∗RP500Z (WLCSP-6-P2) is the non-promotion product. As of March in 2014.

RICOH



# 600mA* Step-down DC/DC Converter with Synchronous Rectifier

NO.EA-155-111124

## OUTLINE

The RP500x Series are CMOS-based 600mA* step-down DC/DC Converters with synchronous rectifier.

Each of these ICs consists of an oscillator, a switching control circuit, a reference voltage unit, an error amplifier, a soft-start circuit, protection circuits, UVLO circuit, switching transistors, and so on. A low ripple, high efficiency step-down DC/DC converter can be easily composed of this IC with only an inductor and capacitors.

In terms of the output voltage, since the feedback resistances are built-in, the voltage is fixed internally. 0.1V step output can be set by laser-trim and 1.5% or 24mV tolerance depending on the output voltage is guaranteed. Mode alternative circuit works automatically for improving the efficiency. Considering fixed noise frequency, PWM fixed control type is also available.

As protection circuits, the current limit circuit which limits peak current of Lx at each clock cycle, and the latch type protection circuit which works if the term of the over-current condition keeps on a certain time exist. The latch-type protection circuit works to latch an internal driver with keeping it disable. To release the condition of the protection, after disabling 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.

Since packages are WLCSP-6-P2, DFN1616-6, DFN(PLP)1820-6, SOT-23-6W, high density mounting on boards is possible.

*)This is an approximate value, because output current depends on conditions and external parts.

## FEATURES

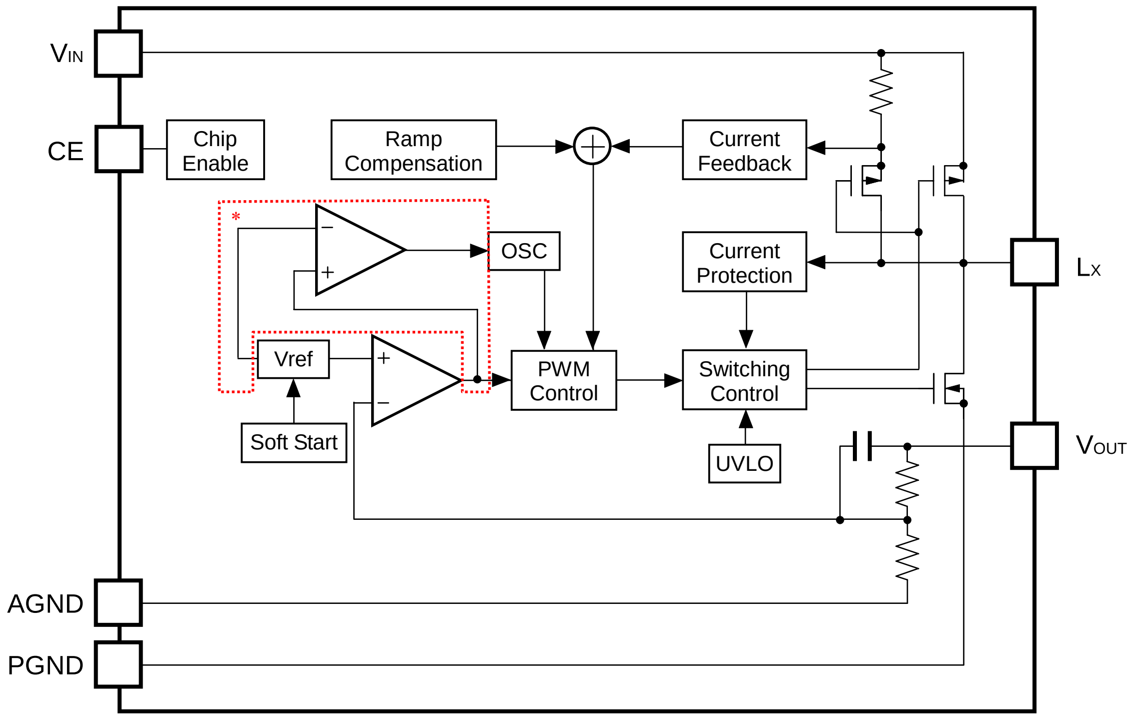
- Supply Current ........ Typ. 400μA (at PWM mode)
  Typ. 100μA (at VFM mode)
- Standby Current ........ Max. 5μA
- Input Voltage Range ........ 2.55V to 5.50V
- Output Voltage Range ........ 1.1V to 3.3V (0.1V steps)
  (For other voltages, please refer to MARK INFORMATIONS.)
- Output Voltage Accuracy ........ ±1.5% ($V_{OUT}\geq1.6V$), ±24mV ($V_{OUT}<1.6V$)
- Temperature-Drift Coefficient of Output Voltage ... Typ. ±100ppm/°C
- Oscillator Frequency ........ Typ. 1.2MHz
- Oscillator Maximum Duty Cycle ........ Min. 100%
- Built-in Driver ON Resistance ........ Typ. Pch. 0.3Ω, Nch. 0.38Ω ($V_{IN}$=3.6V)
- UVLO Detector Threshold ........ Typ. 2.2V
- Soft Start Time ........ Typ. 120μs
- Lx Current Limit ........ Typ. 900mA
- Latch type Protection Circuit ........ Typ. 1.5ms
- Two choices of Switching Mode ........ Automatic PWM/VFM mode change / PWM fixed
- Packages ........ WLCSP-6-P2, DFN1616-6, DFN(PLP)1820-6, SOT-23-6W

## APPLICATIONS

- Power source for battery-powered equipment.
- Power source for hand-held communication equipment, cameras, VCRs, camcorders.
- Power source for HDD, portable equipment.

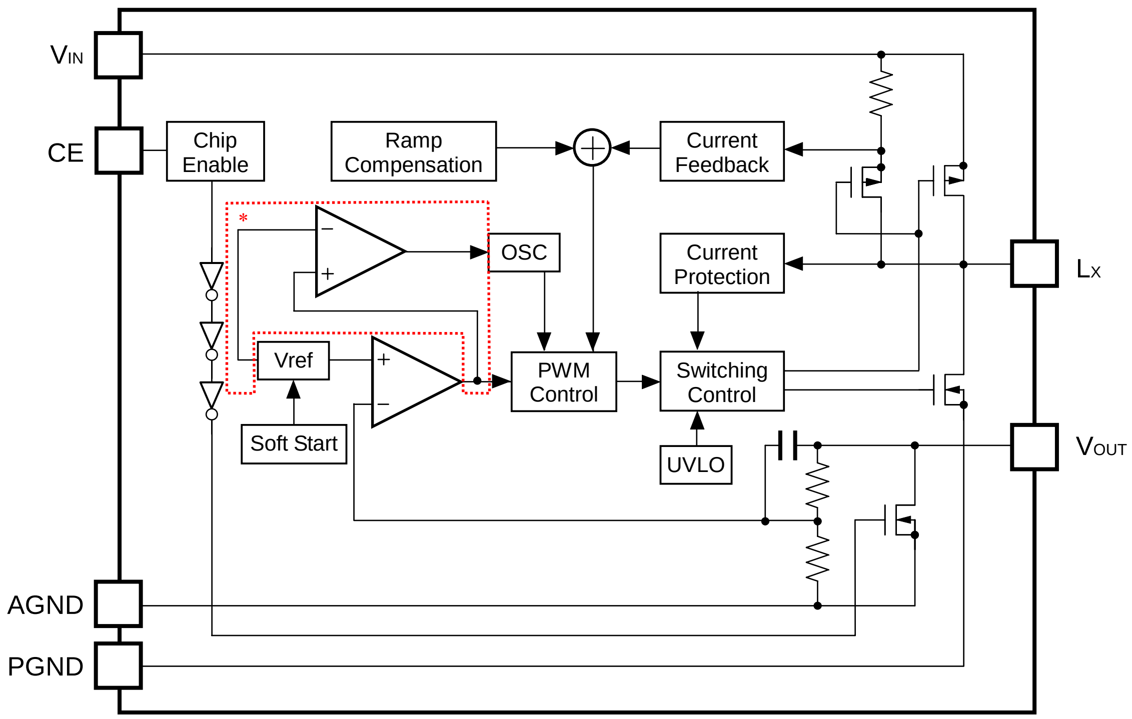
# BLOCK DIAGRAMS

**RP500xxx1A/2A**




∗) only RP500xxx1A for automatic PWM/VFM mode change

**RP500xxx3A/4A**




∗) only RP500xxx3A for automatic PWM/VFM mode change

## SELECTION GUIDE

The output voltage, switching mode, and auto discharge function for the ICs can be selected at the user's request.

| Product Name | Package | Quantity per Reel | Pb Free | Halogen Free |
|---|---|---|---|---|
| RP500Zxx∗A-E2-F | WLCSP-6-P2 | 5,000 pcs | Yes | Yes |
| RP500Lxx∗A-TR | DFN1616-6 | 5,000 pcs | Yes | Yes |
| RP500Kxx∗A-TR | DFN(PLP)1820-6 | 5,000 pcs | Yes | Yes |
| RP500Nxx∗A-TR-FE | SOT-23-6W | 3,000 pcs | Yes | Yes |

xx: The output voltage can be designated in the range from 1.1V(11) to 3.3V(33) in 0.1V steps[*1].
(For other voltages, please refer to MARK INFORMATIONS.)

∗ : The switching mode, and auto discharge function can be designated.

| Code | Modulation method | Auto discharge function |
|---|---|---|
| 1 | PWM/VFM auto switching | No |
| 2 | PWM fixed | No |
| 3 | PWM/VFM auto switching | Yes |
| 4 | PWM fixed | Yes |

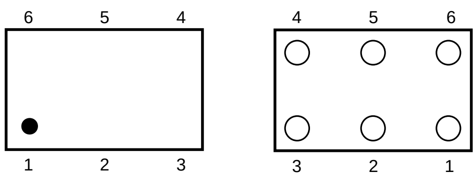
(The RP500Kxx3A does not exist. Please use RP500Lxx3A.)

∗1) 0.05V step is also available as a custom code.

# PIN CONFIGURATIONS

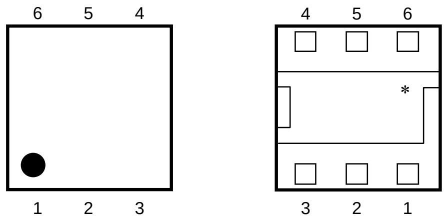
- WLCSP-6-P2

Mark Side / Bump Side



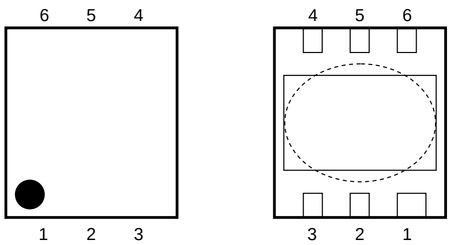

- DFN1616-6

Top View / Bottom View

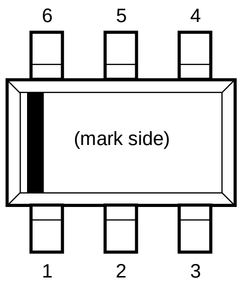



- DFN(PLP)1820-6

Top View / Bottom View




- SOT-23-6W




# PIN DESCRIPTIONS

- **WLCSP-6-P2, SOT-23-6W**

| Pin No | Symbol | Pin Description |
|---|---|---|
| 1 | $V_{OUT}$ | Output Pin |
| 2 | PGND | Ground Pin |
| 3 | Lx | Lx Switching Pin |
| 4 | $V_{IN}$ | Input Pin |
| 5 | AGND | Ground Pin |
| 6 | CE | Chip Enable Pin ("H" Active) |

- **DFN1616-6, DFN(PLP)1820-6**

| Pin No | Symbol | Pin Description |
|---|---|---|
| 1 | CE | Chip Enable Pin ("H" Active) |
| 2 | AGND | Ground Pin |
| 3 | $V_{IN}$ | Input Pin |
| 4 | Lx | Lx Switching Pin |
| 5 | PGND | Ground Pin |
| 6 | $V_{OUT}$ | Output Pin |

∗) Tab is GND level. (They are connected to the reverse side of this IC.)
The tab is better to be connected to the GND, but leaving it open is also acceptable.

