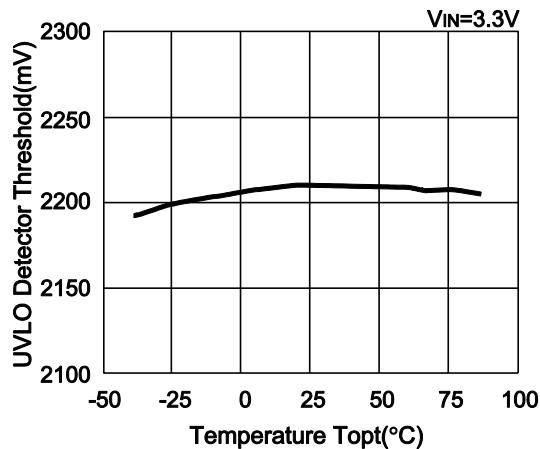


R1211D(SON-6) is the discontinued product.

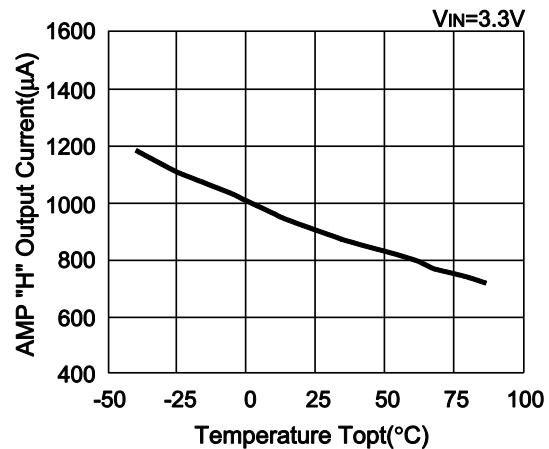
R1211x

NO.EA-088-241115

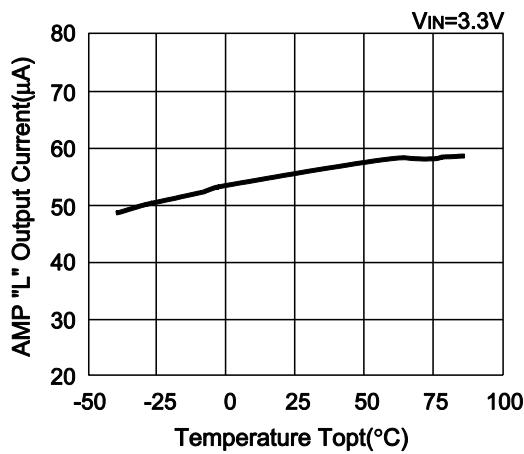
14) UVLO Detector Threshold vs. Temperature
R1211x002x



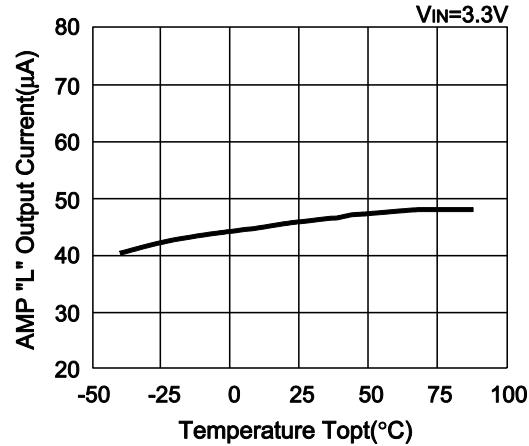
15) AMP "H" Output Current vs. Temperature
R1211x002A/C



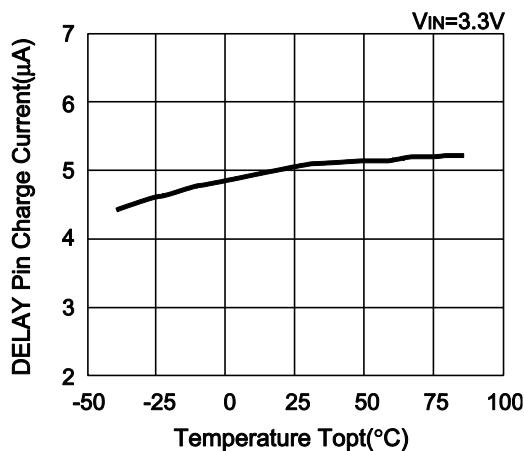
16) AMP "L" Output Current vs. Temperature
R1211x002A



