# RICOH

## HIGH EFFICIENCY, SMALL PACKAGES, STEP-UP DC/DC CONVERTERS

## OUTLINE

RP401x Series are high efficiency, step-up DC/DC converter ICs packaged in compact 5pin SOT23-5 or 6pin DFN(PLP)1820-6. This IC can start up from low voltage (Typ.0.6V), therefore, it is suitable for using with single or 2 serial alkaline batteries, or a nickel-metal-hydride (NiMH) battery, or one-cell Lithium-ion (Li+) battery.

This IC consists of an oscillator, a reference voltage unit with soft start, a chip enable circuit, an error amplifier, phase compensation circuits, a slope circuit, a PWM control circuit, a start-up circuit, a PWM/VFM mode control circuit, internal switches and a protection circuit.

A low ripple high efficiency step-up DC/DC converter can be composed of the RP401x with only an inductor, a diode, (resisters for adjustable type), and capacitors. The output voltage of the RP401K001s is adjustable, and others are fixed internally. The output voltage range is from 1.8V to 5.5V. RP401Kxx1A/B series have a MODE pin to alternate between PWM fix and PWM/VFM automatic shift to improve the efficiency at light load. If MODE pin is set "H", the mode is PWM fix, and when the MODE pin is set "L", PWM/VFM automatic shift. The RP401xxx1C and D do not have MODE pin. The RP401xxx1C is PWM/PFM alternative type, and the RP401xxx1D is PWM fixed type.

## FEATURES

- ● Low Start-up Voltage guaranteed ······················· Typ. 0.6V
- ● Input Voltage Range ································· 0.6V ~ 5.5V
- ● High Efficiency ······························· 86% (100mA / 3.3V, $V_{IN}$ = 1.5V, 25°C)
- ● Output current ·································· 500mA / 1.8V ($V_{IN}$ = 1.5V) / 5.0V ($V_{IN}$ = 3.3V)
- ● Built-in Lx switch ······························ NMOS: 0.4Ω ($V_{OUT}$ = 3.3V, 25°C)
- ● PWM Oscillator Frequency ····················· 1.2MHz
- ● Output Voltage Range ························· Fixed type: 1.8V to 5.5V with 0.1V Stepwise
  Adjustable: 1.8V ~ 5.5V
  (Recommendation range of output voltage)
- ● Lx peak current limit function ···························· Typ. 1.0A
- ● Latch protection delay time ······················· 3.3ms (Only applied to A version)
- ● Small Packages ···························· DFN(PLP)1820-6, SOT23-5
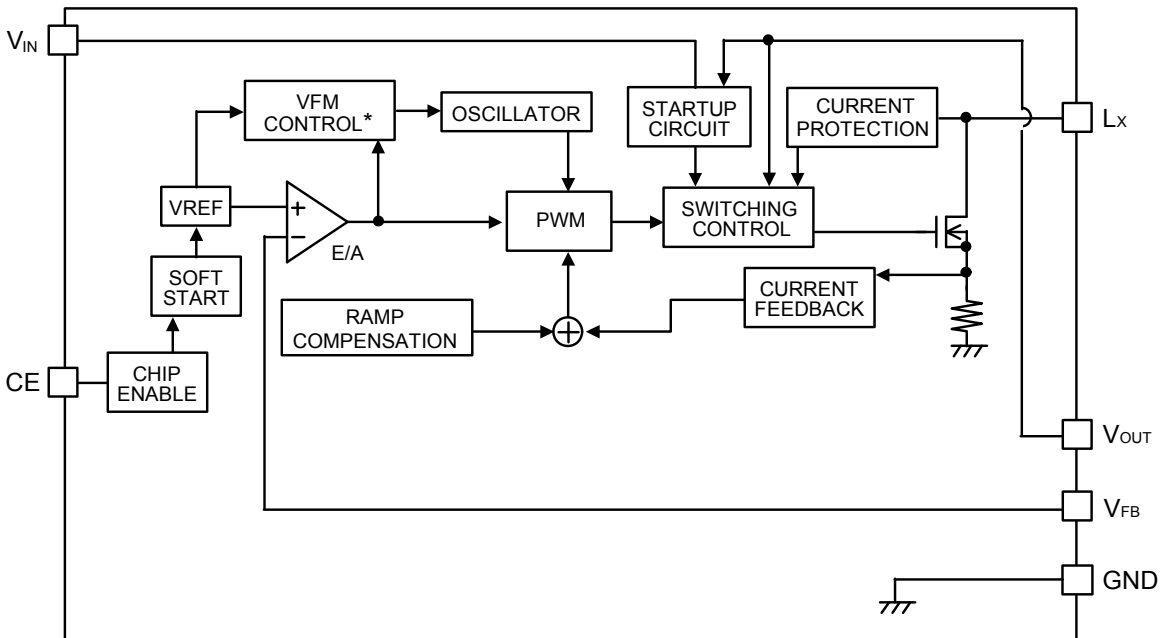
## APPLICATIONS

- ● MP3 players, PDA, cellular phones
- ● Digital Still Cameras
- ● LCD Bias Supplies
- ● Portable blood pressure meter
- ● Wireless Handset
- ● GPS
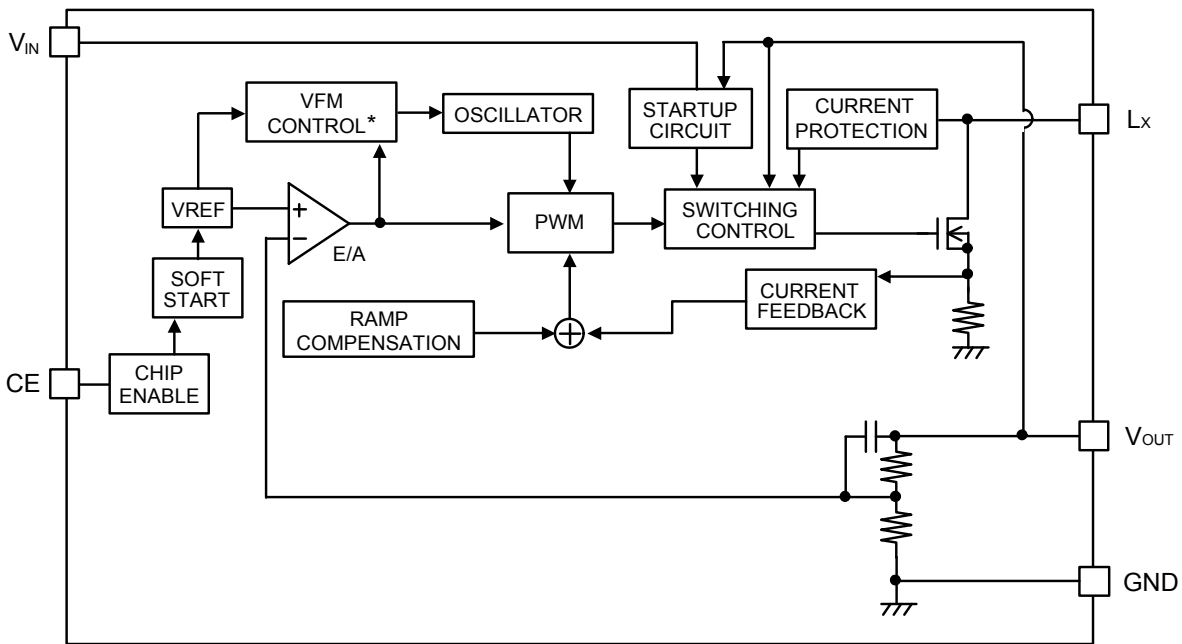
# BLOCK DIAGRAMS

**Fixed output; RP401Kxx1A/B**
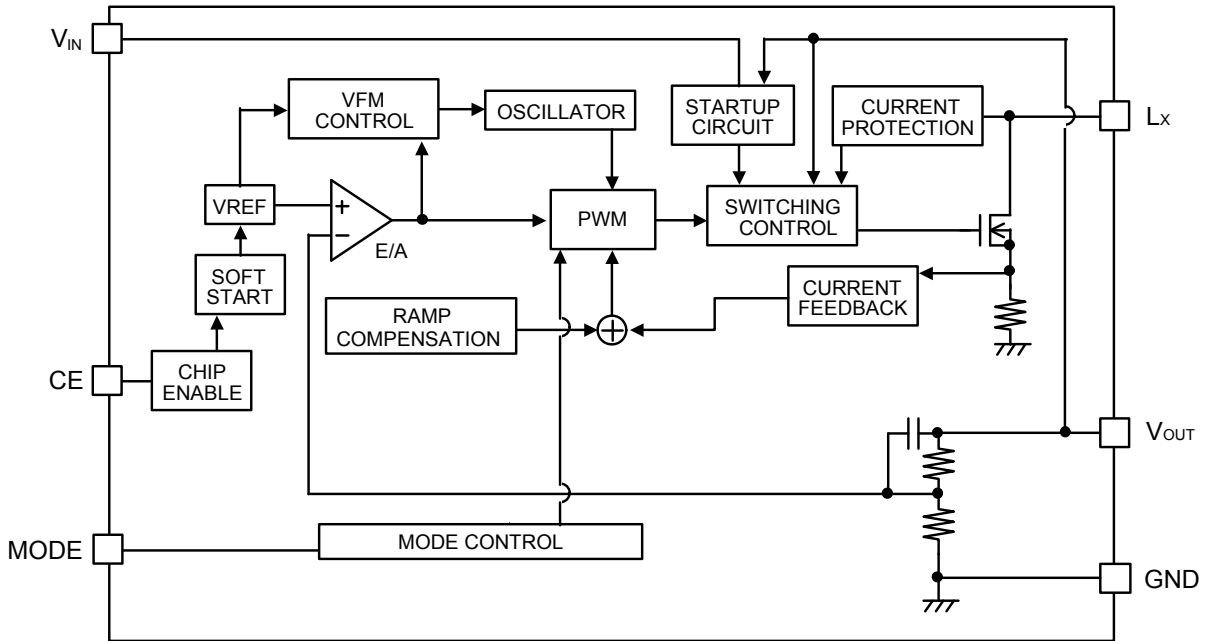


**Adjustable output type: RP401K001C/D**



*) Applied to PWM/VFM automatic shift, RP401K001C only.

