PWM Step-up DC/DC Controller for Automotive Applications

NO.EC-088-131115

OUTLINE

The R1211x Series are CMOS-based PWM step-up DC/DC converter controllers with low supply current.

Each of the R1211x Series 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, high efficiency step-up DC/DC converter can be composed of this IC with some external components, or an inductor, a diode, a power MOSFET, divider resisters, and capacitors. Phase compensation has been made internally in this device, and it has stand-by mode. Max duty cycle is internally fixed typically at 90%.

Soft start function is built-in, and Soft-starting time is set typically at 9ms (B, 700kHz version) or 10.5ms (D, 300kHz version). As for the protection circuit, after the soft-starting time, if the maximum duty cycle is continued for a certain period, the R1211x Series latch the external driver with its off state, or Latch-type protection circuit works.

The delay time for latch the state can be set with an external capacitor. To release the protection circuit, restart with power-on (Voltage supplier is equal or less than UVLO detector threshold level), or once after making the circuit be stand-by with chip enable pin and enable the circuit again.

FEATURES

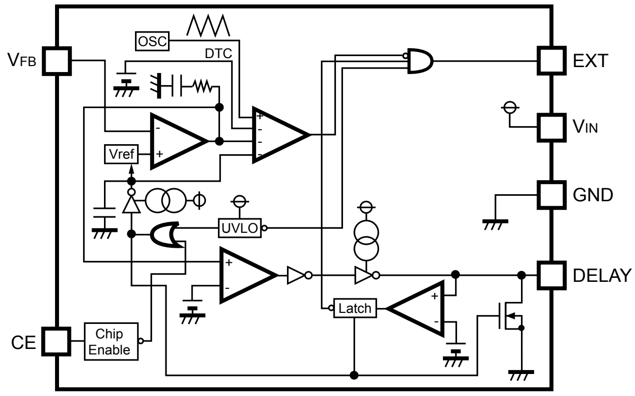
- Input Voltage Range (Maximum Rating)...........2.5V to 6.0V (6.5 V)
- Built-in Latch-type Protection Circuit.................Protection Delay Time can be set with an external capacitor
- Oscillator Frequency (PWM control).................300kHz, 700kHz
- Maximum Duty Cycle ....Typ. 90%
- Standby Current ....Typ. 0μA
- Feedback Voltage 1.0V
- Feedback Voltage Accuracy..............................±1.5%
- UVLO Threshold level.......................................Typ. 2.2V (Hysteresis Typ. 0.13V)
- Feedback Voltage Temperature Coefficient......Typ. ±150ppm/°C
- Package SOT-23-6W

APPLICATIONS

- Power source for accessories such as car audios, car navigation systems, and ETC systems

BLOCK DIAGRAMS

Version B/D



SELECTION GUIDE

In the R1211x Series, the oscillator frequency, the optional function, and the package type for the ICs can be selected at the user's request.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1211N002$-TR-#E	SOT-23-6W	3,000 pcs	Yes	Yes

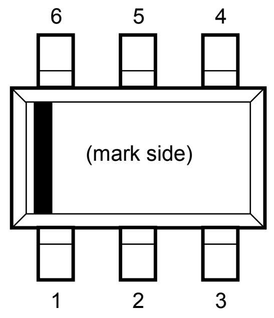
$: Designation of Oscillator Frequency and Optional Function
(B) 700kHz, with CE pin (Internal Phase Compensation Type, with Stand-by)
(D) 300kHz, with CE pin (Internal Phase Compensation Type, with Stand-by)

: Specify Automotive Class Code

	Operating Temperature Range	Guaranteed Specs Temperature Range	Screening
A	-40°C to 85°C	25°C	High Temperature

PIN CONFIGURATIONS

SOT-23-6W



Pin No	Symbol	Pin Description
1	DELAY	Pin for External Capacitor (for Setting Output Delay Time of Protection)
2	CE	Chip Enable Pin ("H" Active)
3	V_{FB}	Feedback Pin for monitoring Output Voltage
4	V_{IN}	Power Supply Pin
5	GND	Ground Pin
6	EXT	External FET Drive Pin (CMOS Output)

ABSOLUTE MAXIMUM RATINGS

(GND=0V)

Symbol	Item		Rating	Unit
V_{IN}	V_{IN} Pin Voltage		6.5	V
V_{EXT}	EXT Pin Output Voltage		–0.3 ~ V_{IN}+0.3	V
V_{DLY}	DELAY Pin Voltage		–0.3 ~ V_{IN}+0.3	V
V_{CE}	CE Pin Input Voltage		–0.3 ~ V_{IN}+0.3	V
V_{FB}	V_{FB} Pin Voltage		–0.3 ~ V_{IN}+0.3	V
I_{EXT}	EXT Pin Inductor Drive Output Current		±50	mA
P_D	Power Dissipation (SOT-23-6W)[*1]	Standard Land Pattern	430	mW
Tj	Junction Temperature		–40 ~ 125	°C
Tstg	Storage Temperature Range		–55 ~ 125	°C

[*1] Refer to *PACKAGE INFORMATION* for detailed 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.

RECOMMENDED OPERATING RATINGS

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	2.5 to 6.0	V
Ta	Operating Temperature Range	−40 to 85	°C

RECOMMENDED OPERATING RATINGS
All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating ratings. The semiconductor devices cannot operate normally over the recommended operating ratings, even if when they are used over such ratings by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating ratings.

ELECTRICAL CHARACTERISTICS

- **R1211x002B**

(Ta=25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{FB}	Feedback Voltage	V_{IN}=3.3V	0.985	1.000	1.015	V
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
$\Delta f_{OSC}/\Delta Ta$	Oscillator Frequency Temperature Coefficient	−40°C ≤ Ta ≤ 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
V_{UVLOL}	UVLO Minimum Operating Voltage		1.15			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

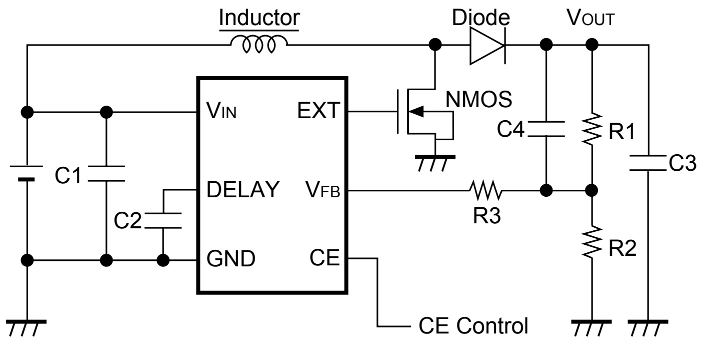
- **R1211x002D**

(Ta=25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{FB}	V_{FB} Voltage Tolerance	V_{IN}=3.3V	0.985	1.000	1.015	V
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
$\Delta f_{OSC}/\Delta$ Ta	Oscillator Frequency Temperature Coefficient	–40°C ≤ Ta ≤ 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, IEXT=–20mA		5	10	Ω
R_{EXTL}	EXT "L" ON Resistance	V_{IN}=3.3V, IEXT=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
V_{UVLOL}	UVLO Minimum Operating Voltage		1.15			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

TYPICAL APPLICATIONS

<R1211x002B/R1211x002D>



NMOS : IRF7601 (International Rectifier)
Inductor: LDR655312T-100 10µH (TDK) for R1211x002B
: LDR655312T-220 22µH (TDK) for R1211x002D
Diode : CRS02 (Toshiba)

C1 : 4.7µF (Ceramic)
C2 : 0.22µF (Ceramic)
C3 : 10µF (Ceramic)
C4 : 680pF (Ceramic)

R1 : Setting Output Voltage Resistor 1
R2 : Setting Output Voltage Resistor 2
R3 : 30kΩ

[**Note**]

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

TECHNICAL NOTES

- Use a 1μF 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 1μF or more value of capacitor between V_{OUT} and GND, C3 as shown in typical applications of the previous page. (Recommended value is from 10μF to 22μF.) 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 V_{OUT} 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 100pF and 1000pF.
- 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 = $V_{FB} \times (R1+R2)/R2$
  $R1+R2=100k\Omega$ 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 D_{ELAY} 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 B/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".
- EXT pin outputs GND level at standby mode.
- In UVLO function, EXT pin outputs GND level when the input voltage becomes lower than or equal to UVLO detector threshold. However, UVLO does not operate if the input voltage is lower than or equal to the minimum operating voltage, and EXT pin might output indeterminately. Therefore, it requires considerable attention when CE input is active and the input voltage rises/falls gradually. In that case, be sure to use the FET with gate cut-off voltage that prevents FET turn on even if EXT pin outputs indeterminately. The recommended FETs are as follows.

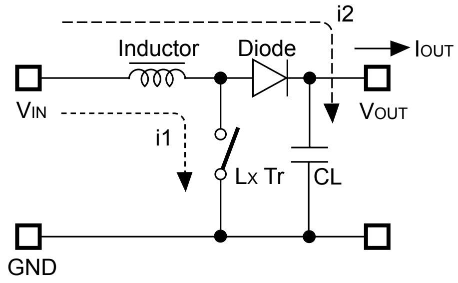
CPH6443 (Sanyo)
TPC6008-H (Toshiba)

- 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 V_F such as Shottky type with low reverse current I_R, 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 V_{OUT} is three times of setting voltage or more.