## ABSOLUTE MAXIMUM RATINGS

AGND=PGND=0V

| Symbol | Item | Rating | Unit |
|---|---|---|---|
| $V_{IN}$ | Input Voltage | −0.3 to 6.5 | V |
| $V_{LX}$ | Lx pin Voltage | −0.3 to $V_{IN}$+0.3 | V |
| $V_{CE}$ | CE Pin Input Voltage | −0.3 to 6.5 | V |
| $V_{OUT}$ | Output Voltage | −0.3 to 6.5 | V |
| $I_{LX}$ | Lx Pin Output Current | 800 | mA |
| $P_D$ | Power Dissipation (WLCSP-6-P2) * | 650 | mW |
| | Power Dissipation (DFN1616-6) * | 640 | |
| | Power Dissipation (DFN(PLP)1820-6) * | 880 | |
| | Power Dissipation (SOT-23-6W) * | 430 | |
| Topt | Operating Temperature Range | −40 to 85 | °C |
| Tstg | Storage Temperature Range | −55 to 125 | °C |

∗) For Power Dissipation, please refer to PACKAGE INFORMATION.

| ABSOLUTE MAXIMUM RATINGS |
|---|
| Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the life time and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured. |

# ELECTRICAL CHARACTERISTICS

- **RP500x**

Topt=25°C

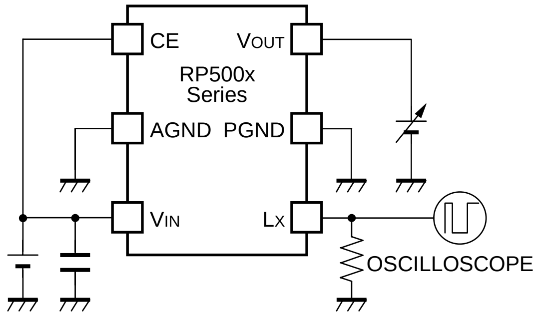
| Symbol | Item | Conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| $V_{IN}$ | Operating Input Voltage | | | 2.55 | | 5.5 | V |
| $V_{OUT}$ | Output Voltage | $V_{IN}=V_{CE}=3.6V$ or Set $V_{OUT}+1V$ | $V_{OUT} \geq 1.6V$ | ×0.985 | | ×1.015 | V |
| | | | $V_{OUT} < 1.6V$ | −24 | | 24 | mV |
| $\Delta V_{OUT}/\Delta Topt$ | Output Voltage Temperature Coefficient | $-40°C \leq Topt \leq 85°C$ | | | ±100 | | ppm /°C |
| fosc | Oscillator Frequency | $V_{IN}=V_{CE}=3.6V$ or Set $V_{OUT}+1V$ | | 0.96 | 1.2 | 1.44 | MHz |
| $I_{DD1}$ | Supply Current 1 | $V_{IN}=V_{CE}=5.5V$, $V_{OUT}=0V$ | | | 400 | 500 | μA |
| $I_{DD2}$ | Supply Current 2 | $V_{IN}=V_{CE}=V_{OUT}=5.5V$ | PWM/VFM | | 100 | 160 | μA |
| | | | PWM fixed | | 400 | 500 | |
| Istandby | Standby Current | $V_{IN}=5.5V$, $V_{CE}=0V$ | | | 0 | 5 | μA |
| $R_{ONP}$ | ON Resistance of Pch Tr. | $V_{IN}=3.6V$, $I_{LX}=-100mA$ | | | 0.3 | | Ω |
| $R_{ONN}$ | ON Resistance of Nch Tr. | $V_{IN}=3.6V$, $I_{LX}=-100mA$ | | | 0.38 | | Ω |
| $I_{LXleakH}$ | Lx Leakage Current "H" | $V_{IN}=V_{LX}=5.5V$, $V_{CE}=0V$ | | −1 | 0 | 5 | μA |
| $I_{LXleakL}$ | Lx Leakage Current "L" | $V_{IN}=5.5V$, $V_{CE}=V_{LX}=0V$ | | −5 | 0 | 1 | μA |
| $I_{VOUTH}$ | $V_{OUT}$ "H" Input Current *1 | $V_{IN}=V_{OUT}=5.5V$, $V_{CE}=0V$ | | −1 | 0 | 1 | μA |
| $I_{VOUTL}$ | $V_{OUT}$ "L" Input Current | $V_{IN}=5.5V$, $V_{CE}=V_{OUT}=0V$ | | −1 | 0 | 1 | μA |
| $I_{CEH}$ | CE "H" Input Current | $V_{IN}=V_{CE}=5.5V$ | | −1 | 0 | 1 | μA |
| $I_{CEL}$ | CE "L" Input Current | $V_{IN}=5.5V$, $V_{CE}=0V$ | | −1 | 0 | 1 | μA |
| $V_{CEH}$ | CE Input Voltage "H" | $V_{IN}=5.5V$ | | 1.0 | | | V |
| $V_{CEL}$ | CE Input Voltage "L" | $V_{IN}=5.5V$ | | | | 0.4 | V |
| Maxduty | Oscillator Maximum Duty Cycle | | | 100 | | | % |
| tstart | Soft-start Time | $V_{IN}=V_{CE}=3.6V$ or Set $V_{OUT}+1V$ | | | 120 | 150 | μs |
| $I_{LXlim}$ | Lx Current Limit | $V_{IN}=V_{CE}=3.6V$ or Set $V_{OUT}+1V$ | | 600 | 900 | | mA |
| tprot | Protection Delay Time | $V_{IN}=V_{CE}=3.6V$ or Set $V_{OUT}+1V$ | | 0.5 | 1.5 | 5.0 | ms |
| $V_{UVLO1}$ | UVLO Detector Threshold | $V_{IN}=V_{CE}$ | | 2.1 | 2.2 | 2.3 | V |
| $V_{UVLO2}$ | UVLO Released Voltage | $V_{IN}=V_{CE}$ | | 2.2 | 2.3 | 2.4 | V |
| $R_{LOW}$ | Low Output Nch Tr. ON Resistance *2 | $V_{IN}=3.6V$, $V_{CE}=0V$ | | | 80 | | Ω |

Test circuit is "OPEN LOOP" and AGND=PGND=0V unless otherwise noted.
∗1) without auto discharge version only
∗2) with auto discharge version only

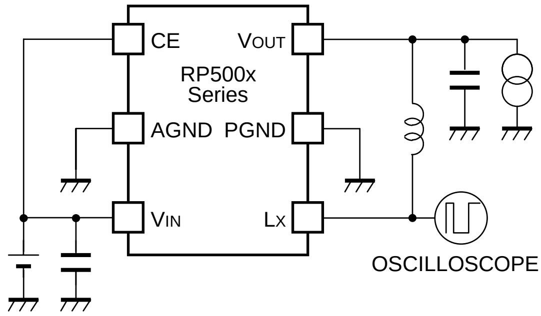
**RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)**

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.

