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## R1230D Series

## ■ OUTLINE

The R1230D Series are PWM step-down DC/DC Converters with synchronous rectifier, low supply current by CMOS process.

Each of these ICs consists of an oscillator, a PWM control circuit, a reference voltage unit, an error amplifier, a soft-start circuit, protection circuits, a protection against miss operation under low voltage (UVLO), PWM/VFM alternative circuit, a chip enable circuit, and a driver transistor. A low ripple, high efficiency step-down DC/DC converter can be easily composed of this IC with only a few kinds of external components, or an inductor and capacitors. (As for R1230D001C/D types, divider resistors are also necessary.) In terms of Output Voltage, it is fixed internally in the R1230DXX1A/B types. While in the R1230D001C/D types, Output Voltage is adjustable with external divider resistors.

PWM/VFM alternative circuit is active with Mode Pin of the R1230D Series. Thus, when the load current is small, the operation can be switching into the VFM operation from PWM operation by the logic of MODE pin and the efficiency at small load current can be improved. As protection circuits, Current Limit circuit which limits peak current of Lx at each clock cycle, and Latch type protection circuit which works if the term of Over-current condition keeps on a certain time in PWM mode exist. Latch-type protection circuit works to latch an internal driver with keeping it disable. To release the condition of protection, after disable this IC with a chip enable circuit, enable it again, or restart this IC with power-on or make the supply voltage at UVLO detector threshold level or lower than UVLO.

## ■ FEATURES

- Built-in Driver ON Resistance • • • • • • • • • • • • • • P-channel 0.35Ω, N-channel 0.45Ω (at $V_{IN}$=3V)
- Built-in Soft-start Function (TYP. 1.5ms), and Latch-type Protection Function (Delay Time; TYP. 1.5ms)
- Two choices of Oscillator Frequency • • • • • • 500kHz, 800kHz
- PWM/VFM alternative with MODE pin • • • • • • PWM operation; MODE pin at "L",
  VFM operation; MODE pin at "H"
- High Efficiency • • • • • • • • • • • • • • • • • • TYP. 90%
- Output Voltage • • • • • • • • • •Stepwise Setting with a step of 0.1V in the range of 1.2V ~ 4.0V(XX1A/B Type)
  or adjustable in the range of 0.8V to $V_{IN}$(001C/D Type)
- High Accuracy Output Voltage • • • • • • • • • •±2.0%(XX1A/B Type)
- Package • • • • • SON8 (Max height 0.9mm, thin type)
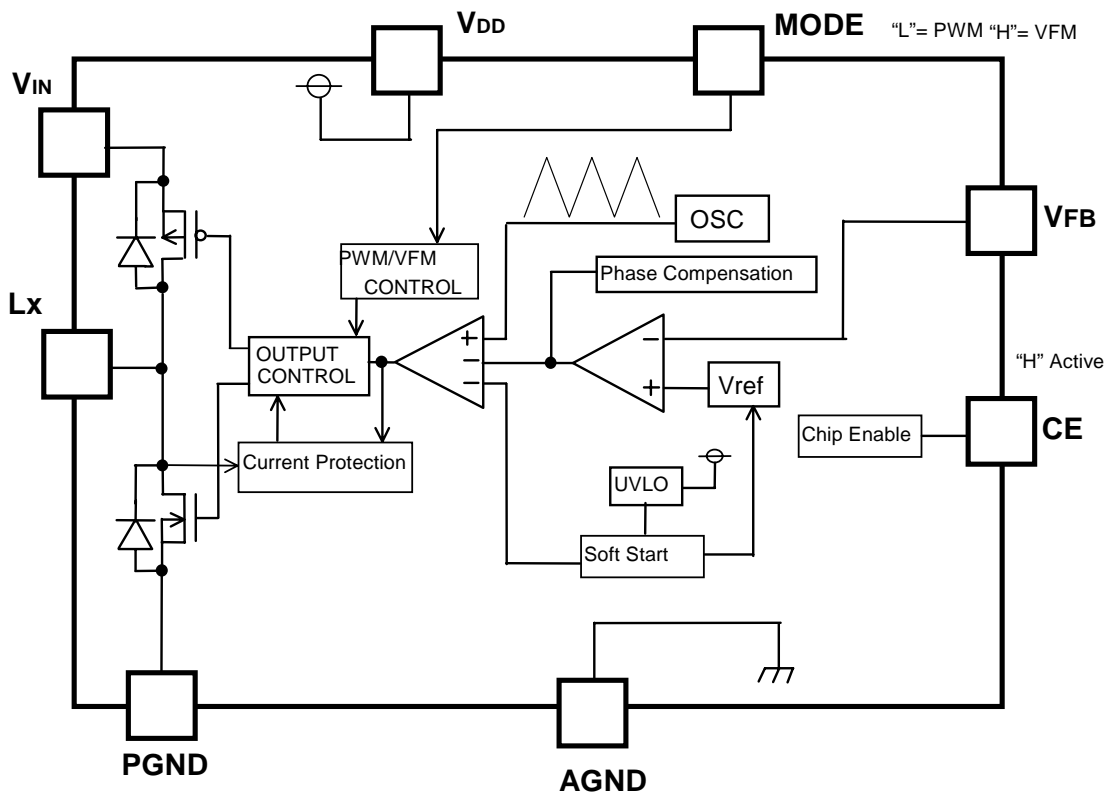
## ■ APPLICATIONS

- Power source for portable equipment.

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# ■ BLOCK DIAGRAM

● R1230DXX1A/B
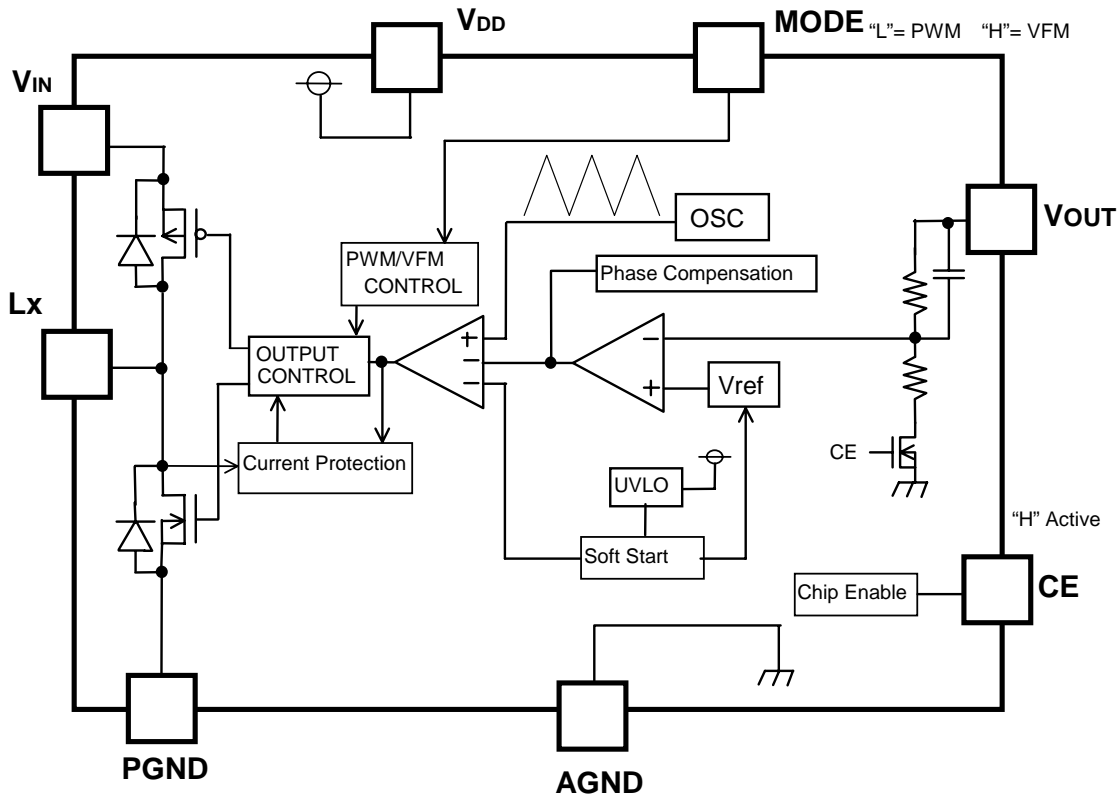


● R1230D001C/D

## ■ SELECTION GUIDE

In the R1230D Series, the output voltage, the oscillator frequency, and the taping type for the ICs can be selected at the user's request.

The selection can be made by designating the part number as shown below;

R1230DXXXX-XX

   ↑ ↑↑ ↑

   a  b c  d

| Code | Contents |
|------|----------|
| a | Setting Output Voltage(V$_{OUT}$):<br>Stepwise setting with a step of 0.1V in the range of 1.2V to 4.0V is possible for A/B version.<br>"00" is for Output Voltage Adjustable C/D version |
| b | 1 : fixed |
| c | Designation of Optional Function<br>A : 500kHz, Fixed Output Voltage<br>B : 800 kHz, Fixed Output Voltage<br>C : 500kHz, Adjustable Output Voltage<br>D : 800kHz, Adjustable Output Voltage |
| d | Designation of Taping Type;   Ex. :TR,TL(refer to Taping Specification)<br>"TR" is prescribed as a standard. |

## ■ PIN CONFIGURATION

● SON-8
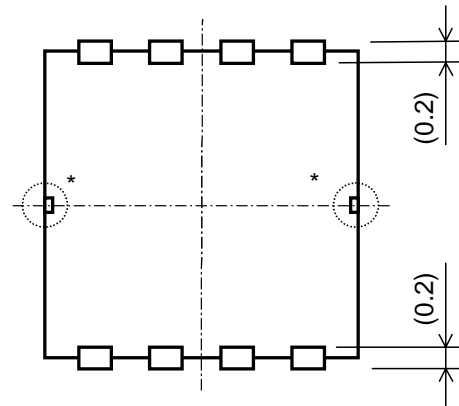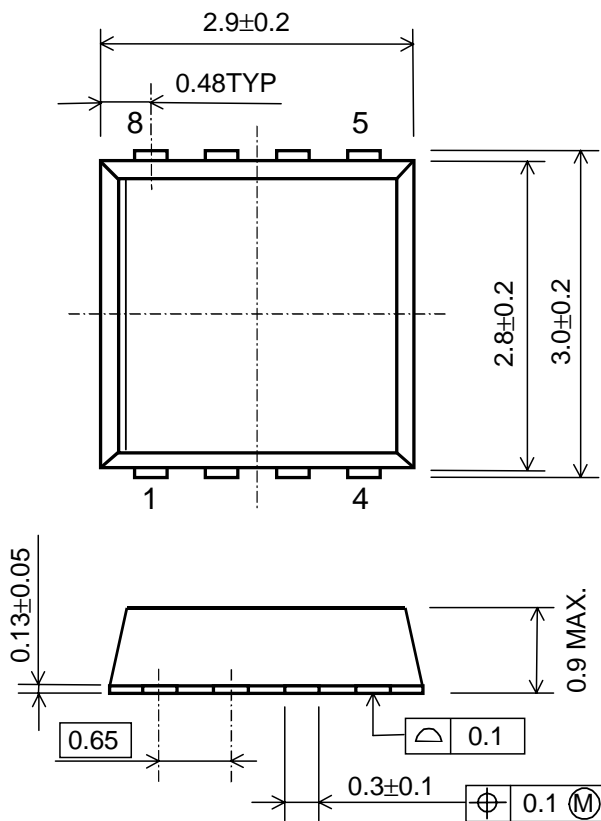


*Attention : Tab suspension leads in the ◯ parts have GND level. (They are connected to the reverse side of this IC.) Do not connect to other wires or land patterns.