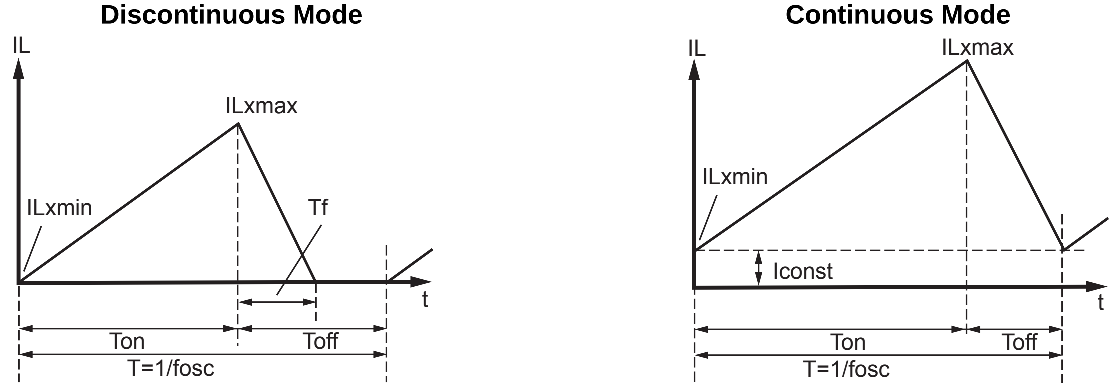
∗ The performance of power circuit with using this IC depends on external components. Choose the most suitable components for your application.

Output Current and Selection of External Components

<Basic Circuit>



<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.

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

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.

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

In this formula, Tf 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.

$$P_{AV} = 1/(T_{ON} + T_{OFF}) \times \{\int_0^{Ton} V_{IN}^2 \times t/L\ dt + \int_0^{Tf} V_{IN} \times (V_{OUT} - V_{IN}) \times t/L\ dt\} \quad \text{.......... Formula 3}$$

In PWM control, when Tf = Toff 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.

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

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 Iconst, then,

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

In this moment, the peak current, ILxmax flowing through the inductor and the driver Tr. is described as follows:

$$ILxmax = Iconst + V_{IN} \times T_{ON}/L \quad \text{.......... Formula 7}$$

With the formula 4,6, and ILxmax is,

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

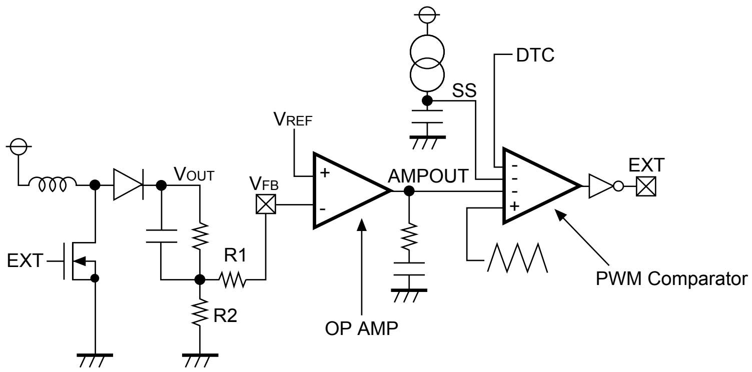
Therefore, peak current is more than I_{OUT}. Considering the value of ILxmax, the condition of input and output, and external components should be selected.

In the formula 7, peak current ILxmax at discontinuous mode can be calculated. Put Iconst=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 ILx 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}, Vf (as much as 0.3V) of the diode should be considered.

TIMING CHART

- **R1211x002B/R1211x002D**



<Soft-start Operation>

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

(Step1)

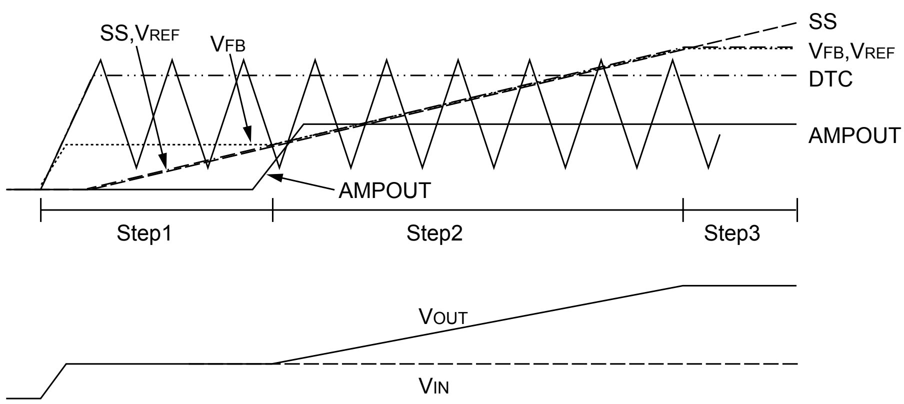
The voltage level of SS is rising gradually by constant current circuit of the IC and a capacitor. V_{REF} level which is input to OP AMP is also gradually rising. V_{OUT} is rising up to input voltage level just after the power-on, therefore, V_{FB} voltage is rising up to the setting voltage with input voltage and the ration 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 ration 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 1V, soft-start operation finishes. V_{REF} becomes constant voltage (=1V). 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.

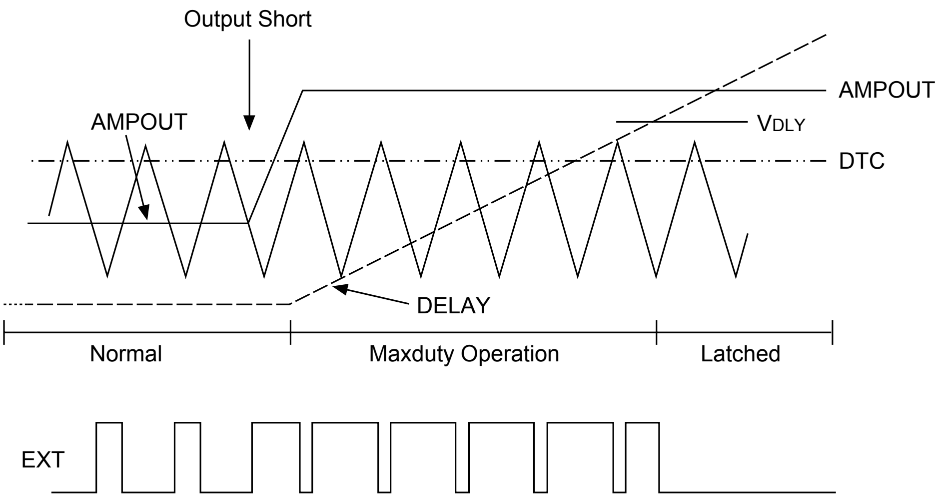
To release the latch protection operation, make the IC be standby mode with CE pin and make it active. Otherwise, make supply voltage down to UVLO detector threshold or lower, and make it rise up to the normal input voltage.

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".



PACKAGE INFORMATION

POWER DISSIPATION (SOT-23-6W)

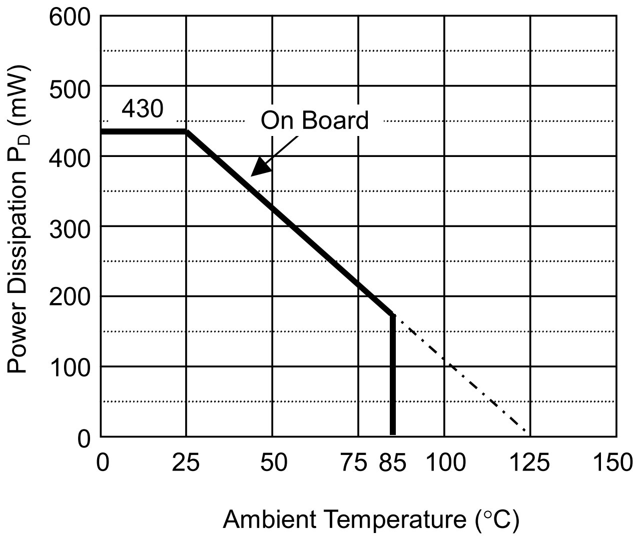
Power Dissipation (P_D) depends on conditions of mounting on board. This specification is based on the measurement at the condition below:

Measurement Conditions

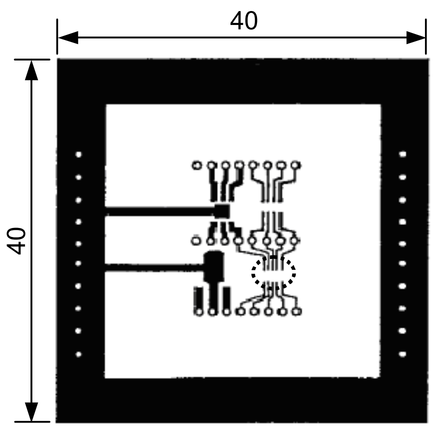
	Standard Land Pattern
Environment	Mounting on Board (Wind velocity=0m/s)
Board Material	Glass cloth epoxy plastic (Double sided)
Board Dimensions	40mm × 40mm × 1.6mm
Copper Ratio	Top side: Approx. 50%, Back side: Approx. 50%
Through-holes	φ 0.5mm × 44pcs

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

	Standard Test Land Pattern
Power Dissipation	430mW
Thermal Resistance	θja = (125-25°C)/0.43W = 233°C/W