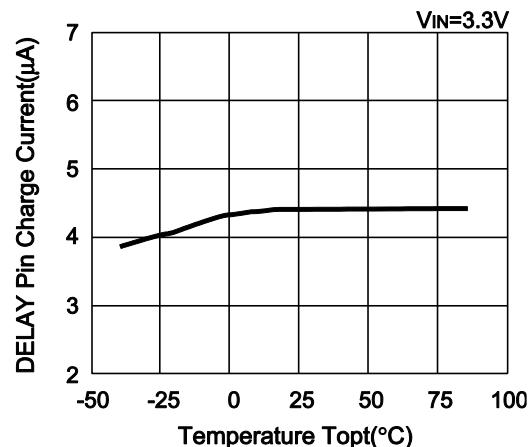
R1211x002C



17) DELAY Pin Charge Current vs. Temperature
R1211x002A/B



R1211x002C/D

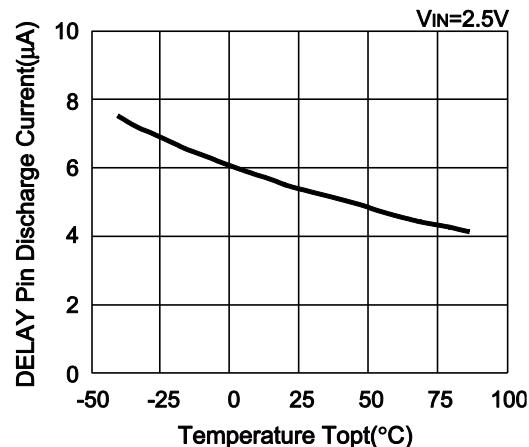
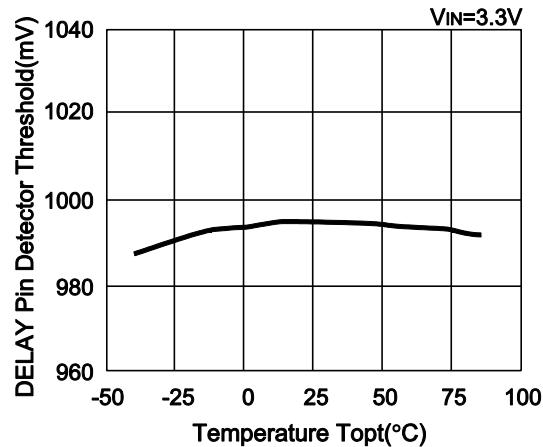


R1211D(SON-6) is the discontinued product.

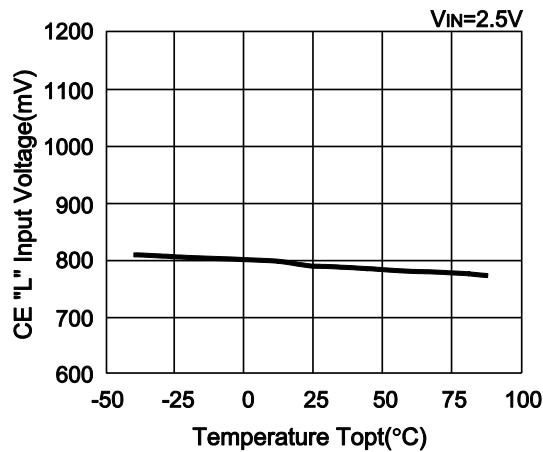
R1211x

NO.EA-088-241115

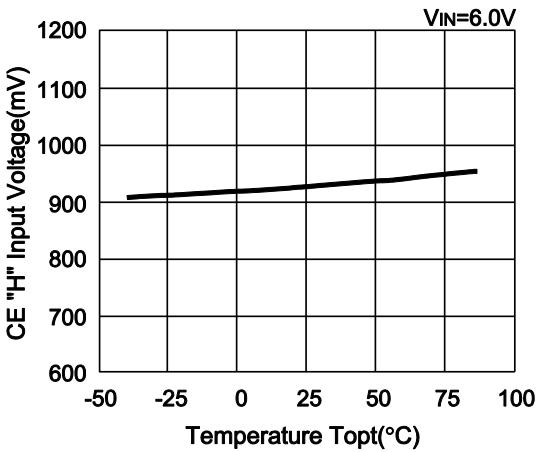
18) DELAY Pin Detector Threshold vs. Temperature 19) DELAY Pin Discharge Current vs. Temperature
R1211x002x R1211x002x



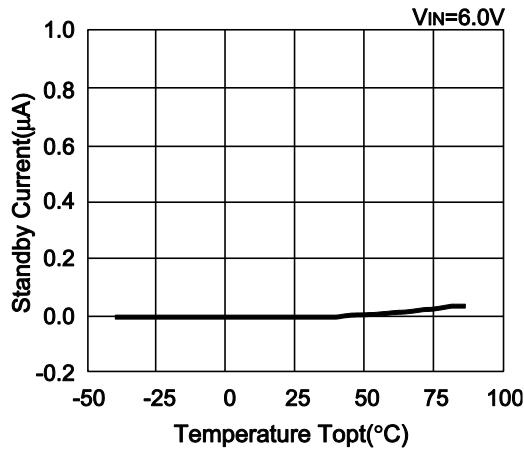
20) CE "L" Input Voltage vs. Temperature
R1211x002B/D



21) CE "H" Input Voltage vs. Temperature
R1211x002B/D



22) Standby Current vs. Temperature
R1211x002B/D



R1211D(SON-6) is the discontinued product.