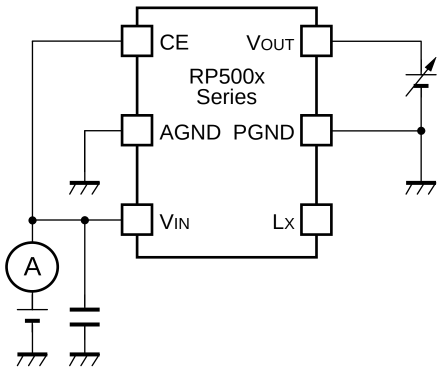
## TEST CIRCUITS



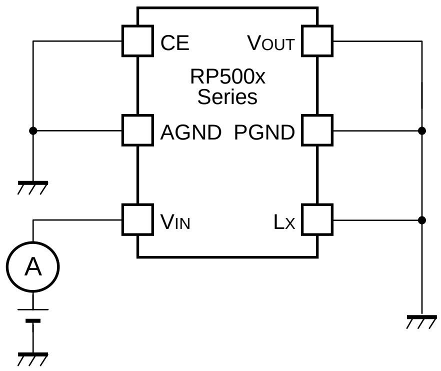

**Output Voltage**



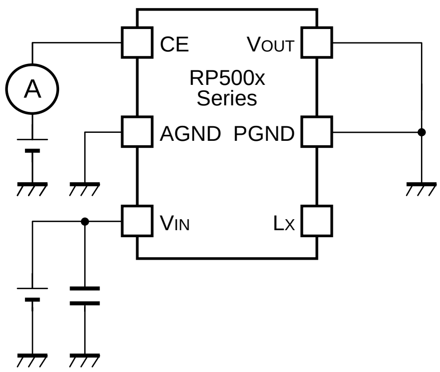

**Oscillator Frequency**



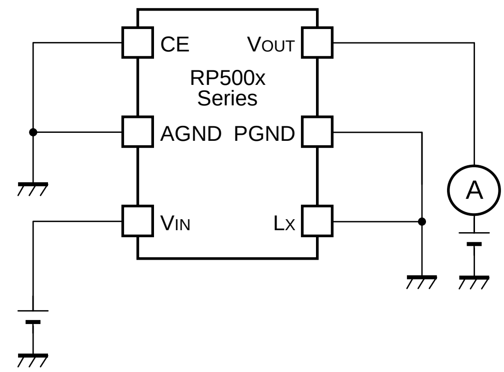

**Supply Current 1,2**



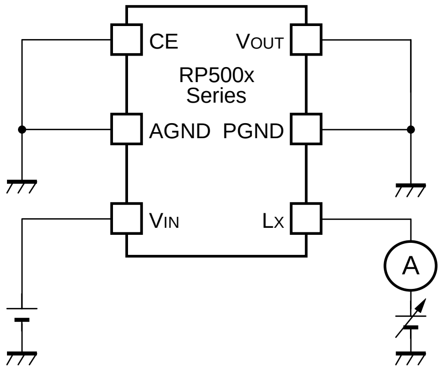

**Standby Current**



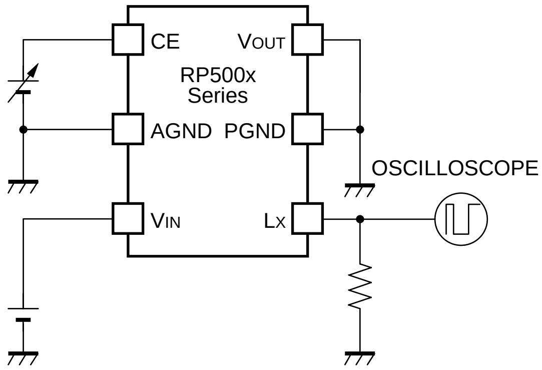

**CE "H"/"L" Input Current**



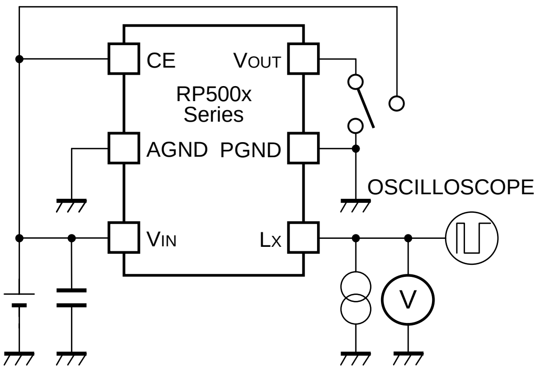

**VOUT "H"/"L" Current**



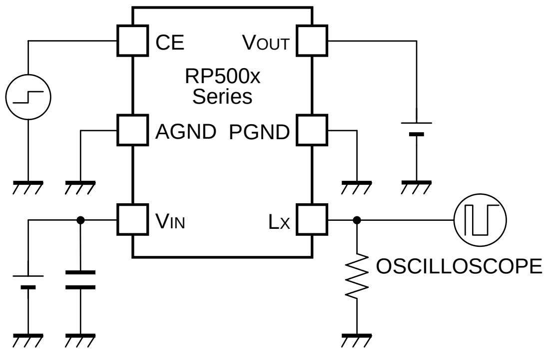

**Lx Leakage Current**



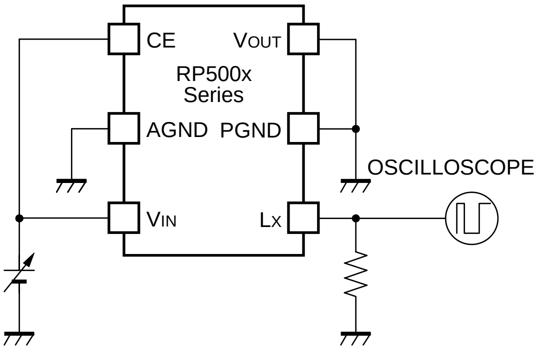

**CE Input Voltage**




**Pch • Nch transistor ON resistance /**
**Output Delay for Protection / Lx Current limit**

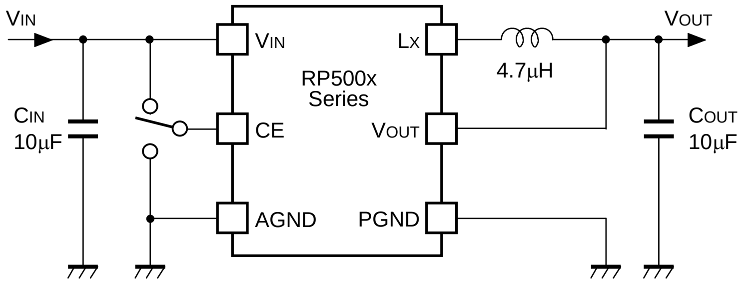



**Soft-start Time**




**UVLO Detector Threshold • Released Voltage**

# TYPICAL APPLICATION




| Symbol | Parts Recommendation | | |
|---|---|---|---|
| $C_{IN}$ | 10µF | Ceramic | C2012JB0J106K (TDK) |
| $C_{OUT}$ | 10µF | Ceramic | C2012JB0J106K (TDK) |
| L | 4.7µH | VLF3010AT-4R7MR30 | |

# TECHNICAL NOTES

When using these ICs, consider the following points:

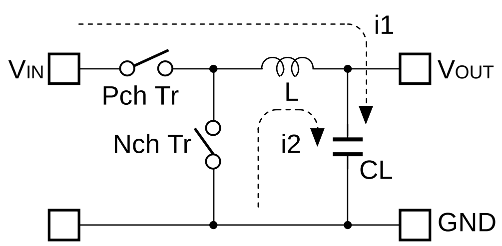
- Set the same level as AGND and PGND.
- Set external components such as an inductor, $C_{IN}$, $C_{OUT}$ as close as possible to the IC, in particular, minimize the wiring to $V_{IN}$ pin and PGND pin. Reinforce the $V_{IN}$, PGND, and $V_{OUT}$ lines sufficiently. Large switching current may flow in 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 wiring between $V_{OUT}$ and load and between L and $V_{OUT}$ should be separated.
- Use an external capacitor $C_{IN}$ between $V_{IN}$ and GND, and $C_{OUT}$ with a capacity of 10µF or more ceramic type.
- Choose an inductor with inductance range from 4.7µH to 10µH. The phase compensation has been made by these values with output capacitors. The recommendation characteristics of the inductor are low DC resistance, large enough permissible current, and strong against the magnetic saturation. Inductance value may shift depending on an inductor. If the inductance value at an actual load current is low, Lx peak current may increase and may overlap the Lx current limit. As a result, over current protection may work.
- Over current protection circuit may be affected by self-heating and heat radiation environment.

∗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. (such as the voltage, current, and power)

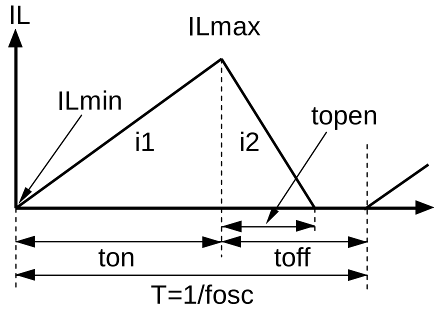
# Operation of step-down DC/DC converter and Output Current

The 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 Circuit>**




**<Current through L>**




- Step 1: Pch Tr. turns on and current IL (=i1) flows, and energy is charged into CL. At this moment, IL increases from $IL_{min}$ (=0) to reach $IL_{max}$ in proportion to the on-time period ($t_{on}$) of Pch Tr.
- Step 2: When Pch Tr. turns off, Synchronous rectifier Nch Tr. turns on in order that L maintains IL at $IL_{max}$, and current IL (=i2) flows.
- Step 3: IL (=i2) decreases gradually and reaches $IL=IL_{min}=0$ after a time period of $t_{open}$, and Nch Tr. turns off. Provided that in the continuous mode, next cycle starts before IL becomes to 0 because $t_{off}$ time is not enough. In this case, IL value increases from this $IL_{min}$ (>0).

In the case of PWM control system, the output voltage is maintained by controlling the on-time period ($t_{on}$), with the oscillator frequency ($f_{osc}$) being maintained constant.

The maximum value ($IL_{max}$) and the minimum value ($IL_{min}$) of the current flowing through the inductor are the same as those when Pch Tr. turns on and off.
The difference between $IL_{max}$ and ILmin, which is represented by ΔI:

$$\Delta I = IL_{max} - IL_{min} = V_{OUT} \times t_{open} / L = (V_{IN} - V_{OUT}) \times t_{on} / L \quad \text{.......................................Equation 1}$$

wherein,

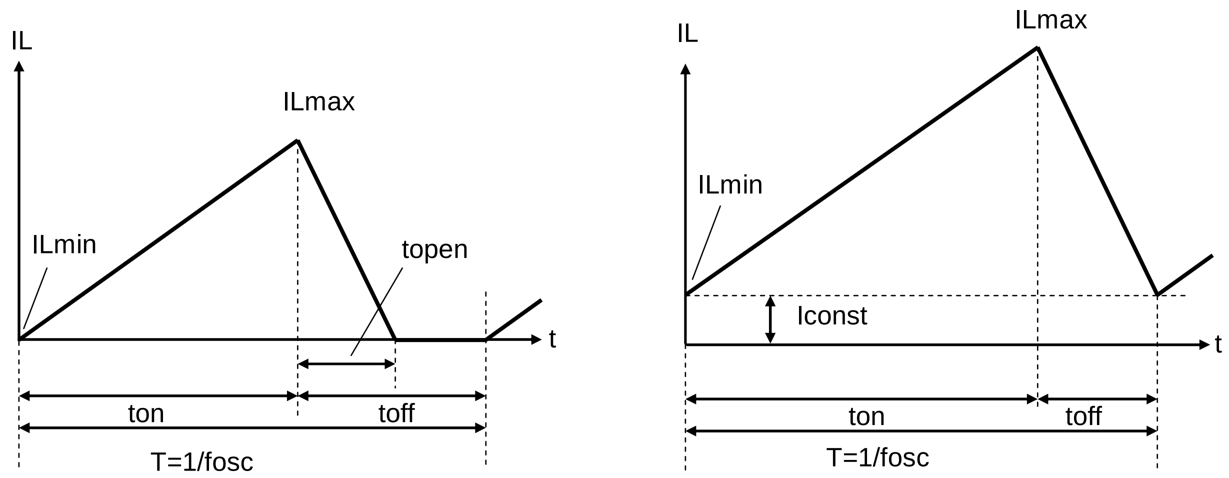
$$T = 1 / f_{osc} = t_{on} + t_{off}$$
$$\text{duty (\%)} = t_{on} / T \times 100 = t_{on} \times f_{osc} \times 100$$
$$t_{open} \leq t_{off}$$

In Equation 1, $V_{OUT} \times t_{open} / L$ and $(V_{IN} - V_{OUT}) \times t_{on} / L$ respectively show the change of the current at "ON", and the change of the current at "OFF".

## Discontinuous mode and Continuous mode

When the output current ($I_{OUT}$) is relatively small, $t_{open}$ < $t_{off}$ as illustrated in the following 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 $t_{off}$, therefore $IL_{min}$ becomes to zero ($IL_{min}$=0). When $I_{OUT}$ is gradually increased, eventually, $t_{open}$ becomes to $t_{off}$ ($t_{open}$=$t_{off}$), and when $I_{OUT}$ is further increased, $IL_{min}$ becomes larger than zero ($IL_{min}$>0). The former mode is referred to as the discontinuous mode and the latter mode is referred to as continuous mode.

**Discontinuous mode** **Continuous mode**




In the continuous mode, when Equation 1 is solved for $t_{on}$ and assumed that the solution is $t_{onc}$,

$$t_{onc} = T \times V_{OUT} / V_{IN} \quad \text{......... Equation 2}$$

When $t_{on}$<$t_{onc}$, the mode is the discontinuous mode, and when $t_{on}$=$t_{onc}$, the mode is the continuous mode.

## Output Current and selection of External components

The relation between the output current and external components is as follows:

When Pch Tr. of $L_X$ is ON:

(Wherein, Ripple Current p-p value is described as $I_{RP}$, ON resistance of Pch Tr. and Nch Tr. of $L_X$ are respectively described as $R_{ONP}$ and $R_{ONN}$, and the DC resistor of the inductor is described as $R_L$.)

$$V_{IN} = V_{OUT} + (R_{ONP} + R_L) \times I_{OUT} + L \times I_{RP} / t_{on} \quad \text{......... Equation 3}$$

When Pch Tr. of $L_X$ is "OFF" (Nch Tr. is "ON"):

$$L \times I_{RP} / t_{off} = R_{ONN} \times I_{OUT} + V_{OUT} + R_L \times I_{OUT} \quad \text{......... Equation 4}$$

Put Equation 4 to Equation 3 and solve for ON duty of Pch transistor, $D_{ON} = t_{on} / (t_{off} + t_{on})$,

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

Ripple Current is as follows:

$I_{RP} = (V_{IN} - V_{OUT} - R_{ONP} \times I_{OUT} - R_L \times I_{OUT}) \times D_{ON} / f_{osc} / L$ .............................................Equation 6

wherein, peak current that flows through L, and $L_X$ Tr. is as follows:

$ILx_{max} = I_{OUT} + I_{RP} / 2$ .........................................................................................Equation 7

Consider $ILx_{max}$, condition of input and output and select external components.

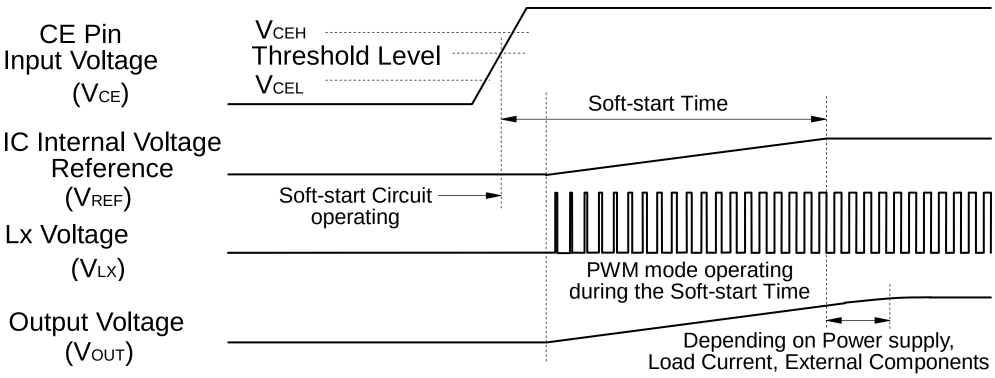
∗The above explanation is directed to the calculation in an ideal case in continuous mode.