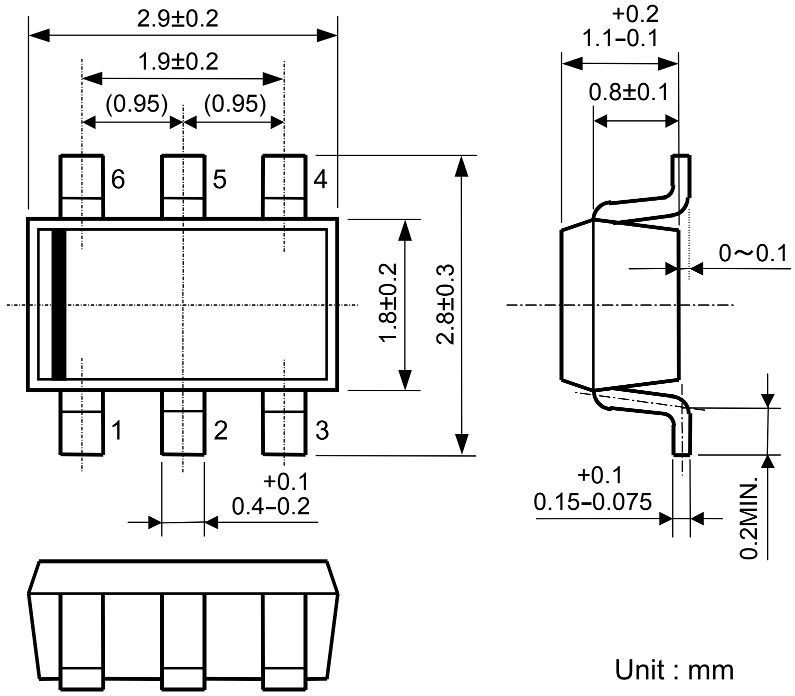
Power Dissipation



Measurement Board Pattern

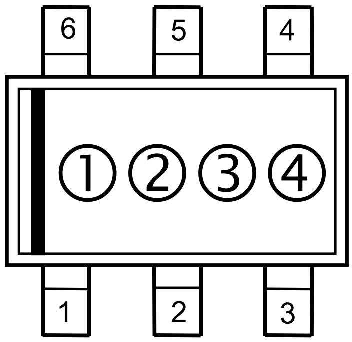
IC Mount Area (Unit: mm)

PACKAGE DIMENSIONS (SOT-23-6W)



MARK SPECIFICATION (SOT-23-6W)

①②: Product Code … **Refer to *MARK SPECIFICATION TABLE (SOT-23-6W)***
③④: Lot Number … Alphanumeric Serial Number



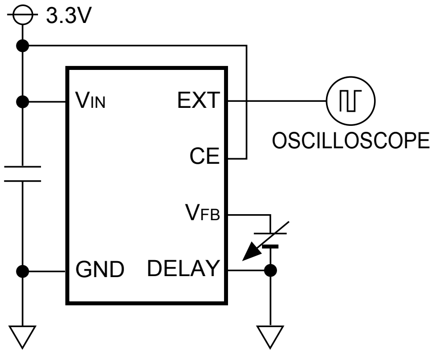
MARK SPECIFICATION TABLE (SOT-23-6W)

Product Name	①②
R1211N002B	L 1
R1211N002D	L 3

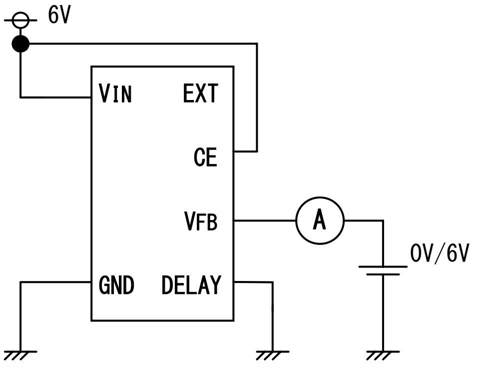
TEST CIRCUITS

- **R1211x002B/R1211x002D**

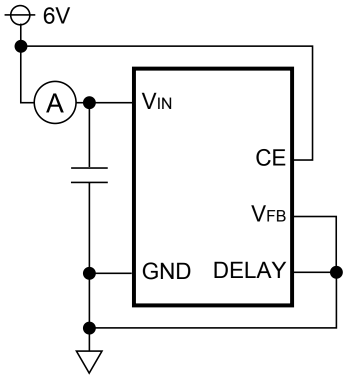
∗Oscillator Frequency, Maximum Duty Cycle, V_{FB} Voltage Test



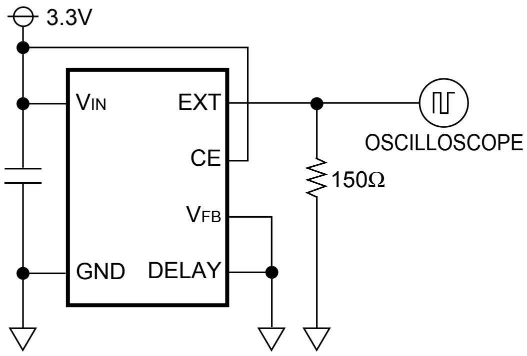
∗V_{FB} Input Current



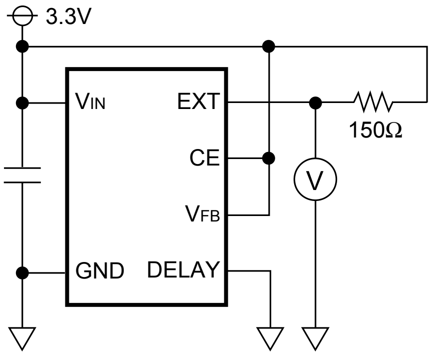
∗Consumption Current Test



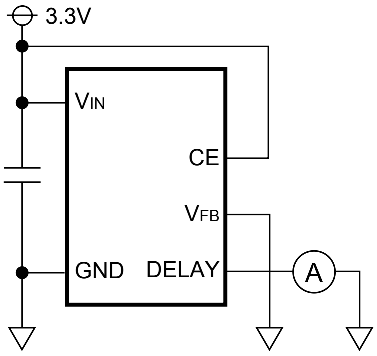
∗EXT "H" ON Resistance



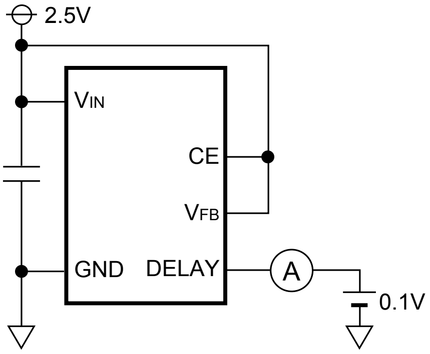
∗EXT "L" ON Resistance



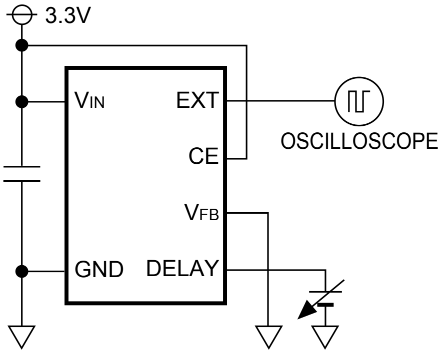
∗DELAY Pin Charge Current



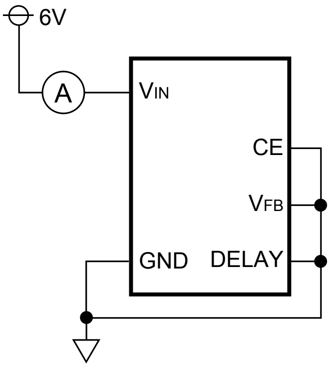
∗DELAY Pin Discharge Current



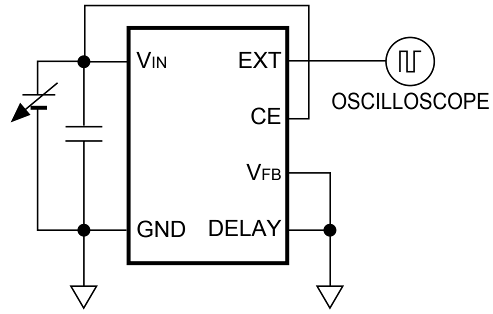
∗DELAY Pin Detector Threshold Voltage Test



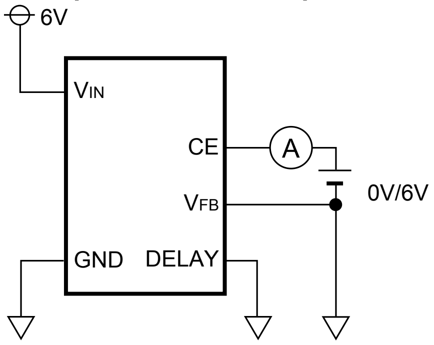
∗Standby Current Test



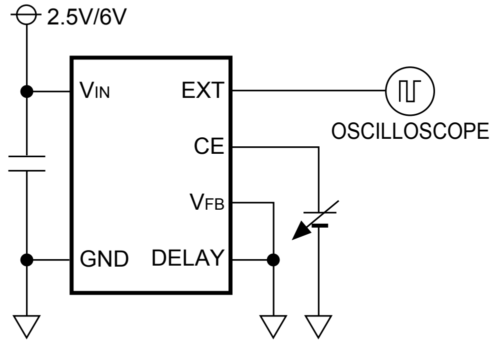
∗UVLO Detector Threshold/ Hysteresis Range Test