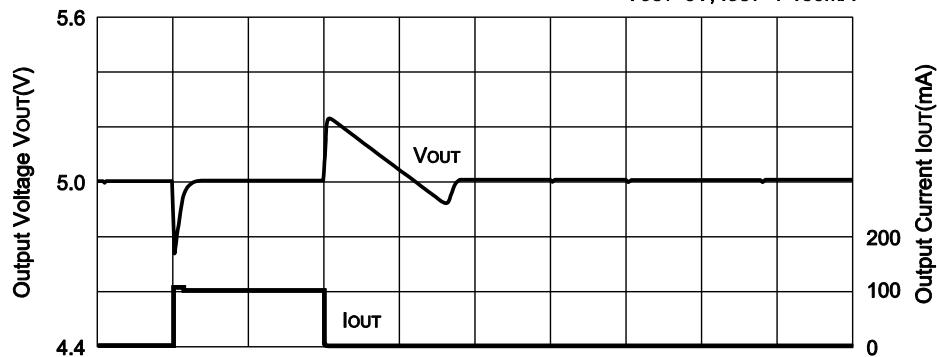
R1211x

NO.EA-088-241115

23) Load Transient Response

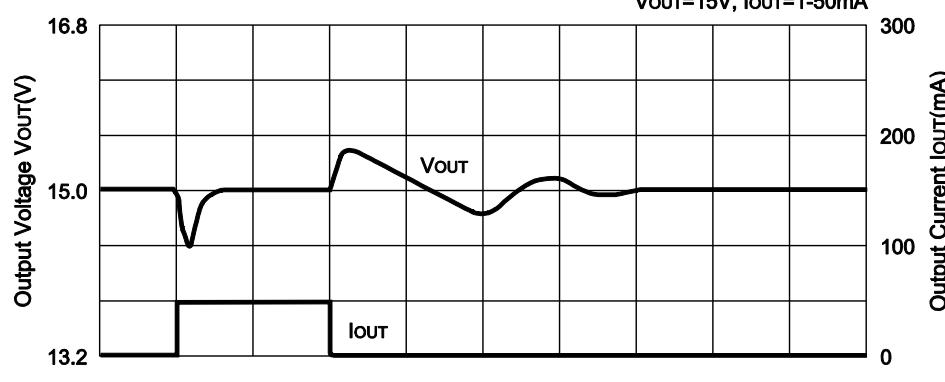
R1211x002A

$L=10\mu H$
 $V_{IN}=3.3V, C_3=22\mu F$
 $V_{OUT}=5V, I_{OUT}=1-100mA$



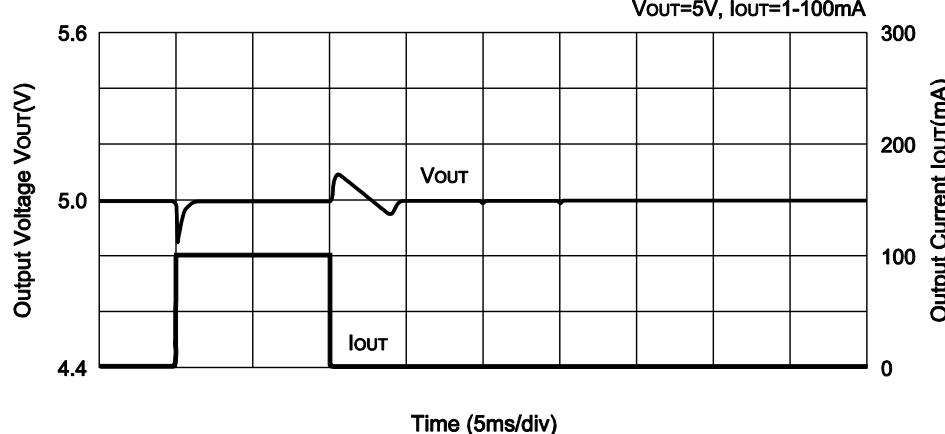
R1211x002A

$L=10\mu H$
 $V_{IN}=3.3V, C_3=22\mu F$
 $V_{OUT}=15V, I_{OUT}=1-50mA$



R1211x002B

$L=10\mu H$
 $V_{IN}=3.3V, C_3=22\mu F$
 $V_{OUT}=5V, I_{OUT}=1-100mA$



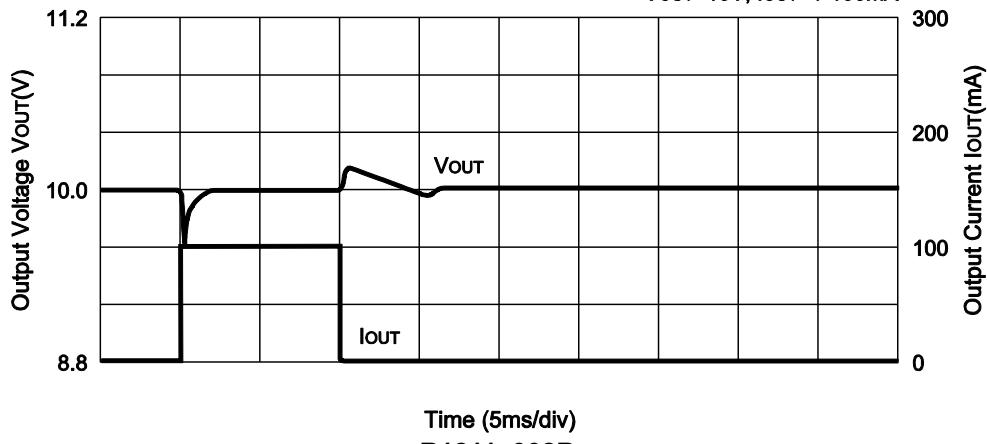
R1211D(SON-6) is the discontinued product.