Unit : mm

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# ■ PIN DESCRIPTION

| Pin No. | Symbol | Description |
|---|---|---|
| 1 | $V_{IN}$ | Voltage Supply Pin |
| 2 | PGND | Ground Pin |
| 3 | $V_{DD}$ | Voltage Supply Pin |
| 4 | CE | Chip Enable Pin (active with "H") |
| 5 | $V_{OUT}/V_{FB}$ | Output/Feedback Pin |
| 6 | MODE | Mode changer Pin (PWM mode at "L", VFM mode at "H".) |
| 7 | AGND | Ground Pin |
| 8 | Lx | Lx Pin |

# ■ ABSOLUTE MAXIMUM RATINGS

(AGND=PGND=0V)

| Symbol | Item | Rating | Unit |
|---|---|---|---|
| $V_{IN}$ | $V_{IN}$ Supply Voltage | 6.5 | V |
| $V_{DD}$ | $V_{DD}$ Pin Voltage | 6.5 | V |
| $V_{LX}$ | Lx Pin Voltage | $-0.3 \sim V_{IN}+0.3$ | V |
| $V_{CE}$ | CE Pin Input Voltage | $-0.3 \sim V_{IN}+0.3$ | V |
| $V_{MODE}$ | MODE Pin Input Voltage | $-0.3 \sim V_{IN}+0.3$ | V |
| $V_{FB}$ | $V_{FB}$ Pin Input Voltage | $-0.3 \sim V_{IN}+0.3$ | V |
| $I_{LX}$ | Lx Pin Output Current | -0.8 | A |
| $P_D$ | Power Dissipation | 250 | mW |
| Topt | Operating Temperature Range | $-40 \sim +85$ | °C |
| Tstg | Storage Temperature Range | $-55 \sim +125$ | °C |

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## ■ ELECTRICAL CHARACTERISTICS

● R1230D\*\*1A/B                                                                                                         (Topt=25°C)

| Symbol | Item | Conditions | MIN. | TYP. | MAX. | Unit |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Operating Input Voltage | | 2.4 | | 5.5 | V |
| $V_{OUT}$ | Step-down Output Voltage | $V_{IN}=V_{CE}=V_{SET}+1.5V$, $V_{MODE}=0V$, $I_{OUT}=10mA$ | TYP.× 0.980 | $V_{SET}$ | TYP.× 1.020 | V |
| $\Delta V_{OUT}/\Delta T$ | Step-down Output Voltage Temperature Coefficient | -40°C ≤ Topt ≤ 85°C | | ±150 | | ppm /°C |
| fosc | Oscillator Frequency(xx1A) | $V_{IN}=V_{CE}=V_{SET}+1.5V$ | 425 | 500 | 575 | kHz |
| fosc | Oscillator Frequency(xx1B) | $V_{IN}=V_{CE}=V_{SET}+1.5V$ | 680 | 800 | 920 | kHz |
| $I_{DD}$ | Supply Current(xx1A) | $V_{IN}=V_{CE}=V_{SET}+1.5V$, $V_{OUT}=V_{MODE}=0V$ | | 230 | 300 | μA |
| $I_{DD}$ | Supply Current(xx1B) | $V_{IN}=V_{CE}=V_{SET}+1.5V$, $V_{OUT}=V_{MODE}=0V$ | | 250 | 350 | μA |
| $I_{stb}$ | Standby Current | $V_{IN}=5.5V$, $V_{CE}=V_{OUT}=0V$ | | 0 | 5 | μA |
| $R_{ONP}$ | ON Resistance of Pch Transistor | $V_{IN}=5.0V$ | 0.20 | 0.35 | 0.60 | Ω |
| $R_{ONN}$ | ON Resistance of Nch Transistor | $V_{IN}=5.0V$ | 0.20 | 0.45 | 0.70 | Ω |
| $I_{LXleak}$ | Lx Leakage Current | $V_{IN}=5.5V$, $V_{CE}=0V$, $V_{LX}=0V/5.5V$ | -0.1 | 0.0 | 0.1 | μA |
| $I_{VOUT}$ | $V_{OUT}$ Leakage Current | $V_{IN}=5.5V$, $V_{CE}=0V$, $V_{LX}=0V/5.5V$ | -0.1 | 0.0 | 0.1 | μA |
| $I_{CE}$ | CE Input Current | $V_{IN}=5.5V$, $V_{MODE}=0V$, $V_{CE}=5.5V/0V$ | -0.1 | 0.0 | 0.1 | μA |
| $V_{CEH}$ | CE "H" Input Voltage | $V_{IN}=5.5V$, $V_{OUT}=0V$ | 1.5 | | | V |
| $V_{CEL}$ | CE "L" Input Voltage | $V_{IN}=2.4V$, $V_{OUT}=0V$ | | | 0.3 | V |
| Maxdty | Oscillator Maximum Duty Cycle | $V_{MODE}=0V$ | 100 | | | % |
| $V_{LX}$ | Lx Limit Voltage | $V_{MODE}=V_{OUT}=0V$, $V_{IN}=V_{CE}=3.0V$ | $V_{IN}$-0.15 | $V_{IN}$-0.35 | $V_{IN}$-0.55 | V |
| $T_{start}$ | Delay Time by Soft-Start function | at no load, $V_{IN}=V_{CE}=V_{SET}+1.5V$ | 0.5 | 1.5 | 2.5 | ms |
| $T_{prot}$ | Delay Time for protection circuit | $V_{IN}=V_{CE}=V_{SET}+1.5V$, $V_{MODE}=0V$ | 0.5 | 1.5 | 2.5 | ms |
| $V_{UVLO1}$ | UVLO Threshold Voltage | $V_{IN}=V_{CE}=2.5V->1.5V$, $V_{OUT}=0V$ | 1.8 | 2.1 | 2.2 | V |
| $V_{UVLO2}$ | UVLO Released Voltage | $V_{IN}=V_{CE}=1.5V->2.5V$, $V_{OUT}=0V$ | 1.9 | 2.2 | 2.3 | V |
| $I_{MODE}$ | MODE Pin Input Current | $V_{IN}=5.5V$, $V_{CE}=0V$, $V_{MODE}=5.5V/0V$ | -0.1 | | 0.1 | μA |
| $V_{MODEH}$ | MODE "H" Input Voltage | $V_{IN}=V_{CE}=5.5V$, $V_{OUT}=0V$ | 1.5 | | | V |
| $V_{MODEL}$ | MODE "L" Input Voltage | $V_{IN}=V_{CE}=2.4V$, $V_{OUT}=0V$ | | | 0.3 | V |
| VFMdty | VFM Duty Cycle | $V_{IN}=V_{CE}=V_{MODE}=2.4V$, $V_{OUT}=0V$ | 55 | 65 | 85 | % |

| Symbol | Item | Conditions | MIN. | TYP. | MAX. | Unit |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Operating Input Voltage | | 2.4 | | 5.5 | V |
| $V_{FB}$ | Feedback Voltage | $V_{IN}=V_{CE}=V_{SET}+1.5V$, $V_{MODE}=0V$, $I_{OUT}=10mA$ | 0.776 | 0.800 | 0.824 | V |
| $\Delta V_{FB}/\Delta T$ | Feedback Voltage Temperature Coefficient | $-40°C \leq Topt \leq 85°C$ | | ±150 | | ppm/°C |
| fosc | Oscillator Frequency(xx1C) | $V_{IN}=V_{CE}=V_{SET}+1.5V$ | 425 | 500 | 575 | kHz |
| fosc | Oscillator Frequency(xx1D) | $V_{IN}=V_{CE}=V_{SET}+1.5V$ | 680 | 800 | 920 | kHz |
| $I_{DD}$ | Supply Current(xx1C) | $V_{IN}=V_{CE}=5.5V$, $V_{FB}=V_{MODE}=0V$ | | 230 | 300 | μA |
| $I_{DD}$ | Supply Current(xx1D) | $V_{IN}=V_{CE}=5.5V$, $V_{FB}=V_{MODE}=0V$ | | 250 | 350 | μA |
| $I_{stb}$ | Standby Current | $V_{IN}=5.5V$, $V_{CE}=V_{FB}=0V$ | | 0 | 5 | μA |
| $R_{ONP}$ | ON Resistance of Pch Transistor | $V_{IN}=5.0V$ | 0.20 | 0.35 | 0.60 | Ω |
| $R_{ONN}$ | ON Resistance of Nch Transistor | $V_{IN}=5.0V$ | 0.20 | 0.45 | 0.70 | Ω |
| $I_{LXleak}$ | Lx Leakage Current | $V_{IN}=5.5V$, $V_{CE}=0V$, $V_{LX}=0V/5.5V$ | -0.1 | 0.0 | 0.1 | μA |
| $I_{VFB}$ | $V_{FB}$ Leakage Current | $V_{IN}=5.5V$, $V_{CE}=0V$, $V_{FB}=0V/5.5V$ | -0.1 | 0.0 | 0.1 | μA |
| $I_{CE}$ | CE Input Current | $V_{IN}=5.5V$, $V_{MODE}=0V$, $V_{CE}=5.5V/0V$ | -0.1 | 0.0 | 0.1 | μA |
| $V_{CEH}$ | CE "H" Input Voltage | $V_{IN}=5.5V$, $V_{FB}=0V$ | 1.5 | | | V |
| $V_{CEL}$ | CE "L" Input Voltage | $V_{IN}=2.4V$, $V_{FB}=0V$ | | | 0.3 | V |
| Maxdty | Oscillator Maximum Duty Cycle | $V_{MODE}=0V$ | 100 | | | % |
| $V_{LX}$ | Lx Limit Voltage | $V_{IN}=V_{CE}=3.0V$, $V_{MODE}=0V$, $V_{FB}=0V$ | $V_{IN}$-0.15 | $V_{IN}$-0.35 | $V_{IN}$-0.55 | V |
| $T_{start}$ | Delay Time by Soft-Start function | at no load, $V_{IN}=V_{CE}=V_{SET}+1.5V$ | 0.5 | 1.5 | 2.5 | ms |
| $T_{prot}$ | Delay Time for protection circuit | $V_{IN}=V_{CE}=3.6V$, $V_{MODE}=0V$ | | 1.5 | | ms |
| $V_{UVLO1}$ | UVLO Threshold Voltage | $V_{IN}=V_{CE}=2.5V->1.5V$, $V_{FB}=0V$ | 1.8 | 2.1 | 2.2 | V |
| $V_{UVLO2}$ | UVLO Released Voltage | $V_{IN}=V_{CE}=1.5V->2.5V$, $V_{FB}=0V$ | 1.9 | 2.2 | 2.3 | V |
| $I_{MODE}$ | MODE Pin Input Current | $V_{IN}=5.5V$, $V_{MODE}=5.5V/0V$, $V_{CE}=0V$ | -0.1 | | 0.1 | μA |
| $V_{MODE}$ | MODE "H" Input Voltage | $V_{IN}=V_{CE}=5.5V$, $V_{FB}=0V$ | 1.5 | | | V |
| $V_{MODEL}$ | MODE "L" Input Voltage | $V_{IN}=V_{CE}=2.4V$, $V_{FB}=0V$ | | | 0.3 | V |
| VFMdty | VFM Duty Cycle | $V_{IN}=V_{CE}=V_{MODE}=2.4V$, $V_{FB}=0V$ | 55 | 65 | 85 | % |