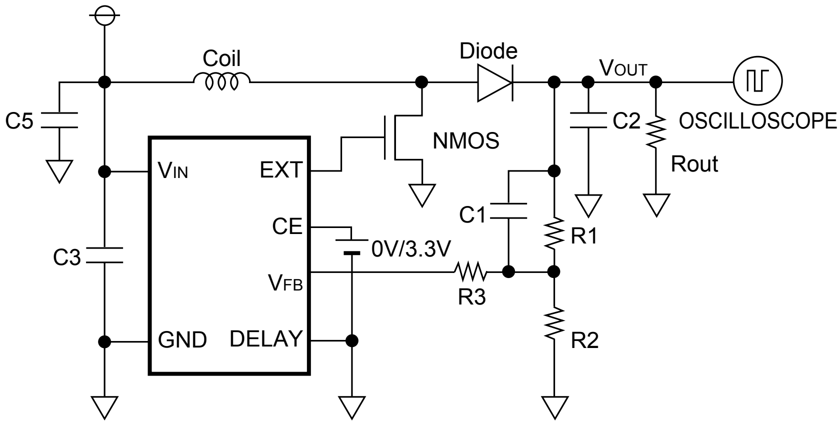
∗ CE "L" Input Current/"H" Input Current Test



∗CE "L" Input Voltage/"H" Input Voltage Test



∗Soft-start Time Test



<Components>

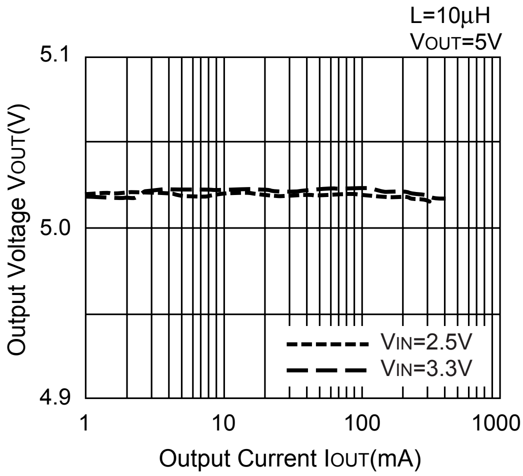
Inductor (L)	: 22μH (TDK LDR655312T-220)
Diode (SD)	: CRS02 (Toshiba)
Capacitors	C1 : 680pF (Ceramic), C2: 22μF (Tantalum)+2.2μF (Ceramic),
	C3 : 68μF (Tantalum)+2.2μF (Ceramic), C5: 22μF (Tantalum)
NMOS Transistor	: IRF7601 (International Rectifier)
Resistors	: R1: 90kΩ, R2: 10kΩ, R3: 30kΩ

TYPICAL CHARACTERISTICS

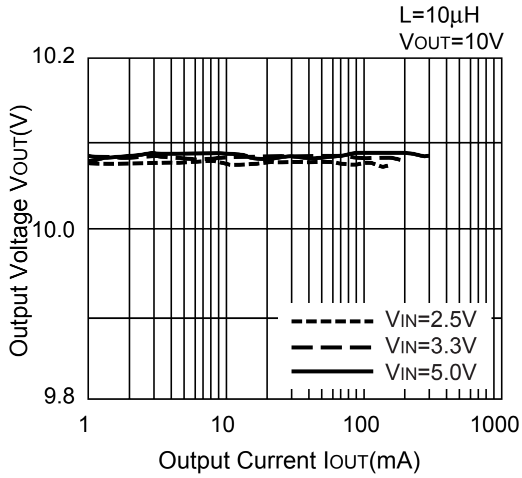
Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