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**Fixed output type: RP401Nxx1C/D**



*) Applied to PWM/VFM automatic shift, RP401Nxx1C only.

## SELECTION GUIDE

In the RP400 Series, output Voltage, Type of Output Voltage, and package for the ICs can be selected at the user's request.

| Product Name | Package | Quantity per Reel | Pb Free | Halogen Free |
|---|---|---|---|---|
| RP401Kxx1$-TR | DFN (PLP)1820-6 | 5,000 pcs | Yes | Yes |
| RP401Nxx1$-TR-FE | SOT-23-5 | 3,000 pcs | Yes | Yes |

xx: Designation of output voltage
    00: Adjustable Version (1.8V ~ 5.5V) **\* recommendation range of output voltage / DFN(PLP)1820-6 only**
    xx: Fixed version: designation is possible in the range from 1.8V to 5.5V with a step of 0.1V

$: Designation of option.
    A: with Mode pin, latch type over-current protection circuit
    B: with Mode pin, without latch type over-current protection circuit
    C: without Mode pin (PWM/VFM automatic shift)
    D: without Mode pin (PWM-fix)

Product code table

| Version | MODE pin | Output Voltage | Latch type over-current protection | package |
|---------|----------|----------------|-----------------------------------|---------|
| A | Yes | Fixed | Yes | DFN(PLP)1820-6 |
| B | Yes | Fixed | No | DFN(PLP)1820-6 |
| C | No (PWM/VFM automatic shift) | Fixed | No | SOT-23-5 |
| C | No (PWM/VFM automatic shift) | Adjustable | No | DFN(PLP)1820-6 |
| D | No (PWM fix) | Fixed | No | SOT-23-5 |
| D | No (PWM fix) | Adjustable | No | DFN(PLP)1820-6 |

# PIN CONFIGURATION

**DFN(PLP)1820-6**

**SOT-23-5**

(Bottom View)

(Top View)
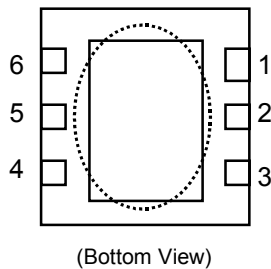
# PIN DESCRIPTION

### RP401Kxx1A/B: DFN(PLP)1820-6

| Pin No | Symbol | Pin Description |
|--------|--------|-----------------|
| 1 | $V_{IN}$ | Power Supply Pin |
| 2 | CE | Chip Enable Pin (Active with "H") |
| 3 | GND | Ground Pin |
| 4 | Lx | Internal NMOS Switch Drain Pin |
| 5 | MODE | Mode pin for switch over PWM-fix or PWM/VFM alternative |
| 6 | $V_{OUT}$ | Output Pin |

\* Tab is GND level. (They are connected to the reverse side of this IC.) Connected to the GND is the recommendation, leaving it open is also possible.

### RP401K001C/D: DFN(PLP)1820-6

| Pin No | Symbol | Pin Description |
|--------|--------|-----------------|
| 1 | $V_{IN}$ | Power Supply Pin |
| 2 | CE | Chip Enable Pin (Active with "H") |
| 3 | GND | Ground Pin |
| 4 | Lx | Internal NMOS Switch Drain Pin |
| 5 | $V_{FB}$ | Feedback input voltage for setting output voltage |
| 6 | $V_{OUT}$ | Output Pin |

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* Tab is GND level. (They are connected to the reverse side of this IC.) Connected to the GND is the recommendation, leaving it open is also possible.

### RP401Nxx1C/D: SOT-23-5

| Pin No | Symbol | Pin Description |
|--------|--------|-----------------|
| 1 | CE | Chip Enable Pin (Active "H") |
| 2 | GND | Ground Pin |
| 3 | $V_{IN}$ | Power Supply Pin |
| 4 | $V_{OUT}$ | Output Pin |
| 5 | Lx | Internal NMOS Switch Drain Pin |

## ABSOLUTE MAXIMAM RATINGS

(GND=0V)

| Symbol | Items | Ratings | | Unit |
|--------|-------|---------|---|------|
| $V_{IN}$ | $V_{IN}$ Supply Voltage | -0.3 to 6.0 | | V |
| $V_{OUT}$ | $V_{OUT}$ Pin Voltage | -0.3 to 6.0 | | V |
| $V_{LX}$ | Lx Pin Input Voltage | -0.3 to 6.0 | | V |
| $V_{CE}$ | CE Pin Voltage | -0.3 to 6.0 | | V |
| $V_{FB}$ | $V_{FB}$ Pin Voltage | RP401K001C/D | -0.3 to 6.0 | V |
| $V_{MODE}$ | MODE Pin Voltage | RP401K001A/B | -0.3 to 6.0 | V |
| $P_D$ | Power Dissipation * | SOT-23-5 | 420 | mW |
| | | DFN(PLP)1820-6 | 880 | |
| Ta | Ambient Temp Range | -40 to +85 | | °C |
| Tstg | Storage Temp Range | -55 to +125 | | °C |

*) As for Power Dissipation, refer to PACKAGE INFORMATION.

| ABSOLUTE MAXIMUM RATINGS |
|---|
| Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the lifetime 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 CONDITIONS (ELECTRICAL CHARACTERISTICS) |
|---|
| All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions. |

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## ELECTRICAL CHARACTERISTICS

**Adjustable types (RP401K001C/D)**  (Ta=25°C)

| Symbol | Item | Conditions | | MIN. | TYP. | MAX. | Unit |
|---|---|---|---|---|---|---|---|
| $V_{IN}$ | Input Voltage | | | | | 5.5 | V |
| Vstart | Start-up Voltage | Load current =1mA | | | 0.6 | 0.8 | V |
| Vhold | Hold-on Voltage | Load current=1mA | | 0.6 | | | V |
| $I_{DD1}$ | Quiescent Current 1 | $V_{IN}$=2V, $V_{OUT}$=2.5V, $V_{FB}$=0V | | | 380 | 500 | μA |
| $I_{DD2}$ | Quiescent Current 2 (No switching) | 001C | $V_{IN}$=$V_{OUT}$=5.5V, $V_{FB}$=1.0V | | 130 | 190 | μA |
| | | 001D | | | 230 | 320 | μA |
| Istandby | Standby Current | $V_{IN}$=$V_{OUT}$=5.5V, $V_{CE}$=0V | | | 0.15 | 3.00 | μA |
| $V_{FB}$ | Feedback Voltage | $V_{IN}$=$V_{OUT}$=3.3V | | 0.588 | 0.600 | 0.612 | V |
| $\Delta V_{OUT}$ /$\Delta$Ta | Output-Voltage Temperature Coefficient | -40°C≤Ta≤85°C | | | ±80 | | ppm /°C |
| Fosc | Switching Frequency | $V_{IN}$=$V_{OUT}$=3.3V, $V_{FB}$=0V | | 1020 | 1200 | 1380 | kHz |
| $\Delta$fosc /$\Delta$Ta | Switching Frequency Temperature Coefficient | -40°C≤Ta≤85°C | | | ±0.2 | | kHz /°C |
| $R_{ONN}$ | NMOS On-Resistance (*1) | $V_{OUT}$=3.3V | | | 0.4 | | Ω |
| $I_{CEH}$ | CE "H" Input Current | $V_{IN}$=$V_{OUT}$=$V_{CE}$=5.5V | | | | 0.2 | μA |
| $I_{CEL}$ | CE "L" Input Current | $V_{IN}$=$V_{OUT}$=5.5V, $V_{CE}$=0V | | -0.2 | | | μA |
| $I_{FBH}$ | FB "H" Input Current | $V_{IN}$=$V_{OUT}$=$V_{FB}$=5.5V | | | | 0.2 | μA |
| $I_{FBL}$ | FB "L" Input Current | $V_{IN}$=$V_{OUT}$=5.5V, $V_{FB}$=0V | | -0.2 | | | μA |
| $I_{LX}$ | Lx Leakage Current | $V_{IN}$=$V_{OUT}$=$V_{LX}$=5.5V, $V_{CE}$=0V | | | | 2 | μA |
| $I_{Lxpeak}$ | Lx Current limit (*2) | $V_{IN}$=$V_{SET}$x0.5V | | 0.86 | 1.00 | | A |
| $V_{CEH}$ | CE Input Voltage "H" | | | 0.7 | | | V |
| $V_{CEL}$ | CE Input Voltage "L" | | | | | 0.4 | V |
| Maxduty | Maximum Duty Cycle | $V_{IN}$=$V_{OUT}$=3.3V, $V_{FB}$=0V | | 80 | 88 | 95 | % |
| tstart | Soft start Time | $V_{IN}$=1.65V, $V_{OUT}$=3.3V, the time interval from $V_{CE}$ changing from 0V to 1.5V edge to $V_{OUT}$ being 2.97V | | | 0.7 | 3.0 | ms |

*1) Guaranteed by design. NMOS On-Resistance depends on the $V_{OUT}$ voltage.
*2) Lx limit current changes according to the switching duty ratio.