# ■ TEST CIRCUITS
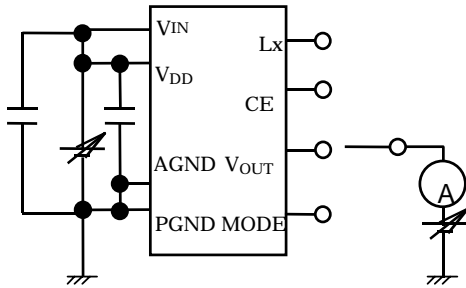


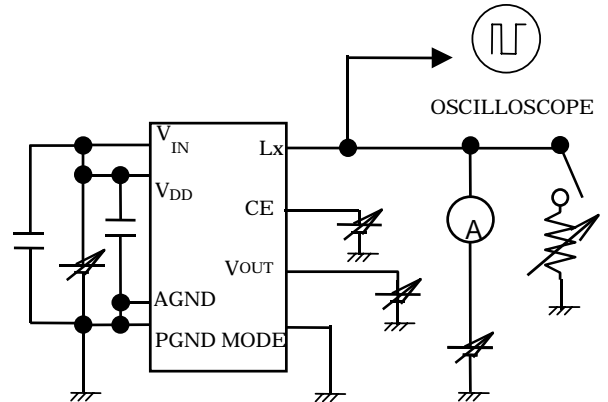Test Circuit for Input Current and Leakage Current
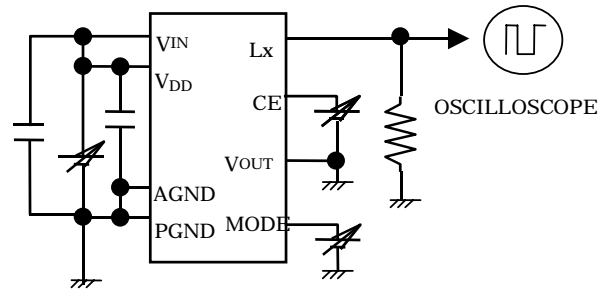


Test Circuit for Input Voltage and UVLO voltage
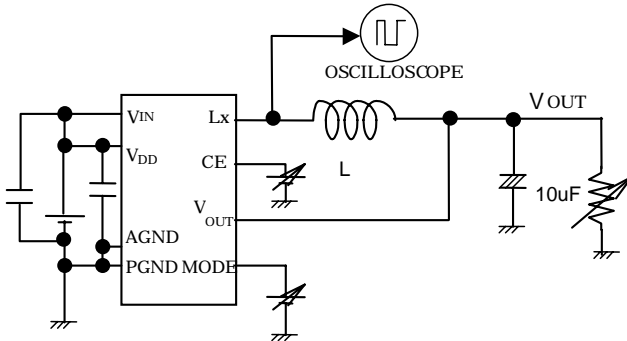


Test Circuit for Output Voltage, Oscillator Frequency, Soft-Starting Time
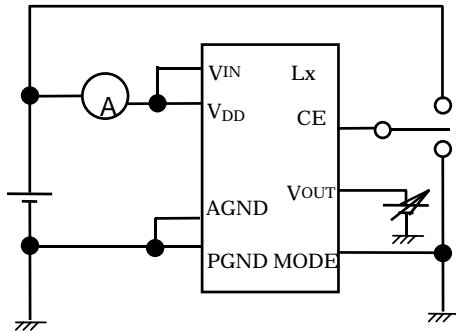


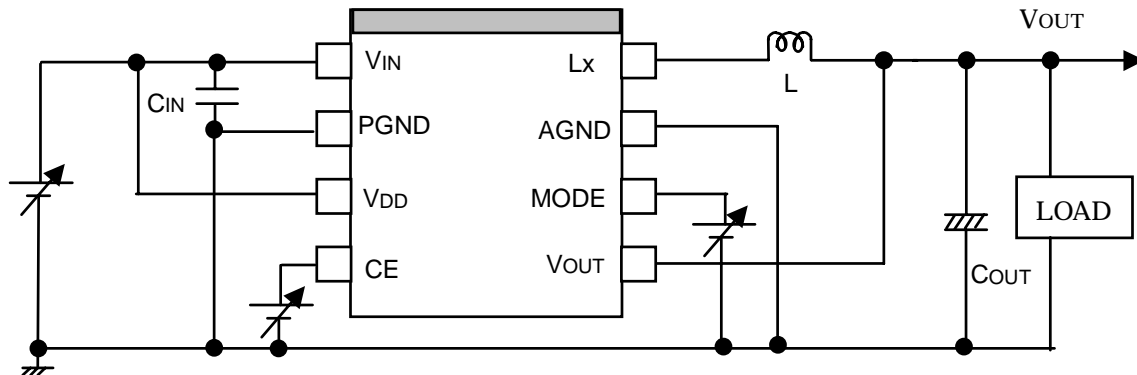Test Circuit for Supply Current and Standby Current



Test Circuit for ON resistance of Lx, Limit Voltage, Delay Time of Protection Circuit

The bypass capacitor between Power Supply and GND is Ceramic capacitor 10μF.
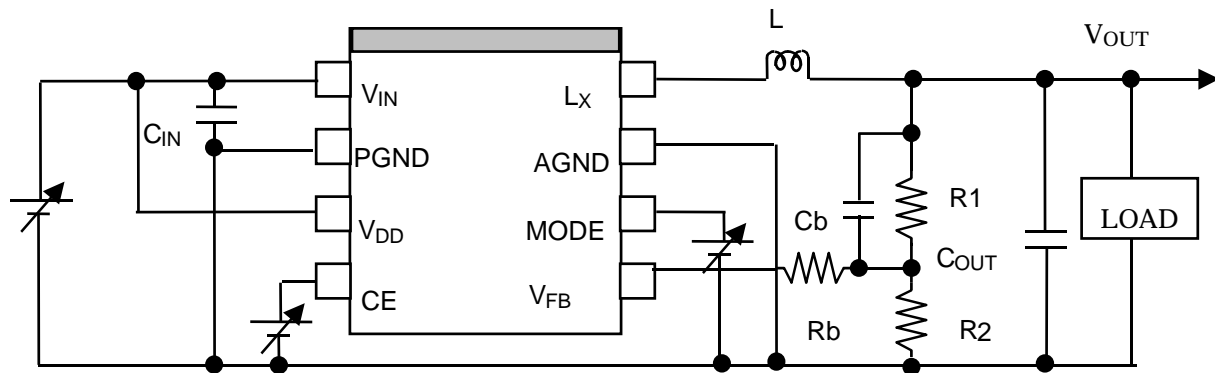
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## ■ TYPICAL APPLICATION AND TECHNICAL NOTES

1) Fixed Output Voltage Type



L    : 10μH LQH3C100K54(Murata)
COUT : 10μF ECSTOJX106R(Panasonic)
CIN   : 10μF C3216JB0J106M(TDK)

2) Adjustable Output Voltage Type



L:           10μH LQH3C100K54 (Murata)
COUT:        10μF ECSTOJX106R (Panasonic)
CIN:         10μF C3216JB0J106M (TDK)

Standard value of the sum of Divider Resistors, R1+R2 is as much as 100kΩ.
Cb value for phase compensation depends on values of L, C, and R1. Refer to the technical notes.
If a ceramic capacitor is used as an output capacitor, add 0.2Ω or more resistance to compensate the ESR of the capacitor.

When you use these ICs, consider the following issues;

● Input same voltage into Power Supply pins, VIN and VDD. Set the same level as AGND and PGND.
● When you control the CE pin and MODE pin by another power supply, do not make its "H" level more than the voltage level of VIN / VDD pin.
● Set external components such as an inductor, CIN, COUT as close as possible to the IC, in particular, minimize the wiring to VIN pin and PGND pin.
● At stand by mode, (CE="L"), the Lx output is Hi-Z, or both P-channel transistor and N-channel transistor of Lx pin turn off.
● Use an external capacitor COUT with a capacity of 10μF or more, and with good high frequency characteristics such as tantalum capacitors.
● At VFM mode, (MODE="H"), Latch protection circuit does not operate.

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- If the mode is switched over into PWM mode from VFM mode during the operation, change the mode at light load current. If the load current us large, output voltage may decline.
- Reinforce the V$_{IN}$, PGND, and V$_{OUT}$ lines sufficiently. Large switching current may flow in these lines. If the impedance of V$_{IN}$ and PGND lines is too large, the internal voltage level in this IC may shift caused by the switching current, and the operation might be unstable.

