# RICOH

# R5212D SERIES

## Step-down DC/DC Converter with VR and Reset

NO.EA-128-0510

## OUTLINE

The R5212D is CMOS-based PWM step-down DC/DC converter combined with a voltage regulator (VR) and a voltage detector (VD), with low supply current.

Each of these ICs consists of an oscillator, a PWM control circuit, a voltage reference unit, an error amplifier, a soft-start circuit, a current limit circuit, a phase compensation circuit, a resistor net for voltage detect circuit, an output driver transistor, and so on. A low ripple, high efficiency step-down DC/DC converter can be easily composed of this IC with some external components, or an inductor, a diode, and capacitors.

The oscillator frequency is 1.2MHz, therefore small inductor and capacitor can be used with this IC. Further, this IC equips the under voltage lockout function (UVLO). If the input voltage becomes equal or less than 2.35V (Typ.), the output of DC/DC converter turns off. However, in the A/B version, embedded voltage regulator and detector continue to operate. In the C/D version, LDO output also turns off and only the voltage detector is working.

The voltage regulator consists of a voltage reference unit, a resistor net for voltage detect circuit, an error amplifier, an output driver transistor, and so on.

The input source voltage of the built-in voltage regulator is $V_{IN}$ pin (A/B version) or $V_{OUT1}$ pin, the output of DC/DC converter (C/D version).

The built-in voltage detector supervises the input voltage and the output is N-channel open drain.

Power-on reset delay time is also included and internally set typically at 12ms (A/C version) or 50ms(B/D version).

## FEATURES

- Range of Input Voltage ............................. 3.0V~5.5V
- Built-in Soft-start Function (Typ. 1ms) and built-in power-on reset delay (Typ. 12ms or 50ms)
- Maximum Output Current..........................500mA (DC/DC), 200mA (VR)
- Accuracy Output Voltage .......................... ±2.0% (DC/DC and Voltage Regulator Output)
- Accuracy of voltage detector .................... ±2.5%
- Output Voltage (VR)(A/B Version) ............ Stepwise Setting with a step of 0.1V in the range of 2.0V to 3.6V
  (C/D Version) ............ Stepwise Setting with a step of 0.1V in the range of 1.2V to 3.0V
- Output Voltage (DC/DC) (A/B Version)..... Stepwise Setting with a step of 0.1V in the range of 1.2V to 3.6V
  (C/D Version)..... Stepwise Setting with a step of 0.1V in the range of 2.5V to 3.6V
- Output Voltage (VD).................................. Stepwise Setting with a step of 0.1V in the range of 3.0V to 4.5V
- Package .................................................... HSON-6 (t=0.9mm)

## APPLICATIONS

- Power source for hand-held communication equipment, CD or DVD drives.
- Power source for battery-powered equipment.

**R5212D**

# BLOCK DIAGRAMS

**R5212xxxA/B**



**R5212DxxxC/D**

RICOH
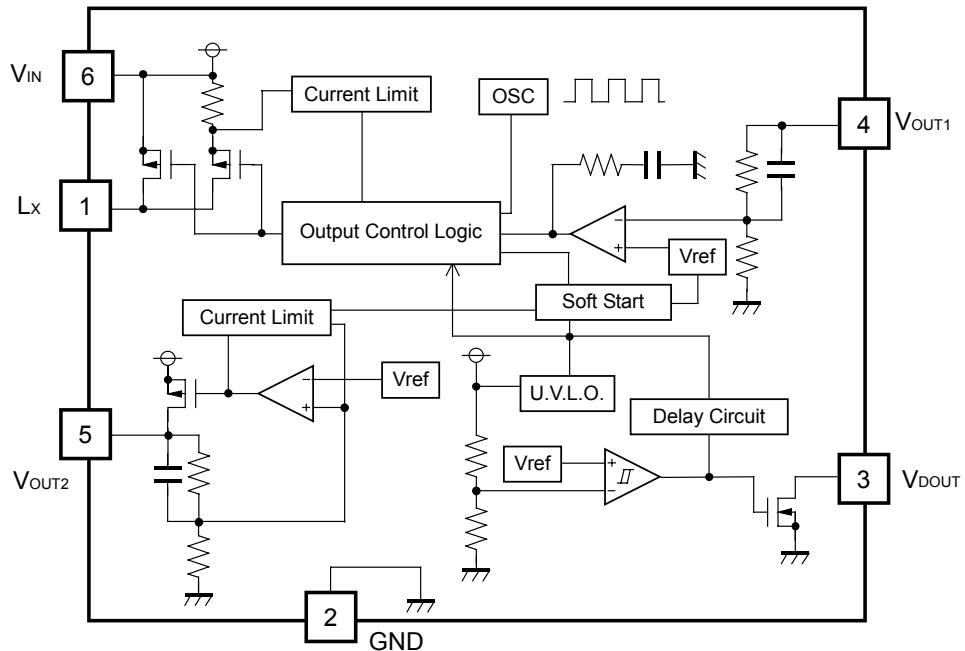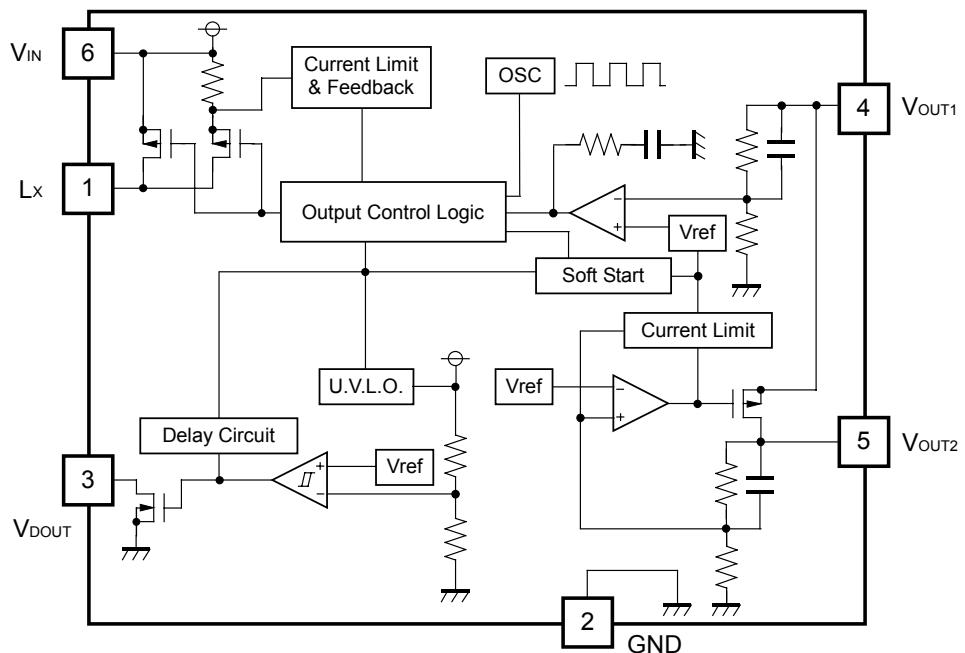
# SELECTION GUIDE

In the R5212D Series, the output voltage combination for the ICs can be selected at the user's re-quest.
The selection can be made with designating the part number as shown below;

R5212D<u>xxxx</u>-<u>TR</u> ←Part Number
　　　↑ ↑ ↑
　　　a b c

| Code | Contents |
|------|----------|
| a | Output Voltage Combination Code Number |
| b | Designation of Optional Function<br>A: VR input pin=$V_{IN}$ pin, VD delay=12ms<br>B: VR input pin=$V_{IN}$ pin, VD delay=50ms<br>C: VR input pin=DC/DC Output, VD delay=Typ. 12ms<br>D: VR input pin=DC/DC Output, VD delay=Typ. 50ms |
| c | Designation of Taping Type: Refer to Taping specification. |

**R5212D**

# PIN CONFIGURATION

**HSON-6**

**Top View**     **Bottom View**
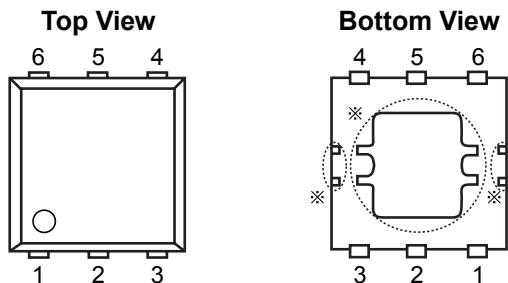
# PIN DESCRIPTIONS

| Pin No | Symbol | Pin Description |
|--------|--------|-----------------|
| 1 | $L_X$ | Switching Pin (P-channel open-drain output type) |
| 2 | GND | Ground Pin |
| 3 | $V_{DOUT}$ | Output Pin of Voltage Detector (N-channel open-drain out-put type) |
| 4 | $V_{OUT1}$ | DC/DC converter Step-down Output monitoring Pin |
| 5 | $V_{OUT2}$ | Output Pin of Voltage Regulator |
| 6 | $V_{IN}$ | Voltage Supply Pin |

∗ Tab 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

(GND=0V)

| Symbol | Item | Rating | Unit |
|--------|------|--------|------|
| $V_{IN}$ | $V_{IN}$ Pin Voltage | 6.5 | V |
| $V_{LX}$ | Lx Pin Voltage | $-0.3 \sim V_{IN}+0.3$ | V |
| $V_{OUT1}$ | $V_{OUT1}$ Pin Voltage | $-0.3 \sim V_{IN}+0.3$ | V |
| $V_{OUT2}$ | $V_{OUT2}$ Pin Voltage | $-0.3 \sim V_{IN}+0.3$ | V |
| $V_{DOUT}$ | $V_{DOUT}$ Pin Voltage | $-0.3 \sim 6.5$ | V |
| $I_{LX}$ | Lx Pin Output Current | 800 | mA |
| $I_{OUT2}$ | $V_{OUT2}$ Pin Output Current | 400 | mA |
| $P_D$ | Power Dissipation (On Board)[1] | 900 | mW |
| Topt | Operating Temperature Range | $-40 \sim +85$ | °C |
| Tstg | Storage Temperature Range | $-55 \sim +125$ | °C |

∗1 ) For Power Dissipation please refer to PACKAGE INFORMATION to be described.