# TIMING CHART

## (1) Soft Start Time

### ● In the case of starting this IC with CE

In the case of starting this IC with CE, the operation can be as in the timing chart below.
When the voltage of CE pin ($V_{CE}$) is beyond the threshold level, the operation of the IC starts. The threshold voltage of CE pin is in between CE "H" input voltage ($V_{CEH}$) and CE "L" input voltage ($V_{CEL}$) described in the electrical characteristics table. Soft-start circuit operates, and after the certain time, the reference voltage inside the IC ($V_{REF}$) is rising gradually up to the constant value.

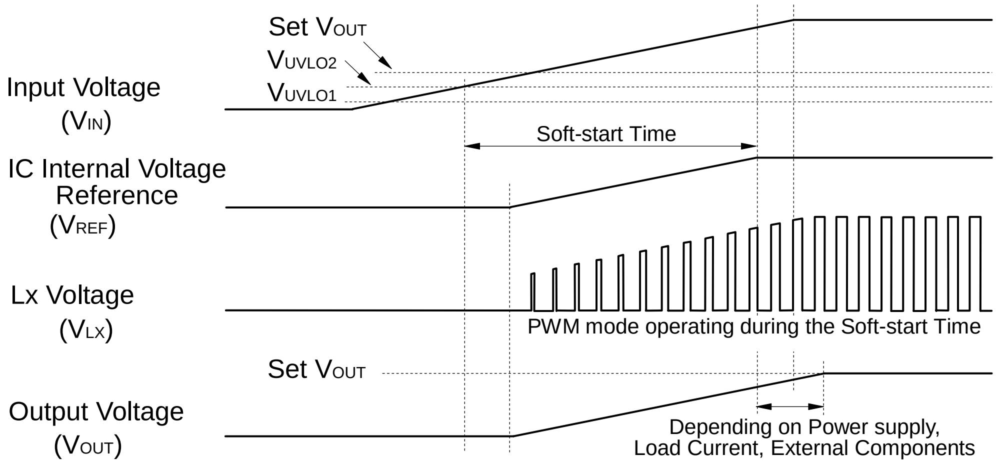



Soft-start time is the time interval from soft start circuit starting point to the reference voltage level reaching point up to this constant level.

∗Soft start time is not always equal to the turn-on speed of DC/DC converter.
The power supply capacity for this IC, load current, inductance and capacitance values affect the turn-on speed.

### ● In the case of starting with power supply

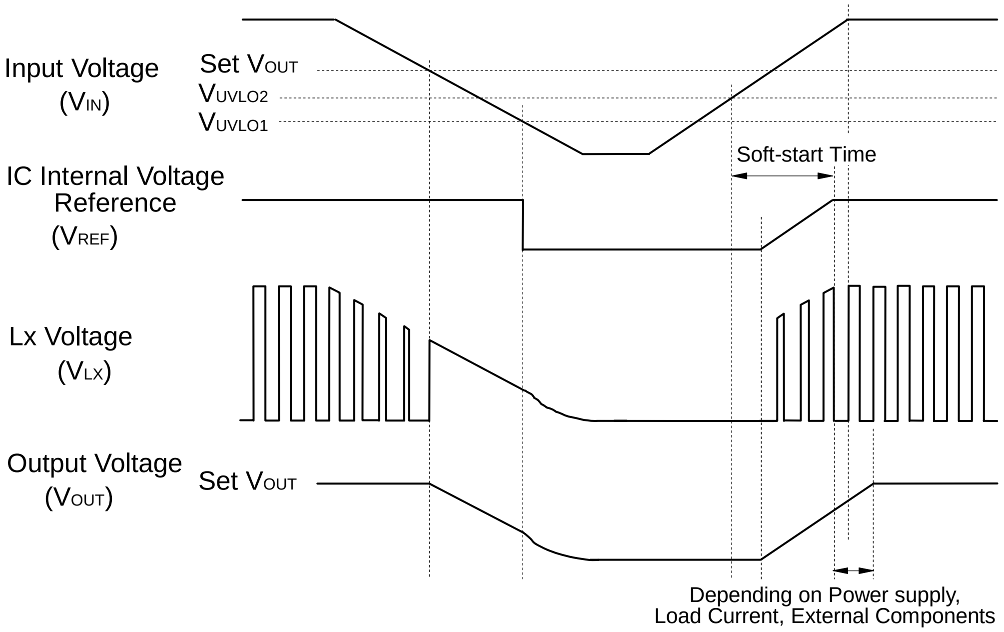
In the case of starting with power supply, when the input voltage ($V_{IN}$) is larger than UVLO released voltage ($V_{UVLO2}$), soft start circuit operates, and after that, the same explanation above is applied to the operation.
Soft-start time is the time interval from soft start circuit starting point to the reference voltage level reaching point up to this constant level.




∗Turn-on speed is affected by next conditions;
(a) Input Voltage ($V_{IN}$) rising speed depending on the power supplier to the IC and input capacitor $C_{IN}$.
(b) Output Capacitor $C_{OUT}$ value and load current value.

### (2) Under Voltage Lockout (UVLO) Circuit

The step-down DC/DC converter stops and ON duty becomes 100%, if input voltage ($V_{IN}$) becomes less than the set output voltage (Set $V_{OUT}$), the output voltage ($V_{OUT}$) gradually drops according to the input voltage ($V_{IN}$). If the input voltage drops more and becomes less than UVLO detector threshold ($V_{UVLO1}$), the under voltage lockout circuit (UVLO) operates, the IC internal reference voltage ($V_{REF}$) stops, switching transistors turn off and the output voltage drops according to the load and output capacitor $C_{OUT}$ value.
To restart the normal operation, the input voltage ($V_{IN}$) must be more than the UVLO released voltage ($V_{UVLO2}$).
The timing chart below describes the operation with varying the input voltage ($V_{IN}$).

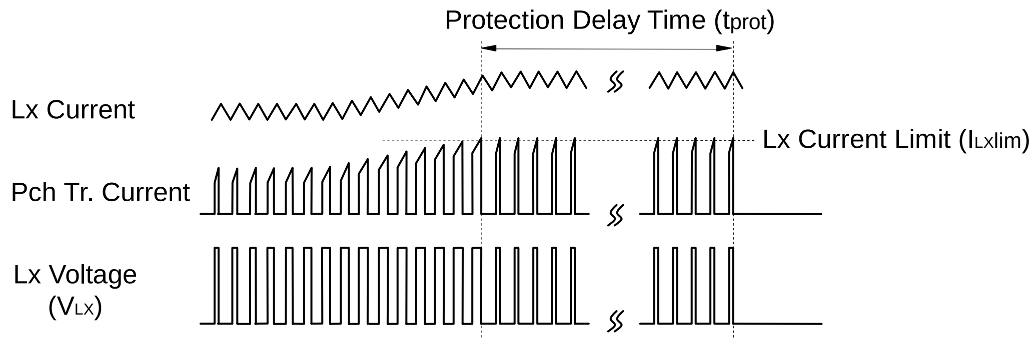



∗Actually, the waveform of $V_{OUT}$ at UVLO working and releasing varies depending on the initial voltage of $C_{OUT}$ and load current situation.

### (3) Over Current Protection Circuit, Latch Type Protection Circuit

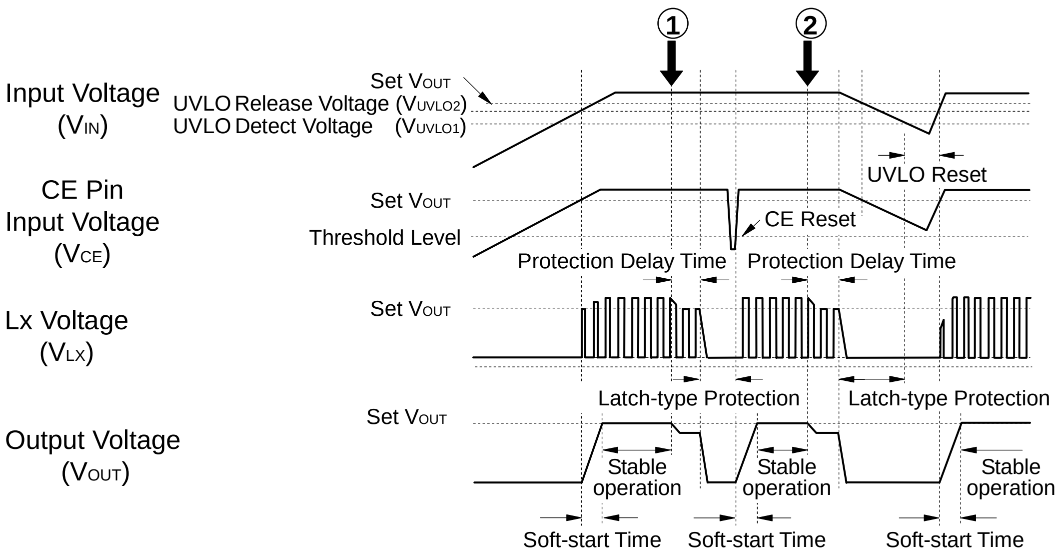
Over current protection circuit supervises the coil peak current (the current flowing Pch transistor) at each switching cycle, and if the current beyond the Lx current limit ($I_{LXlim}$), Pch transistor is turned off. the Lx current limit of RP500x is Typ.900mA.
Further, if the over current status continues equal or longer than protection delay time, or, when the Lx limit current is exceeded even once when the driver operates by duty 100%, a built-in driver is latched in the OFF state and the operation of DC/DC converter stops.

∗Lx current limit and protection delay time is affected by self-heating and ambient environment. If the output is short and the input voltage ($V_{IN}$) is drastically dropped or becomes unstable, the protection operation and delay time may vary.




To release the condition of latch type protection, restart this IC by inputting "L" signal to CE pin, or restart this IC with power-on or make the supply voltage lower than UVLO detector threshold ($V_{UVLO1}$) level.

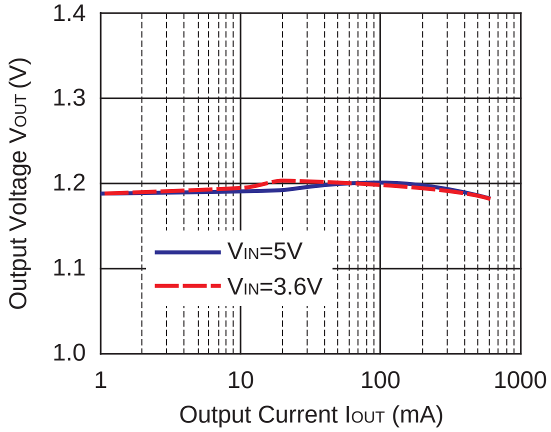
The timing chart shown below describes the changing process of input voltage rising, stable operating, operating with large current, reset with CE pin, stable operating, input voltage falling, input voltage recovering, and stable operating.
If too large current flows through the circuit because of short or other reasons, after the delay time of latch type protection a built-in driver is latched in the OFF state and $V_{LX}$ signal will be "L", then output will turn off.
At the point (1), release the latch type protection is realized with CE reset as changed CE signal from "L" to "H".
At the point (2), release the latch type protection is realized with UVLO reset as make the supply voltage lower than UVLO detector threshold ($V_{UVLO1}$) level.