R1211x

NO.EA-088-241115

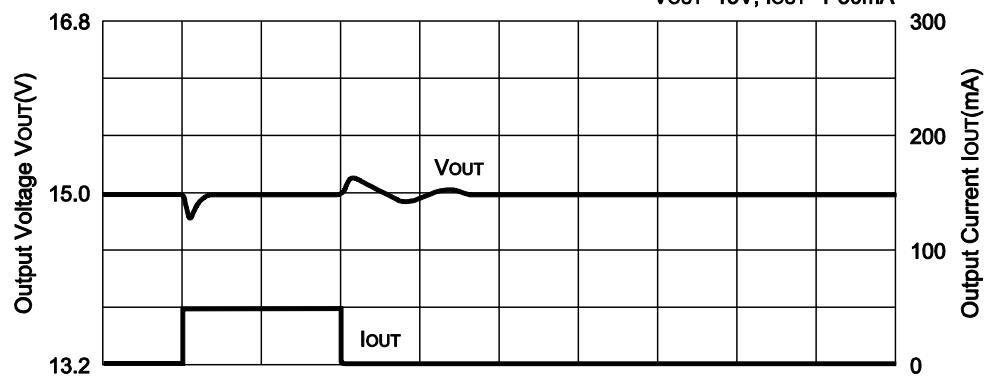
R1211x002B

$L=10\mu H$
 $V_{IN}=3.3V, C_3=22\mu F$
 $V_{OUT}=10V, I_{OUT}=1-100mA$



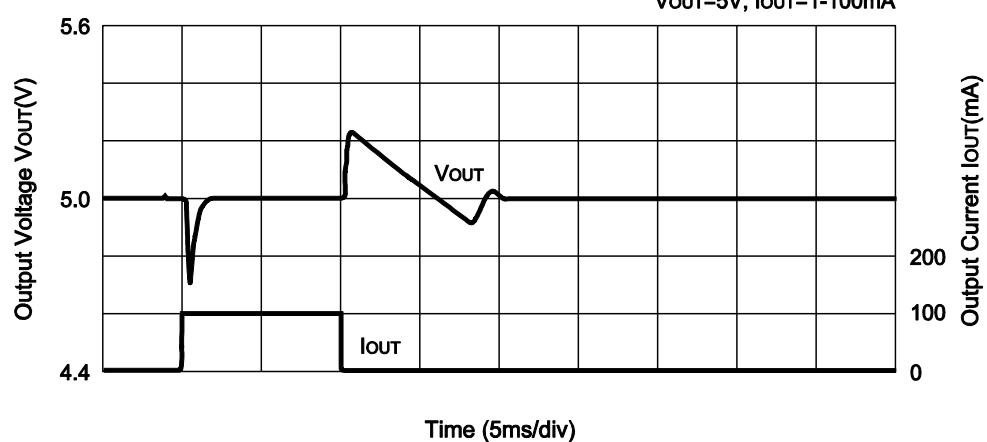
R1211x002B

$L=10\mu H$
 $V_{IN}=3.3V, C_3=22\mu F$
 $V_{OUT}=15V, I_{OUT}=1-50mA$



R1211x002C

$L=22\mu H$
 $V_{IN}=3.3V, C_3=22\mu F$
 $V_{OUT}=5V, I_{OUT}=1-100mA$



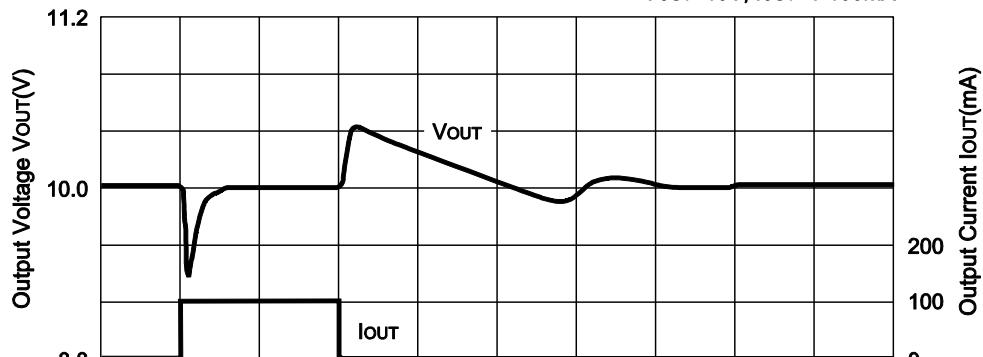
R1211D(SON-6) is the discontinued product.