**RICOH**

# ELECTRICAL CHARACTERISTICS

● **R5212DxxxA**                                                                Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Operating Input Voltage | | 3.0 | | 5.5 | V |
| $I_{DD}$ | Supply Current | $V_{IN}$=5.0V, $V_{OUT1}$=0V | | 400 | 800 | μA |
| $V_{UVLO2}$ | UVLO Release Voltage | | 2.35 | 2.50 | 2.65 | V |
| $V_{UVLOHYS}$ | UVLO Detector Threshold Voltage Hysteresis | | 0.05 | 0.15 | 0.25 | V |

● **DC/DC Part**                                                                Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{OUT1}$ | DC/DC Output Voltage | $V_{IN}$=5.0V, at no load OPEN LOOP | $V_{OUT1}$ ×0.98 | | $V_{OUT1}$ ×1.02 | V |
| $\Delta V_{OUT1}/\Delta Topt$ | DC/DC Output Voltage Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm /°C |
| fosc | Oscillator Frequency | $V_{IN}$=5.0V | 960 | 1200 | 1440 | kHz |
| $R_{LX}$ | Lx on Resistance | $V_{IN}$=5.0V, $I_{LX}$=100mA | | 0.4 | 0.8 | Ω |
| $I_{LXleak}$ | Lx Leakage Current | $V_{IN}$=$V_{OUT1}$=5.5V, $V_{LX}$=0V | | 0.01 | 5.00 | μA |
| $I_{LXLIM}$ | Lx Current Limit | $V_{IN}$=5.0V | 600 | 800 | | mA |
| Maxduty | Maximum duty cycle | | 100 | | | % |
| tstart | Soft-start Time | $V_{IN}$=5.0V | 0.35 | 1.00 | 3.00 | ms |

● **VR Part**                                                                Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{OUT2}$ | VR Output Voltage | $V_{IN}$=5.0V, $I_{OUT2}$=10mA | $V_{OUT2}$ ×0.98 | | $V_{OUT2}$ ×1.02 | V |
| $I_{OUT2}$ | Maximum Output Current of VR | $V_{IN}$=5.0V | 200 | | | mA |
| $V_{REG2}$ | VR Load Regulation | $V_{IN}$−$V_{OUT2}$=0V 1mA ≦ $I_{OUT2}$ ≦ 80mA | | 20 | 60 | mV |
| $V_{DIF2}$ | Dropout Voltage | $I_{OUT2}$=100mA | | 0.2 | 0.3 | V |
| $I_{LIM2}$ | Short Current Limit | $V_{OUT2}$=0V | | 50 | | mA |
| $\Delta V_{OUT2}/\Delta Topt$ | VR Output Voltage Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm /°C |

● **VD Part**                                                                Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $-V_{DET}$ | VD Detector Threshold | | $-V_{DET}$ ×0.975 | | $-V_{DET}$ ×1.025 | V |
| $\Delta-V_{DET}/\Delta Topt$ | VD Detector Threshold Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm /°C |
| $V_{HYS}$ | Hysteresis Range | | | $-V_{DET}$ ×0.05 | | V |
| $t_{PLH}$ | VD Output Delay Time for Release | $V_{IN}$=$V_{DOUT}$=$-V_{DET}$×0.9 to 5.0 | 3 | 12 | 30 | ms |
| $I_{DOUTL}$ | $V_{DOUT}$ "L" Output Current | $V_{IN}$=2.0V, $I_{OUT}$=0.1V | 2 | 7 | 20 | mA |

**RICOH**

**R5212D**

● **R5212DxxxB**

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Operating Input Voltage | | 3.0 | | 5.5 | V |
| $I_{DD}$ | Supply Current | $V_{IN}$=5.0V, $V_{OUT1}$=0V | | 400 | 800 | µA |
| $V_{UVLO2}$ | UVLO Release Voltage | | 2.35 | 2.50 | 2.65 | V |
| $V_{UVLOHYS}$ | UVLO Detector Threshold Voltage Hysteresis | | 0.05 | 0.15 | 0.25 | V |

● **DC/DC Part**

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{OUT1}$ | DC/DC Output Voltage | $V_{IN}$=5.0V, at no load OPEN LOOP | $V_{OUT1}$ ×0.98 | | $V_{OUT1}$ ×1.02 | V |
| $\Delta V_{OUT1}/$ $\Delta Topt$ | DC/DC Output Voltage Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm /°C |
| fosc | Oscillator Frequency | $V_{IN}$=5.0V | 960 | 1200 | 1440 | kHz |
| $R_{LX}$ | Lx on Resistance | $V_{IN}$=5.0V, $I_{LX}$=100mA | | 0.4 | 0.8 | Ω |
| $I_{LXleak}$ | Lx Leakage Current | $V_{IN}$=$V_{OUT1}$=5.5V, $V_{LX}$=0V | | 0.01 | 5.00 | µA |
| $I_{LXLIM}$ | Lx Current Limit | $V_{IN}$=5.0V | 600 | 850 | | mA |
| Maxduty | Maximum duty cycle | | 100 | | | % |
| tstart | Soft-start Time | $V_{IN}$=5.0V | 0.35 | 1.00 | 3.00 | ms |

● **VR Part**

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{OUT2}$ | VR Output Voltage | $V_{IN}$=5.0V, $I_{OUT2}$=10mA | $V_{OUT2}$ ×0.98 | | $V_{OUT2}$ ×1.02 | V |
| $I_{OUT2}$ | Maximum Output Current of VR | $V_{IN}$=5.0V | 200 | | | mA |
| $V_{REG2}$ | VR Load Regulation | $V_{IN}-V_{OUT2}$=0V 1mA ≦ $I_{OUT2}$ ≦ 80mA | | 20 | 60 | mV |
| $V_{DIF2}$ | Dropout Voltage | $I_{OUT2}$=100mA | | 0.2 | 0.3 | V |
| $I_{LIM2}$ | Short Current Limit | $V_{OUT2}$=0V | | 50 | | mA |
| $\Delta V_{OUT2}/$ $\Delta Topt$ | VR Output Voltage Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm /°C |

● **VD Part**

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $-V_{DET}$ | VD Detector Threshold | | $-V_{DET}$ ×0.975 | | $-V_{DET}$ ×1.025 | V |
| $\Delta-V_{DET}/$ $\Delta Topt$ | VD Detector Threshold Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm /°C |
| $V_{HYS}$ | Hysteresis Range | | | $-V_{DET}$ ×0.05 | | V |
| $t_{PLH}$ | VD Output Delay Time for Release | $V_{IN}$=$V_{DOUT}$=$-V_{DET}$×0.9 to 5.0 | 3 | 12 | 30 | ms |
| $I_{DOUTL}$ | $V_{DOUT}$ "L" Output Current | $V_{IN}$=2.0V, $V_{DOUT}$=0.1V | 2 | 7 | 20 | mA |

**RICOH**

● **R5212DxxxC**

Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|--------|------|-----------|------|------|------|------|
| $V_{IN}$ | Operating Input Voltage | | 3.0 | | 5.5 | V |
| $I_{DD}$ | Supply Current | $V_{IN}$=5.0V, $V_{OUT1}$=0V | | 400 | 800 | μA |
| $V_{UVLO2}$ | UVLO Release Voltage | | 2.35 | 2.50 | 2.65 | V |
| $V_{UVLOHYS}$ | UVLO Detector Threshold Voltage Hysteresis | | 0.05 | 0.15 | 0.25 | V |

● **DC/DC Part**

Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|--------|------|-----------|------|------|------|------|
| $V_{OUT1}$ | DC/DC Output Voltage | $V_{IN}$=5.0V, at no load OPEN LOOP | $V_{OUT1}$ ×0.98 | | $V_{OUT1}$ ×1.02 | V |
| $\Delta V_{OUT1}/\Delta Topt$ | DC/DC Output Voltage Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm/°C |
| fosc | Oscillator Frequency | $V_{IN}$=5.0V | 960 | 1200 | 1440 | kHz |
| $R_{LX}$ | Lx on Resistance | $V_{IN}$=5.0V, $I_{LX}$=100mA | | 0.4 | 0.8 | Ω |
| $I_{LXleak}$ | Lx Leakage Current | $V_{IN}$=$V_{OUT1}$=5.5V, $V_{LX}$=0V | | 0.01 | 5.00 | μA |
| $I_{LXLIM}$ | Lx Current Limit | $V_{IN}$=5.0V | 600 | 850 | | mA |
| Maxduty | Maximum duty cycle | | 100 | | | % |
| tstart | Soft-start Time | $V_{IN}$=5.0V | 0.35 | 1.00 | 3.00 | ms |

● **VR Part**

Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|--------|------|-----------|------|------|------|------|
| $V_{OUT2}$ | VR Output Voltage | $V_{OUT1}$=3.3V $I_{OUT2}$=10mA | $V_{OUT2}$ ×0.98 | | $V_{OUT2}$ ×1.02 | V |
| $I_{OUT2}$ | Maximum Output Current of VR | $V_{IN}$=5.0V | 200 | | | mA |
| $V_{REG2}$ | VR Load Regulation | $V_{IN}$–$V_{OUT2}$=0V 1mA ≦ $I_{OUT2}$ ≦ 80mA | | 20 | 60 | mV |
| $V_{DIF2}$ | Dropout Voltage | $I_{OUT2}$=100mA | | 0.2 | 0.3 | V |
| $I_{LIM2}$ | Short Current Limit | $V_{OUT2}$=0V | | 50 | | mA |
| $\Delta V_{OUT2}/\Delta Topt$ | VR Output Voltage Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm/°C |