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

## ■ OPERATION of step-down DC/DC converter and Output Current

The step-down DC/DC converter charges energy in the inductor when Lx transistor is ON, and discharges the energy from the inductor when Lx transistor is OFF and controls with less energy loss, so that a lower output voltage than the input voltage is obtained. The operation will be explained with reference to the following diagrams:

**&lt;Basic Circuits&gt;**  **&lt;Current through L&gt;**
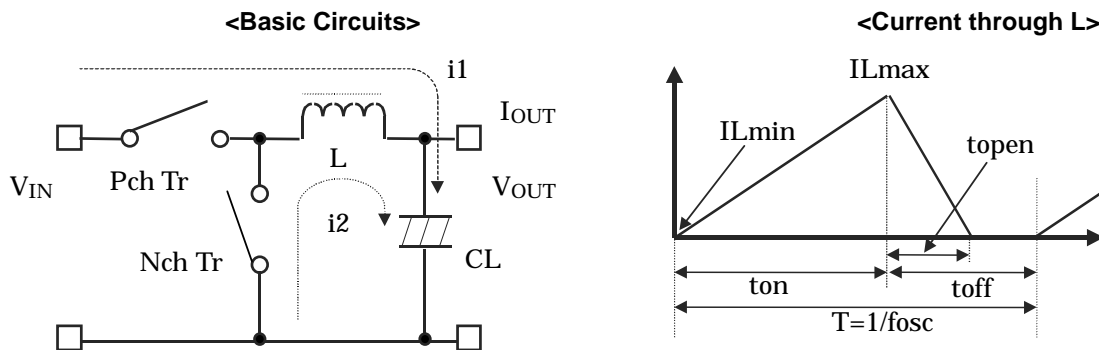


Step 1:  P-channel Tr. turns on and current IL (=i1) flows, and energy is charged into CL. At this moment, IL increases from ILmin(=0) to reach ILmax in proportion to the on-time period(ton) of P-channel Tr.
Step 2:  When P-channel Tr. turns off, Synchronous rectifier N-channel Tr. turns on in order that L maintains IL at ILmax, and current IL (=i2) flows.
Step 3:  IL (=i2) decreases gradually and reaches IL=ILmin=0 after a time period of topen, and N-channel Tr. turns off. Provided that in the continuous mode, next cycle starts before IL becomes to 0 because toff time is not enough. In this case, IL value increases from this ILmin(>0).

In the case of PWM control system, the output voltage is maintained by controlling the on-time period (ton), with the oscillator frequency (fosc) being maintained constant.

● **Discontinuous Conduction Mode and Continuous Conduction Mode**

The maximum value (ILmax) and the minimum value (ILmin) of the current flowing through the inductor are the same as those when P-channel Tr. turns on and off.
The difference between ILmax and ILmin, which is represented by ΔI;

ΔI = ILmax − ILmin = V$_{OUT}$ × topen / L = (V$_{IN}$-V$_{OUT}$)×ton/L···Equation 1

Wherein T=1/fosc=ton+toff
duty (%)=ton/T×100=ton×fosc×100
topen ≤ toff
In Equation 1, V$_{OUT}$×topen/L and (V$_{IN}$-V$_{OUT}$)×ton/L respectively show the change of the current at "ON", and the change of the current at "OFF".
When the output current (I$_{OUT}$) is relatively small, topen<toff as illustrated in the above diagram. In this case, the energy is charged in the inductor during the time period of ton and is discharged in its entirely during the time period of toff, therefore ILmin becomes to zero (ILmin=0). When Iout is gradually increased, eventually, topen becomes to toff (topen=toff), and when I$_{OUT}$ is further increased, ILmin becomes larger than zero (ILmin>0). The former mode is referred to as the discontinuous mode and the latter mode is referred to as continuous mode.

In the continuous mode, when Equation 1 is solved for ton and assumed that the solution is tonc,

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tonc $= T \times V_{IN}/V_{OUT} \cdots$ Equation 2

When ton<tonc, the mode is the discontinuous mode, and when ton=tonc, the mode is the continuous mode.

## ■ OUTPUT CURRENT AND SELECTION OF EXTERNAL COMPONENTS

When P-channel Tr. of Lx is ON:

(Wherein, Ripple Current P-P value is described as $I_{RP}$, ON resistance of P-channel Tr. and N-channel Tr. of Lx are respectively described as Ronp and Ronn, and the DC resistor of the inductor is described as $R_L$.)

$$V_{IN} = V_{OUT} + (Ronp + R_L) \times I_{OUT} + L \times I_{RP}/ton \qquad \cdots \text{Equation 3}$$

When P-channel Tr. of Lx is "OFF" (N-channel Tr. is "ON"):
$$L \times I_{RP}/toff = R_L \times I_{OUT} + V_{OUT} + Ronn \times I_{OUT} \qquad \cdots \text{Equation 4}$$

Put Equation 4 to Equation 3 and solve for ON duty of P-channel transistor, ton/(toff+ton)=$D_{ON}$,

$$D_{ON} = (V_{OUT} - Ronn \times I_{OUT} + R_L \times I_{OUT})/(V_{IN} + Ronn \times I_{OUT} - Ronp \times I_{OUT}) \cdots \text{Equation 5}$$

Ripple Current is as follows;

$$I_{RP} = (V_{IN} - V_{OUT} - Ronp \times I_{OUT} - R_L \times I_{OUT}) \times D_{ON}/fosc/L \qquad \ldots \text{Equation 6}$$
wherein, peak current that flows through L, and Lx Tr. is as follows;

$$ILmax = I_{OUT} + I_{RP}/2 \qquad \ldots \text{Equation 7}$$

Consider ILmax, condition of input and output and select external components.

★The above explanation is directed to the calculation in an ideal case in continuous mode.

## ■ How to Adjust Output Voltage and about Phase Compensation

As for Adjustable Output type, feedback pin ($V_{FB}$) voltage is controlled to maintain 0.8V.
Output Voltage, $V_{OUT}$ is as following equation;
$$V_{OUT}: R1+R2=V_{FB}: R2$$
$$V_{OUT} = V_{FB} \times (R1+R2)/R2$$
Thus, with changing the value of R1 and R2, output voltage can be set in the specified range.
In the DC/DC converter, with the load current and external components such as L and C, phase might be behind 180 degree. In this case, the phase margin of the system will be less and stability will be worse. To prevent this, phase margin should be secured with proceeding the phase. A zero is formed with R1, R2, and Cb.
$$Fpole \sim 1/2\pi\sqrt{LC_{OUT}}$$
$$\cong Fzero \sim 1/(2\pi \times (R1+R2) \times Cb)$$
Considering external components, LC, set the appropriate value of R1+R2 and Cb.
Rb is effective for reducing the noise on $V_{FB}$, therefore, add Rb so that R1+Rb=30k$\Omega$.
When the R1≥30k$\Omega$, additional Rb is not necessary, so it should be wired to $V_{FB}$ directly.

## ■ External Components

### 1. Inductor
Select an inductor that peak current does not exceed ILmax. If larger current than allowable current flows, magnetic saturation occurs and make transform efficiency worse.
Supposed that the load current is at the same, the smaller value of L is used, the larger the ripple current is.
Provided that the allowable current is large in that case and DC current is small, therefore, for large output current, efficiency is better than using an inductor with a large value of L and vice versa.
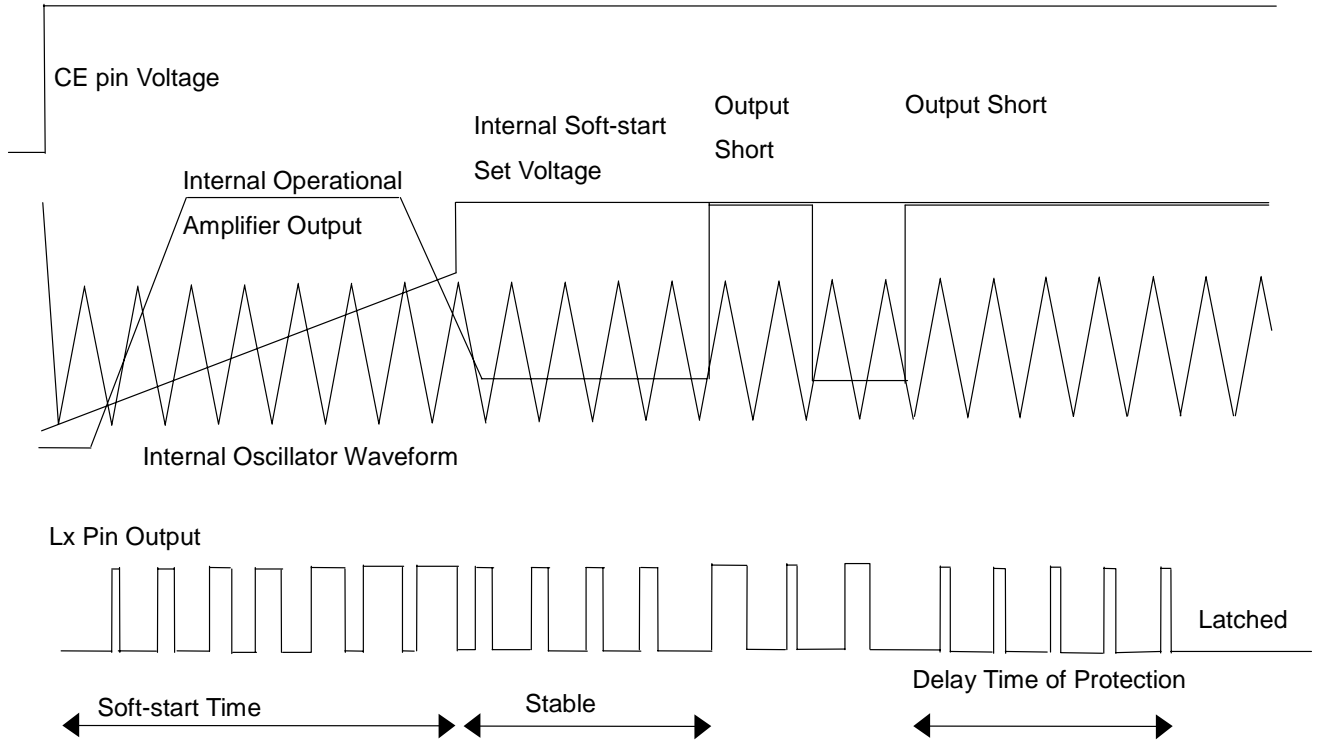
### 2. Capacitor

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As for C$_{IN}$, use a capacitor with low ESR (Equivalent Series Resistance) Ceramic type of a capacity at least 10μF for stable operation.