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**Fixed output voltage types (RP401Kxx1A/B, RP401Nxx1C/D)** (Ta=25°C)

| Symbol | Item | Conditions | MIN. | TYP. | MAX. | Unit |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Input Voltage | | | | 5.5 | V |
| Vstart | Start-up Voltage | Load current =1mA | | 0.6 | 0.8 | V |
| Vhold | Hold-on Voltage | Load current=1mA | 0.6 | | | V |
| $I_{DD1}$ | Quiescent Current 1 | $V_{IN}$=0.5x$V_{SET}$, $V_{OUT}$=0.95x$V_{SET}$ | | $V_{OUT}$x90 +130 | $V_{OUT}$x100 +250 | μA |
| $I_{DD2}$ | Quiescent Current 2 (No switching) | xx1A/B/C | $V_{IN}$=$V_{OUT}$=5.5V | | 130 | 190 | μA |
| | | xx1D | | | 230 | 320 | μA |
| Istandby | Standby Current | $V_{IN}$=$V_{OUT}$=5.5V, $V_{CE}$=0V | | 0.15 | 3.00 | μA |
| $V_{OUT}$ | Output Voltage | $V_{IN}$=$V_{CE}$=1.5V | x0.98 | | x1.02 | V |
| $\Delta V_{OUT}$ /$\Delta$Ta | Output-Voltage Temperature Coefficient | -40°C≤Ta≤85°C | | ±80 | | ppm /°C |
| Fosc | Switching Frequency | $V_{IN}$=$V_{OUT}$=3.3V, $V_{FB}$=0V | 1020 | 1200 | 1380 | kHz |
| $\Delta$fosc /$\Delta$Ta | Switching Frequency Temperature Coefficient | -40°C≤Ta≤85°C | | ±0.2 | | kHz /°C |
| $R_{ONN}$ | NMOS On-Resistance (*1) | $V_{OUT}$=3.3V | | 0.4 | | Ω |
| $I_{CEH}$ | CE "H" Input Current | $V_{IN}$=$V_{OUT}$=$V_{CE}$=5.5V | | | 0.2 | μA |
| $I_{CEL}$ | CE "L" Input Current | $V_{IN}$=$V_{OUT}$=5.5V, $V_{CE}$=0V | -0.2 | | | μA |
| $I_{MODEH}$ | MODE "H" Input Current | $V_{IN}$=$V_{OUT}$=$V_{MODE}$=5.5V | | | 0.2 | μA |
| $I_{MODEL}$ | MODE "L" Input Current | $V_{IN}$=$V_{OUT}$=5.5V, $V_{MODE}$=0V | -0.2 | | | μA |
| $I_{LX}$ | Lx Leakage Current | $V_{IN}$=$V_{OUT}$=$V_{LX}$=5.5V, $V_{CE}$=0V | | | 2 | μA |
| $I_{Lxpeak}$ | Lx Current limit (*2) | $V_{IN}$=$V_{SET}$x0.5V | 0.86 | 1.00 | | A |
| $V_{CEH}$ | CE Input Voltage "H" | | 0.7 | | | V |
| $V_{CEL}$ | CE Input Voltage "L" | | | | 0.4 | V |
| Maxduty | Maximum Duty Cycle | $V_{IN}$=$V_{OUT}$=0.95 x $V_{SET}$ | 80 | 88 | 95 | % |
| tstart | Soft start Time | $V_{IN}$=$V_{SET}$ x 0.5, the time interval from $V_{CE}$ changing from 0V to 1.5V edge to $V_{OUT}$ being $V_{SET}$ x 0.9 | | 0.7 | 3.0 | ms |
| tprot | Protection Delay Time | $V_{IN}$=$V_{CE}$=3.3V | | 3.3 | 5.0 | ms |

*1) Guaranteed by design. NMOS On-Resistance depends on the $V_{OUT}$ voltage.
*2) Lx limit current changes according to the switching duty ratio.
*3) Applied to A/B version
*4) Applied to A version.

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# APPLICATION NOTES

**Fixed Output Voltage Type (RP401Kxx1A/B)**



**Adjustable output type (RP401K001C/D)**

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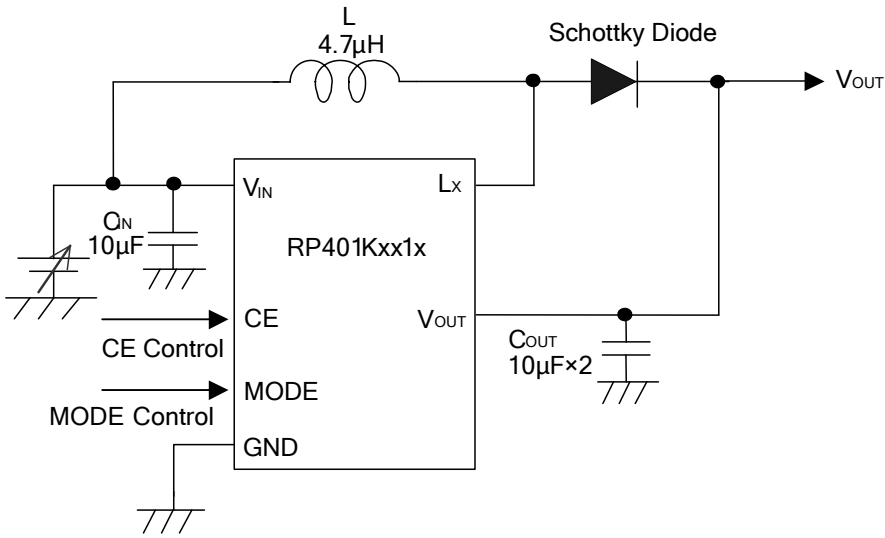
**Fixed output type (RP401Nxx1C/D)**
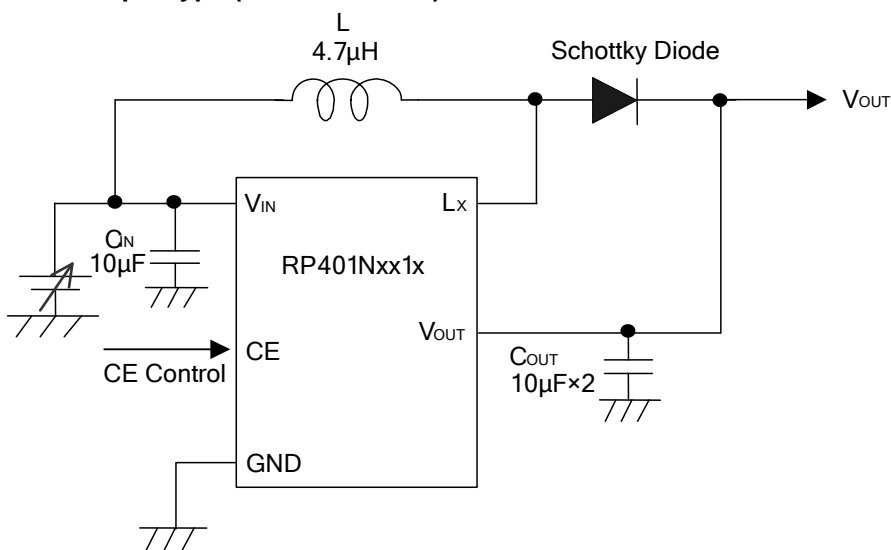


**External components**

Capacitor $C_{IN}$: C1608JB0J106M (TDK), $C_{OUT}$:

| $V_{OUT}$[V] | ILmax<700mA | ILmax≥700mA |
|---|---|---|
| 1.8≤$V_{OUT}$<3.3 | C1608JB0J106M×2 (10µF×2,TDK) | |
| 3.3≤$V_{OUT}$≤5.5 | C1608JB0J106M (10µF,TDK) | C1608JB0J106M×2 (10µF×2,TDK) |

Diode: ILmax<700mA, CRS10I30A (TOSHIBA). ILmax≥700mA, CMS06 (TOSHIBA)
Inductor: SLF6028T-4R7M1R6-PF (TDK), depending on the conditions, smaller L can be used with.
(ex. VLS2012: TDK)

● **Setting of Output Voltage for RP401K001C/D**

Output voltage can be set with divider resistors for voltage setting, R1 and R2 as shown in the typical application. Refer to the next formula.