● **VD Part**

Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|--------|------|-----------|------|------|------|------|
| $-V_{DET}$ | VD Detector Threshold | | $-V_{DET}$ ×0.975 | | $-V_{DET}$ ×1.025 | V |
| $\Delta -V_{DET}/\Delta Topt$ | VD Detector Threshold Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm/°C |
| $V_{HYS}$ | Hysteresis Range | | | $-V_{DET}$ ×0.05 | | V |
| $t_{PLH}$ | VD Output Delay Time for Release | $V_{IN}$=$V_{DOUT}$=$-V_{DET}$×0.9 to 5.0 | 3 | 12 | 30 | ms |
| $I_{DOUTL}$ | $V_{DOUT}$ "L" Output Current | $V_{IN}$=2.0V, $V_{DOUT}$=0.1V | 2 | 7 | 20 | mA |

**RICOH**

7

**R5212D**

● **R5212DxxxD**

Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|--------|------|-----------|------|------|------|------|
| $V_{IN}$ | Operating Input Voltage | | 3.0 | | 5.5 | V |
| $I_{DD}$ | Supply Current | $V_{IN}$=5.0V, $V_{OUT1}$=0V | | 400 | 800 | μA |
| $V_{UVLO2}$ | UVLO Release Voltage | | 2.35 | 2.50 | 2.65 | V |
| $V_{UVLOHYS}$ | UVLO Detector Threshold Voltage Hysteresis | | 0.05 | 0.15 | 0.25 | V |

● **DC/DC Part**

Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|--------|------|-----------|------|------|------|------|
| $V_{OUT1}$ | DC/DC Output Voltage | $V_{IN}$=5.0V, at no load OPEN LOOP | $V_{OUT1}$ ×0.98 | | $V_{OUT1}$ ×1.02 | V |
| $\Delta V_{OUT1}/\Delta$Topt | DC/DC Output Voltage Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm /°C |
| fosc | Oscillator Frequency | $V_{IN}$=5.0V | 960 | 1200 | 1440 | kHz |
| $R_{LX}$ | Lx on Resistance | $V_{IN}$=5.0V, $I_{LX}$=100mA | | 0.4 | 0.8 | Ω |
| $I_{LXleak}$ | Lx Leakage Current | $V_{IN}$=$V_{OUT1}$=5.5V, $V_{LX}$=0V | | 0.01 | 5.00 | μA |
| $I_{LXLIM}$ | Lx Current Limit | $V_{IN}$=5.0V | 600 | 850 | | mA |
| Maxduty | Maximum duty cycle | | 100 | | | % |
| tstart | Soft-start Time | $V_{IN}$=5.0V | 0.35 | 1.00 | 3.00 | ms |

● **VR Part**

Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|--------|------|-----------|------|------|------|------|
| $V_{OUT2}$ | VR Output Voltage | $V_{OUT1}$=3.3V $I_{OUT2}$=10mA | $V_{OUT2}$ ×0.98 | | $V_{OUT2}$ ×1.02 | V |
| $I_{OUT2}$ | Maximum Output Current of VR | $V_{IN}$=5.0V, $V_{OUT1}$=3.3V | 200 | | | mA |
| $V_{REG2}$ | VR Load Regulation | $V_{IN}$−$V_{OUT2}$=0V 1mA ≦ $I_{OUT2}$ ≦ 80mA | | 20 | 60 | mV |
| $V_{DIF2}$ | Dropout Voltage | $I_{OUT2}$=100mA | | 0.2 | 0.3 | V |
| $I_{LIM2}$ | Short Current Limit | $V_{OUT2}$=0V | | 50 | | mA |
| $\Delta V_{OUT2}/\Delta$Topt | VR Output Voltage Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm /°C |

● **VD Part**

Topt=25°C

| Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
|--------|------|-----------|------|------|------|------|
| $-V_{DET}$ | VD Detector Threshold | | $-V_{DET}$ ×0.975 | | $-V_{DET}$ ×1.025 | V |
| $\Delta-V_{DET}/\Delta$Topt | VD Detector Threshold Temperature Coefficient | 40°C ≦ Topt ≦ 85°C | | ±100 | | ppm /°C |
| $V_{HYS}$ | Hysteresis Range | | | $-V_{DET}$ ×0.05 | | V |
| $t_{PLH}$ | VD Output Delay Time for Release | $V_{IN}$=$V_{DOUT}$=$-V_{DET}$×0.9 to 5.0 | 10 | 50 | 120 | ms |
| $I_{DOUTL}$ | $V_{DOUT}$ "L" Output Current | $V_{IN}$=2.0V, $V_{DOUT}$=0.1V | 2 | 7 | 20 | mA |

**RICOH**

# TYPICAL APPLICATION AND APPLICATION HINTS

**R5212Dxxxx**
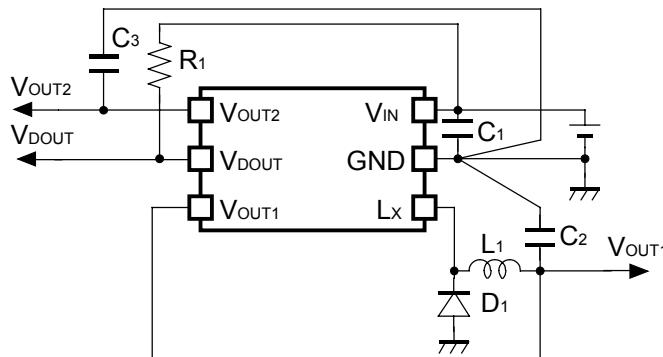


Examples of Components

| Symbol | Item | | | |
|--------|------|---|---|---|
| L$_1$ | (V$_{OUT1}$ ≦ 1.6V) | 4.7μH | LQH43C Series | Murata |
| | | 4.7μH | VLP5610 Series | TDK |
| | (V$_{OUT1}$ > 1.6V) | 6.8μH | LQH43C Series | Murata |
| | | 6.8μH | VLP5610 Series | TDK |
| D$_1$ | RB491D(ROHM) or EP05Q03 (Nihon Inter) | | | |
| R$_1$ | 50kΩ | | | |
| C$_1$ | 10μF Ceramic Capacitor | | | |
| C$_2$ | 10μF Ceramic Capacitor | | | |
| C$_3$ | 2.2μF Ceramic Capacitor | | | |

**R5212D**

When you use these ICs, consider the following issues;

Set external components as close as possible to the IC and minimize the connection between the components and the IC. In particular, a capacitor should be connected to between $V_{IN}$ and GND with the minimum connection. Make sufficient grounding, and reinforce supplying. A large switching current may flow through the connection of power supply, an inductor and the connection of $V_{OUT1}$. If the impedance of the connection of power supply or ground is high, the voltage level of power supply of the IC fluctuates with the switching current. This may cause unstable operation of the IC.

Use a capacitor with a capacity of $10\mu F$ or more for $V_{IN}$ and GND, and with low ESR ceramic type. In terms of $V_{OUT1}$, use a ceramic capacitor with a capacity of $10\mu F$ or more. For $V_{OUT2}$ pin, use a ceramic capacitor with a capacitance of $2.2\mu F$ or around.

Choose an inductor that has a small D.C. resistance and large allowable current and which is hard to reach magnetic saturation. If the value of inductance of an inductor is extremely small, the $IL_x$ , which flows through Lx transistor and an inductor, may exceed the absolute maximum rating at the maximum loading.

Use an inductor with appropriate inductance.

Use a diode of a Schottky type with high switching speed, and also pay attention to its current capacity.

If the spike noise of Lx pin is too large, make snub circuit (such as serial connection of CR) between Lx and GND, then the noise will be reduced. The time constant of the CR depends on the actual PCB, so evaluate it on the actual PCB.

If the load current of the voltage regulator is small, because of the switching noise of DC/DC converter, the output voltage of $V_{OUT2}$ may be large. To avoid this, use the voltage regulator with a load current at least 0.5mA.

In terms of LDO, the difference between the set output voltage and input voltage should be 0.5V or more,

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.

**RICOH**

# 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:

**<Basic Circuits>**

**<Current through L>**
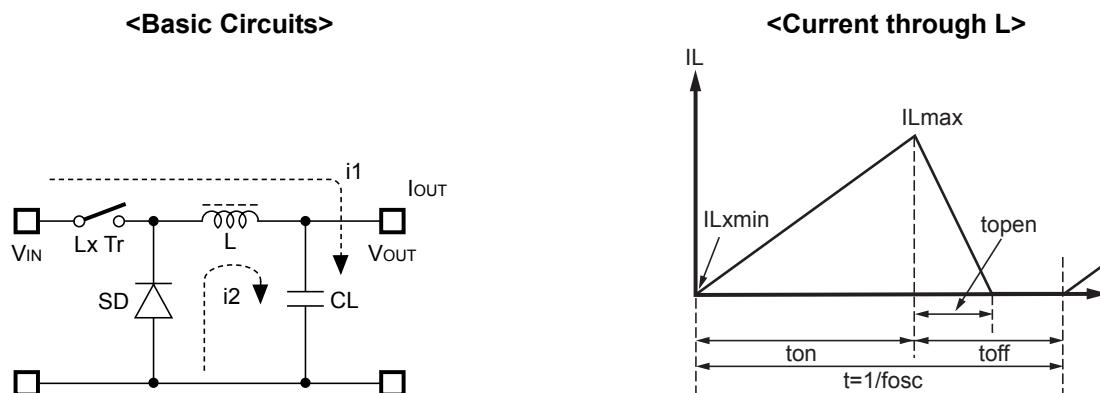
Step 1 : Lx Tr. turns on and current IL (=i1) flows, and energy is charged into CL. At this moment,
IL increases from ILmin (=0) to reach ILmax in proportion to the on-time period (ton) of $L_X$ Tr.