R1211x

NO.EA-088-241115

R1211x002C

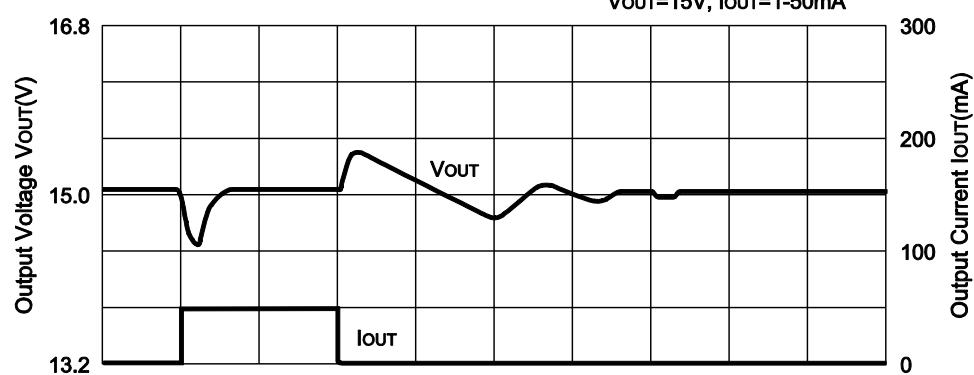
$L=22\mu H$
 $V_{IN}=3.3V, C_3=22\mu F$
 $V_{OUT}=10V, I_{OUT}=1-100mA$



Time (5ms/div)

R1211x002C

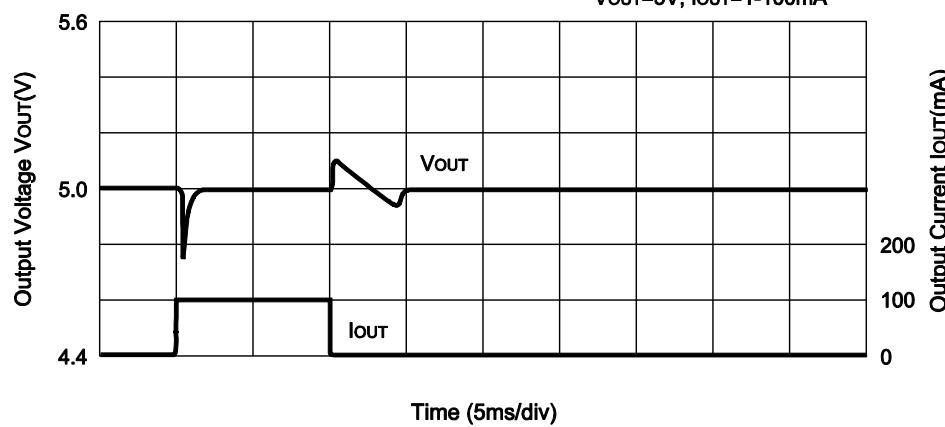
$L=22\mu H$
 $V_{IN}=3.3V, C_3=22\mu F$
 $V_{OUT}=15V, I_{OUT}=1-50mA$



Time (5ms/div)

R1211x002D

$L=22\mu H$
 $V_{IN}=3.3V, C_3=22\mu F$
 $V_{OUT}=5V, I_{OUT}=1-100mA$



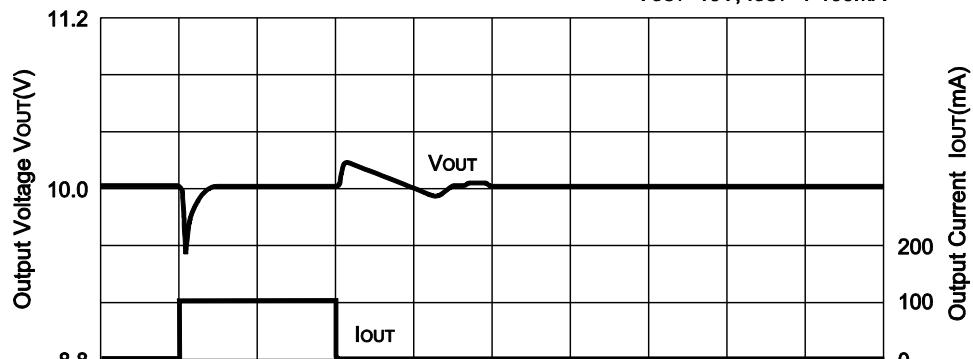
R1211D(SON-6) is the discontinued product.