1) Output Voltage vs. Output Current

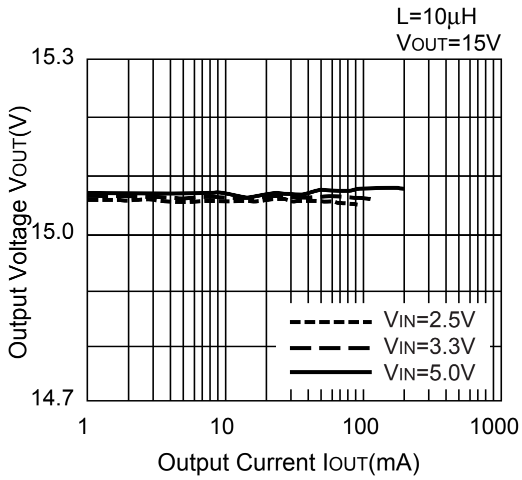
R1211x002B



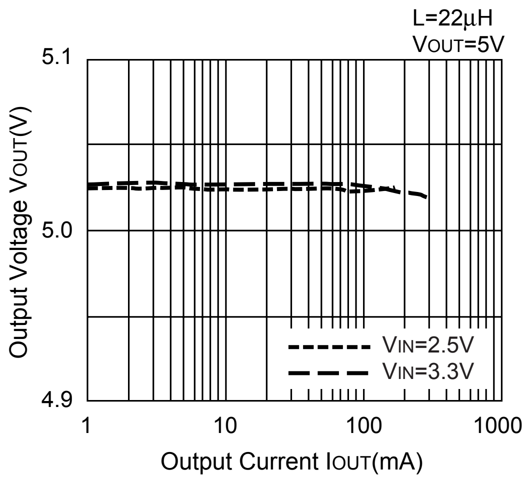
R1211x002B



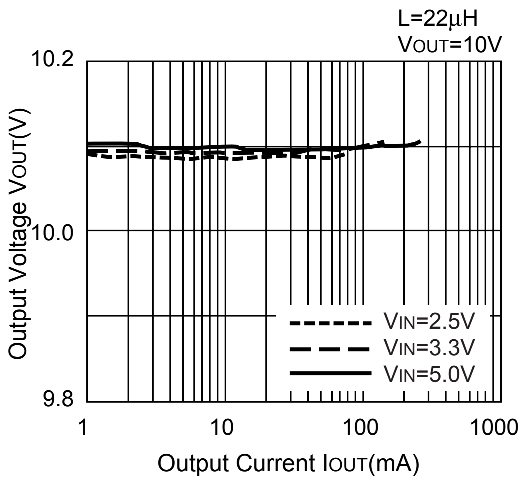
R1211x002B



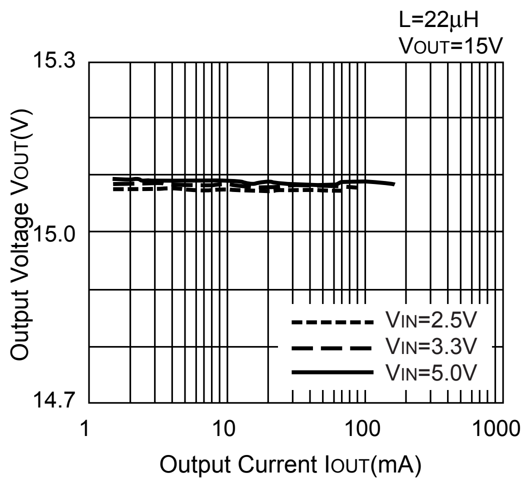
R1211x002D



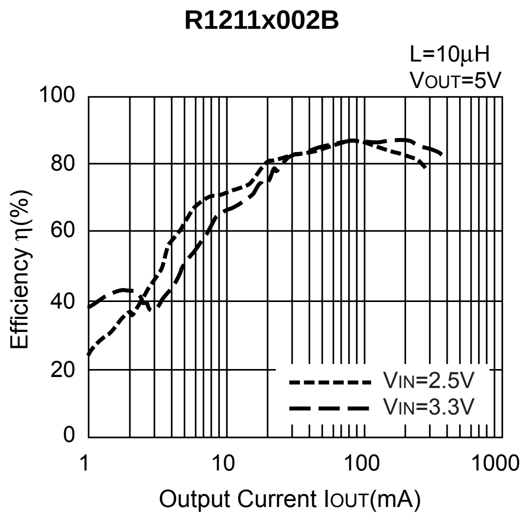
R1211x002D

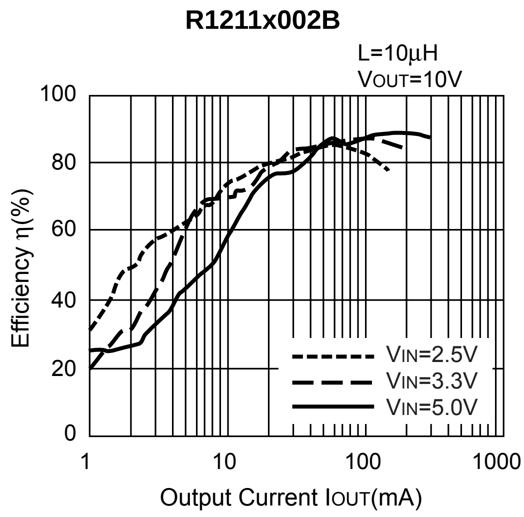


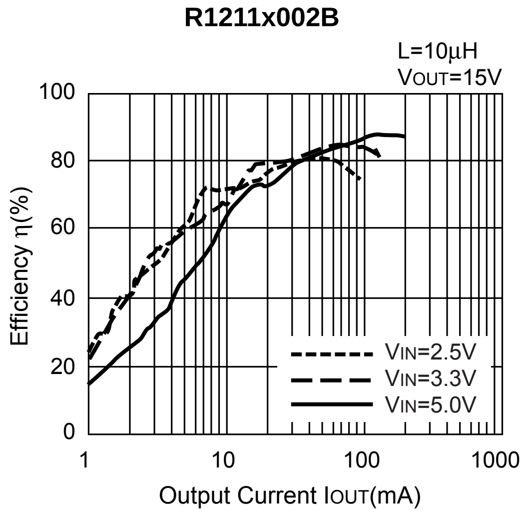
R1211x002D

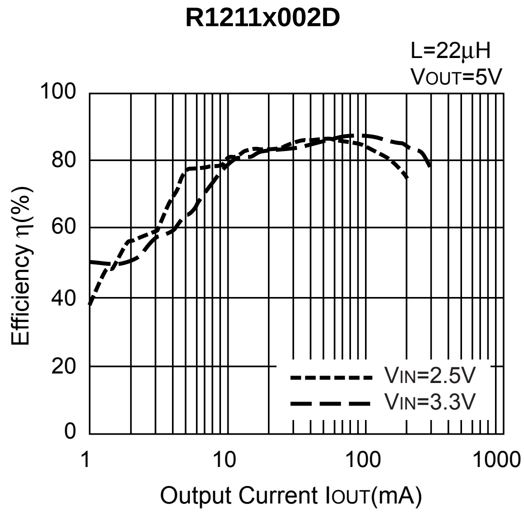


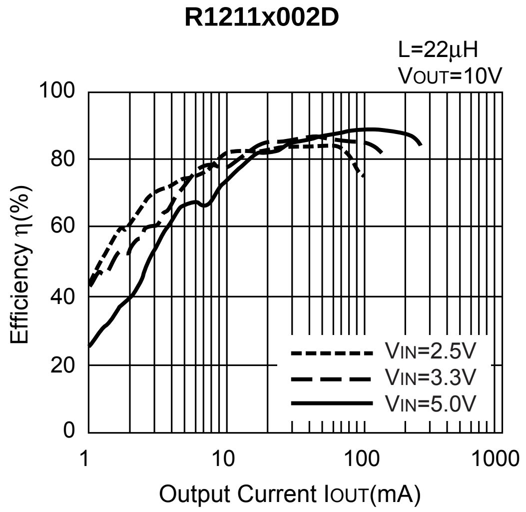
2) Efficiency vs. Output Current

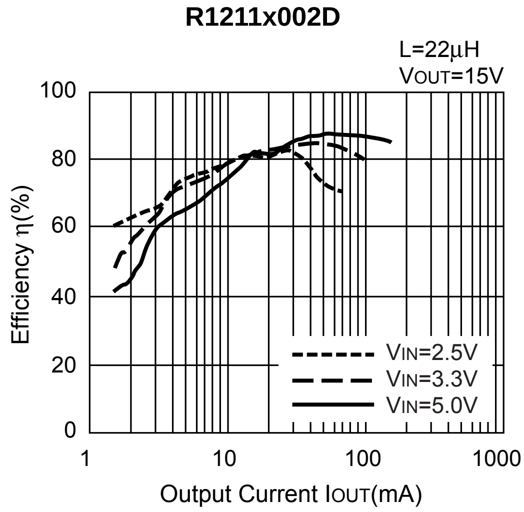






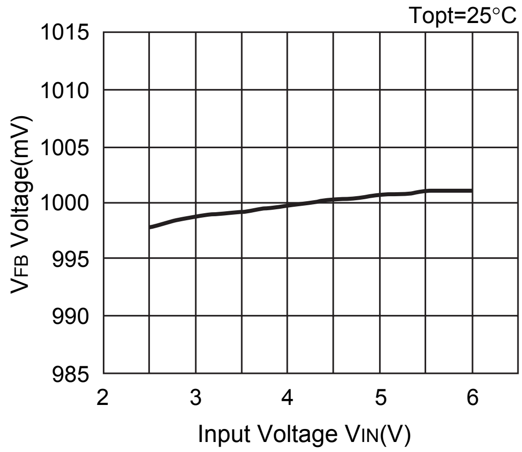






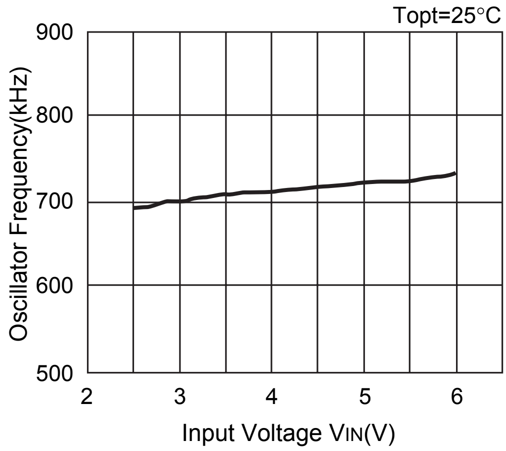
3) V_{FB} Voltage vs. Input Voltage (Ta=25°C)

R1211x002x

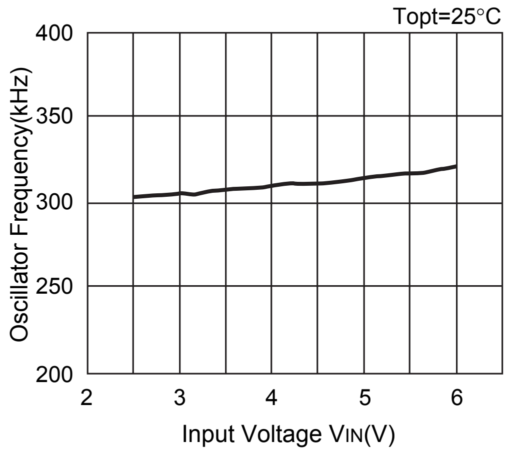


4) Oscillator Frequency vs. Input Voltage (Ta=25°C)

R1211x002B

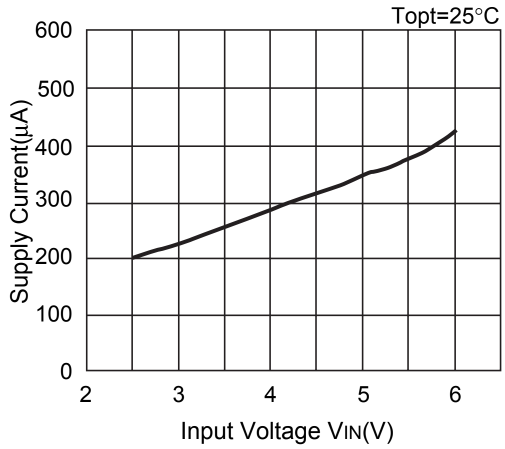


R1211x002D

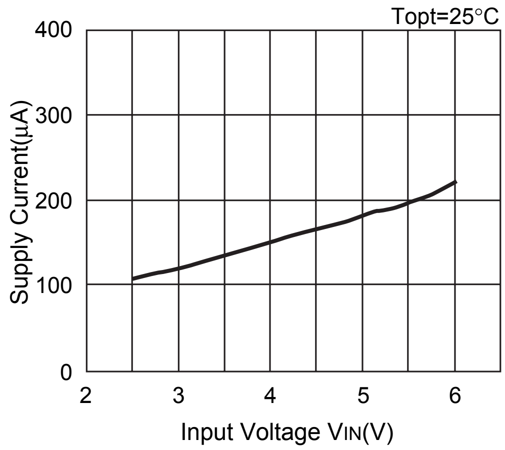


5) Supply Current vs. Input Voltage (Ta=25°C)

R1211x002B

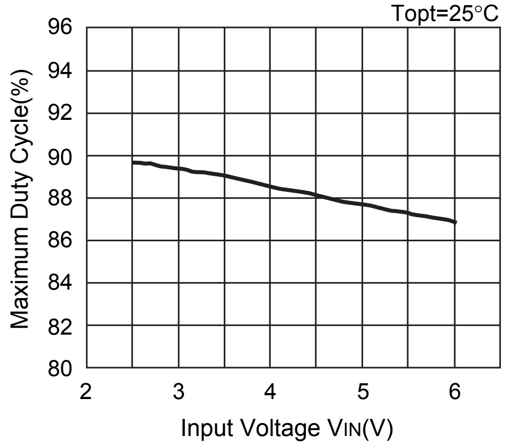


R1211x002D

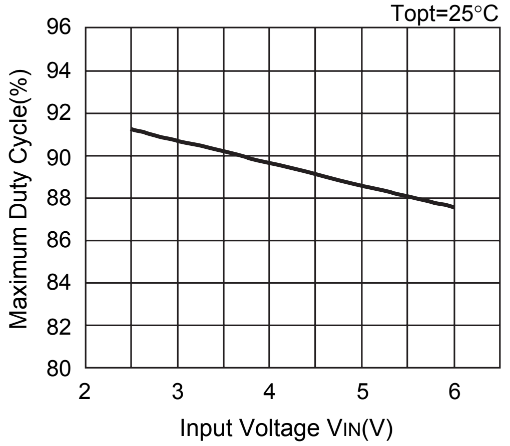


6) Maximum Duty Cycle vs. Input Voltage (Ta=25°C)