Step 2 : When Lx Tr. turns off, Schottky diode (SD) turns on in order that L maintains IL at ILmax,
and current IL (=i2) flows.

Step 3 : IL decreases gradually and reaches ILmin after a time period of topen, and SD 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 is 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.

**R5212D**

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

The maximum value (ILmax) and the minimum value (ILmin) current which flow through the inductor is the same as those when Lx Tr. turns on and when it turns off.

The difference between ILmax and ILmin, which is represented by $\Delta I$;

$$\Delta I = ILmax - ILmin = V_{OUT} \times topen/L = (V_{IN} - V_{OUT}) \times ton/L \quad\text{...................................................Equation 1}$$

Where, $t = 1/fosc = ton + toff$
duty (%) $= ton/t \times 100 = ton \times fosc \times 100$
$topen \leqq toff$

In Equation A, $V_{OUT} \times topen/L$ and $(V_{IN} - V_{OUT}) \times ton/L$ are respectively shown 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 $I_{OUT}$ 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

$$tonc = t \times V_{OUT}/V_{IN} \quad\text{.......................................................................................................Equation 2}$$

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 Lx Tr. is "ON":

(Wherein, Ripple Current P-P value is described as $I_{RP}$, ON resistance of $L_x$ Tr. is described as $R_P$ the direct current of the inductor is described as $R_L$. The threshold level of Shottky diode is described as $V_F$.)

$$V_{IN} = V_{OUT} + (R_P + R_L) \times I_{OUT} + L \times I_{RP}/ton \quad\text{.................................................................Equation 3}$$

When Lx Tr. is "OFF":

$$L \times I_{RP}/toff = V_F + V_{OUT} + R_L \times I_{OUT} \quad\text{......................................................................Equation 4}$$

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

$$D_{ON} = (V_{OUT} + V_F + R_L \times I_{OUT})/(V_{IN} + V_F - R_P \times I_{OUT}) \quad\text{.......................................................Equation 5}$$

Ripple Current is as follows;

$$I_{RP} = (V_{IN} - V_{OUT} - R_P \times I_{OUT} - R_L \times I_{OUT}) \times D_{ON}/f/L \quad\text{.........................................................Equation 6}$$

Wherein, peak current that flows through L, Lx Tr., and SD is as follows;

$$ILmax = I_{OUT} + I_{RP}/2 \quad\text{.........................................................................................................Equation 7}$$

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.

**RICOH**

# Timing Chart

● **R5212DxxxA/B**

**RICOH**
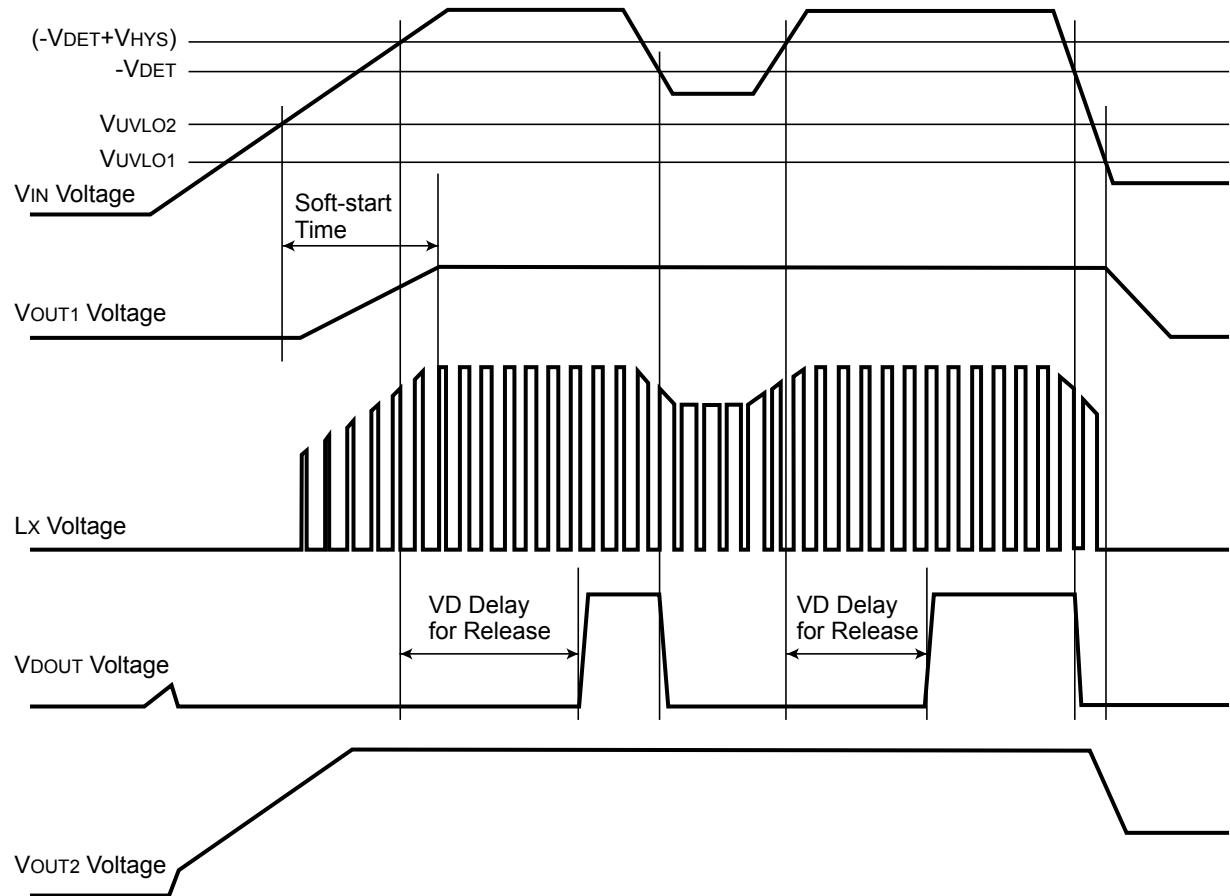
● **R5212DxxxC/D**
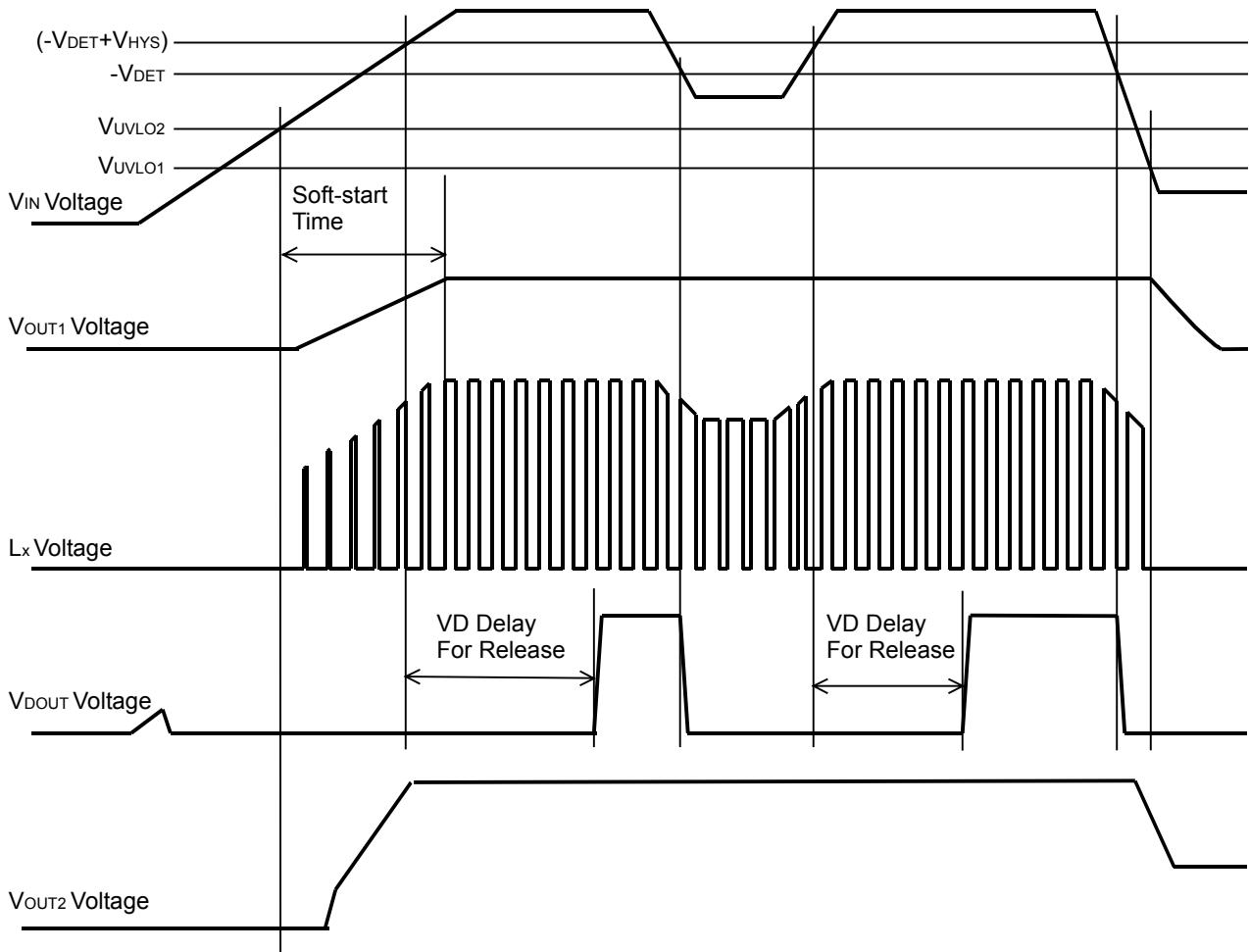


The timing chart which is shown in the previous page describes the relation of supply voltage changes with time and each output of DC/DC converter, voltage detector, and voltage regulator.