R1211x

NO.EA-088-241115

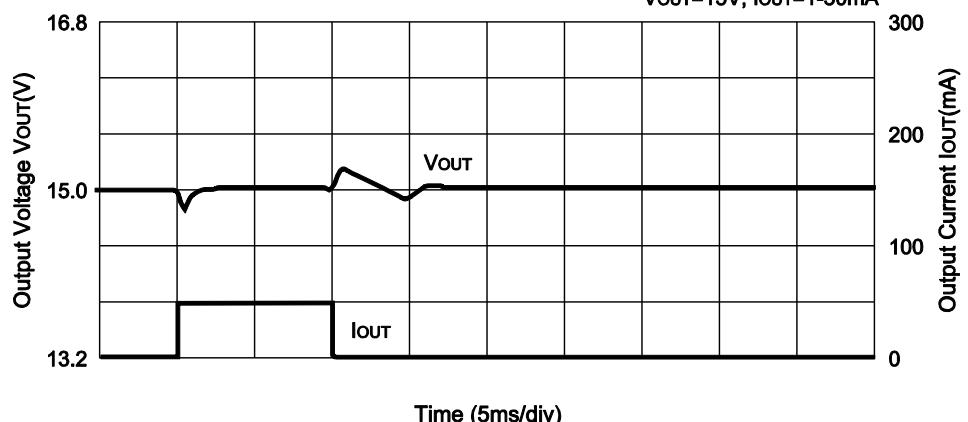
R1211x002D

$L=22\mu H$
 $V_{IN}=3.3V, C_3=22\mu F$
 $V_{OUT}=10V, I_{OUT}=1-100mA$



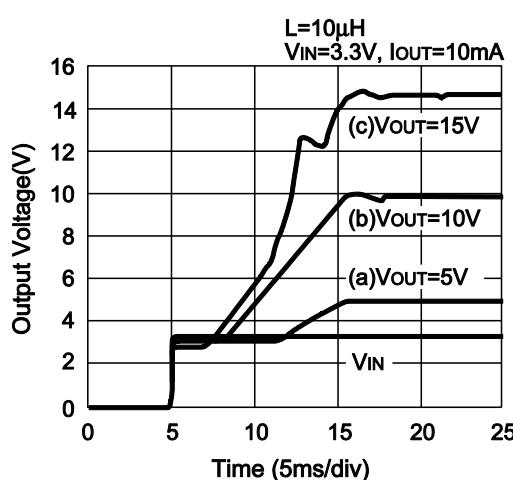
R1211x002D

$L=22\mu H$
 $V_{IN}=3.3V, C_3=22\mu F$
 $V_{OUT}=15V, I_{OUT}=1-50mA$

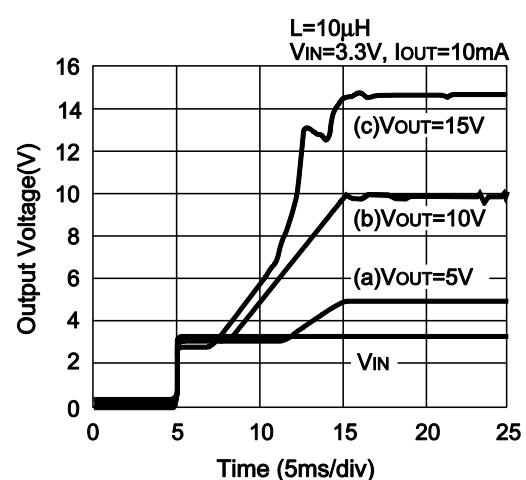


24) Power-on Response

R1211x002A



R1211x002B

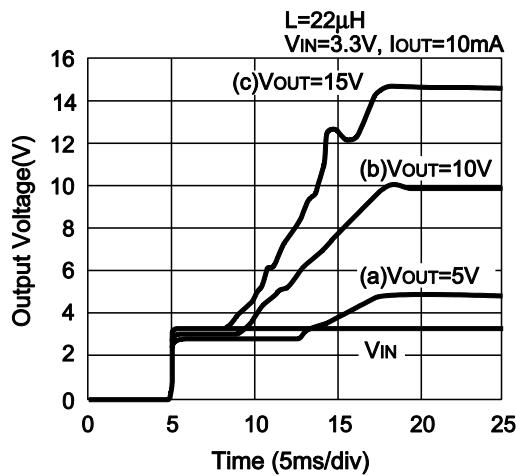


R1211D(SON-6) is the discontinued product.