Output Voltage = $V_{FB} \times$ (R1 + R2) / R1      ($V_{FB}$ = 0.6V)
Recommended value of resistors: Choose R1 and R2 so as to become (R1 + R2) being lower than 100kΩ.

Make sufficient power supply and ground. The large switching current may flow through the power line and GND line. If their impedance is high, the internal voltage of the IC may shift by the switching current and unstable operation may result. At turning off the built-in Lx switch, an over-shoot spike on the output may be generated by the inductor, therefore voltage rating of the output capacitor and the diode is 1.5 or more times as much as setting output voltage.

Use a diode of a low Vf Schottky type with high switching speed, low reverse current, and the current rating.

The RP401x uses the $V_{OUT}$ voltage as the main power supply after start-up. Therefore the capacitor between Vout and GND has a role of the bypass capacitor for this IC. Use capacitors with a capacity of 10µF or more for

$V_{OUT}$ pin. Consider the bias shift, choose the enough capacity of the capacitor. A ceramic capacitor (10$\mu$F) between $V_{IN}$ and ground should be set.

The inductor value recommendation is 4.7$\mu$H. Choose an inductor that has small D.C. resistance and large enough permissible current and hard to reach magnetic saturation.

If the spike noise on Lx pin is large, put a snub circuit (CR serial connection etc.) in parallel with the diode and reduce the spike noise. The time constants of CR depends on the PCB and have an impact on the efficiency, therefore fully evaluation is necessary. (Basic value is 10ohm and 300pF)

The MODE pin is controlled with a logic voltage. To make it "H", 1.0V or more must be forced to the MODE pin. If power supply is less than 1.0V, MODE pin must be pulled up to $V_{OUT}$.

The RP401xxxxA can reset the latch protection with CE signal. If $C_{IN}$ is too large, and $V_{IN}$ does not reach 0.8V, even if the IC starts up with CE signal, the latch operation may not be reset correctly. The sequence of $V_{IN}$ and CE must be cared. In the case of CE pin pulled-up to $V_{IN}$ pin or $V_{OUT}$ pin, the operation of latch protection reset may not work correctly.

*The performance of power circuit using those 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. (such as the voltage, current , and power)

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# OUTPUT CURRENT OF STEP-UP CIRCUIT AND EXTERNAL COMPONENTS

<Basic Circuit>

<Current   through L>

Discontinuous
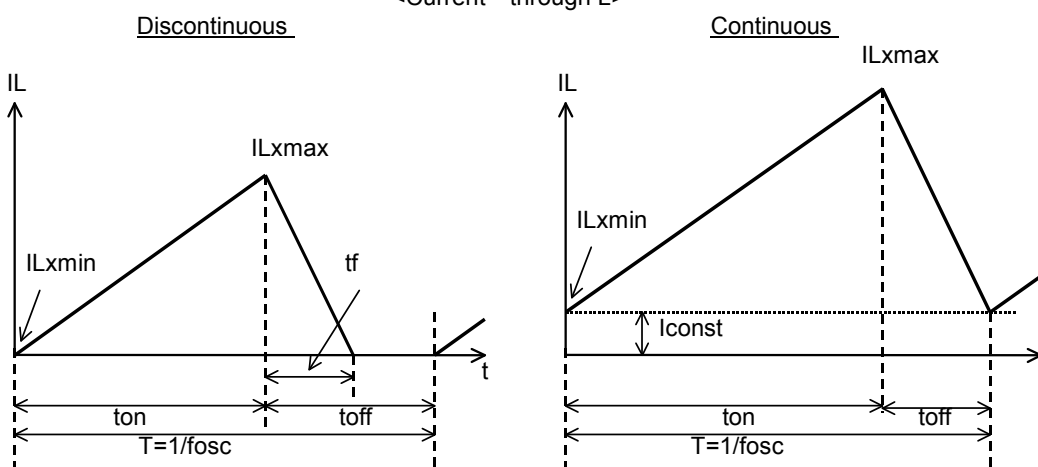
Continuous

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 the 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 the next formula.

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

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.

$$P_{AV} = 1/(ton + toff) \times \{\int_0^{ton} V_{IN}^2 \times t/L \ dt + \int_0^{tf} V_{IN} \times (V_{OUT} - V_{IN})t/L \ dt\} \quad\text{Formula 3}$$

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.

$$V_{IN} \times ton / L = (V_{OUT} - V_{IN}) \times toff / L \cdots\cdots\cdots \text{Formula 4}$$

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

$$I_{OUT} = fosc \times V_{IN}^2 \times ton^2 / \{2 \times L (V_{OUT} - V_{IN})\} = V_{IN}^2 \times ton / (2 \times L \times V_{OUT}) \cdots\cdots \text{Formula 5}$$

When $I_{OUT}$ becomes more than $V_{IN} \times ton \times toff / (2 \times L \times (ton + toff))$, the current flows through the inductor and the mode becomes continuous. The continuous current through the inductor is described as Iconst, then,

$$I_{OUT} = fosc \times V_{IN}^2 \times ton^2 / (2 \times L \times (V_{OUT} - V_{IN})) + V_{IN} \times Iconst / V_{OUT} \cdots\cdots \text{Formula 6}$$

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

$$Ilxmax = Iconst + V_{IN} \times ton / L \cdots\cdots\cdots \text{Formula 7}$$

With the formula 4, 6 and Ilxmax is

$$Ilxmax = V_{OUT} / V_{IN} \times I_{OUT} + V_{IN} \times ton / (2 \times L) \cdots\cdots\cdots \text{Formula 8}$$
$$\text{However, } ton = (1 - V_{IN} / V_{OUT}) / fosc$$

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.

Select the inductor and the diode with considering the peak current of the (Formula 8).

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# ■ TIMING CHART

## Soft start operation and Latch protection operation



*1) Applied to A/B/C version. (MODE="L" for version A/B)

*2) Applied to A version only.

<Start-up> When the CE pin becomes from "L" to "H", then the DC/DC converter starts up. In the RP401 series, low input voltage (Typ. 0.6V) operation is possible due to the low- boost mode. Until the output voltage reaches 1.65V (Typ.) the mode is low-boost mode. When the output voltage becomes 1.65V or more, to suppress the inrush current, soft start operation starts and boosts the output voltage to set value.

*) At the low-boost mode, the oscillator frequency is reduced to 200kHz (Typ.), therefore, compared with the normal operation frequency 1.2MHz, the boost capability is worse. Therefore, step-up ratio and load current must be cared.

*) Soft-start time depends on the set output voltage, input voltage, temperature, and the load current. Refer to the next graphs.

Soft Start Period vs. Input Voltage RP401xxx1x
I<sub>OUT</sub>=1mA
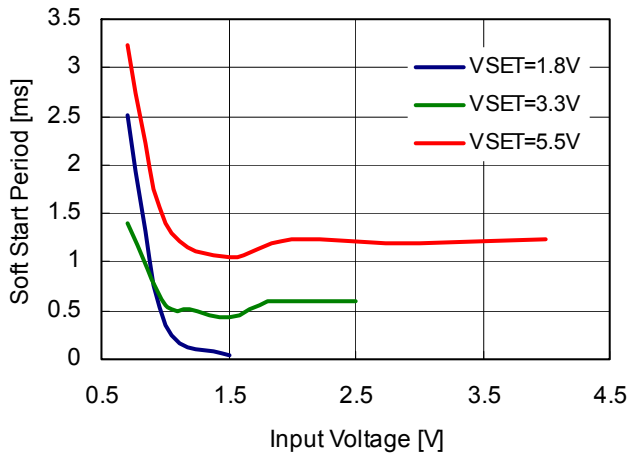
Soft Start Period vs. Temperature RP401xxx1x
V<sub>IN</sub>=V<sub>SET</sub>×0.5, RL=1kΩ





### <Over-current protection operation>

If the Lx peak current reaches 1.0A (Typ.), then Lx peak current limit circuit operates and control the duty ratio of Lx switch.

<Latch Protection Operation> applied to A version only

If over current state continues for a protection delay time ($t_{PROT}$), then latch protection function starts and latch the internal driver switch being off and the operation of DC/DC converter will stop.

To release the latch protection circuit, toggled input for CE pin is necessary.

Lx current limit($I_{LXPEAK}$) and the protection delay time (tprot) are influenced by the self-heating, heat radiation environment at mounting on board. If short circuit may happen, input voltage ($V_{IN}$) drops largely or becomes unstable, the protection operation and the delay time will be influenced.