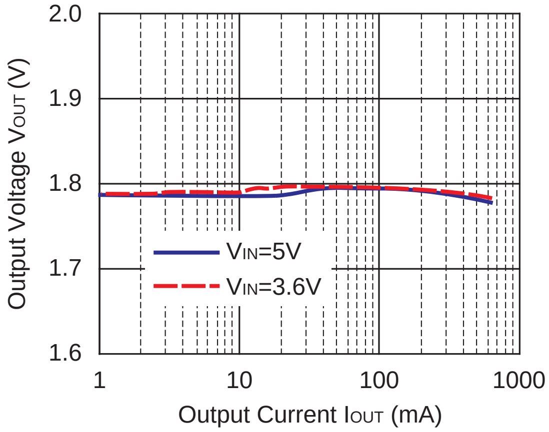
# TYPICAL CHARACTERISTICS

## 1) Output Voltage vs. Output Current

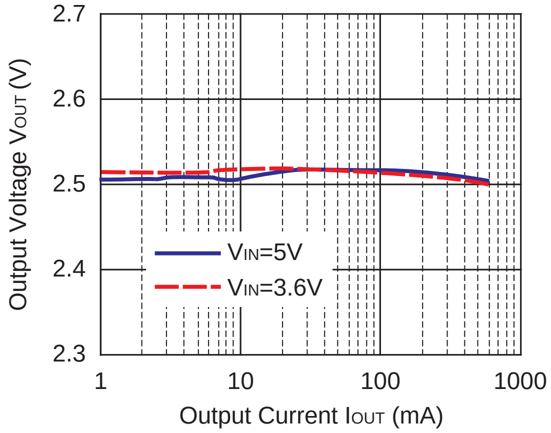
RP500x121A/123A



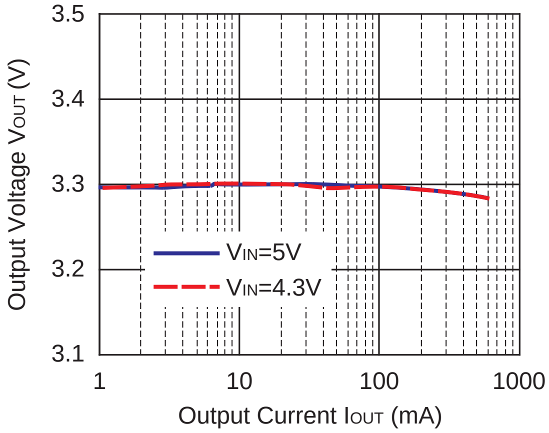

RP500x181A/183A



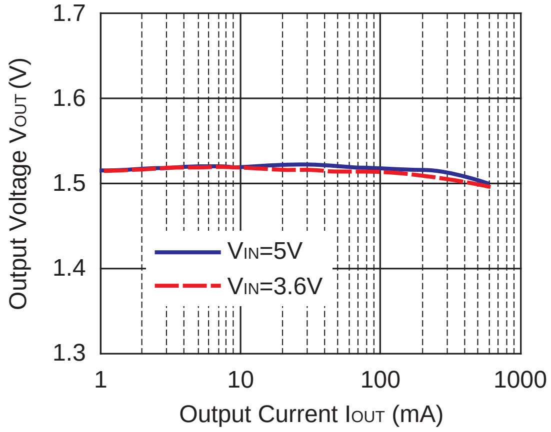

RP500x251A/253A




RP500x331A/333A

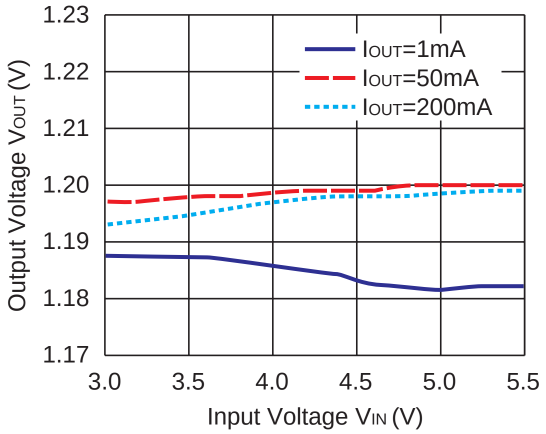



RP500x152A/154A

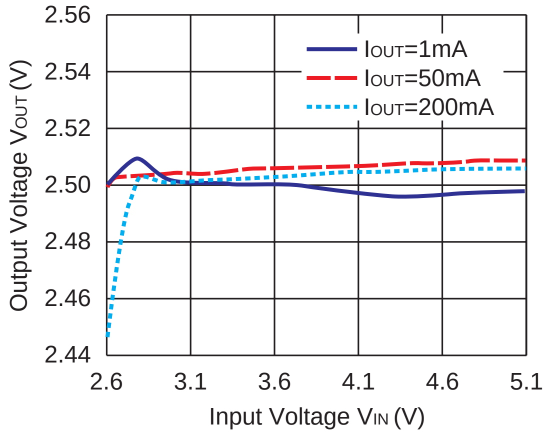


### 2) Output Voltage vs. Input Voltage

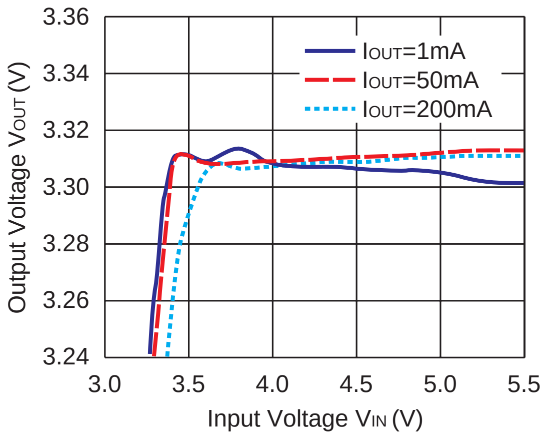
RP500x121A/123A



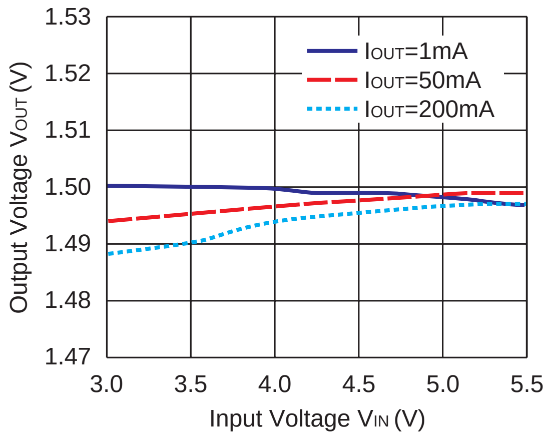

RP500x251A/253A




RP500x331A/333A

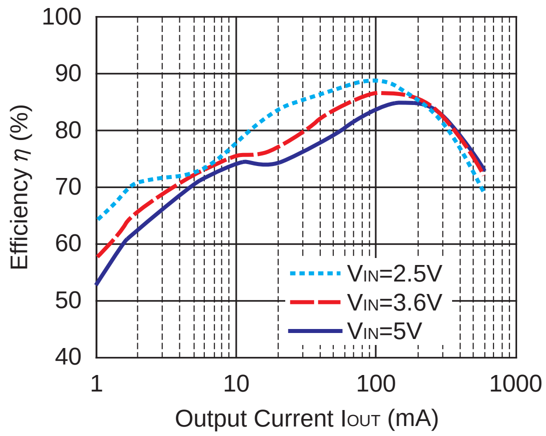



RP500x152A/154A

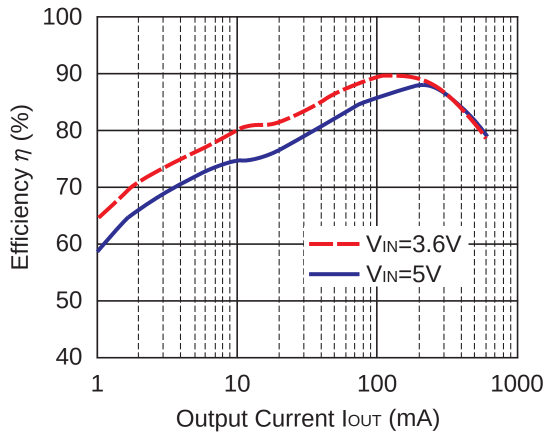



### 3) Efficiency vs. Output Current

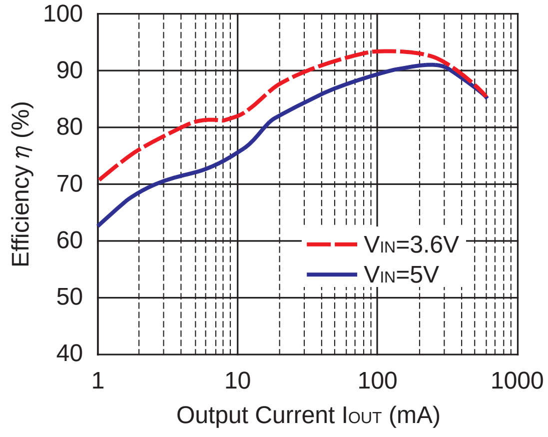
RP500x121A/123A



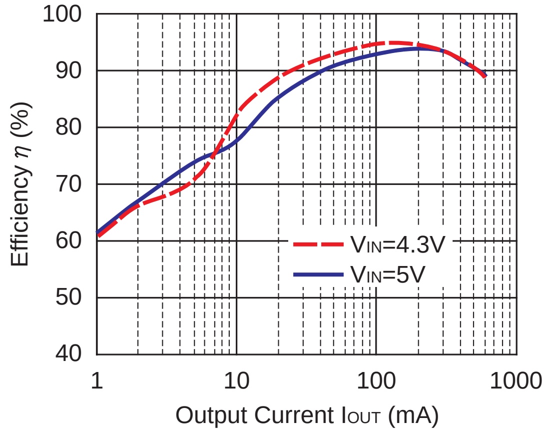

RP500x181A/183A