## (1) DC/DC converter

When the power turns on and in the case of rising the $V_{IN}$ voltage, while the $V_{IN}$ voltage is at UVLO release level ($V_{UVLO2}$) or less, the operation of the DC/DC converter stops and does not make switching, therefore $V_{OUT1}$ voltage does not rise.

When the $V_{IN}$ voltage becomes UVLO release level or more, the DC/DC converter starts soft-start operation, and start switching, then $V_{OUT1}$ will rise. After the soft-start time, if $V_{IN}$ voltage becomes set $V_{OUT1}$ level or more, $V_{OUT1}$ will be settled at $V_{OUT1}$ set output voltage. If $V_{IN}$ voltage becomes UVLO detector threshold level ($V_{UVLO1}$) or less, the DC/DC converter stops switching then Lx transistor in the IC turns off.

## (2) Voltage Detector

If the $V_{IN}$ voltage is at VD detector threshold level or less, the N-channel transistor of $V_{DOUT}$ pin turns on and outputs "L" to $V_{DOUT}$ pin. Then, when the $V_{IN}$ voltage becomes VD detector threshold level + its hysteresis range ($-V_{DET} + V_{HYS}$) or more, after VD delay for release ($t_{PLH}$) passing, the N-channel transistor inside the IC turns off, $V_{DOUT}$ pin voltage reaches to the pull-up voltage. Besides, the release circuit for VD starts from when $V_{IN}$ voltage reaches ($-V_{DET} + V_{HYS}$).

**RICOH**

### (3)Voltage Regulator
● **R5212DxxxA/B**

The voltage regulator always operates even if UVLO function would work. Therefore, $V_{OUT2}$ voltage is nearly equal to $V_{IN}$ voltage. Actual value depends on the load current. When the $V_{IN}$ voltage becomes set $V_{OUT2}$ voltage or more, $V_{OUT2}$ voltage will be the set output voltage. The short current limit can operate after soft-start time.

● **R5212DxxxC/D**

$V_{OUT1}$ voltage is the input voltage for the built-in LDO, when the $V_{OUT1}$ voltage is equal or less than $V_{OUT2}$ set voltage, $V_{OUT2}$ voltage is depending on the load current for $V_{OUT2}$, however almost same as $V_{OUT1}$ Voltage. When the $V_{OUT1}$ voltage is equal or more than set $V_{OUT2}$ voltage, $V_{OUT2}$ voltage becomes the set output voltage. Short Current Limit works after soft-start operation.

## TEST CIRCUITS
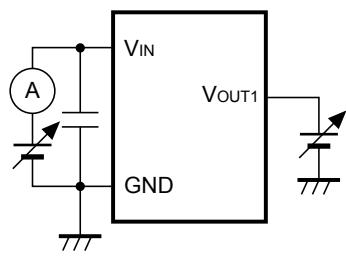


**Supply Current**
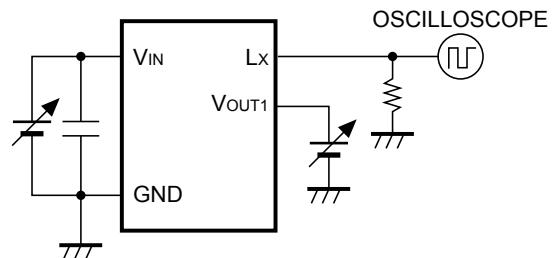


**UVLO Detector Threshold/ Released Voltage**
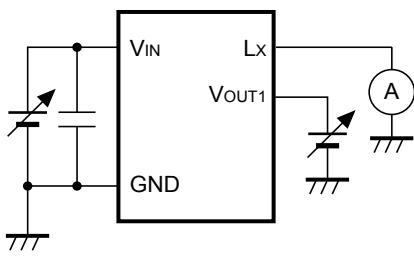


**Lx Leakage Current**
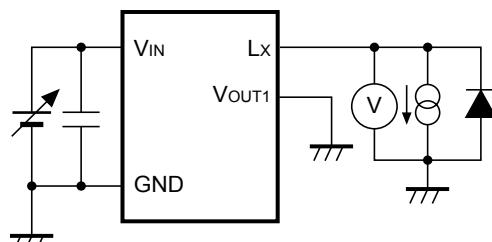


**Lx On Resistance**
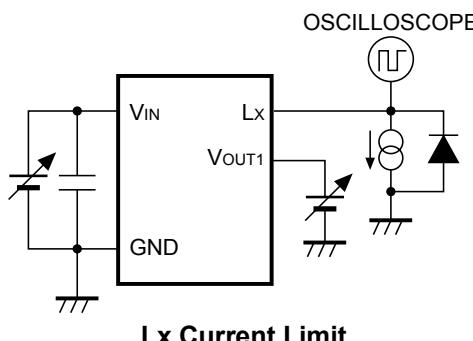


**Lx Current Limit**
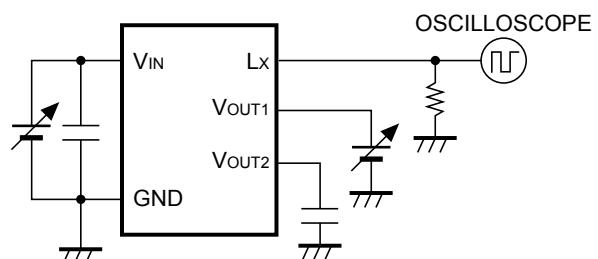


**$V_{OUT1}$ Output Voltage**

**RICOH**

15
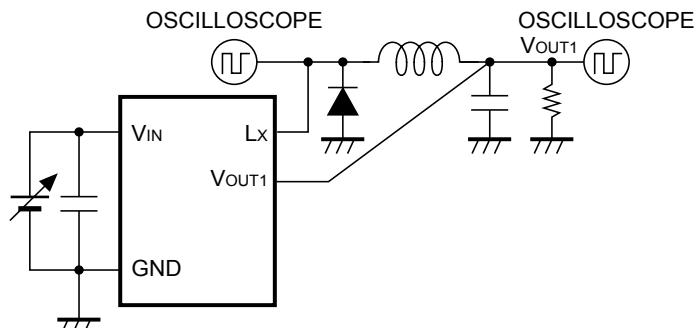
**Oscillator Frequency, Soft-start Time**
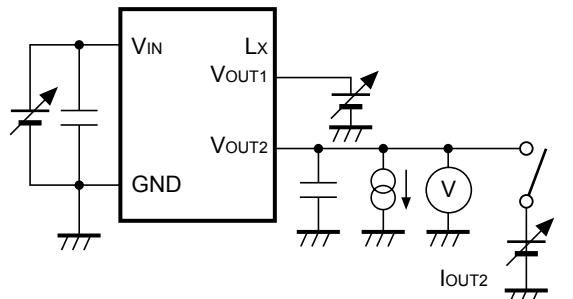


**V$_{OUT2}$ Output Voltage, Load Regulation, Dropout
Voltage, Current Limit, Short Current Limit**
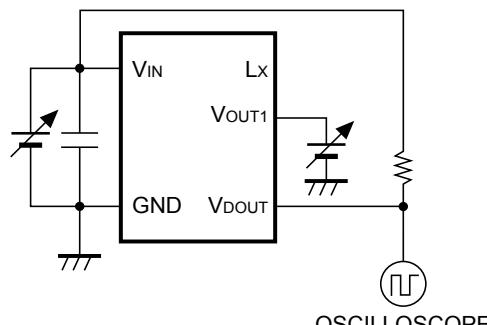