C$_{OUT}$ can reduce ripple of Output Voltage, therefore as much as 10μF tantalum type is recommended.
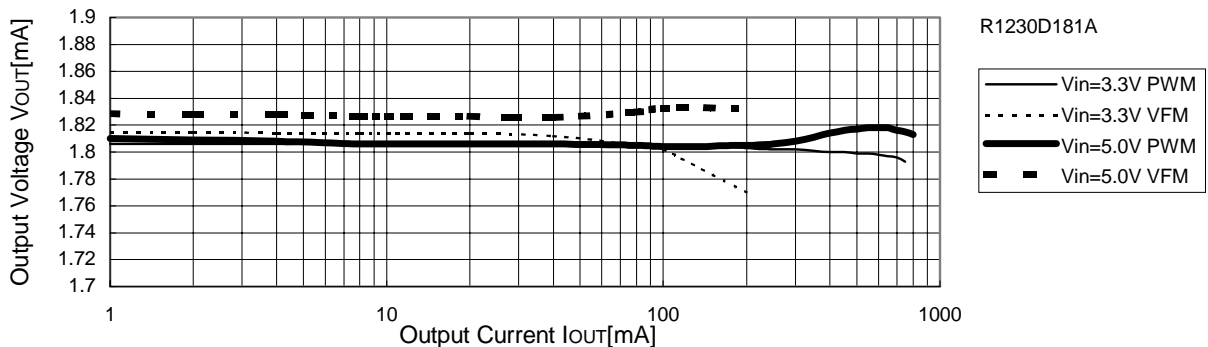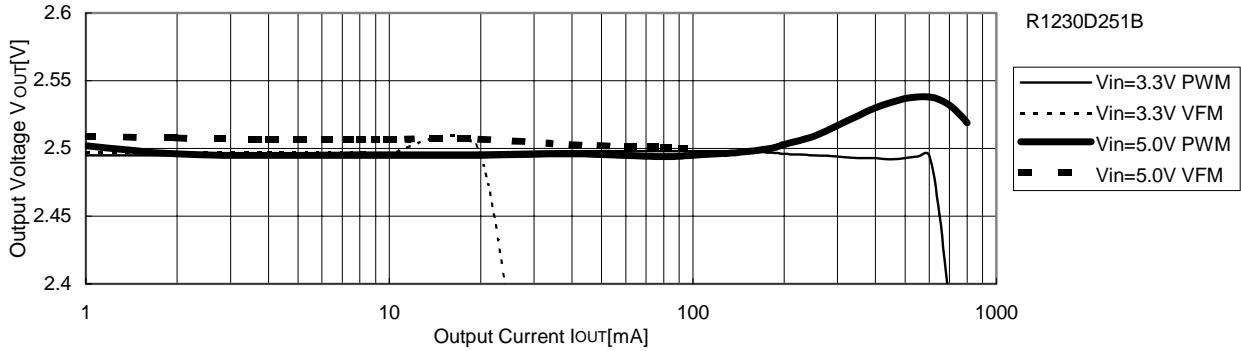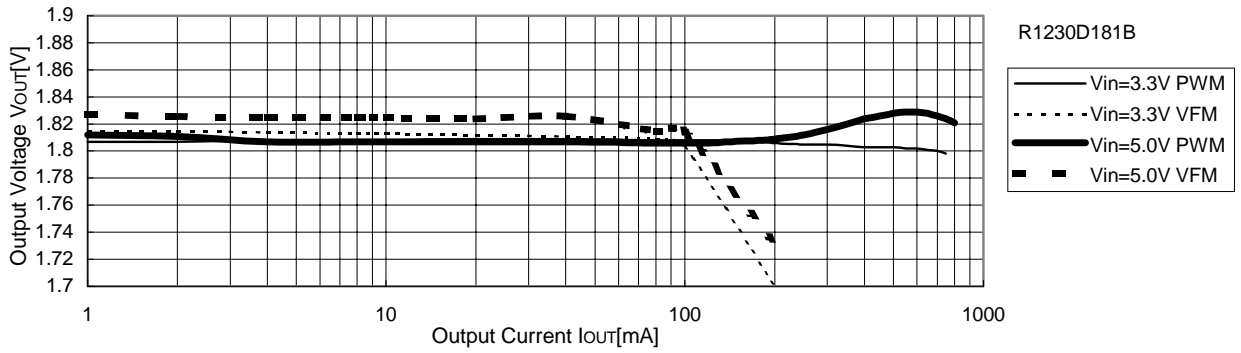
## ■ TIMING CHART



The timing chart as shown above describes the waveforms starting from the IC is enabled with CE and latched with protection. During the soft-start time, until the level is rising up to the internal soft-start set voltage, the duty cycle of Lx is gradually wider and wider to prevent the over-shoot of the voltage. During the term, the output of amplifier is "H", then after the output voltage reaches the set output voltage, they are balanced with the stable state. Herein, if the output pin would be short circuit, the output of amplifier would become "H" again, and the condition would continue for 1.5ms (TYP.), latch circuit would work and the output of Lx would be latched with "OFF". (Output ="High-Z")

If the output short is released before the latch circuit works (within 1.5ms after output shorted), the output of amplifier is balanced in the stable state again.

Once the IC is latched, to release the protection, input "L" with CE pin, or make the supply voltage at UVLO level or less.

## ■ TYPICAL CHARACTERISTICS

### 1) Output Voltage vs. Output Current

RICOH

R1230D181B

Vin=3.3V PWM
Vin=3.3V VFM
Vin=5.0V PWM
Vin=5.0V VFM

Output Voltage V$_{OUT}$[V]

Output Current I$_{OUT}$[mA]

R1230D251B

Vin=3.3V PWM
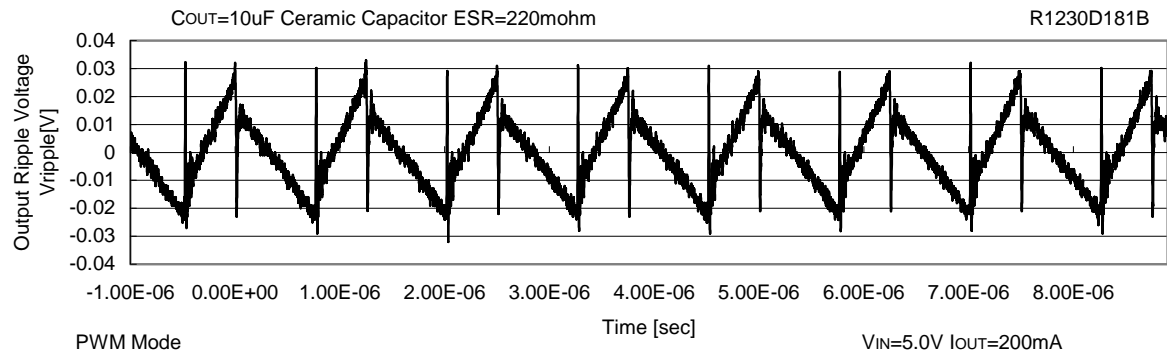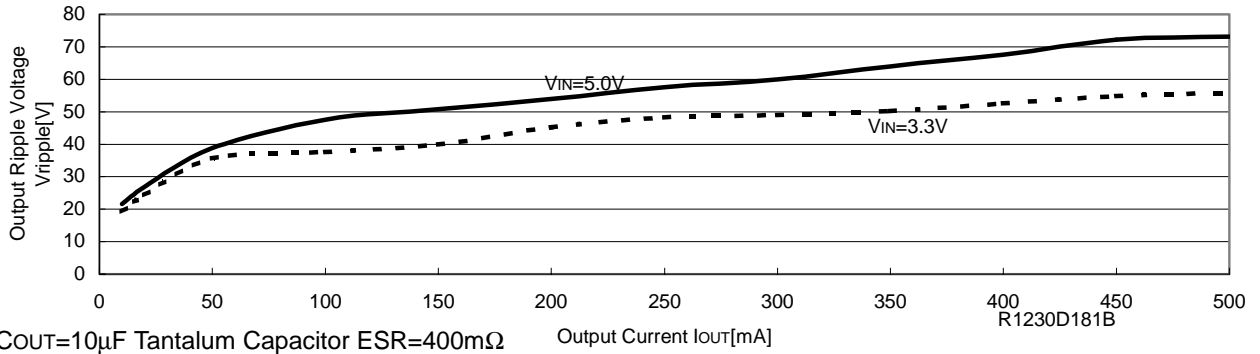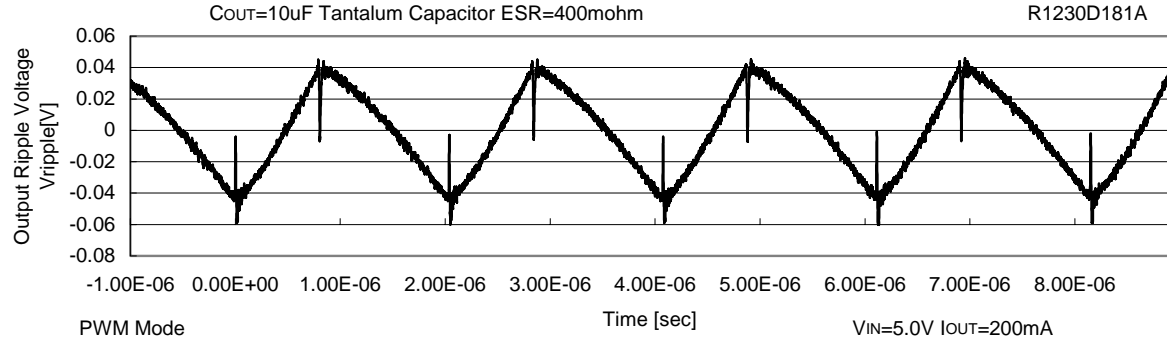Vin=3.3V VFM
Vin=5.0V PWM
Vin=5.0V VFM

Output Voltage V$_{OUT}$[V]

Output Current I$_{OUT}$[mA]

## 2) Efficiency vs. Output Current

R1230D181A

Vin=3.3V PWM
Vin=3.3V VFM
Vin=5.0V PWM
Vin=5.0V VFM

Efficiency [%]

Output Current I$_{OUT}$[mA]

R1230D181B

Vin=3.3V PWM
Vin=3.3V VFM
Vin=5.0V PWM
Vin=5.0V VFM

Efficiency [%]

Output Current I$_{OUT}$[mA]

