The R5220x Series are CMOS-based PWM step-down DC/DC Converters with synchronous rectifier, low supply current and LDO mode.

DC/DC converter of the R5220x consists of an oscillator, a PWM control circuit, a reference voltage unit, an error amplifier, a soft-start circuit, protection circuits, a protection against miss operation under low voltage (UVLO), PWM-DC to DC converter / LDO alternative circuit, a chip enable circuit, and a driver transistor. A high efficiency step-down DC/DC converter can be easily composed of this IC with only a few kinds of external components, or an inductor and capacitors.

LDO of the R5220x consists of a vortage reference unit, an error amplifier, resistors for voltage setting, output current limit circuit, a driver transistor, and so on. The output voltage is fixed internally in the R5220x. The output voltage of the DC/DC converter and the LDO can be set independently.

PWM step-down DC/DC converter / LDO alternative circuit is active with Mode Pin of the R5220x Series. Thus, when the load current is small, the operation can be switching into the LDO operation from PWM operation by the logic of MODE pin and the consumption current of the IC itself will be small at light load current. 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 in PWM mode. Latch-type protection circuit works to latch an internal driver with keeping it disable. To release the protection, after disable this IC with a chip enable circuit, enable it again, or restart this IC with power-on or make the supply voltage at UVLO detector threshold level or lower than UVLO.

FEATURES

- Supply Current .................................................................Typ. 350μA (DC/DC), Typ. 5μA (VR)
- Standby Current ...............................................................Typ. 0.1μA
- Built-in Driver ON Resistance ............................................P-channel 0.5Ω, N-channel 0.5Ω (at \( V_{IN} = 3.6V \))
- Output Current .................................................................Min. 400mA (DC/DC), Min. 50mA (VR)
- Input Voltage .................................................................2.8V to 5.5V (Absolute Input Maximum: 6.5V)
- Output Voltage .................................................................1.0V to 3.3V (0.1V steps)

(For other voltages, please refer to MARK INFORMATIONS.)
- Output Voltage Accuracy ..................................................±2.0% (\( V_{OUT} \geq 1.5 \)), ±30mV (\( V_{OUT} < 1.5V \))
- Oscillator Frequency (DC/DC) .........................................Typ. 1.2MHz
- Package .................................................................SON-6, DFN(PLP)2514-6
- Built-in Soft-start Function ................................................Typ. 0.2ms
- Latch-type Protection Function (Delay Time) ......................Typ. 3.0ms
- Built-in fold-back protection circuit (DC/DC, VR)
- Ceramic Capacitor is recommended.

APPLICATIONS

- Power source for portable equipment such as DSC, DVC, and communication equipment.
**R5220x**

**BLOCK DIAGRAM**

* R5220xxxxA: DC/DC mode: Mode pin= "H", VR mode: Mode pin= "L"
  R5220xxxxB: DC/DC mode: Mode pin= "L", VR mode: Mode pin= "H"

**SELECTION GUIDE**

In the R5220x Series, the output voltage, the version and the pin polarities for the ICs can be selected at the user's request.

<table>
<thead>
<tr>
<th>Product Name</th>
<th>package</th>
<th>Quantity per Reel</th>
<th>Pb Free</th>
<th>Halogen Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>R5220Kxx-$-TR</td>
<td>DFN(PLP)2514-6</td>
<td>5,000 pcs</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>R5220Dxx-$-TR-FE</td>
<td>SON-6</td>
<td>3,000 pcs</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

xx : Output Voltage (V_out) or serial number.
   - The output voltage can be designed in the range from 1.0V(10) to 3.3V(33) in 0.1V steps.
   - (If selected the custum-made product) The output voltage can be designed by Serial numbers.
   - Please refer to the attached Mark Informations.