R1211x002B

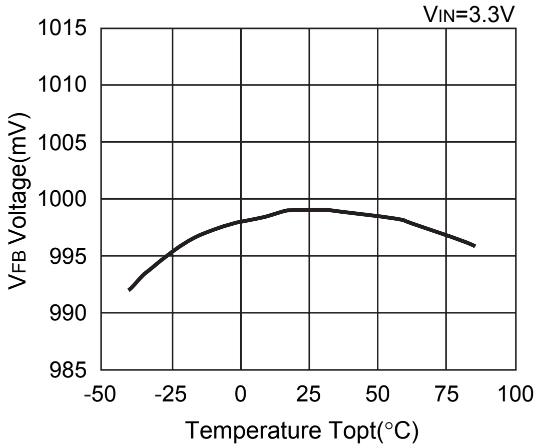


R1211x002D



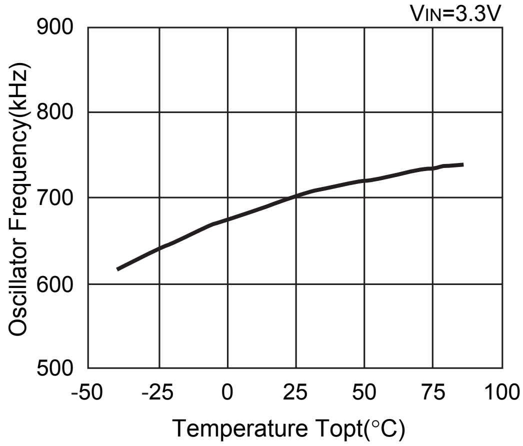
7) V_{FB} Voltage vs. Temperature

R1211x002x

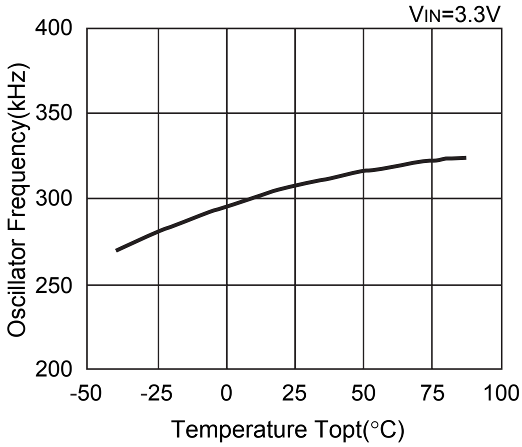


8) Oscillator Frequency vs. Temperature

R1211x002B

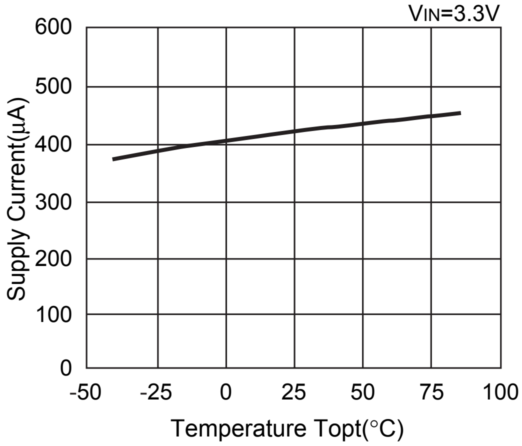


R1211x002D

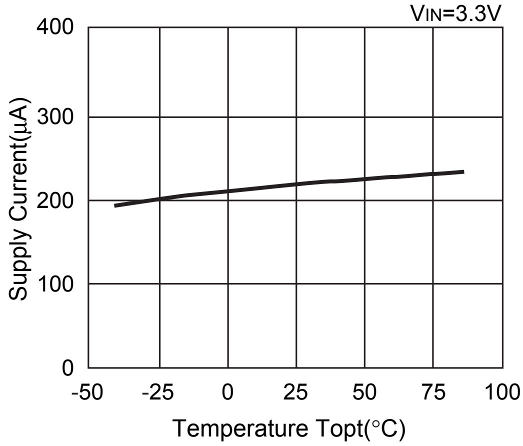


9) Supply Current vs. Temperature

R1211x002B

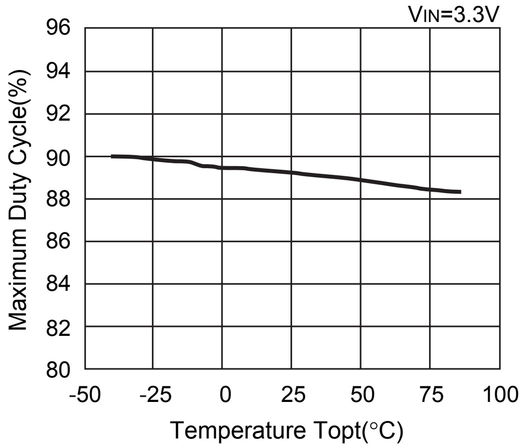


R1211x002D

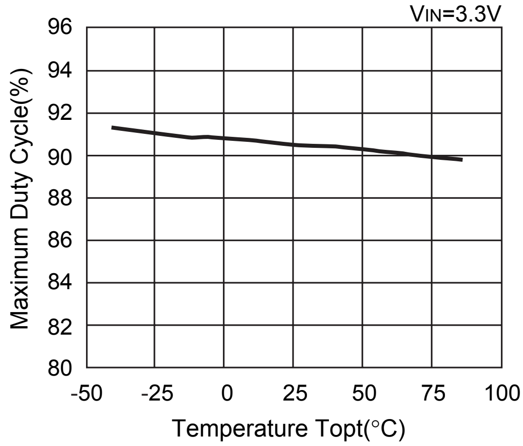


10) Maximum Duty Cycle vs. Temperature

R1211x002B

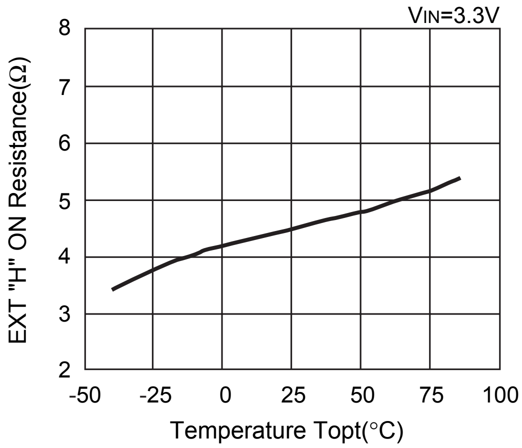


R1211x002D



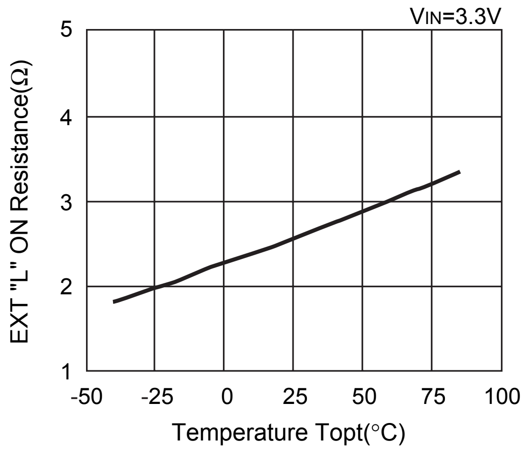
11) EXT "H" On Resistance vs. Temperature

R1211x002x



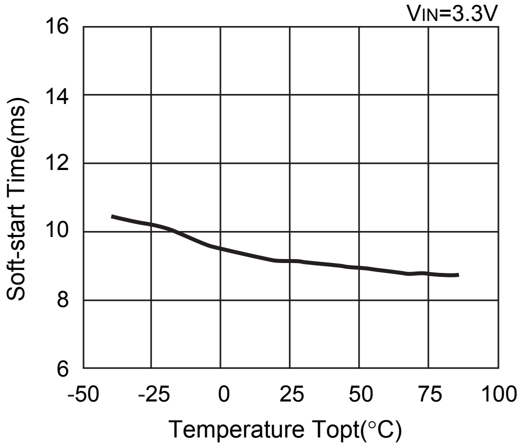
12) EXT "L" On Resistance vs. Temperature

R1211x002x

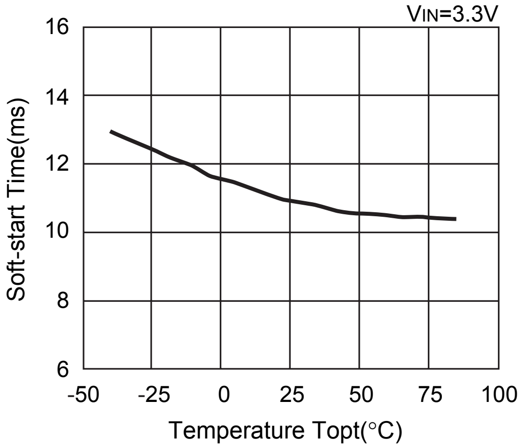


13) Soft-start Time vs. Temperature

R1211x002B

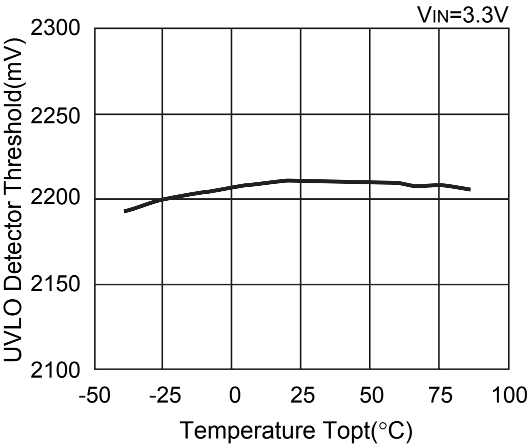


R1211x002D



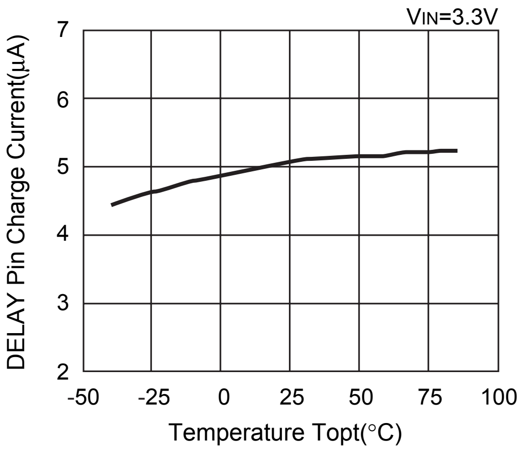
14) UVLO Detector Threshold vs. Temperature