RICOH

R1230D251B

Vin=3.3V PWM
Vin=3.3V VFM
Vin=5.0V PWM
Vin=5.0V VFM
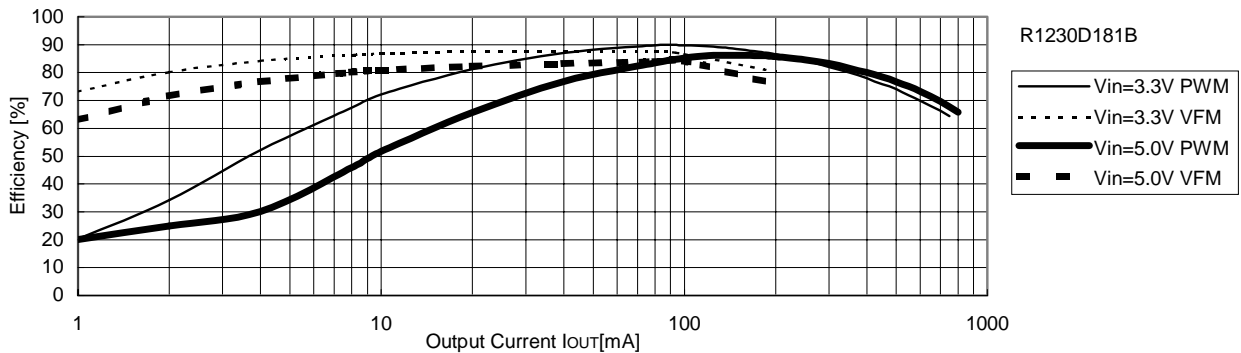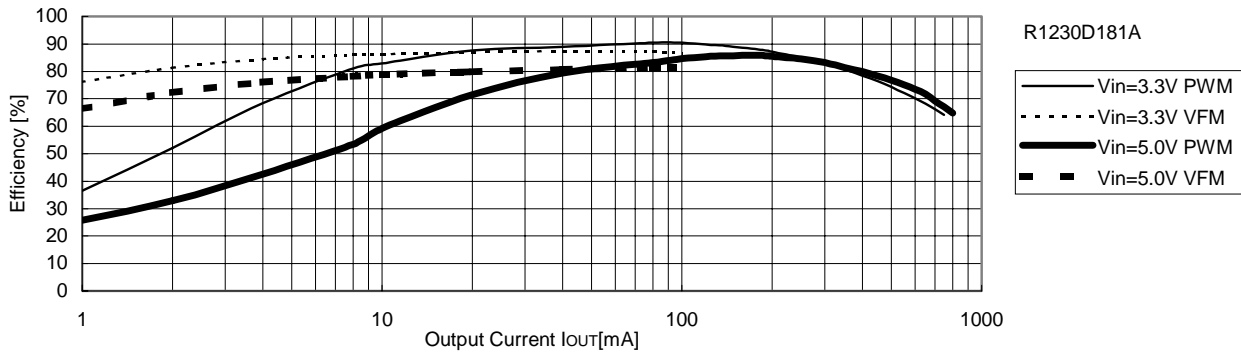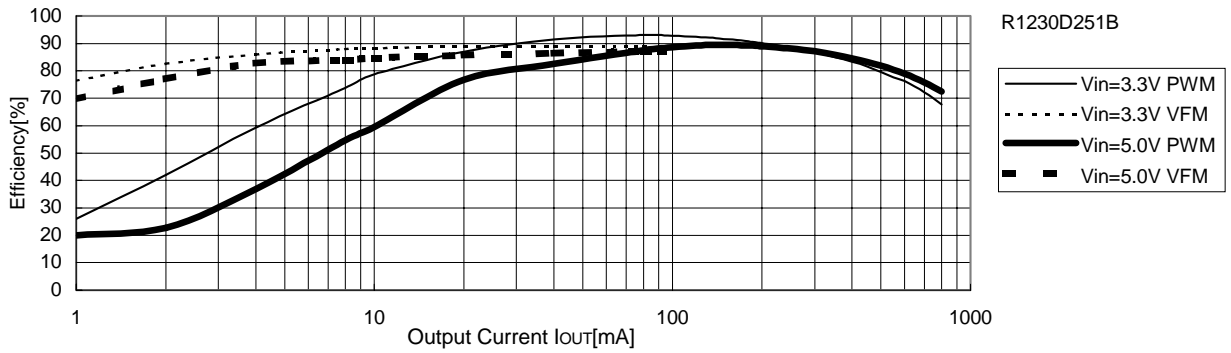
## 3) Ripple Voltage vs. Output Current



$C_{OUT}$=10uF Tantalum Capacitor ESR=400mohm — R1230D181A

PWM Mode — Time [sec] — $V_{IN}$=5.0V $I_{OUT}$=200mA



$V_{IN}$=5.0V
$V_{IN}$=3.3V

$C_{OUT}$=10$\mu$F Tantalum Capacitor ESR=400m$\Omega$ — Output Current $I_{OUT}$[mA] — R1230D181B



$C_{OUT}$=10uF Ceramic Capacitor ESR=220mohm — R1230D181B

PWM Mode — Time [sec] — $V_{IN}$=5.0V $I_{OUT}$=200mA

RICOH

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## 4) Output Waveform



Cₒᵤₜ=10uF Tantalum Capacitor ESR=400mohm      R1230D181B

PWM Mode      VIN=5.0V IOUT=10mA



Cₒᵤₜ=10uF Tantalum Capacitor ESR=400mohm      R1230D181B

PWM Mode      VIN=5.0V IOUT=100mA

## 5) Output Voltage vs. Input Voltage



R1230D181B IOUT=20mA

## 6) Output Voltage vs. Temperature



R1230D181B IOUT=100mA

**RICOH**

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**R1230D001C/D I<sub>OUT</sub>=100mA**
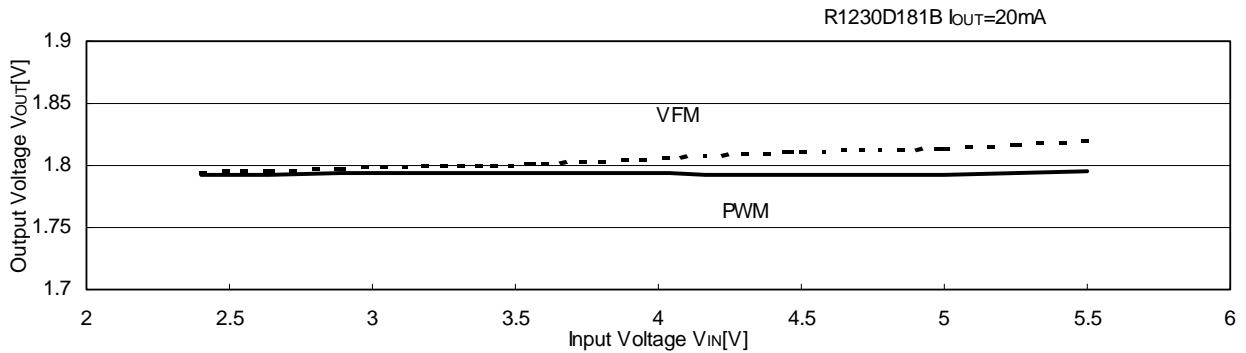
Output Voltage V<sub>OUT</sub>[V] vs. Temperature T<sub>opt</sub> (°C)
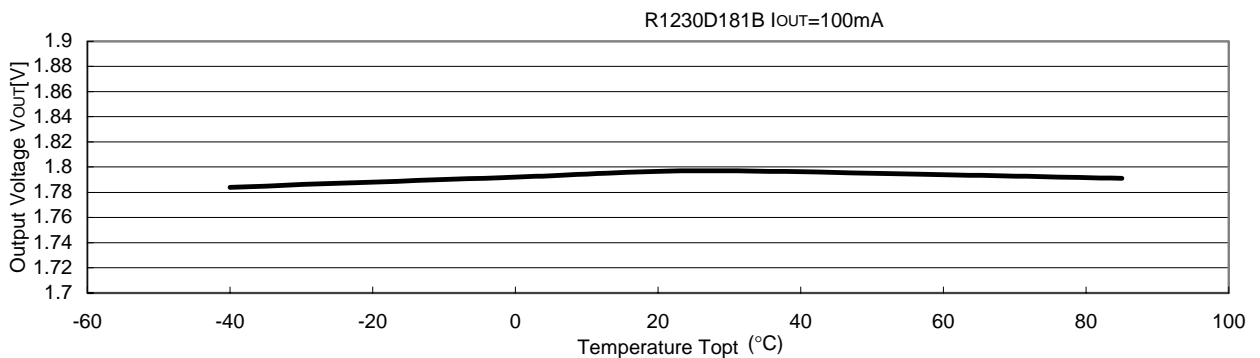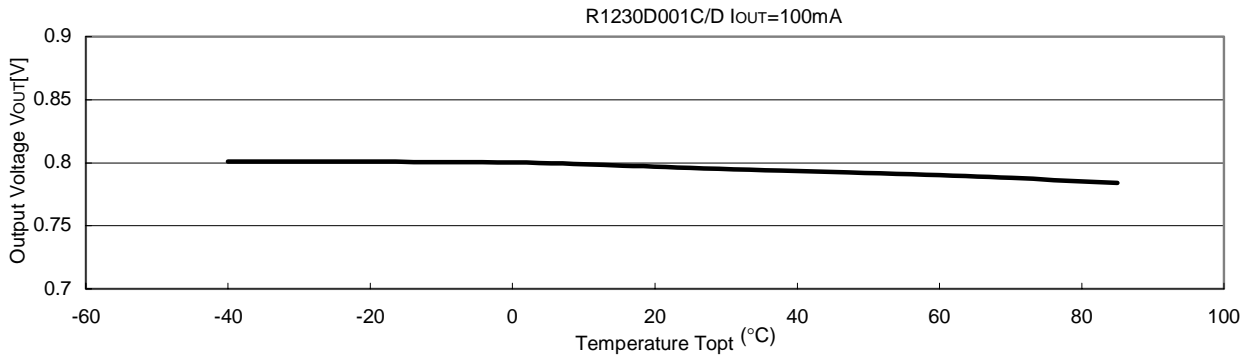
### 7) Oscillator Frequency vs. Temperature

Frequency f<sub>OSC</sub>[kHz] vs. Temperature T<sub>opt</sub> (°C)    V<sub>IN</sub>=V<sub>OUT</sub>+1.5V
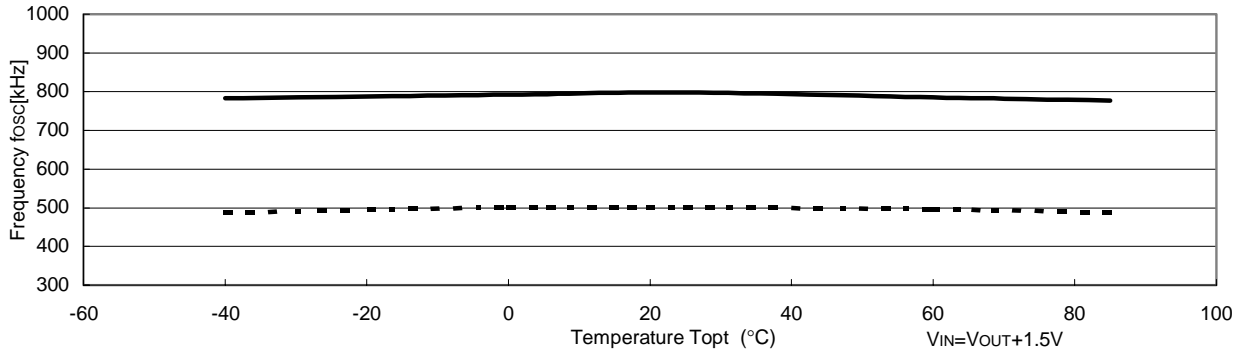
### 8) Supply Current vs. Temperature