**V$_{DOUT}$ Detector Threshold, Hysteresis Range,
VD Output Delay Time for Release**



**V$_{DOUT}$ "L" Output Current**

**RICOH**
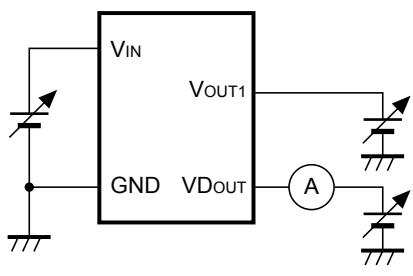
## TYPICAL CHARACTERISTICS

### 1) DC/DC Output Voltage vs. Output Current (Topt=25°C)
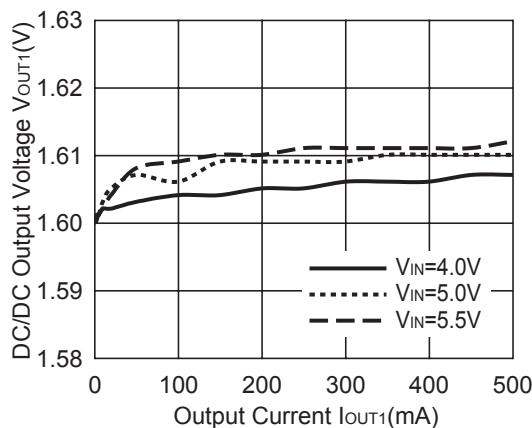
**R5212D011A**

**R5212D014C**
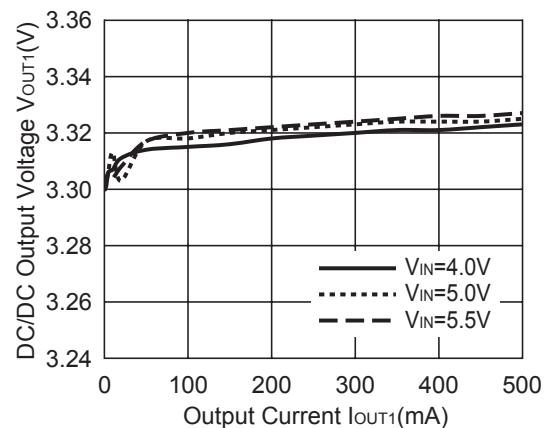
### 2) Efficiency vs. Output Current (Topt=25°C)

**R5211D011A**

$V_{OUT1}$=1.6V

**R5211D014C**

$V_{OUT1}$=3.3V

### 3) VR Output Voltage vs. Output Current (Topt=25°C)
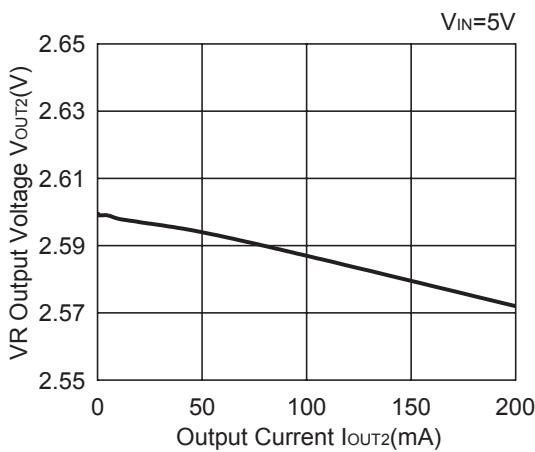
**R5212D011A**

$V_{IN}$=5V

**R5212D011A**

$V_{IN}$=5V

**RICOH**

17

**R5212D**

**R5212D011A**

$V_{IN}$=5V



**4) DC/DC Output Voltage vs. Temperature**
**R5212D011A**

$V_{IN}$=5V OpenLooP
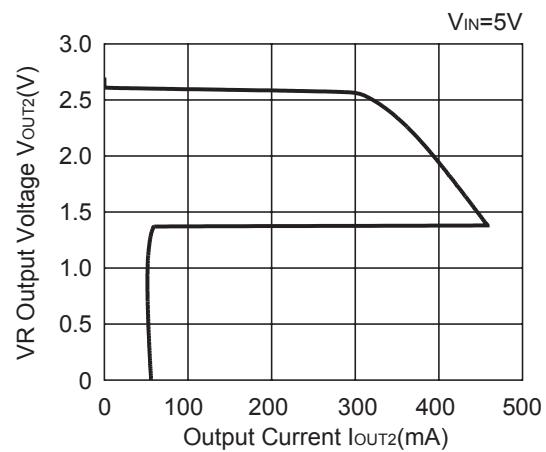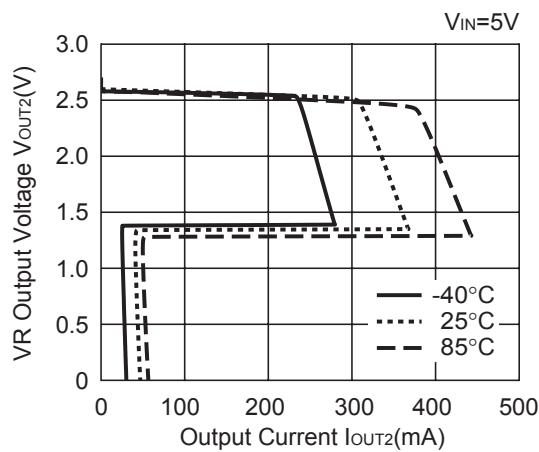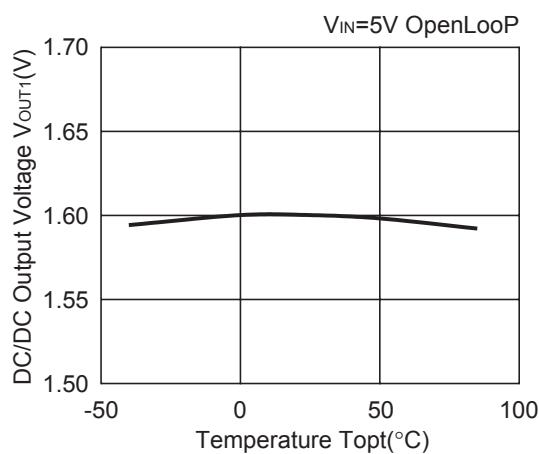