R1211x002x

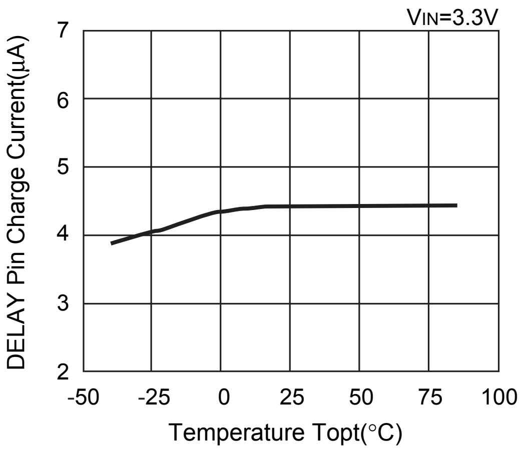


15) DELAY Pin Charge Current vs. Temperature

R1211x002B

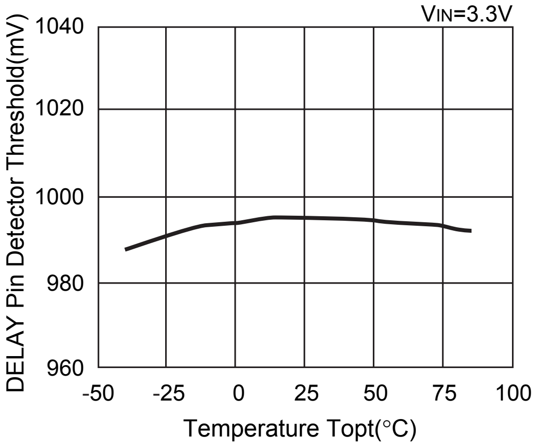


R1211x002D



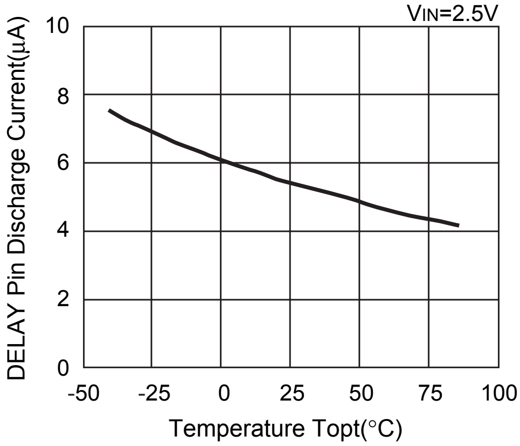
16) DELAY Pin Detector Threshold vs. Temperature

R1211x002x



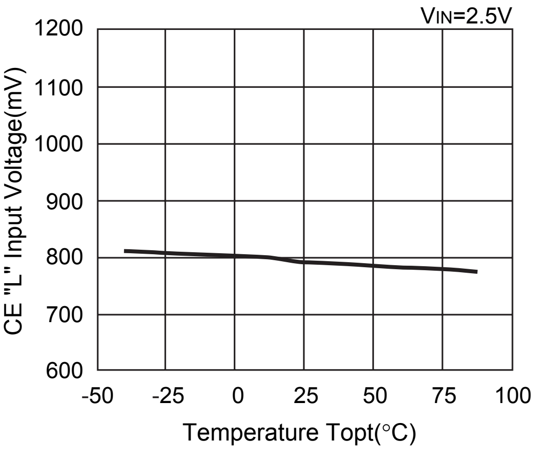
17) DELAY Pin Discharge Current vs. Temperature

R1211x002x



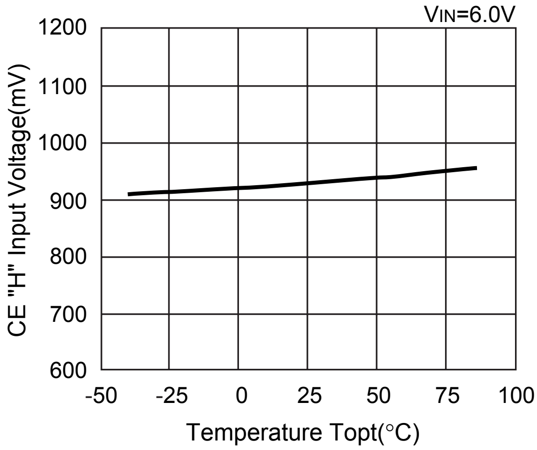
18) CE "L" Input Voltage vs. Temperature

R1211x002B/D



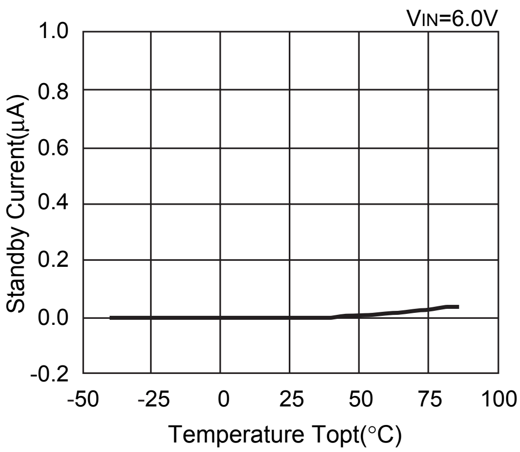
19) CE "H" Input Voltage vs. Temperature