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# TYPICAL CHARACTERISTICS

1) Output voltage vs. output current (Ta=25°C)

RP401K001x
RP401x181x
$V_{OUT}$=1.8V
MODE=L

RP401K001x
RP401x181x
$V_{OUT}$=1.8V
MODE=H

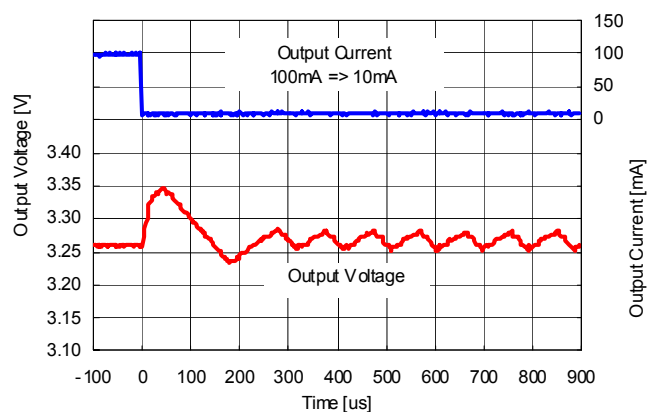RP401K001x
RP401x331x
$V_{OUT}$=3.3V
MODE=L

RP401K001x
RP401x331x
$V_{OUT}$=3.3V
MODE=H

RP401K001x
RP401x501x
$V_{OUT}$=5.0V
MODE=L

RP401K001x
RP401x501x
$V_{OUT}$=5.0V
MODE=H

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RP401K001x
RP401x551x   $V_{OUT}$=5.5V
MODE=L

RP401K001x
RP401x551x   $V_{OUT}$=5.5V
MODE=H
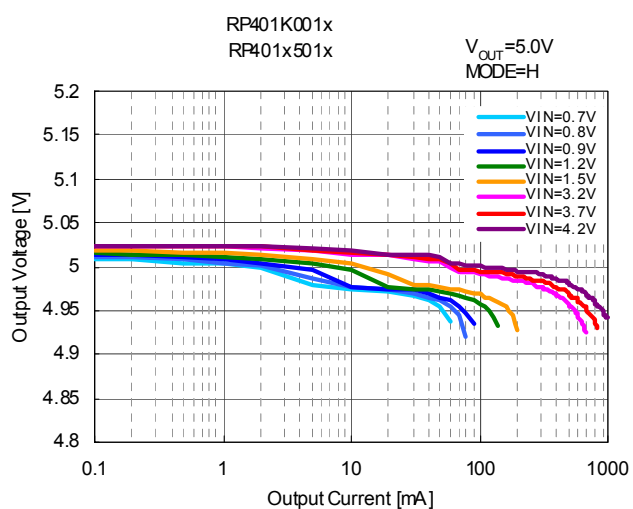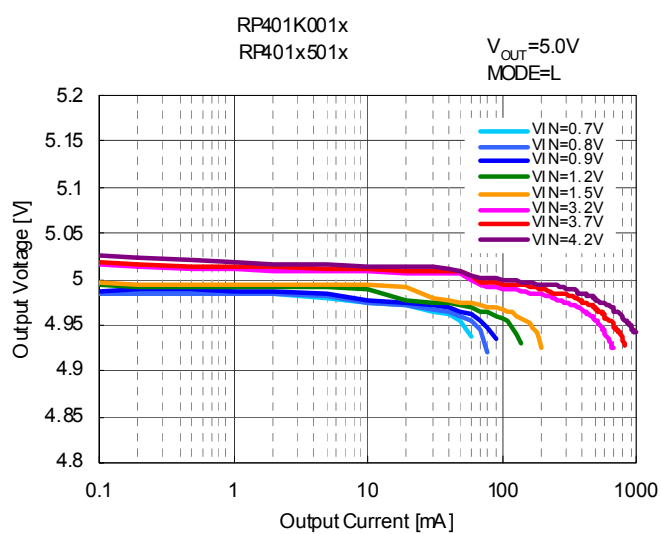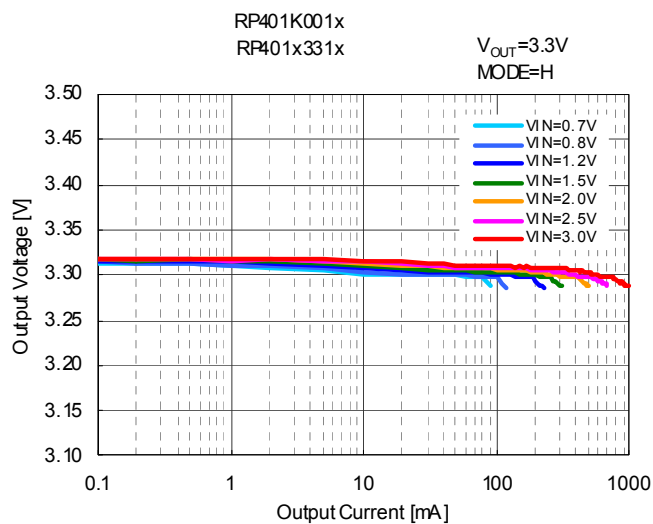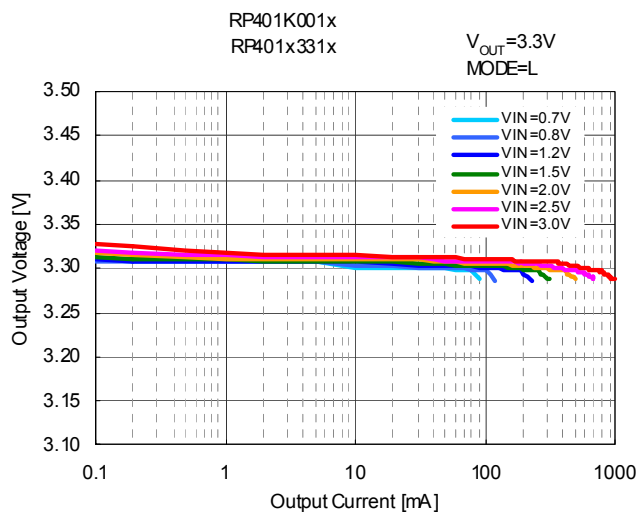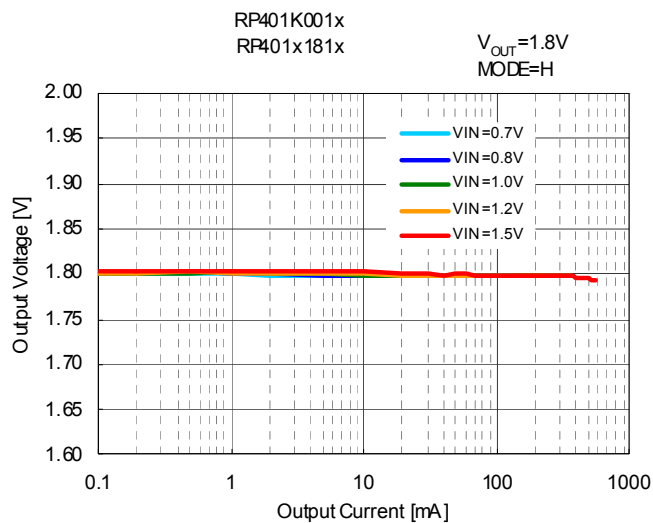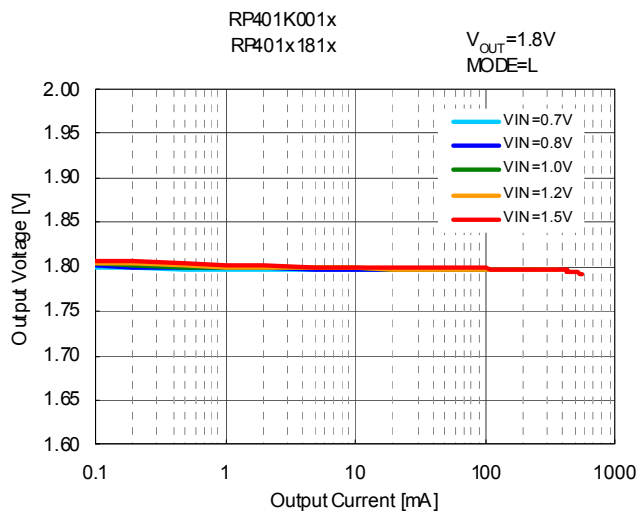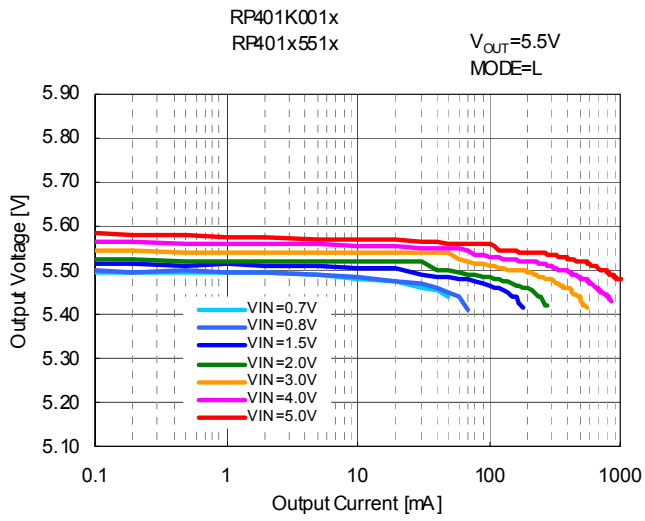
2) Efficiency vs. Output current (Ta=25°C)

RP401K001x
RP401x181x   $V_{OUT}$=1.8V
MODE=L

RP401K001x
RP401x181x   $V_{OUT}$=1.8V
MODE=H

RP401K001x
RP401x331x   $V_{OUT}$=3.3V
MODE=L

RP401K001x
RP401x331x   $V_{OUT}$=3.3V
MODE=H

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RP401K001x
RP401x501x

$V_{OUT}$=5.0V
MODE=L

Efficiency [%]