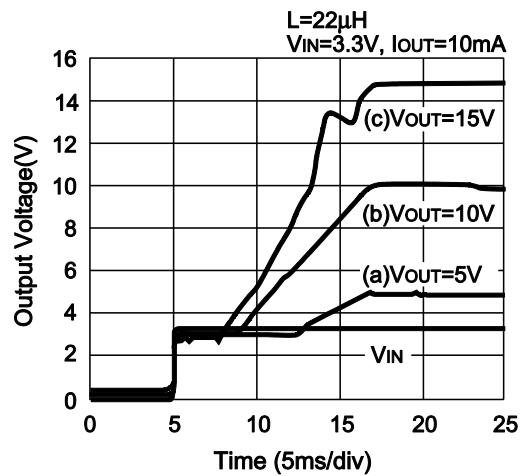
R1211x

NO.EA-088-241115

R1211x002C

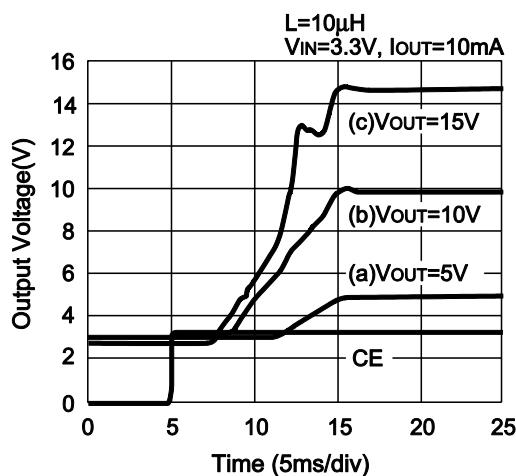


R1211x002D

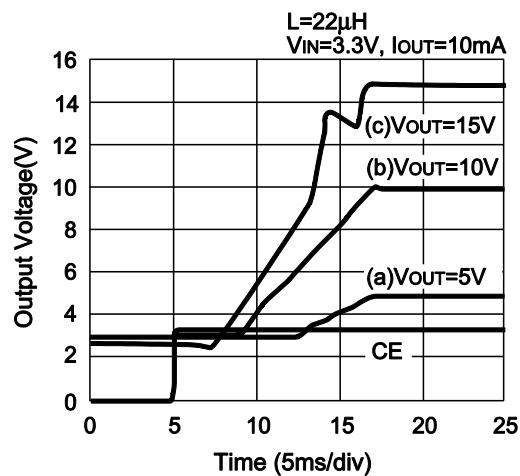


25) Turn-on speed with CE pin

R1211x002B



R1211x002D



The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following conditions are used in this measurement.

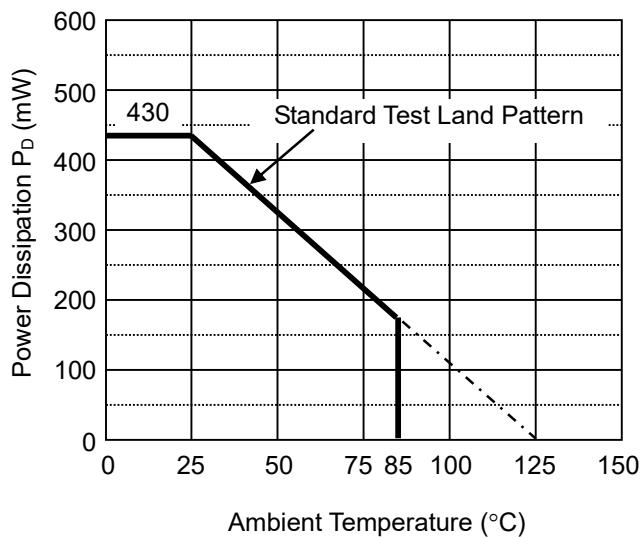
Measurement Conditions

	Standard Test Land Pattern
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Double-Sided Board)
Board Dimensions	40 mm × 40 mm × 1.6 mm
Copper Ratio	Top Side: Approx. 50% Bottom Side: Approx. 50%
Through-holes	Ø 0.5 mm × 44 pcs

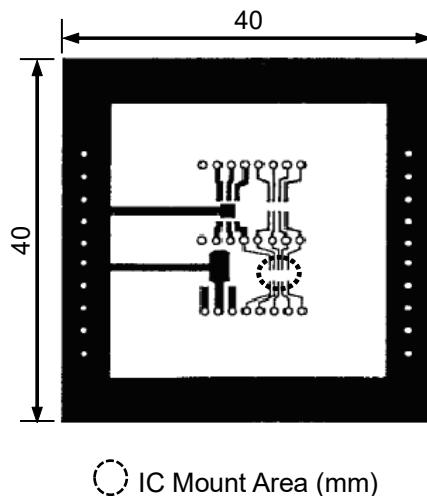
Measurement Result

(Ta = 25°C, Tjmax = 125°C)

	Standard Test Land Pattern
Power Dissipation	430 mW
Thermal Resistance	$\theta_{ja} = (125 - 25°C) / 0.43 W = 233°C/W$