R1211x002B/D

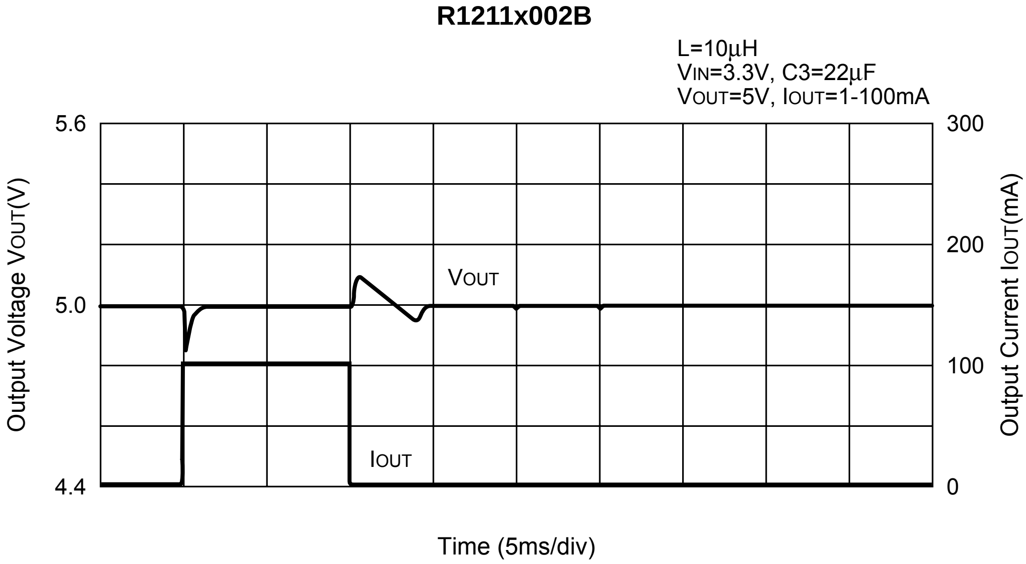


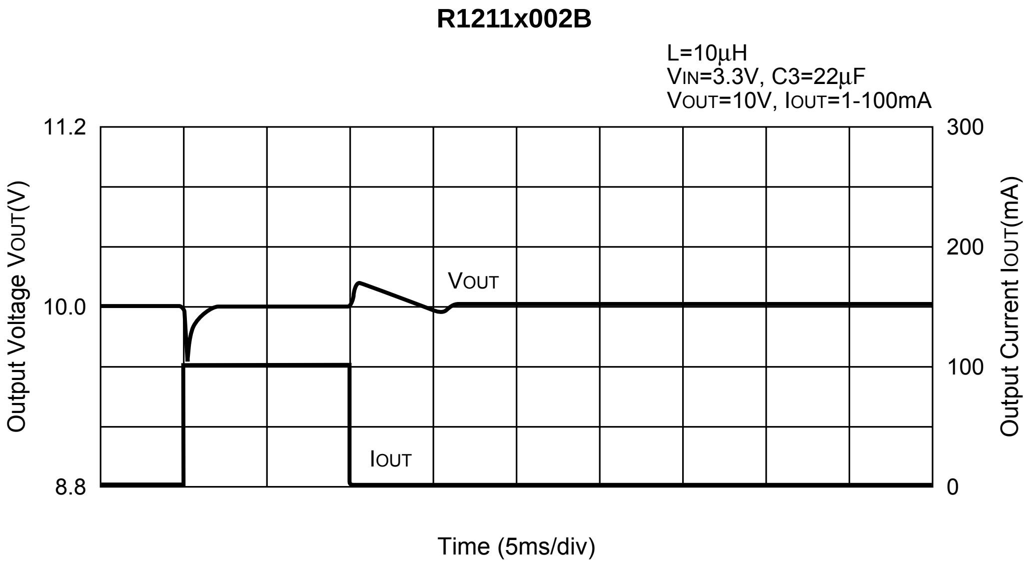
20) Standby Current vs. Temperature

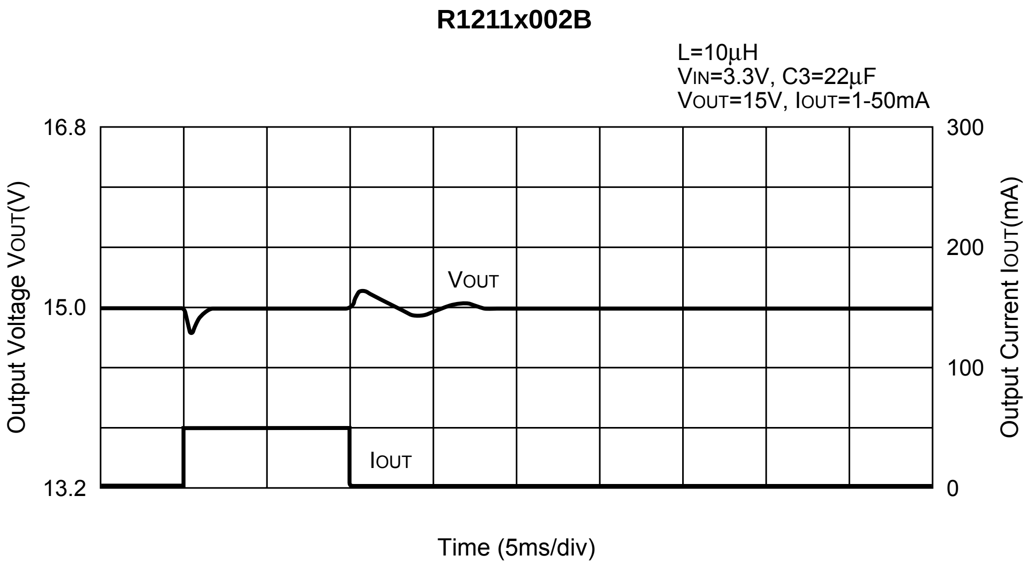
R1211x002B/D



21) Load Transient Response

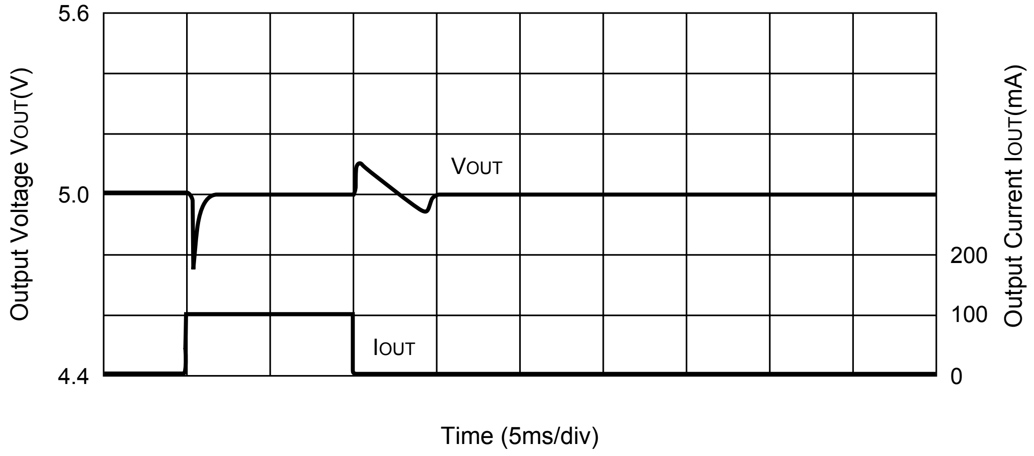






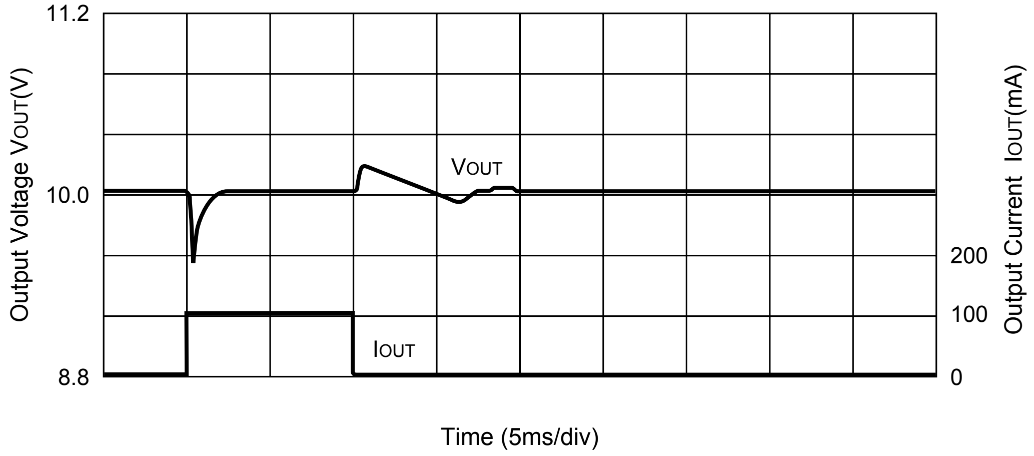
R1211x002D

L=22µH
V_{IN}=3.3V, C3=22µF
V_{OUT}=5V, I_{OUT}=1-100mA



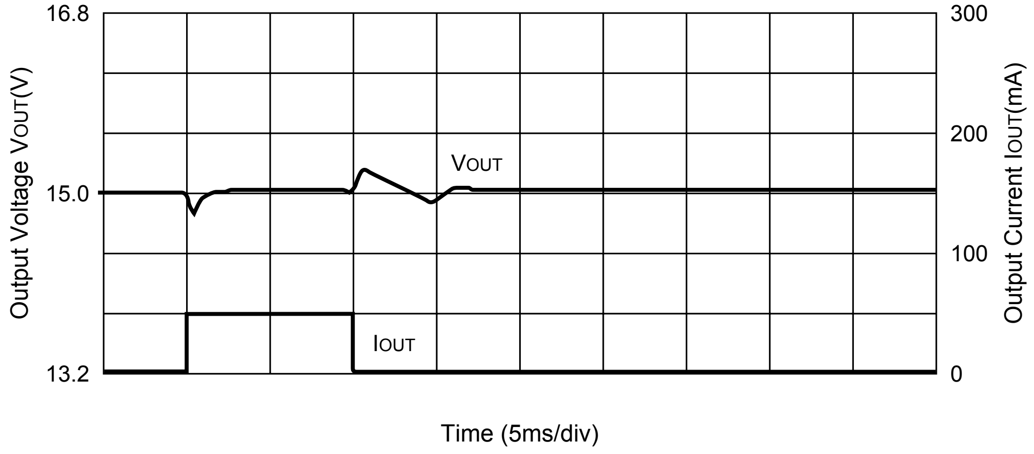
R1211x002D

L=22µH
V_{IN}=3.3V, C3=22µF
V_{OUT}=10V, I_{OUT}=1-100mA



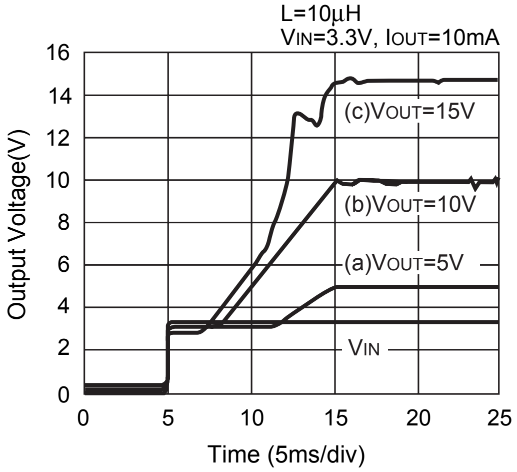
R1211x002D

L=22µH
V_{IN}=3.3V, C3=22µF
V_{OUT}=15V, I_{OUT}=1-50mA

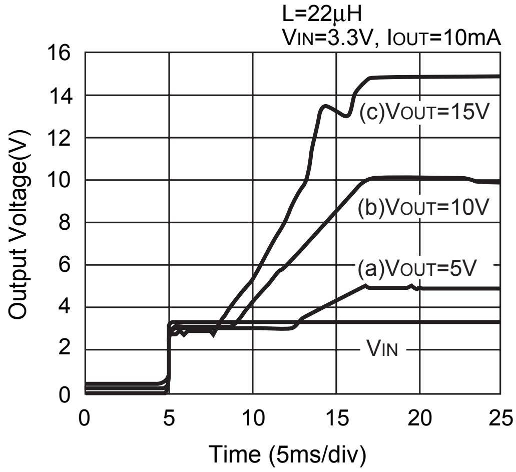


22) Power-on Response

R1211x002B

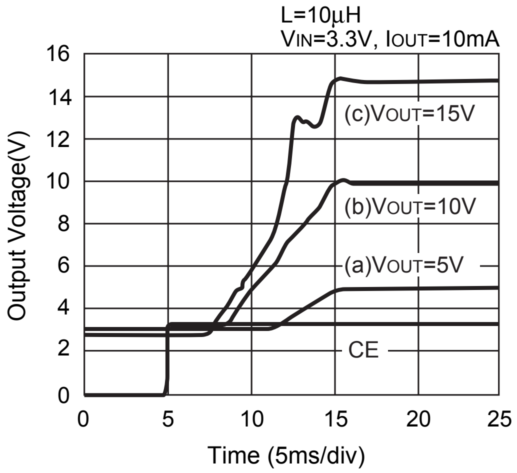


R1211x002D

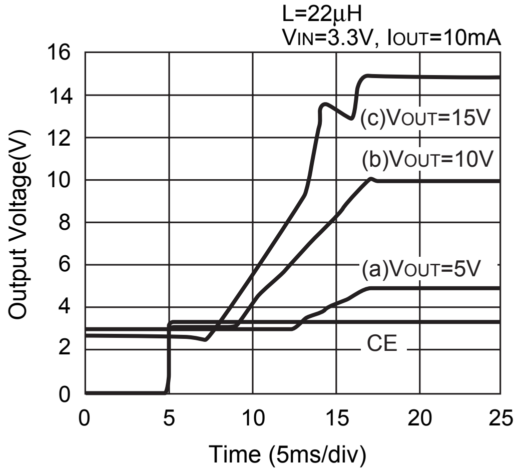


23) Turn-on speed with CE pin

R1211x002B



R1211x002D



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