VIN=0.7V
VIN=0.8V
VIN=0.9V
VIN=1.2V
VIN=1.5V
VIN=3.2V
VIN=3.7V
VIN=4.2V

Output Current [mA]

RP401K001x
RP401x501x

$V_{OUT}$=5.0V
MODE=H

Efficiency [%]

VIN=0.7V
VIN=0.8V
VIN=0.9V
VIN=1.2V
VIN=1.5V
VIN=3.2V
VIN=3.7V
VIN=4.2V

Output Current [mA]

RP401K001x
RP401x551x

$V_{OUT}$=5.5V
MODE=L

Efficiency [%]

VIN=0.7V
VIN=0.8V
VIN=1.5V
VIN=2.0V
VIN=3.0V
VIN=4.0V
VIN=5.0V

Output Current [mA]

RP401K001x
RP401x551x

$V_{OUT}$=5.5V
MODE=H

Efficiency [%]

VIN=0.7V
VIN=0.8V
VIN=1.5V
VIN=2.0V
VIN=3.0V
VIN=4.0V
VIN=5.0V

Output Current [mA]

3) Standby Current vs. Temperature

RP401K001x
RP401x331x

$V_{OUT}$=3.3V

Stanby Current [uA]

Ta [℃]
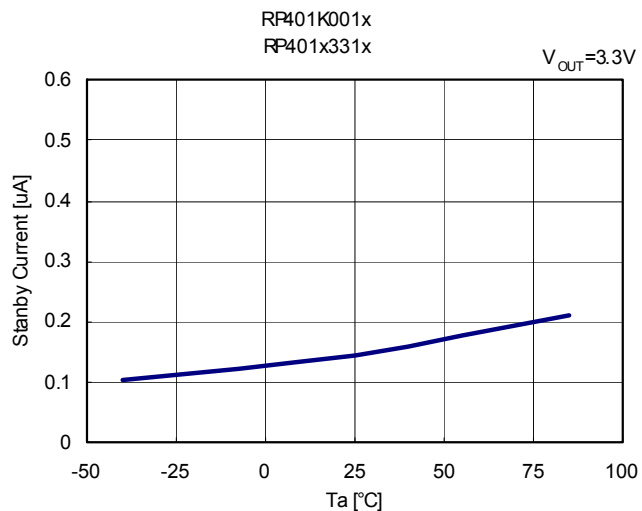
4) Supply Current1 vs. Temperature

RP401K001x
RP401x331x

$V_{OUT}$=3.3V

IDD1 [μA]

Ta [℃]

# RICOH
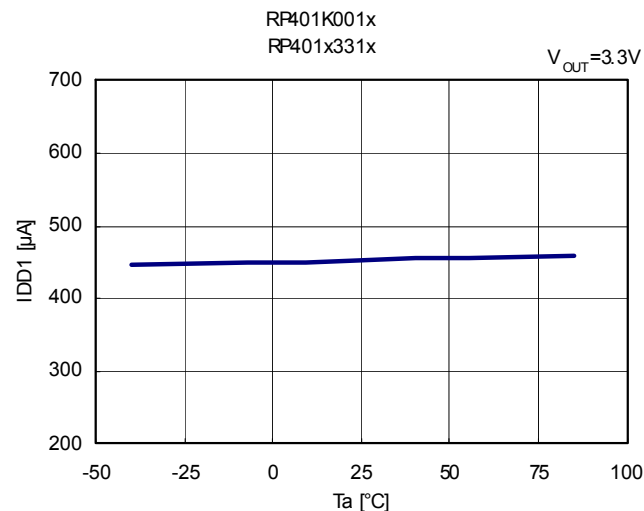
5) Supply Current 2 vs. Temperature

RP401K001C
RP401x331A/B/C

$V_{OUT}$=3.3V

RP401K001D
RP401N331D

$V_{OUT}$=3.3V

6) Start-up voltage 1 vs. Temperature

RP401K001x
RP401x551x

$V_{OUT}$=5.5V
CE=$V_{IN}$
RL=5.5kO

7) Start-up Voltage 2 vs. Temperature

RP401K001x
RP401x551x

$V_{OUT}$=5.5V
CE=$V_{OUT}$
RL=5.5kO

8) Soft start time vs. Temperature

RP401K001x
RP401xxx1x

RL=1kO
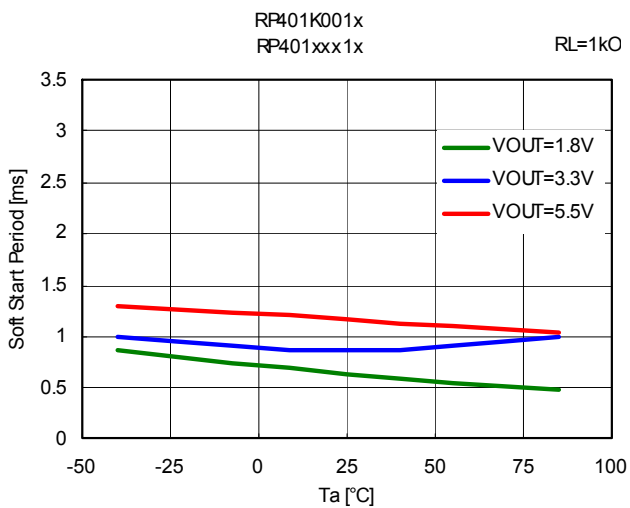
9) Soft start time vs. Input voltage (Ta=25°C)

RP401K001x
RP401xxx1x

$I_{OUT}$=1mA

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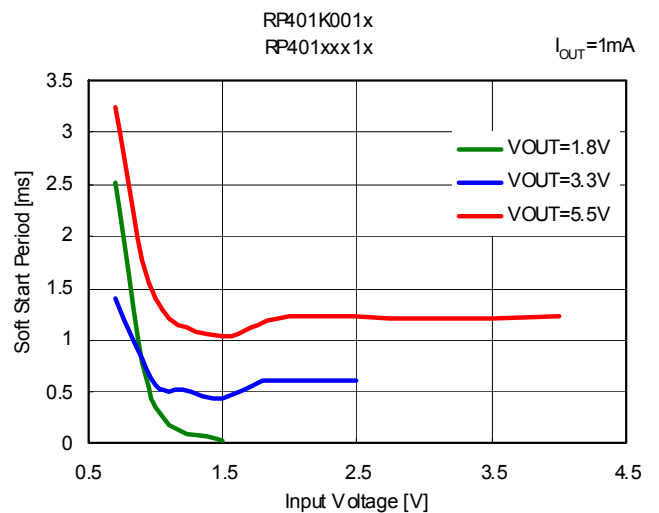
10) Frequency vs. Temperature

RP401K001x
RP401x331x

$V_{OUT}$=3.3V



11) Maximum duty cycle vs. Temperature

RP401K001x
RP401x331x

$V_{OUT}$=3.3V



12) Lx current limit vs. duty cycle

RP401K001x
RP401x181x

$V_{OUT}$=1.8V



RP401K001x
RP401x331x

$V_{OUT}$=3.3V



RP401K001x
RP401x551x

$V_{OUT}$=5.5V



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## 13) Lx Current limit vs. Temperature
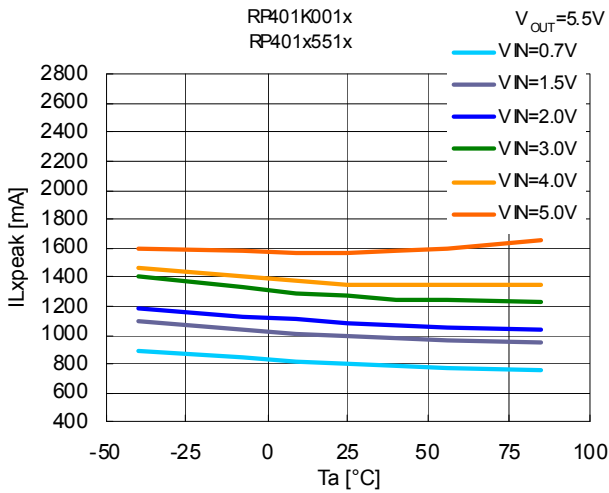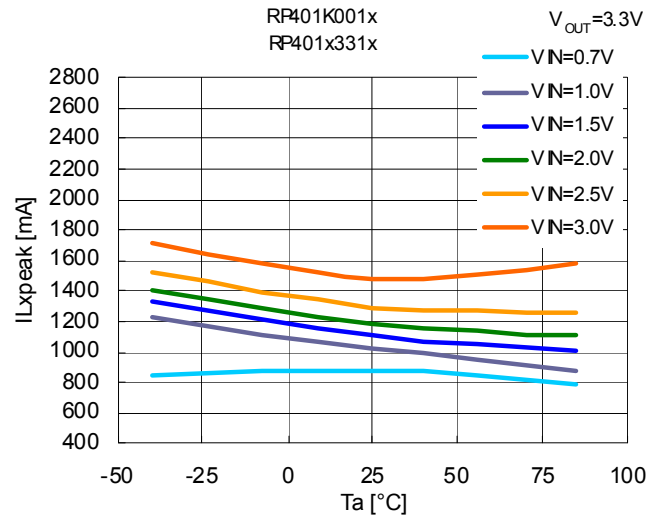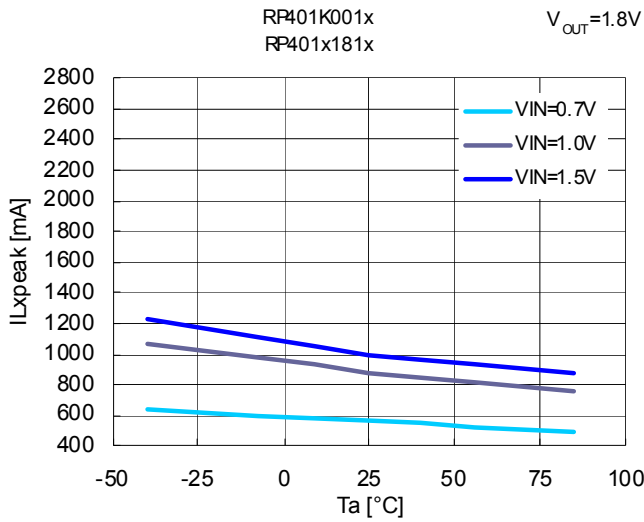
RP401K001x
RP401x181x  $V_{OUT}$=1.8V