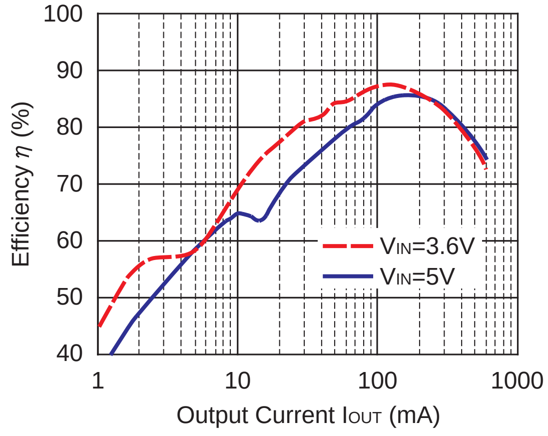
**RP500x251A/253A**




**RP500x331A/333A**

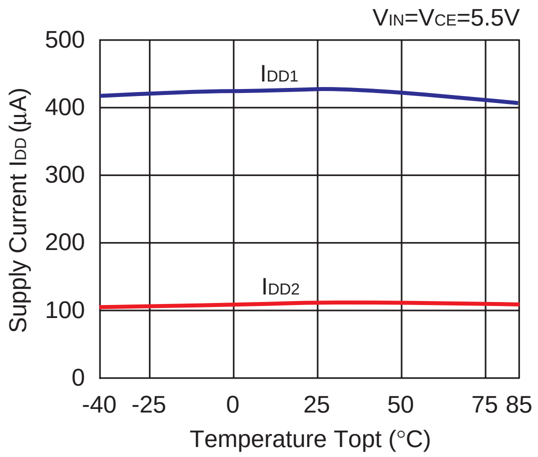



**RP500x152A/154A**



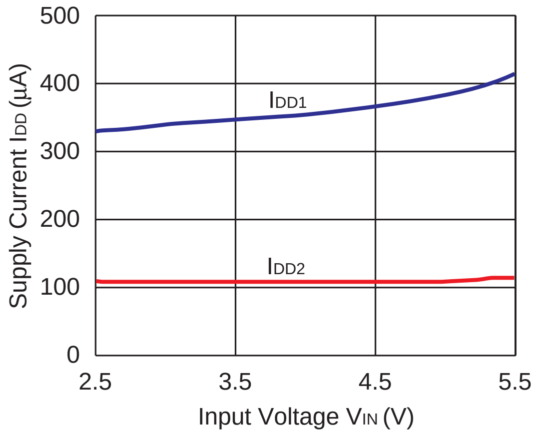

### 4) Supply Current 1, 2 vs. Temperature

**RP500x15xA**



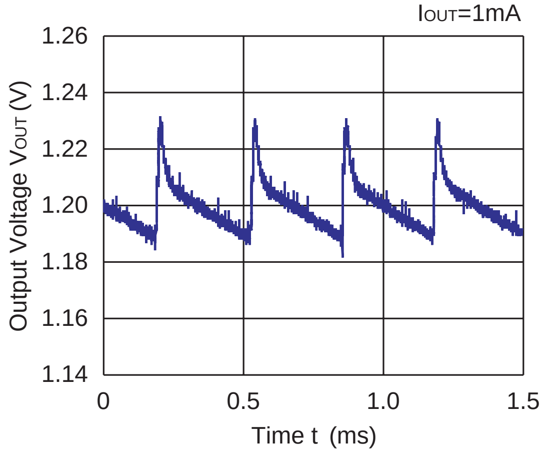

### 5) Supply Current 1, 2 vs. Input Voltage

**RP500x15xA**

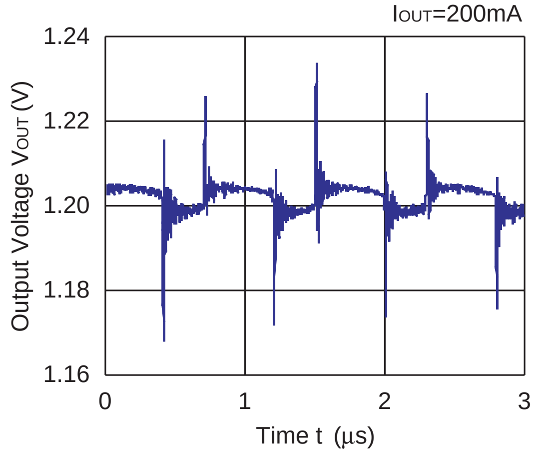


### 6) DC/DC Output Waveform ($C_{IN}$=$C_{OUT}$=10µF, L=4.7µH)

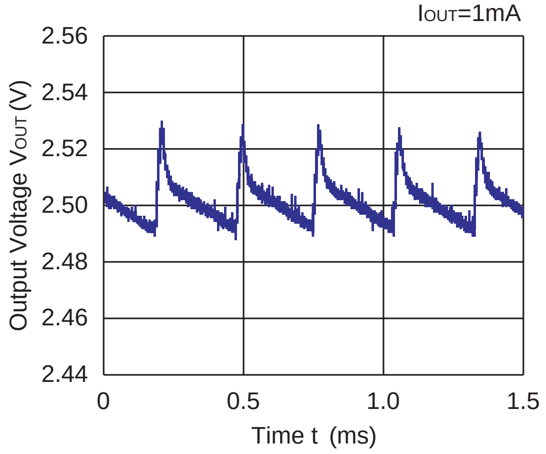
**RP500x121A/123A**



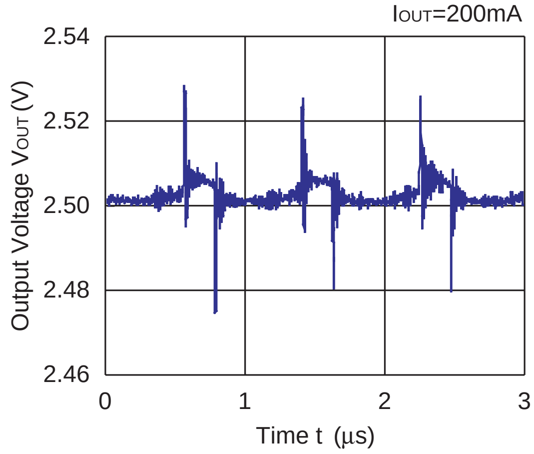

**RP500x12xA**



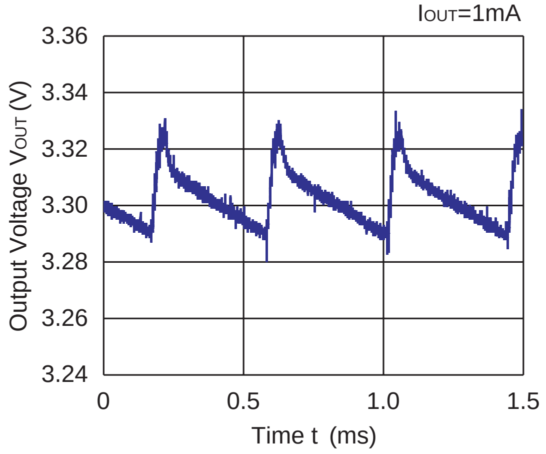

**RP500x251A/253A**




**RP500x25xA**




**RP500x331A/333A**

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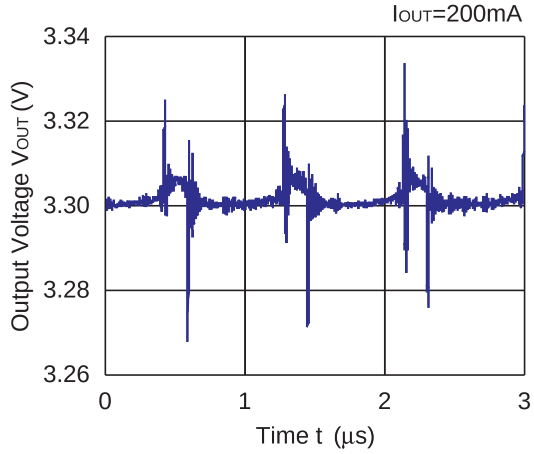
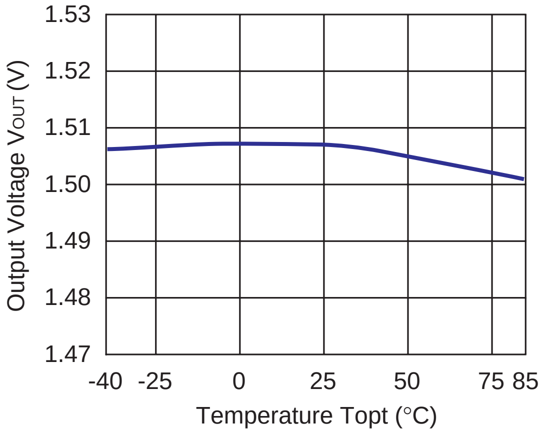
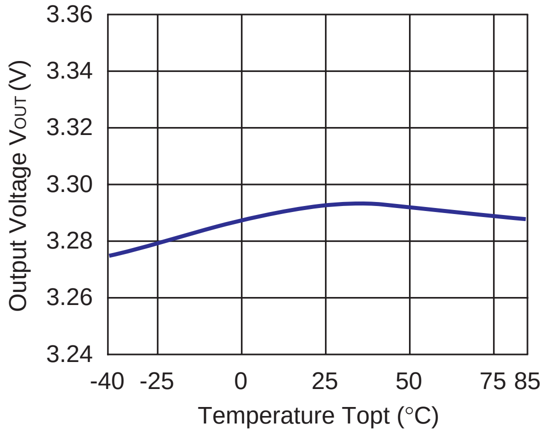