Supply Current I<sub>SS</sub>[uA] vs. Temperature T<sub>opt</sub> (°C)

800kHz

500kHz

V<sub>IN</sub>=5.5V
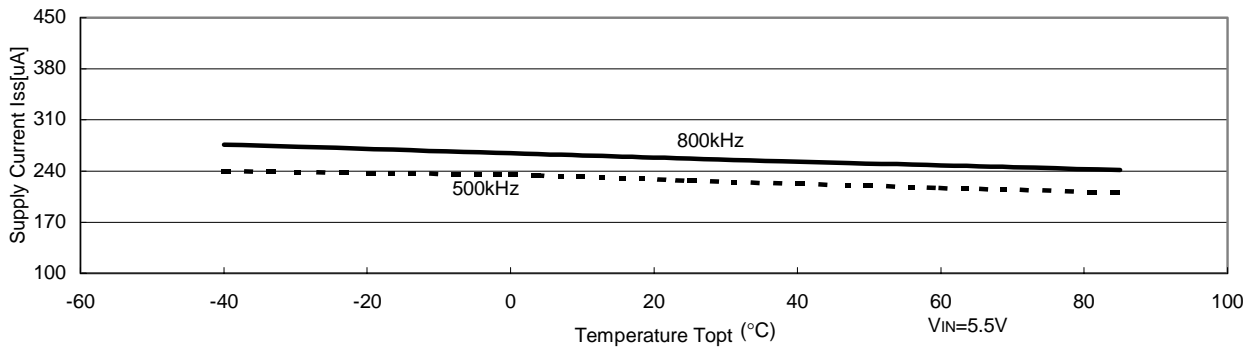
### 9) Soft-start time vs. Temperature

**R1230D181B V<sub>IN</sub>=3.3V**

Soft-start Time T<sub>soft</sub>[ms] vs. Temperature T<sub>opt</sub> (°C)

800kHz

500kHz

RICOH
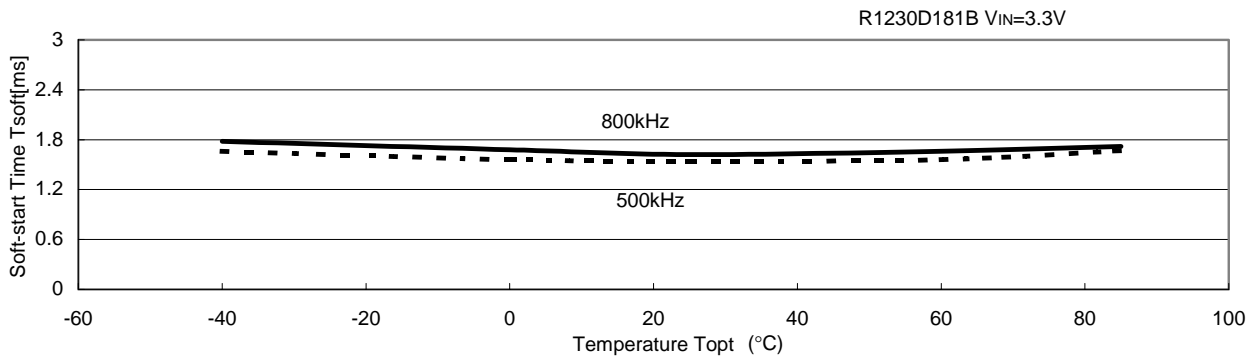
**10) Delay Time for protection vs. Temperature**
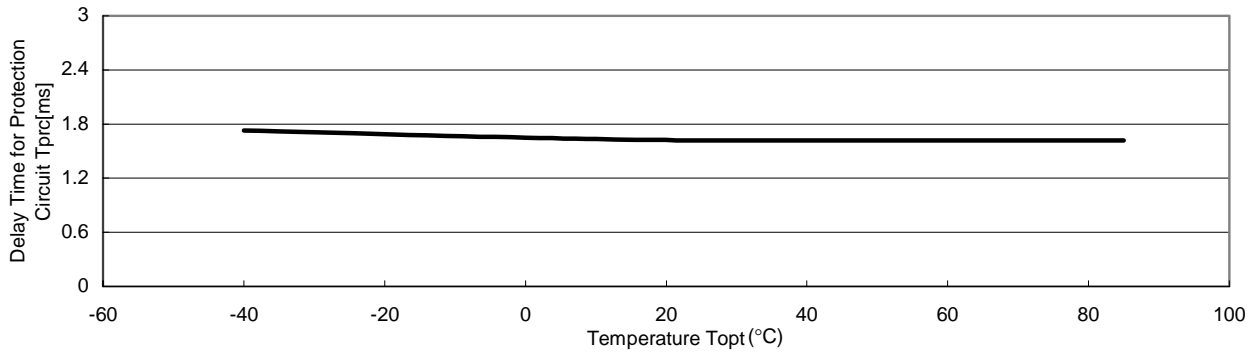


**11) UVLO Threshold/Released Voltage vs. Temperature**
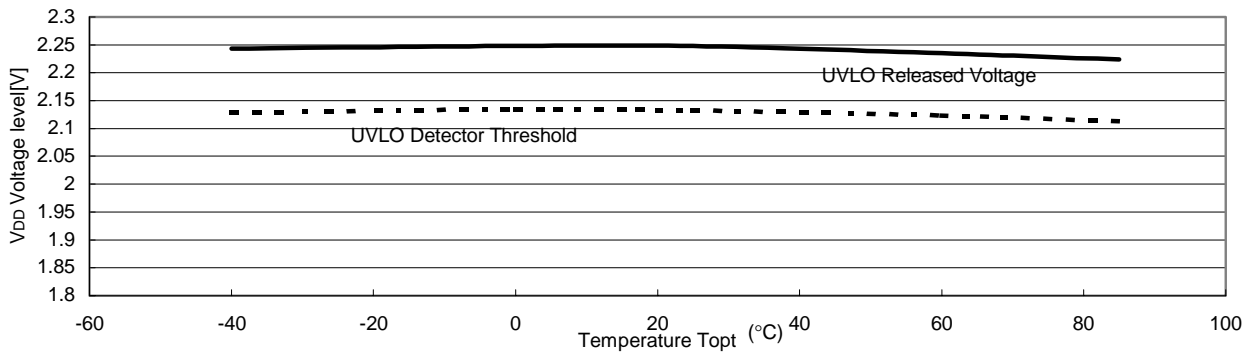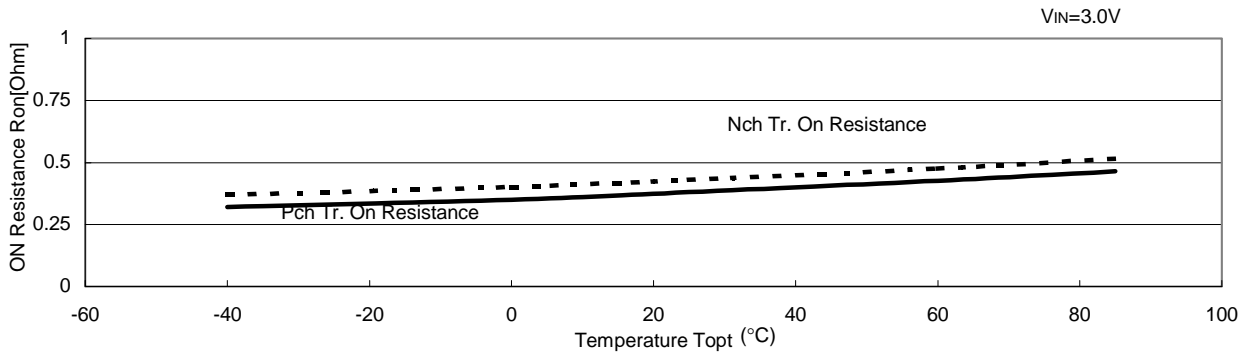