ILxpeak [mA] vs Ta [°C]

- VIN=0.7V
- VIN=1.0V
- VIN=1.5V

RP401K001x
RP401x331x  $V_{OUT}$=3.3V

- VIN=0.7V
- VIN=1.0V
- VIN=1.5V
- VIN=2.0V
- VIN=2.5V
- VIN=3.0V

RP401K001x
RP401x551x  $V_{OUT}$=5.5V

- VIN=0.7V
- VIN=1.5V
- VIN=2.0V
- VIN=3.0V
- VIN=4.0V
- VIN=5.0V

## 14) CE input voltage "H" vs. Temperature

RP401K001x
RP401x331x  $V_{OUT}$=3.3V

VCEH [V] vs Ta [°C]

## 15) MODE input voltage "H" vs. Temperature

RP401K331A/B

VMODEH [V] vs Ta [°C]

**RICOH**
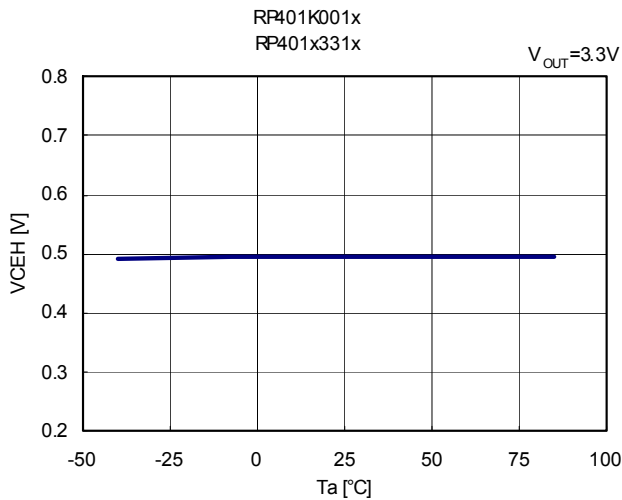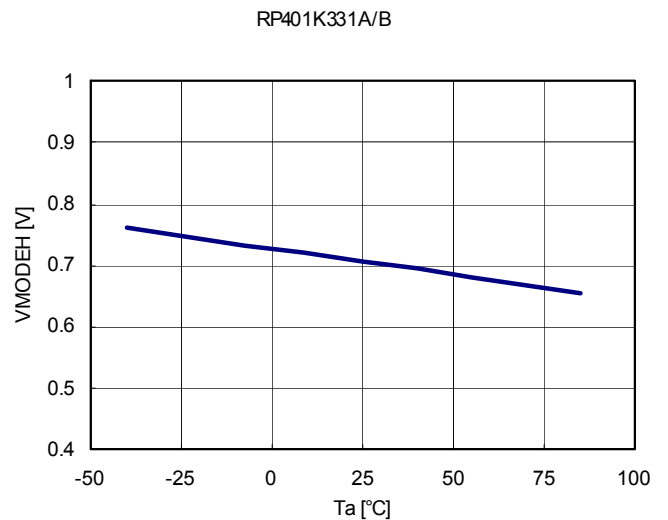
## 16) Output voltage vs. Temperature

RP401x331x
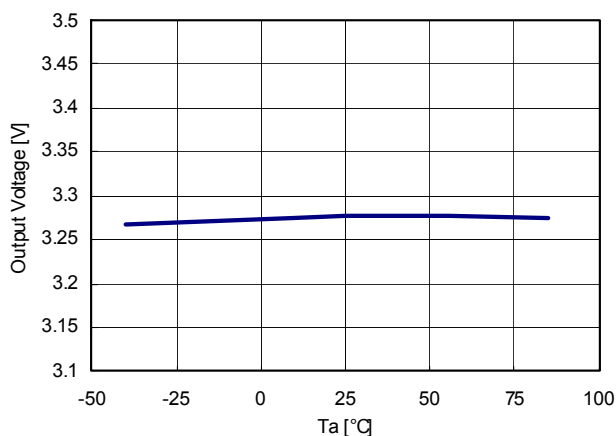


## 17) Feedback voltage vs. Temperature
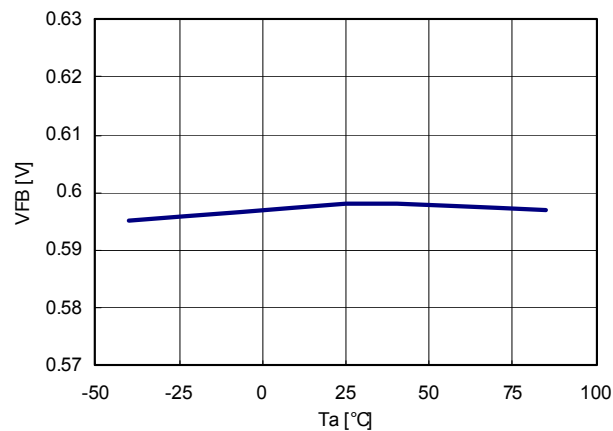
RP401K001x



## 18) Start-up waveform (Ta=25°C)

RP401K001x       $V_{OUT}$=3.3V
RP401x331x       $V_{IN}$=2.0V $I_{OUT}$=1mA



## 19) Load transient response (Ta=25°C)

RP401K001x       $V_{OUT}$=3.3V
RP401x331x       $V_{IN}$=1.5V MODE=L



RP401K001x       $V_{OUT}$=3.3V
RP401x331x       $V_{IN}$=1.5V MODE=L



**RICOH**
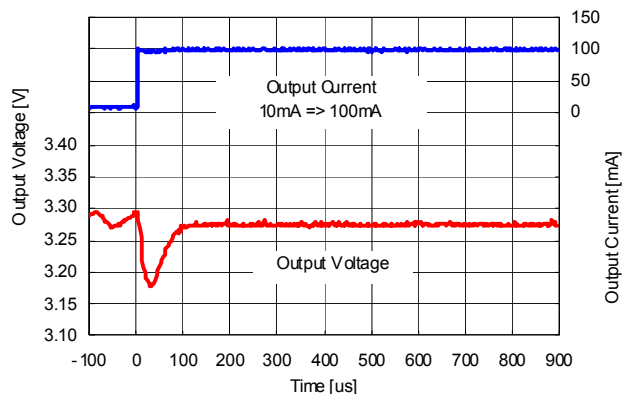
## 20) Output voltage waveform (Ta=25°C)



RP401K001C
RP401x331x
$V_{OUT}$=3.3V $V_{IN}$=1.5V
$I_{OUT}$=1mA MODE=L



RP401K001D
RP401x331x
$V_{OUT}$=3.3V $V_{IN}$=1.5V
$I_{OUT}$=1mA MODE=H



RP401K001C
RP401x331x
$V_{OUT}$=3.3V $V_{IN}$=1.5V
$I_{OUT}$=100mA MODE=L



RP401K001D
RP401x331x
$V_{OUT}$=3.3V $V_{IN}$=1.5V
$I_{OUT}$=100mA MODE=H
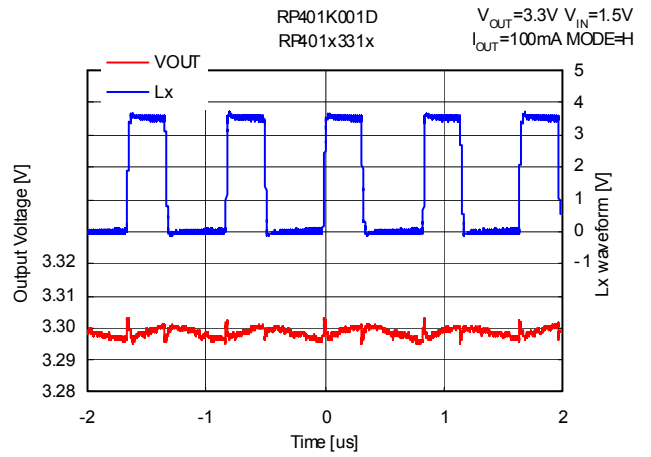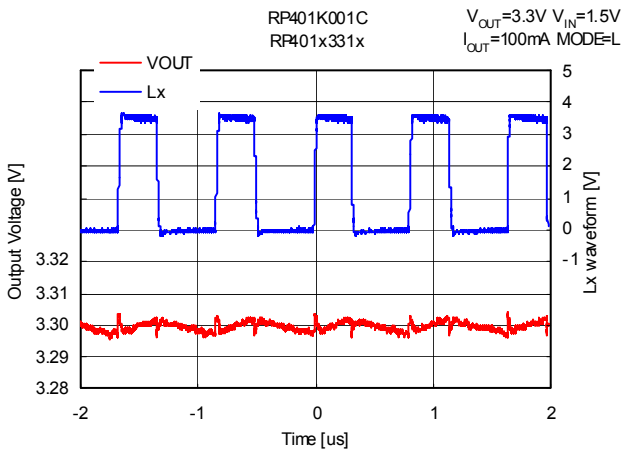
## 21) Hold-on voltage vs. Temperature