### 7) Output Voltage vs. Temperature

**RP500x15xA**

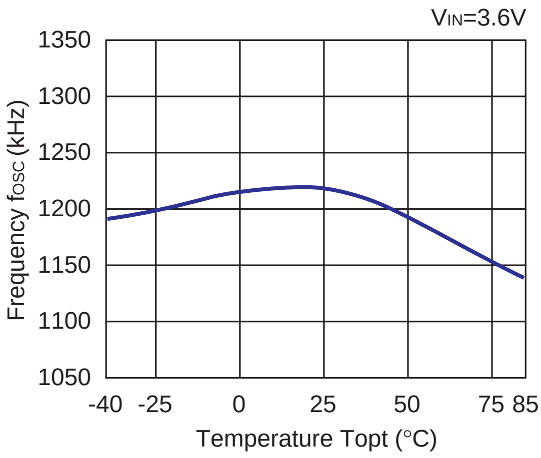



**RP500x33xA**



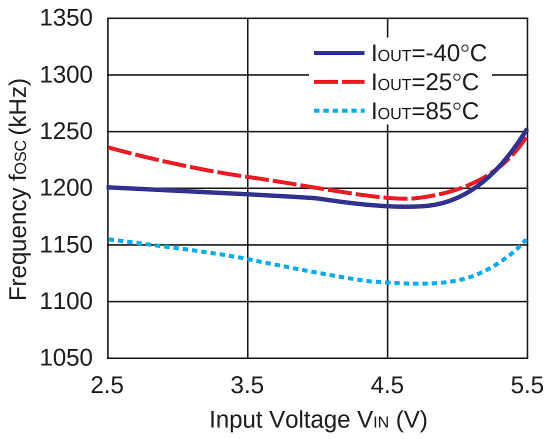

### 8) Oscillator Frequency vs. Temperature

**RP500x15xA**



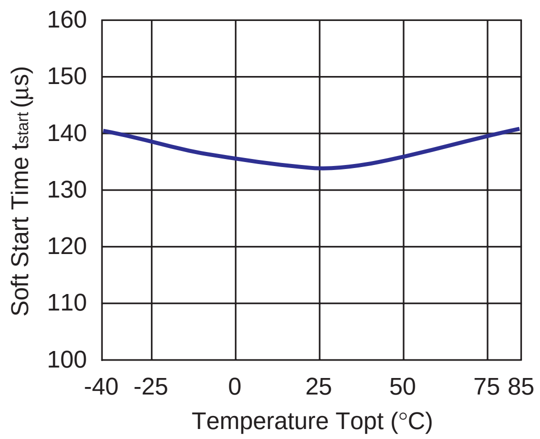

### 9) Oscillator Frequency vs. Input Voltage

**RP500x15xA**



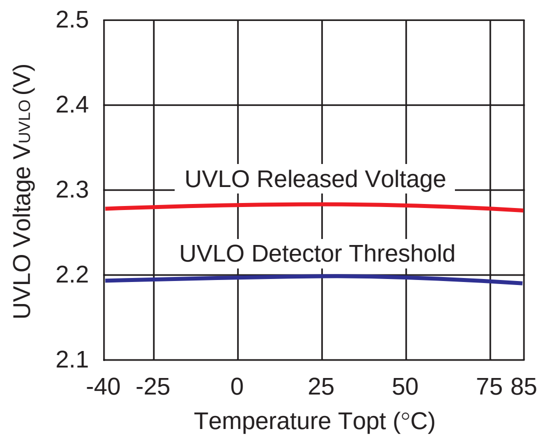

### 10) Soft-start Time vs. Temperature

**RP500x16xA**

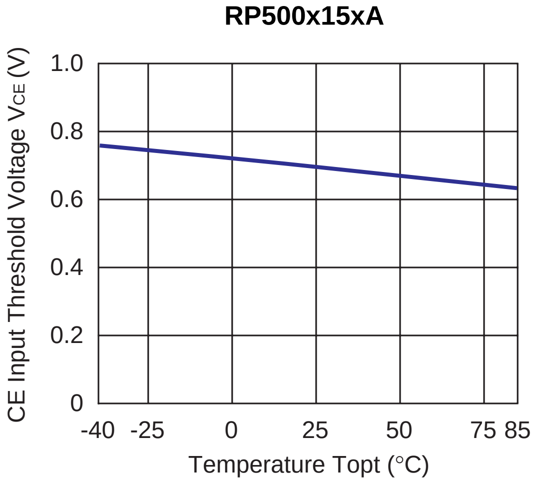



### 11) UVLO Detector Threshold/ Released Voltage vs. Temperature

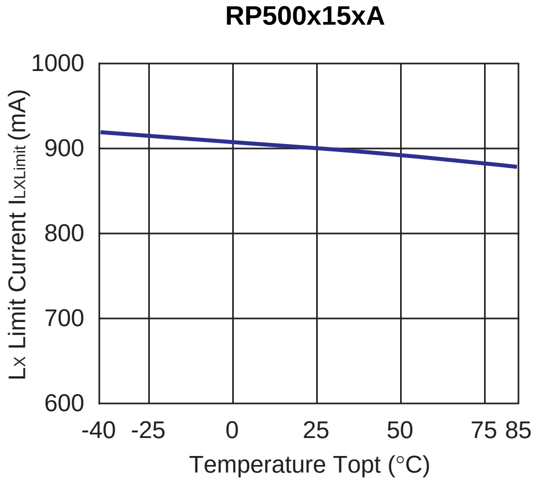
**RP500x15xA**



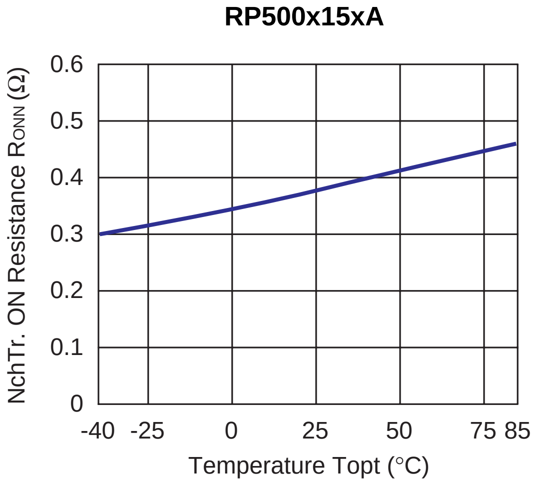
### 12) CE Input vs. Temperature



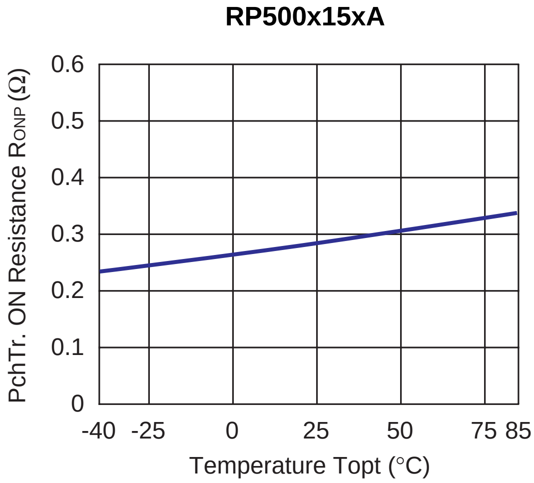

### 13) Lx Current Limit vs. Temperature



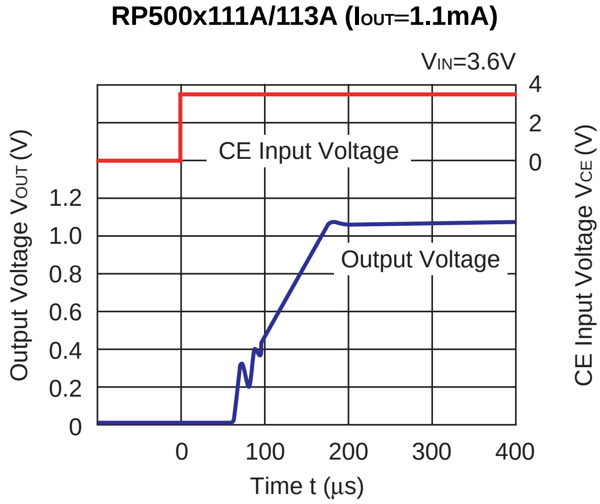

### 14) Nch Tr. ON Resistance vs. Temperature

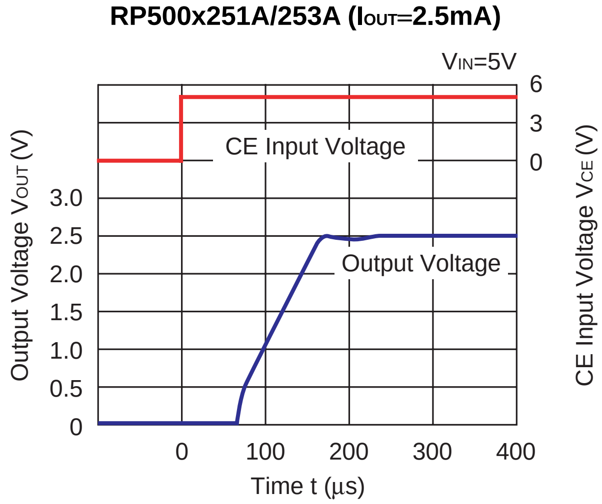



### 15) Pch Tr. ON Resistance vs. Temperature

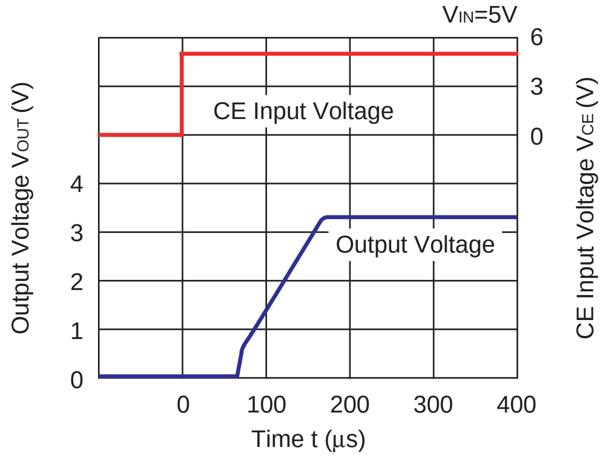



### 16) Turn on speed with CE pin ($C_{IN}$=$C_{OUT}$=Ceramic 10µF, L=4.7µH)

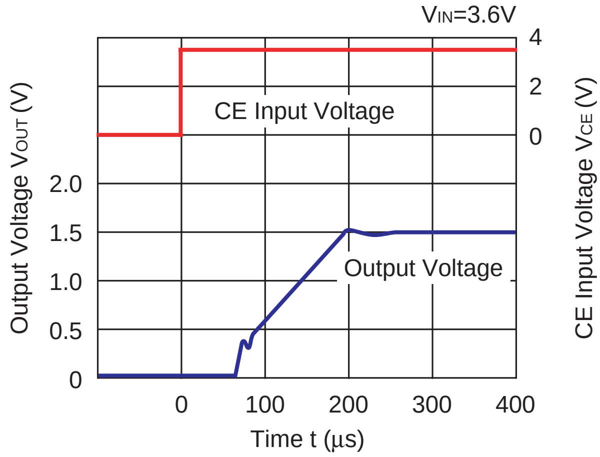


**RP500x331A/333A ($I_{OUT}$=3.3mA)**

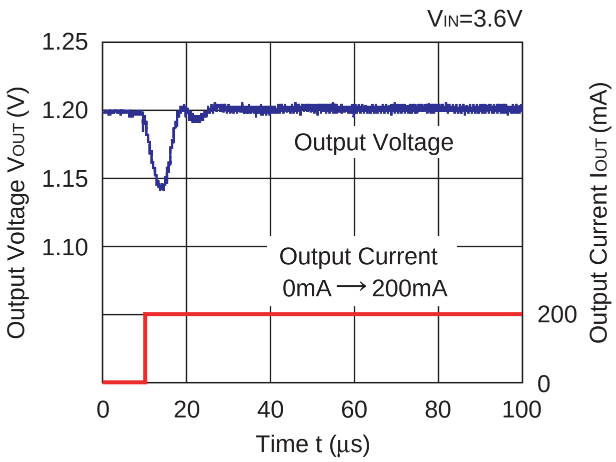



**RP500x152A/154A ($I_{OUT}$=1.5mA)**

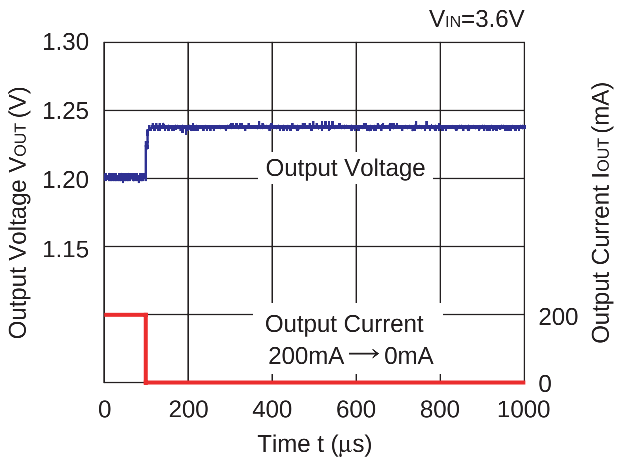