Power Dissipation vs. Ambient Temperature

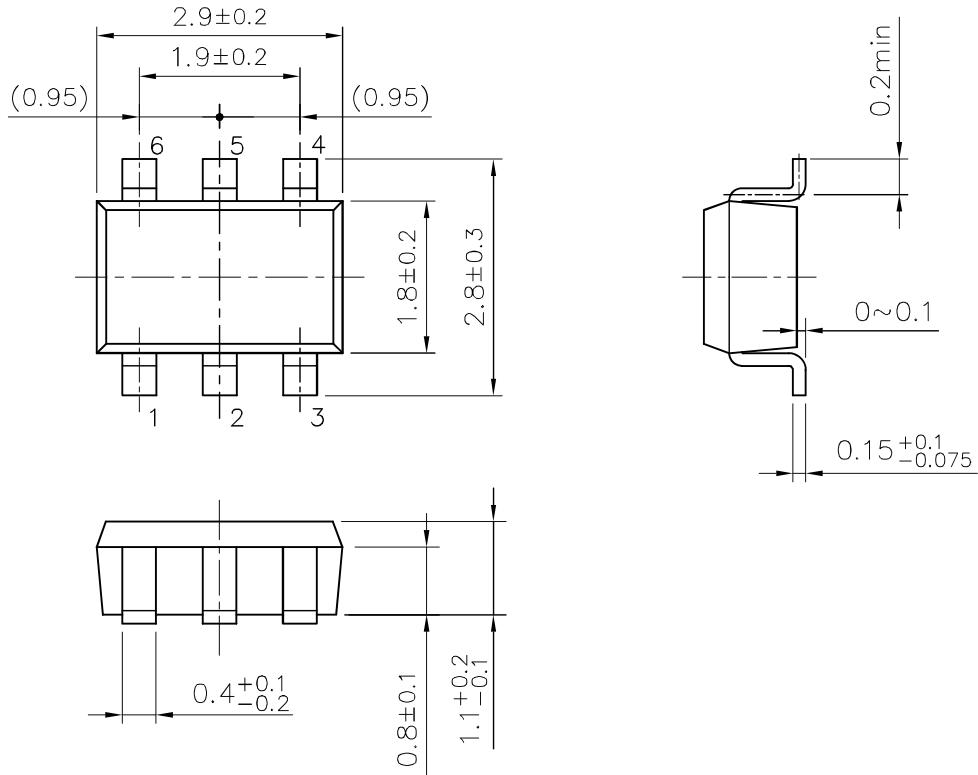


Measurement Board Pattern

PACKAGE DIMENSIONS

SOT-23-6W

DM-SOT-23-6W-JE-A

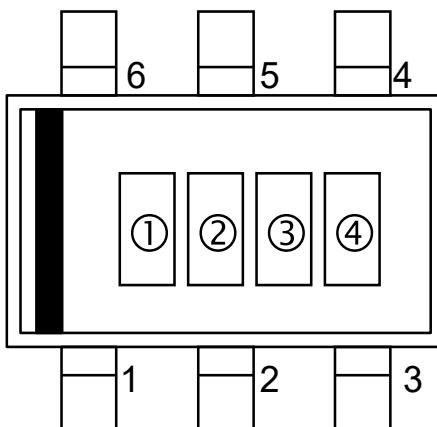


UNIT: mm

SOT-23-6W Package Dimensions

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

③④: Lot Number … Alphanumeric Serial Number



SOT-23-6W 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 our distributor before attempting to use AOI.

R1211N002x Part Marking List: Consumer Grade, Automotive Grade*

Product Name	① ②
R1211N002A	L 0
R1211N002B	L 1
R1211N002C	L 2
R1211N002D	L 3

* The target product may differ depending on the quality grade. Refer to the datasheet for details.

1. The products and the product specifications described in this document are subject to change or discontinuation of production without notice for reasons such as improvement. Therefore, before deciding to use the products, please refer to our sales representatives for the latest information thereon.
2. The materials in this document may not be copied or otherwise reproduced in whole or in part without the prior written consent of us.
3. This product and any technical information relating thereto are subject to complementary export controls (so-called KNOW controls) under the Foreign Exchange and Foreign Trade Law, and related politics ministerial ordinance of the law. (Note that the complementary export controls are inapplicable to any application-specific products, except rockets and pilotless aircraft, that are insusceptible to design or program changes.) Accordingly, when exporting or carrying abroad this product, follow the Foreign Exchange and Foreign Trade Control Law and its related regulations with respect to the complementary export controls.
4. The technical information described in this document shows typical characteristics and example application circuits for the products. The release of such information is not to be construed as a warranty of or a grant of license under our or any third party's intellectual property rights or any other rights.
5. The products listed in this document are intended and designed for use as general electronic components in standard applications (office equipment, telecommunication equipment, measuring instruments, consumer electronic products, amusement equipment etc.). Those customers intending to use a product in an application requiring extreme quality and reliability, for example, in a highly specific application where the failure or misoperation of the product could result in human injury or death should first contact us.
 - Aerospace Equipment
 - Equipment Used in the Deep Sea
 - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
 - Life Maintenance Medical Equipment
 - Fire Alarms / Intruder Detectors
 - Vehicle Control Equipment (automotive, airplane, railroad, ship, etc.)
 - Various Safety Devices
 - Traffic control system
 - Combustion equipment

In case your company desires to use this product for any applications other than general electronic equipment mentioned above, make sure to contact our company in advance. Note that the important requirements mentioned in this section are not applicable to cases where operation requirements such as application conditions are confirmed by our company in writing after consultation with your company.

6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, fire containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. The products have been designed and tested to function within controlled environmental conditions. Do not use products under conditions that deviate from methods or applications specified in this datasheet. Failure to employ the products in the proper applications can lead to deterioration, destruction or failure of the products. We shall not be responsible for any bodily injury, fires or accident, property damage or any consequential damages resulting from misuse or misapplication of the products.
8. Quality Warranty
 - 8-1. Quality Warranty Period

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.

9. Anti-radiation design is not implemented in the products described in this document.
10. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
11. WL CSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
12. Warning for handling Gallium and Arsenic (GaAs) products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.
13. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.



Nisshinbo Micro Devices Inc.

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