**5) VR Output Voltage vs. Temperature**
**R5212D011A**

$V_{IN}$=5V $I_{OUT2}$=10mA
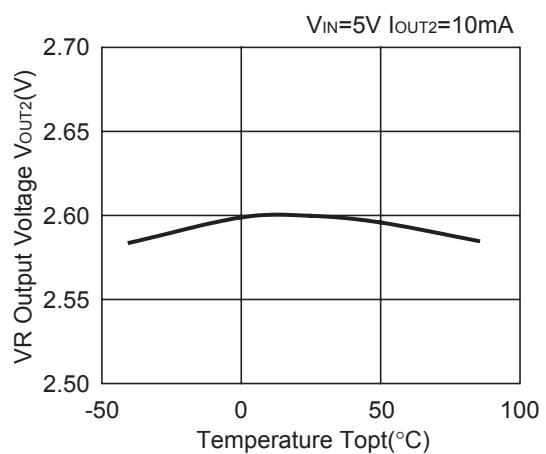


**6) VD Detector Threshold vs. Temperature**
**R5212D011A**

$V_{IN}$=5V
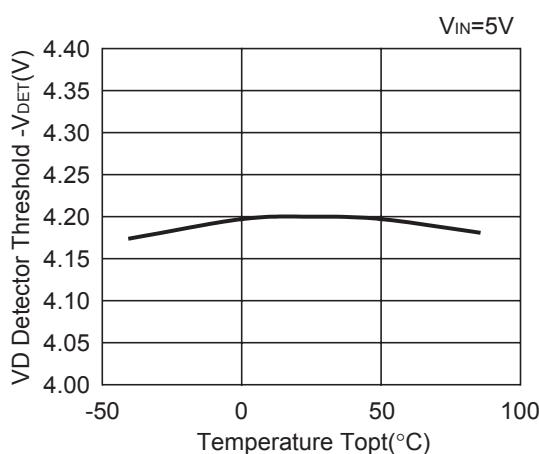


**7) VD Released Delay Time vs. Temperature**
**R5212D**



**RICOH**
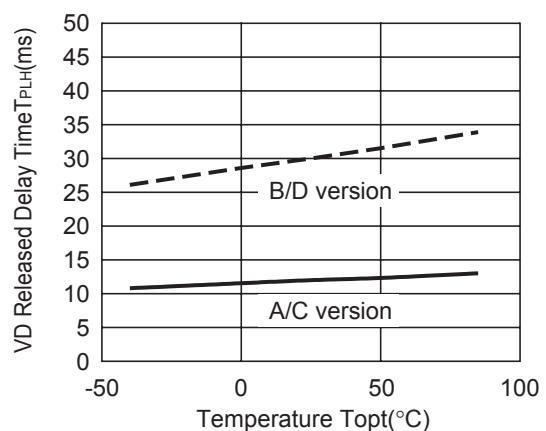
## 8) Soft-start time vs. Temperature
### R5212D011A

$V_{IN}$=5V
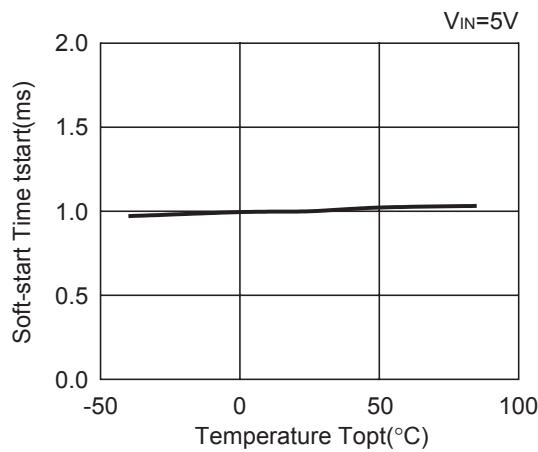


## 9)Frequency vs. Temperature
### R5212D011A

$V_{IN}$=5V
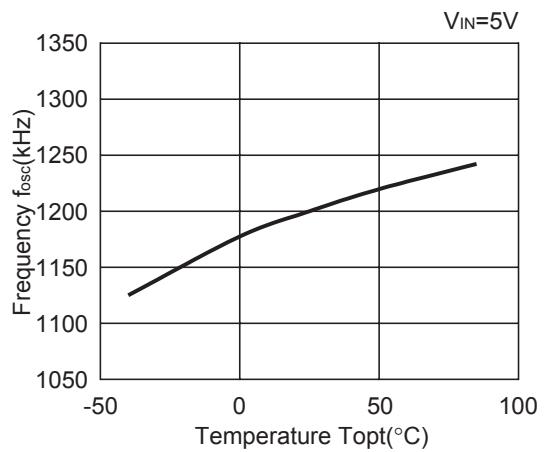


## 10) Supply Current vs. Temperature
### R5212D011A

$V_{IN}$=5V
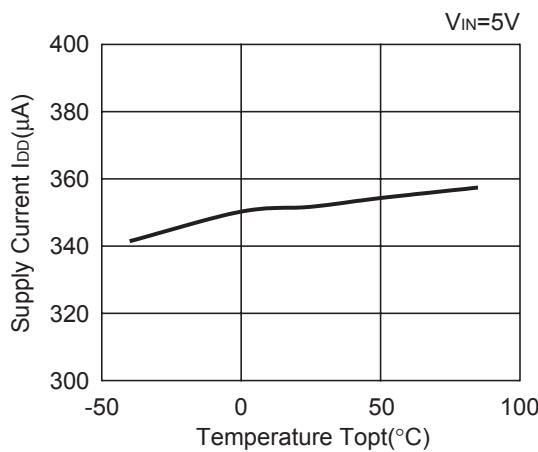


## 11) ON Resistance vs. Temperature
### R5212D011A

$V_{IN}$=5V
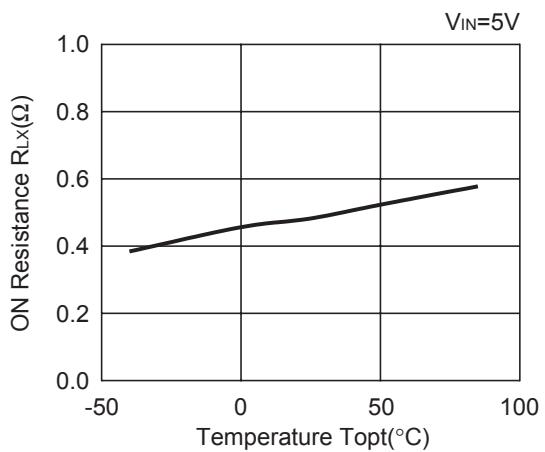


## 12) UVLO Released Voltage vs. Temperature
### R5212D011A
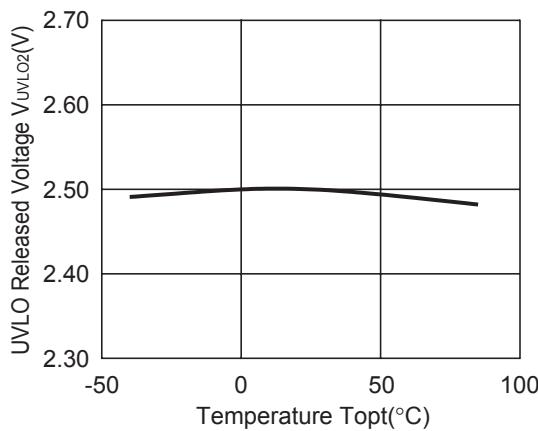


## 13) Lx Current Limit vs. Temperature
### R5212D011A
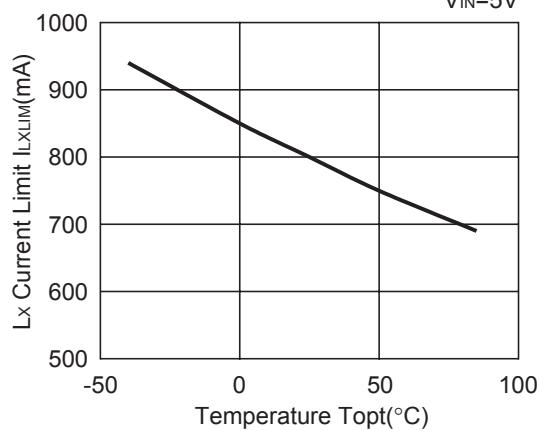
$V_{IN}$=5V



**RICOH**

---

## R5212D014C

L=10µH, C1=C2=10µF, V_IN=5V



## R5212D011A

L=4.7µH, C1=C2=10µF, V_IN=5V



## R5212D014C

L=10µH, C1=C2=10µF V_IN=5V



**RICOH**
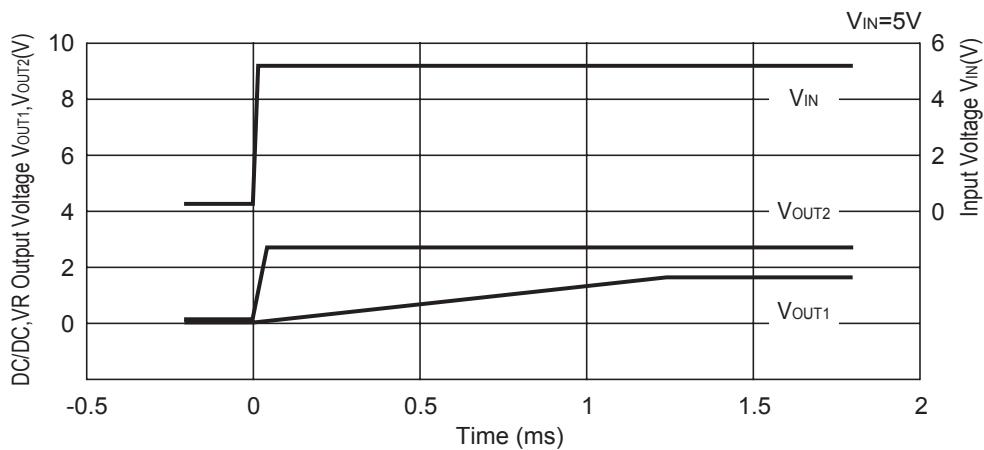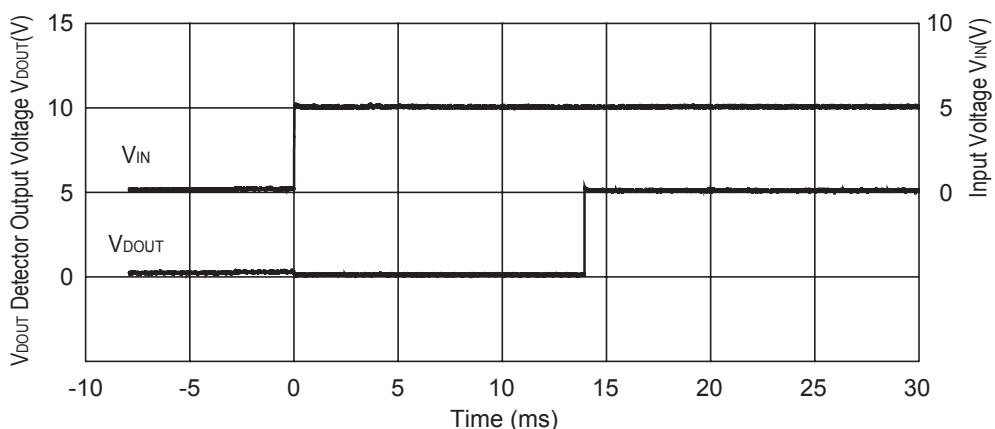
R5212D

## 17) VR Load Transient Response (Topt=25°C)

### R5212D011A

C1=C2=10μF, C3=2.2μF VIN=5V



$I_{OUT2}$:10mA→150mA
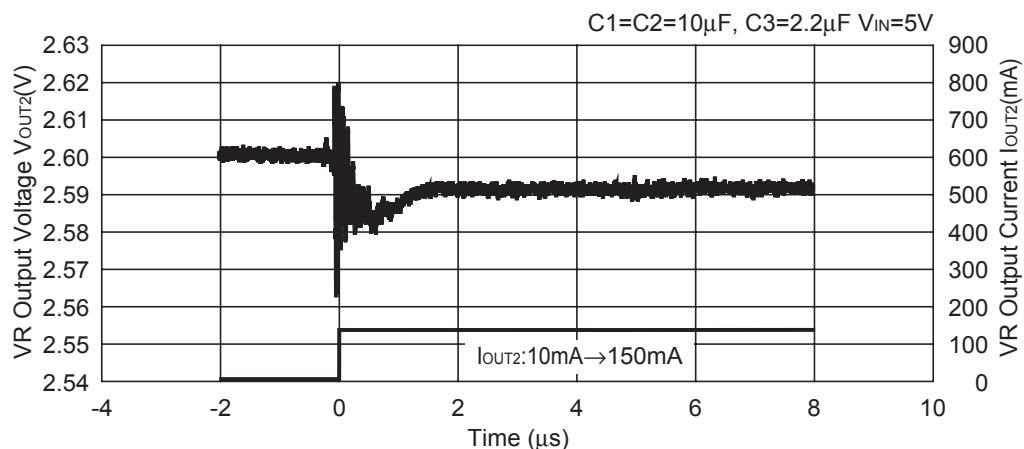
## 18) DC/DC, VR Ripple Waveform (C=10μF, VIN=5V, IOUT1=280mA, IOUT2=150mA, Topt=25°C)

### R5212D011A

L=4.7μH, $V_{OUT1}$=1.6V, $V_{OUT2}$=2.6V
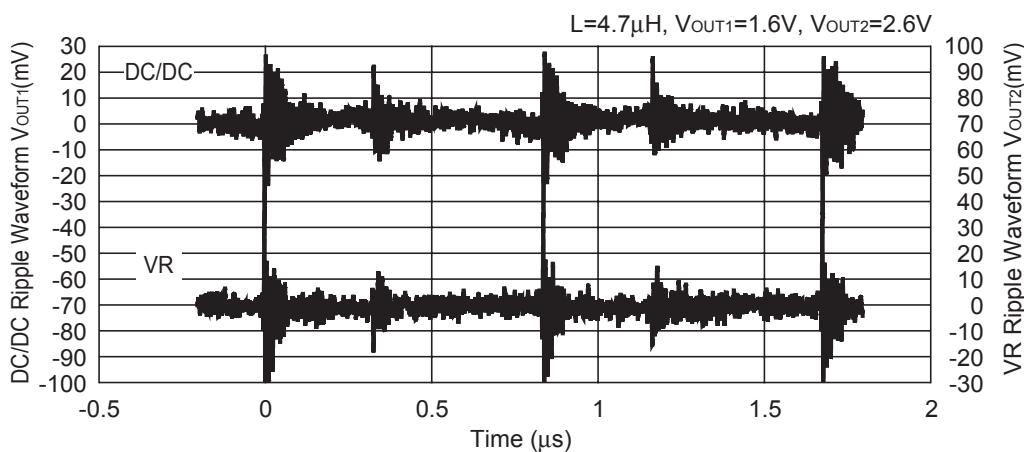