**12) CE Pin Input Voltage vs. Temperature**
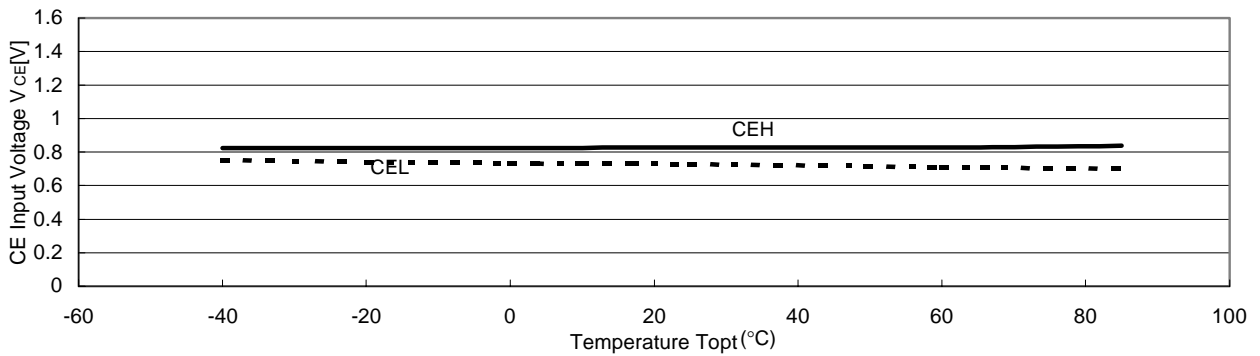


**13) Mode Pin Input Voltage vs. Temperature**



**RICOH**

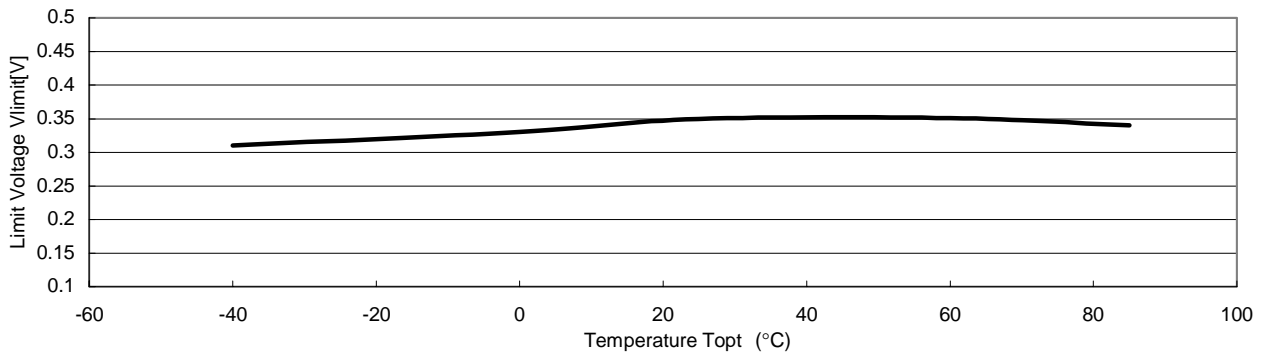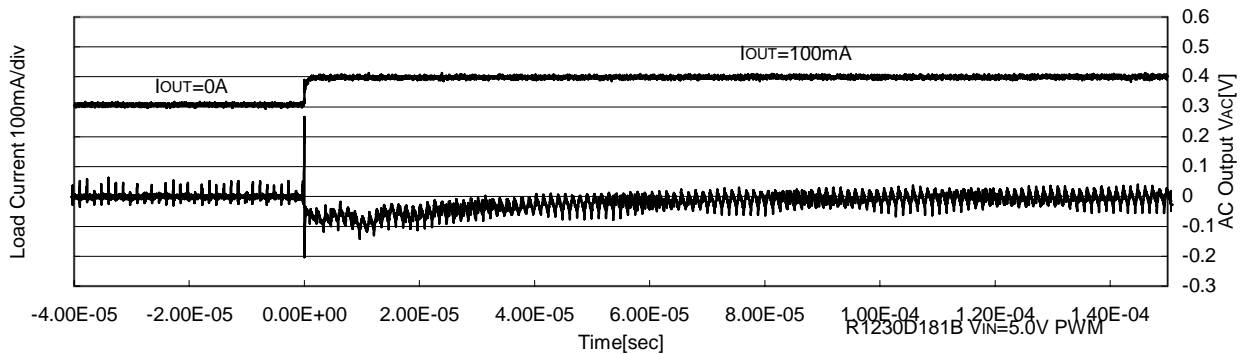Rev. 1.12                                    - 16 -
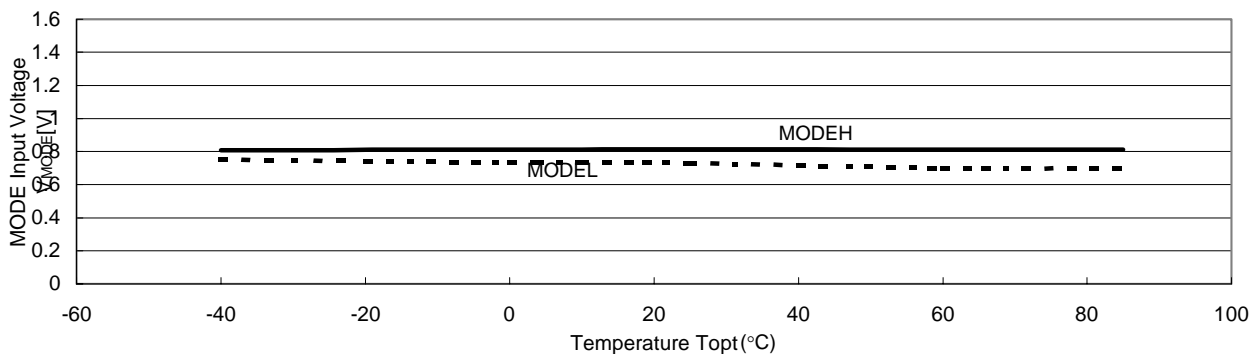
### 14) Duty Cycle at VFM Mode vs. Temperature
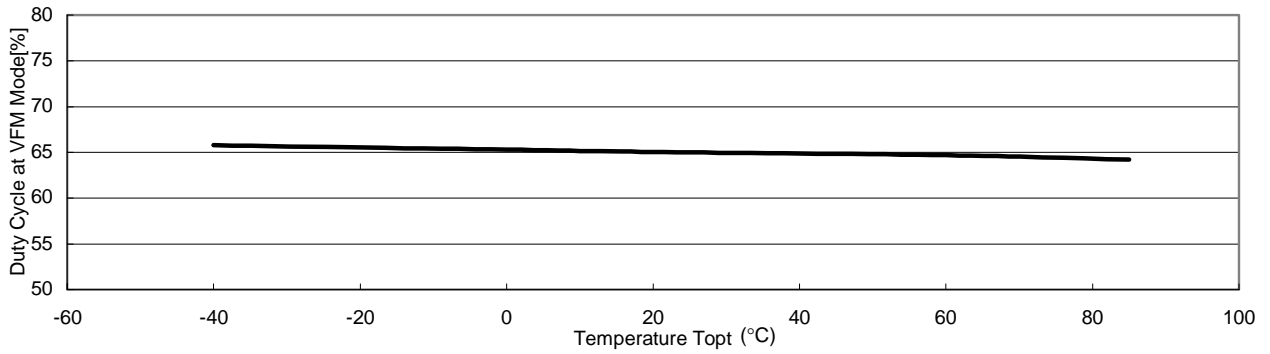


### 15) Lx Transistor On Resistance vs. Temperature

$V_{IN}$=3.0V
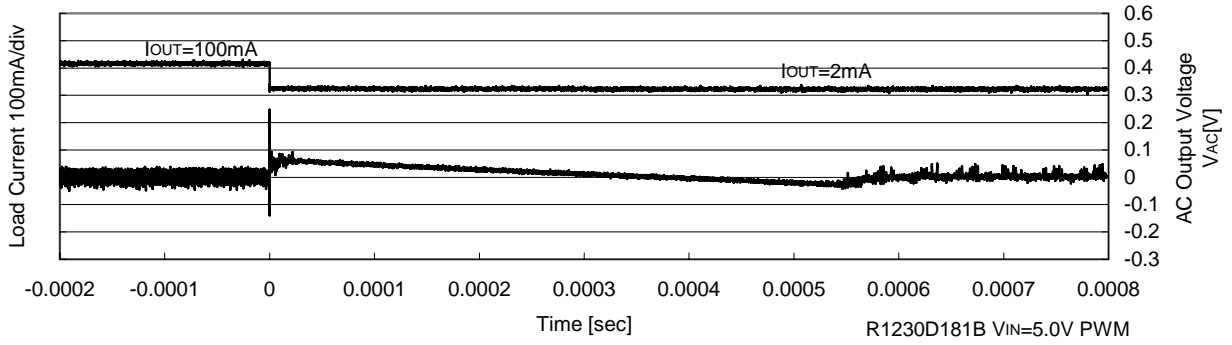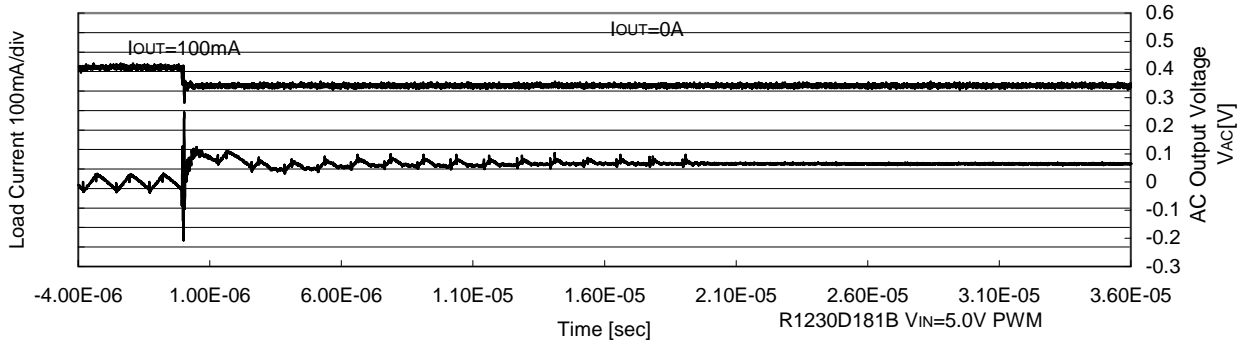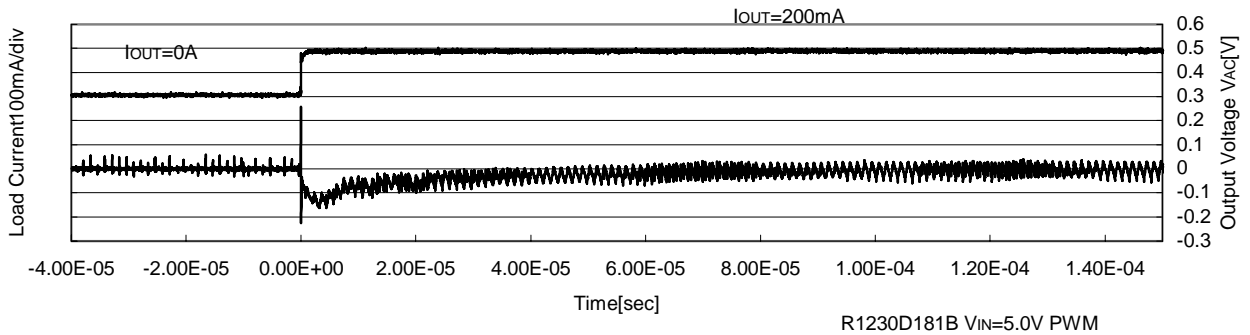


Nch Tr. On Resistance

Pch Tr. On Resistance

### 16) Limit Voltage vs. Temperature



### 17) Load Transient Response



$I_{OUT}$=0A

$I_{OUT}$=100mA

R1230D181B $V_{IN}$=5.0V PWM

RICOH

R1230D181B V<sub>IN</sub>=5.0V PWM



R1230D181B V<sub>IN</sub>=5.0V PWM



R1230D181B V<sub>IN</sub>=5.0V PWM



R1230D181B V<sub>IN</sub>=5.0V PWM

RICOH

R1230D181B VIN=5.0V PWM

## 18) Turn-on Waveform



R1230D181B VIN=5.0V



R1230D181B VIN=5.0V



R1230D181B VIN=5.0V

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RICOH

VFM Mode I$_{OUT}$=0A

R1230D181B V$_{IN}$=5.0V

VFM Mode I$_{OUT}$=50mA

R1230D181B V$_{IN}$=5.0V