RP401K001x
RP401xxx1x
$I_{OUT}$=1mA

**RICOH**
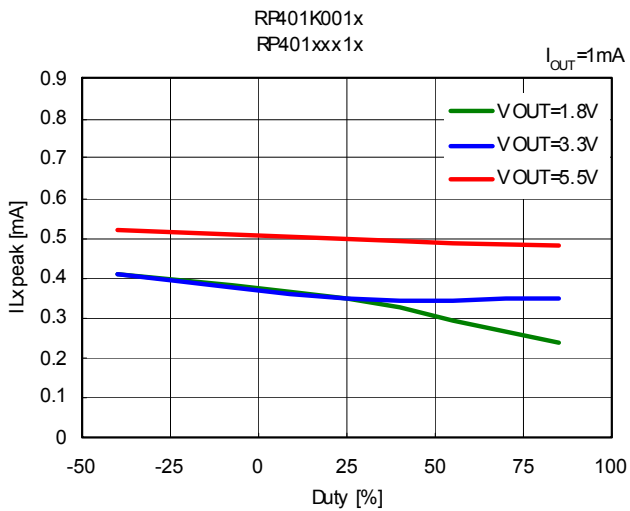
22) Mode alternative waveform (Ta=25°C)

RP401K331A/B

$V_{IN}$=1.5V $I_{OUT}$=0.1mA

MODE Input Voltage
0V => 1.5V

Output Voltage

RP401K331A/B

$V_{IN}$=1.5V $I_{OUT}$=0.1mA

MODE Input Voltage
1.5V => 0V

Output Voltage

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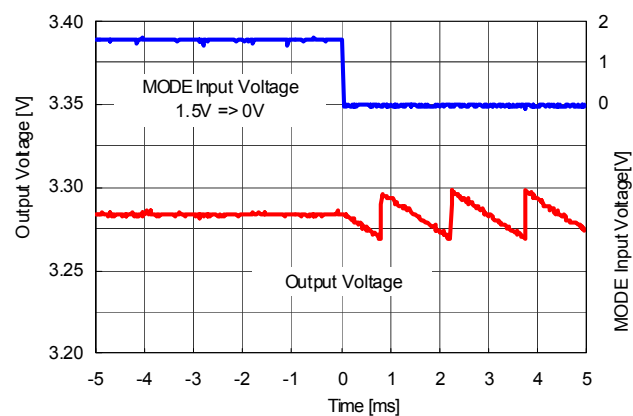
The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following conditions are used in this measurement.

## Measurement Conditions

|  | Standard Test Land Pattern |
|---|---|
| Environment | Mounting on Board (Wind Velocity = 0 m/s) |
| Board Material | Glass Cloth Epoxy Plastic (Double-Sided Board) |
| Board Dimensions | 40 mm × 40 mm × 1.6 mm |
| Copper Ratio | Top Side: Approx. 50% <br> Bottom Side: Approx. 50% |
| Through-holes | $\phi$ 0.54 mm × 30 pcs |

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

|  | Standard Test Land Pattern |
|---|---|
| Power Dissipation | 880 mW |
| Thermal Resistance | $\theta ja = (125 - 25°C) / 0.88 W = 114°C/W$ |
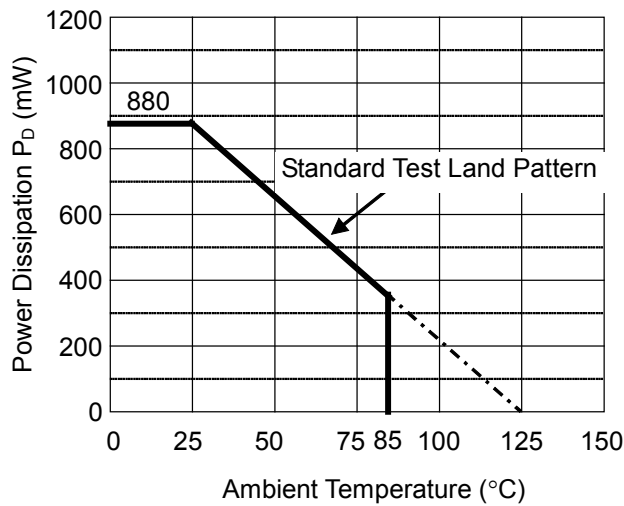


Power Dissipation vs. Ambient Temperature
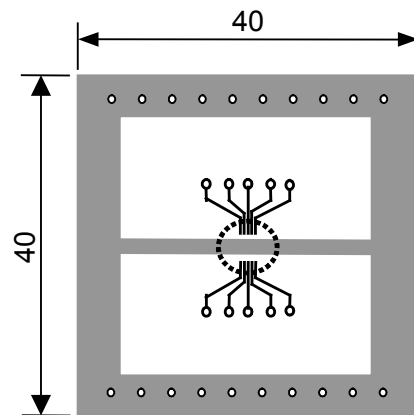


IC Mount Area (mm)

Measurement Board Pattern

**RICOH**
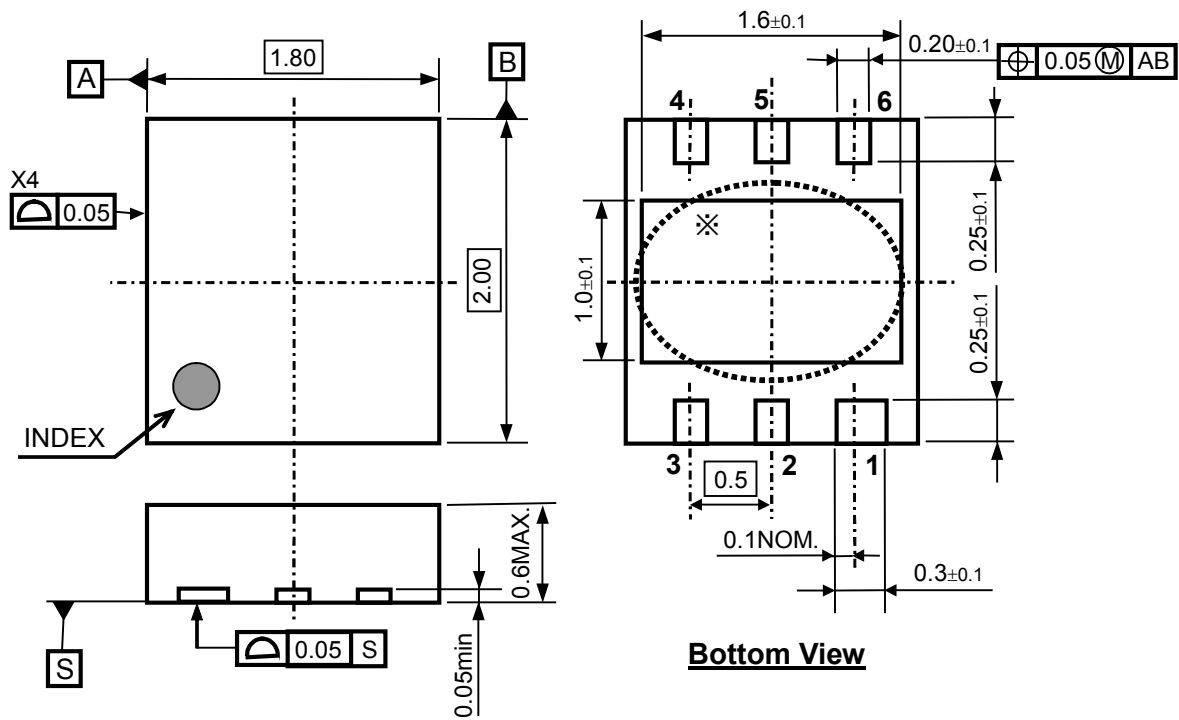
**DFN(PLP)1820-6 Package Dimensions (Unit: mm)**

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∗ The tab on the bottom of the package is substrate level (GND). It is recommended that the tab be connected to the ground plane on the board, or otherwise be left floating.

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