### R5212D014C

L=10μH, $V_{OUT1}$=3.3V, $V_{OUT2}$=2.5V

RICOH
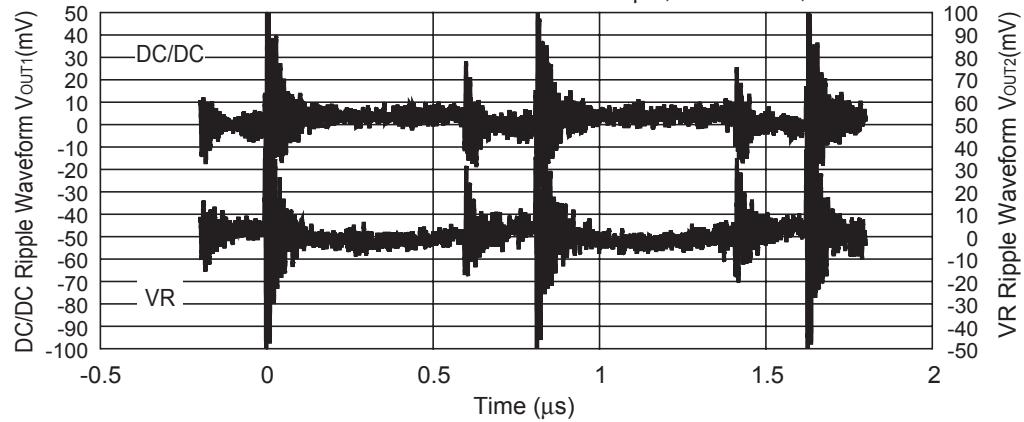
### 19) DC/DC Output Voltage vs. Input Voltage (Topt=25°C)

**R5212D011A**



$I_{OUT1}=10mA$

**R5212D014C**



$I_{OUT1}=10mA$
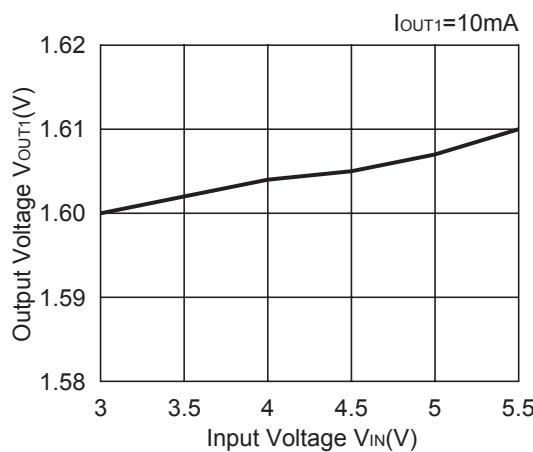
### 20) VR Output Voltage vs. Input Voltage (Topt=25°C)

**R5212D011A**



$I_{OUT2}=10mA$

**RICOH**

23
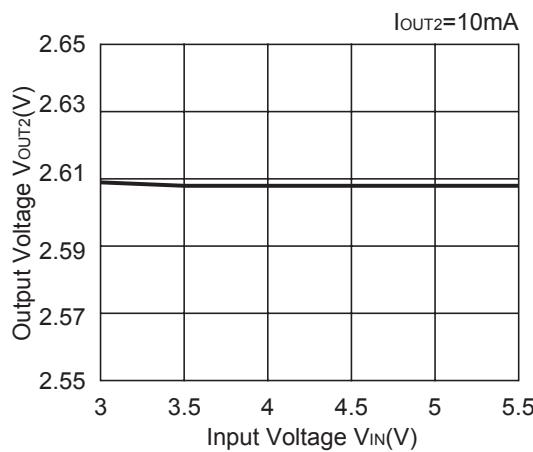
● **HSON-6**                                                              Unit: mm

# PACKAGE DIMENSIONS



Bottom View

※ Attention: Tabs or Tab suspension leads in the
parts have V$_{DD}$ or GND level.(They are
connected to the reverse side of this IC.)
Refer to PIN DESCRIPTIONS.
Do not connect to other wires or land patterns.
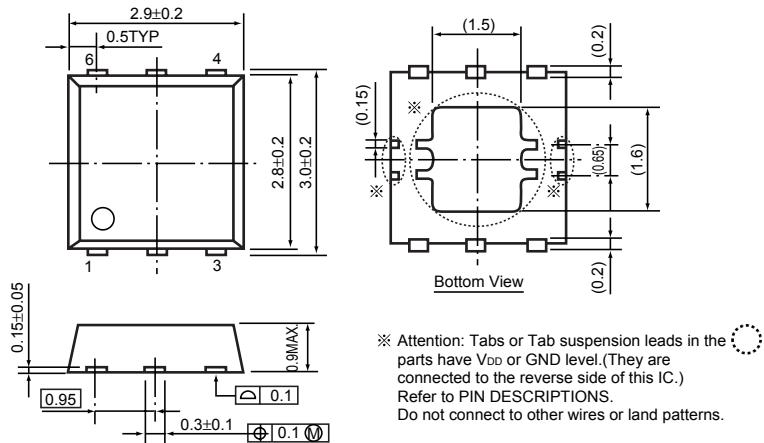
# TAPING SPECIFICATION



TR

User Direction of Feed
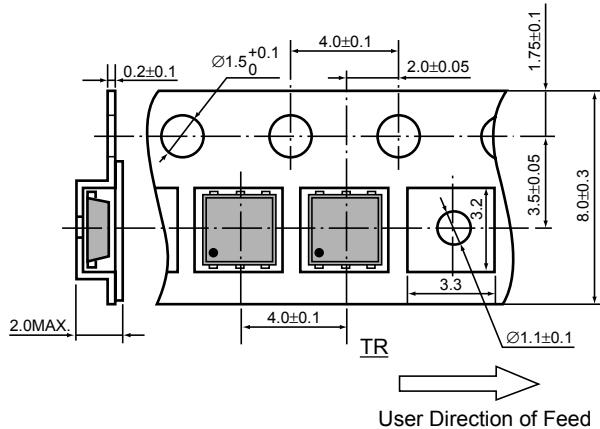
# TAPING REEL DIMENSIONS

(1reel=3000pcs)
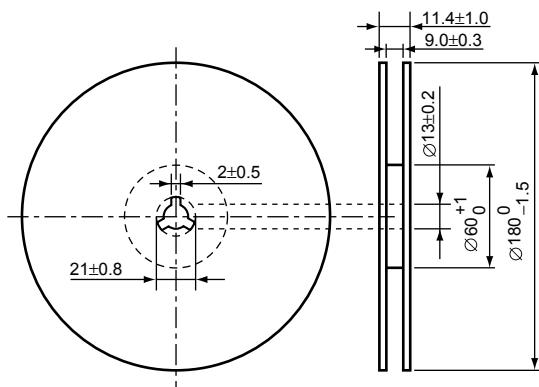
**RICOH**

## POWER DISSIPATION (HSON-6)

This specification is at mounted on board. 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 plactic (Double sided) |
| Board Dimensions | 40mm × 40mm × 1.6mm |
| Copper Ratio | Top side : Approx. 50% , Back side : Approx. 50% |
| Through-hole | $\phi$0.5mm × 44pcs |

Measurement Result

(Topt=25°C,Tjmax=125°C)

|  | Standard Land Pattern | Free Air |
|---|---|---|
| Power Dissipation | 900mW | 400mW |
| Thermal Resistance | $\theta$ja=(125−25°C)/0.9W=111°C/W | 250°C/W |
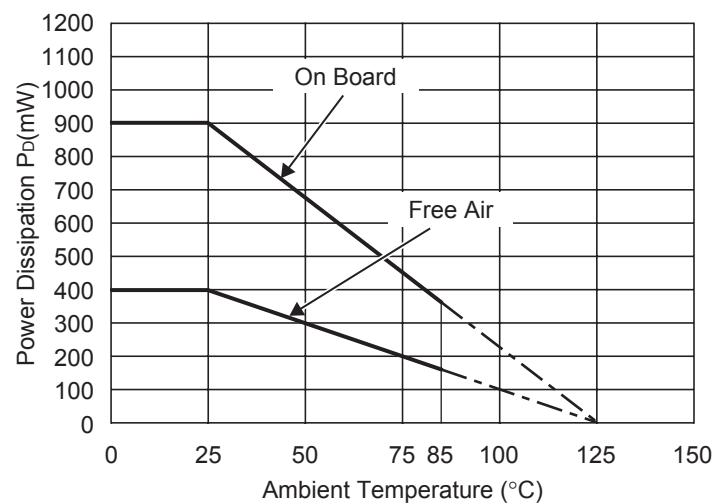


**Power Dissipation**
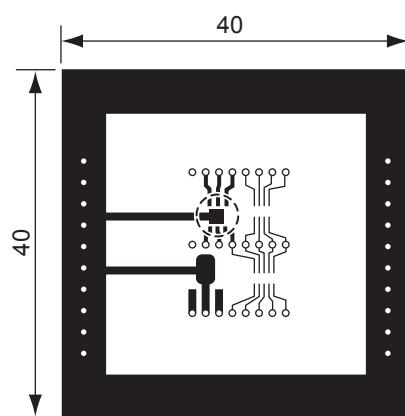


**Measurement Board Pattern**
◯ IC Mount Area Unit : mm

## RECOMMENDED LAND PATTERN



(Unit: mm)
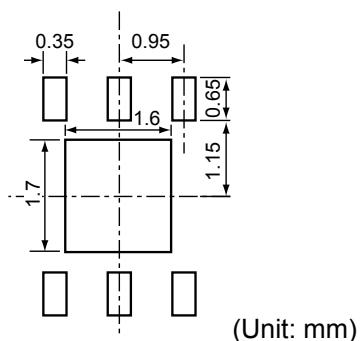
**RICOH**

## R5212D SERIES MARK SPECIFICATION

● **HSON-6**
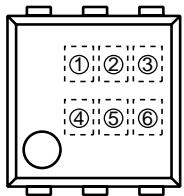


① to ④: Product Code (refer to Part Number vs. Product Code)

⑤, ⑥  : Lot Number

● **Part Number vs. Product Code**

| Part Number | Product Code | | | |
|---|---|---|---|---|
| | ① | ② | ③ | ④ |
| R5212D011A | D | 1 | 1 | A |
| R5212D014C | D | 1 | 4 | C |
| R5212D017A | D | 1 | 7 | A |
| R5212D016B | D | 1 | 6 | B |

**RICOH**