## 17) Load Transient Response ($C_{IN}$=$C_{OUT}$=Ceramic 10µF, L=4.7µH)

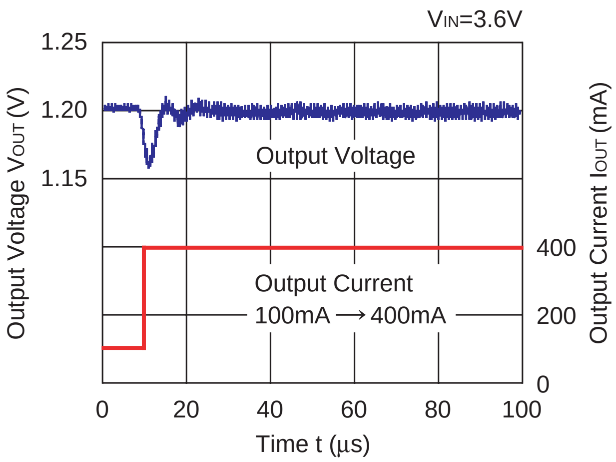
**RP500x121A/123A**




**RP500x121A/123A**




**RP500x12xA**

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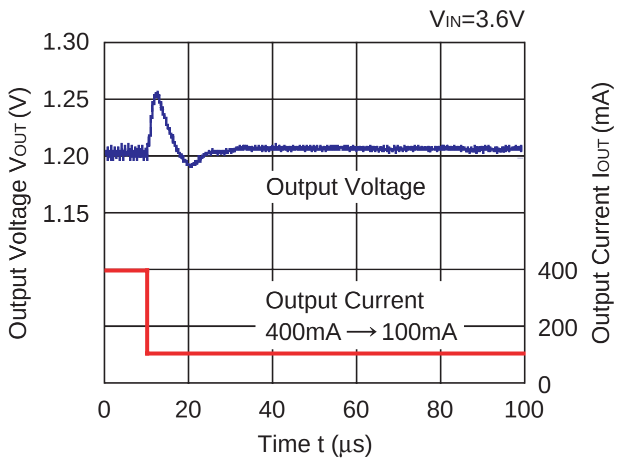
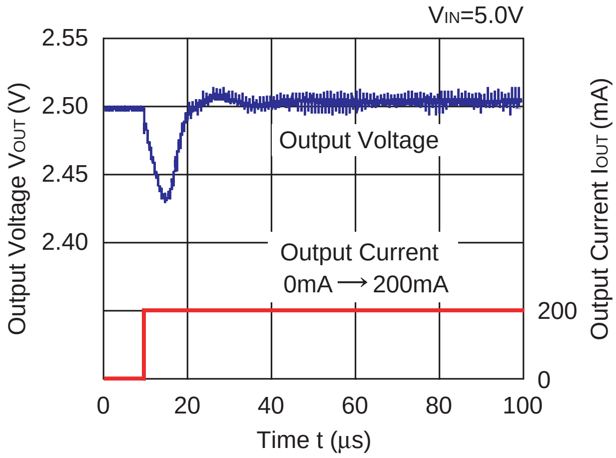
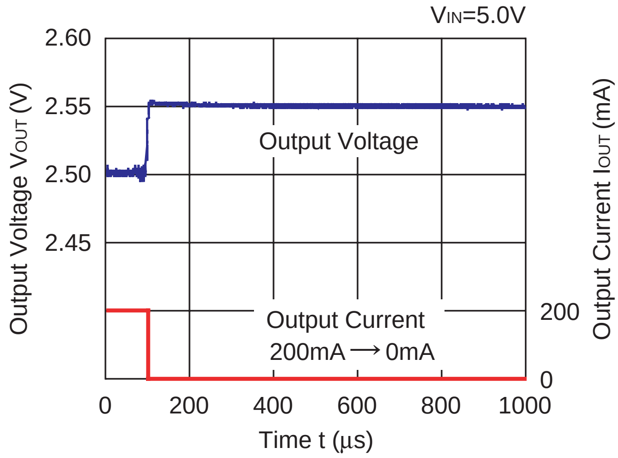


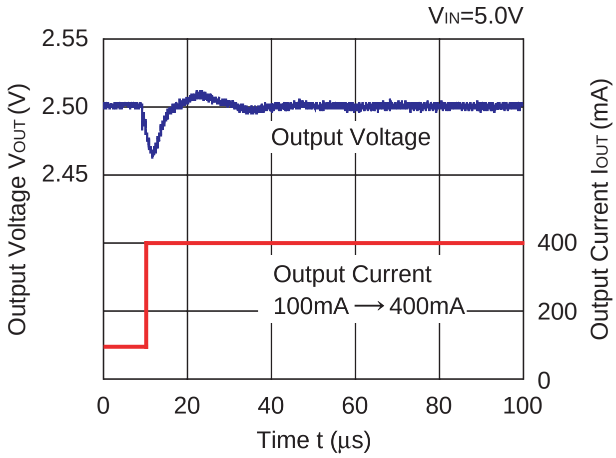
**RP500x251A/253A**



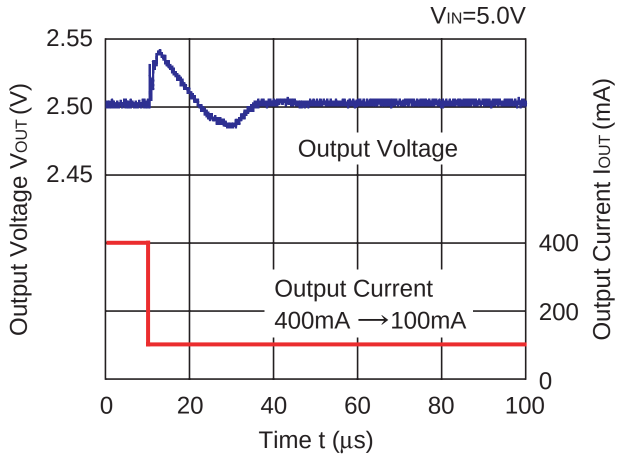

**RP500x251A/253A**




**RP500x25xA**




**RP500x25xA**

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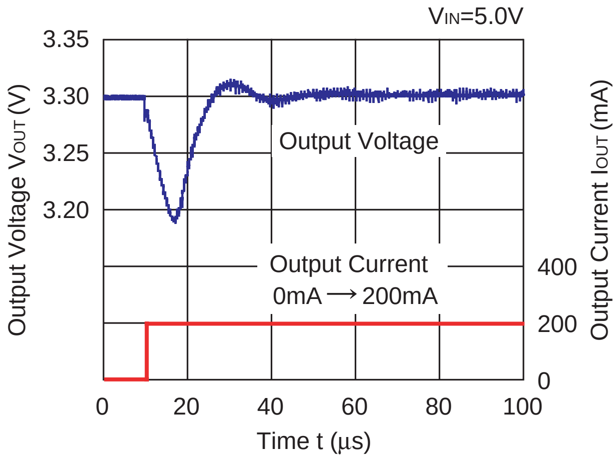


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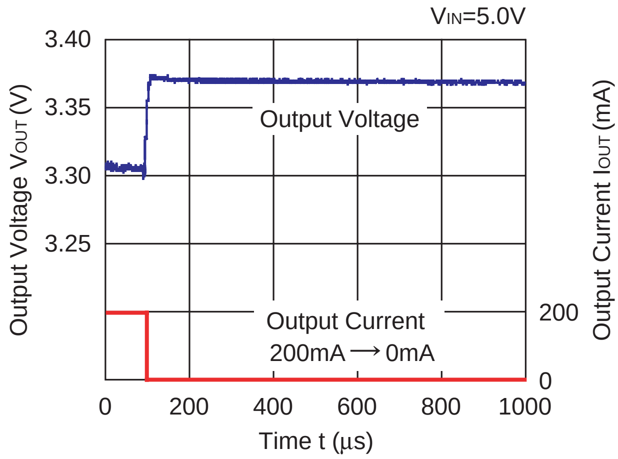

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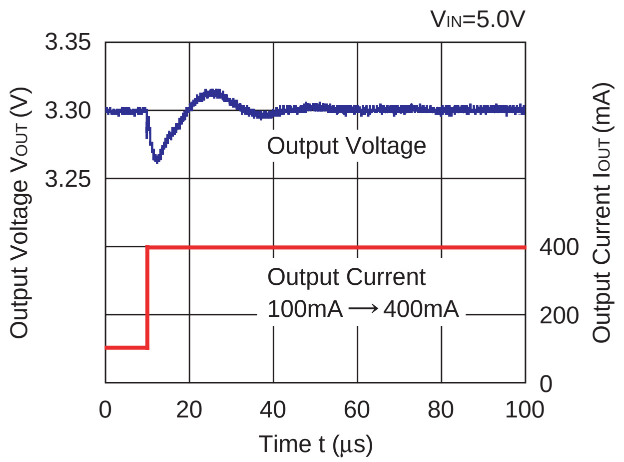


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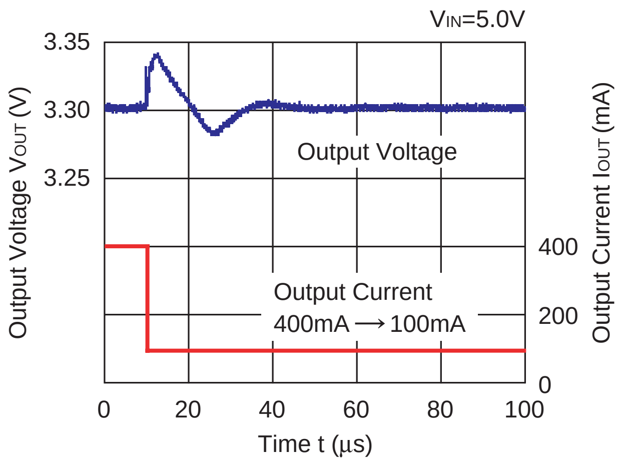
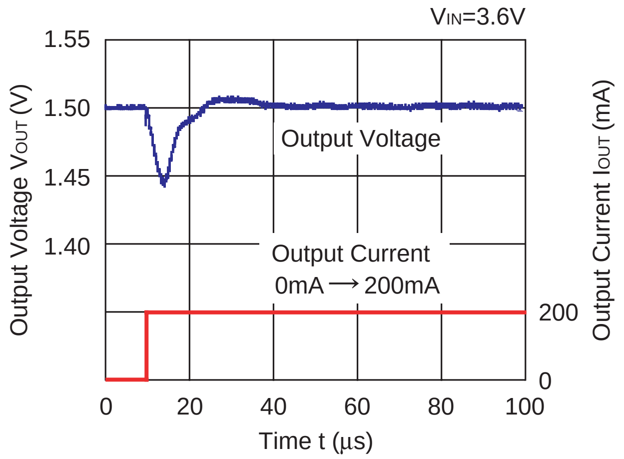



**RP500x152A/154A**

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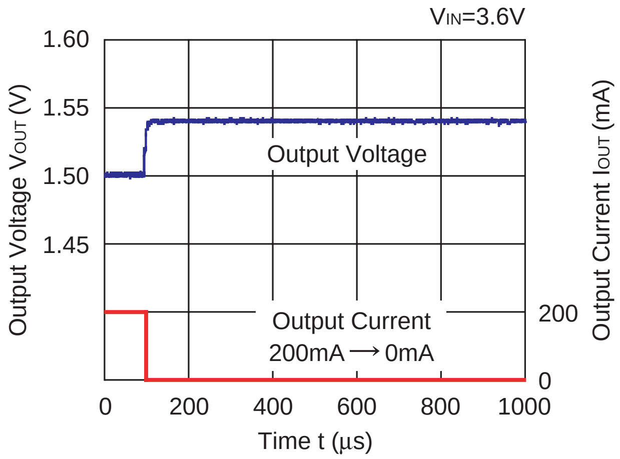
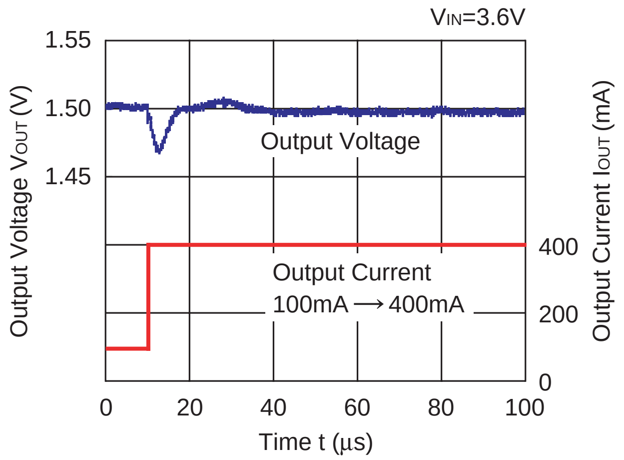



**RP500x15xA**

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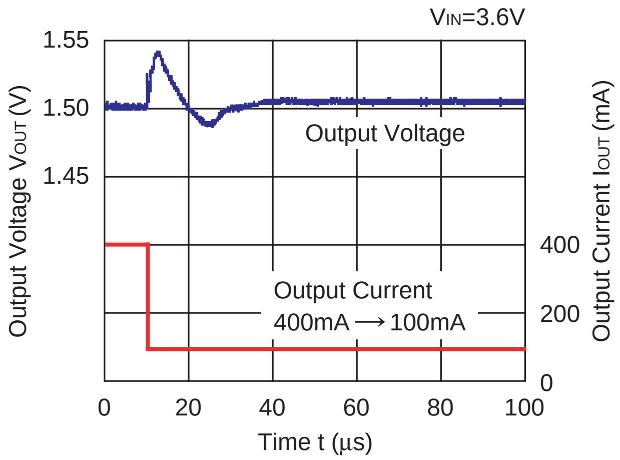

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