* : (1) Standard (DC/DC output voltage = LDO output voltage)
   (2) Custom-made (DC/DC output voltage ≠ LDO output voltage)

$ : Designation of chip enable and Mode pin polarities
   (A) Mode pin; "H"=DC/DC converter mode, "L"=LDO Mode
   (B) Mode pin; "L"=DC/DC converter mode, "H"=LDO Mode

*R5220D (SON-6) is the non-promotion product. As of March in 2014.*
PIN CONFIGURATIONS

SON-6
Top View  Bottom View

DFN(PLP)2514-6
Top View  Bottom View

PIN DESCRIPTIONS

<table>
<thead>
<tr>
<th>Pin No</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lx</td>
<td>Lx Pin Voltage Supply Pin</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground Pin</td>
</tr>
</tbody>
</table>
| 3      | MODE   | Mode changer Pin
|        |        | (Refer to the Selection Guide)    |
| 4      | CE     | Chip Enable Pin (active with "H")|
| 5      | V_{OUT}| Output Pin                        |
| 6      | V_{IN} | Voltage Supply Pin                |

*1) 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.

* R5220D (SON-6) is the non-promotion product. As of March in 2014.
### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_IN</td>
<td>VIN Supply Voltage</td>
<td>6.5</td>
<td>V</td>
</tr>
<tr>
<td>V_LX</td>
<td>Lx Pin Voltage</td>
<td>−0.3 to V_IN+0.3</td>
<td>V</td>
</tr>
<tr>
<td>V_CE</td>
<td>CE Pin Input Voltage</td>
<td>−0.3 to 6.5</td>
<td>V</td>
</tr>
<tr>
<td>V_MODE</td>
<td>MODE Pin Input Voltage</td>
<td>−0.3 to 6.5</td>
<td>V</td>
</tr>
<tr>
<td>V_OUT</td>
<td>V_OUT Pin Voltage</td>
<td>−0.3 to V_IN+0.3</td>
<td>V</td>
</tr>
<tr>
<td>I_LX</td>
<td>Lx Pin Output Current</td>
<td>600</td>
<td>mA</td>
</tr>
<tr>
<td>I_OUT</td>
<td>V_OUT Pin Output Current</td>
<td>200</td>
<td>mA</td>
</tr>
<tr>
<td>P_D</td>
<td>Power Dissipation (SON-6)</td>
<td>500</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>Power Dissipation (DFN(PLP)2514-6)</td>
<td>730</td>
<td>mW</td>
</tr>
<tr>
<td>T_0pt</td>
<td>Operating Temperature Range</td>
<td>−40 to 85</td>
<td>°C</td>
</tr>
<tr>
<td>T_stg</td>
<td>Storage Temperature Range</td>
<td>−55 to 125</td>
<td>°C</td>
</tr>
</tbody>
</table>

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

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.

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.
## ELECTRICAL CHARACTERISTICS

**R5220xxxxA**

**Symbol** | **Item** | **Conditions** | **Min.** | **Typ.** | **Max.** | **Unit**
---|---|---|---|---|---|---
$V_{IN}$ | Input Voltage | | 2.8 | 5.5 | V |
$I_{SS1}$ | Supply Current 1 (Standby mode) | $V_{IN}=V_{OUT}+1.0V, V_{CE}=GND, V_{MODE}=GND$ or $V_{IN}=0V, V_{OUT}=0V$ | 0.1 | 1.0 | μA |
$I_{SS2}$ | Supply Current 2 (Power Save mode) | $V_{IN}=V_{CE}=V_{OUT}+1.0V, V_{MODE}=GND$ | 5 | 10 | μA |
$I_{SS3}$ | Supply Current 3 | $V_{IN}=V_{CE}=V_{MODE}=3.6V$ | 350 | 450 | μA |

### DC/DC Part

**Symbol** | **Item** | **Conditions** | **Min.** | **Typ.** | **Max.** | **Unit**
---|---|---|---|---|---|---
$V_{OUT1}$ | Output Voltage | $V_{IN}=3.6V, I_{OUT}=50mA$ | $V_{OUT1} ≥ 1.5$ | ×0.98 | ×1.02 | V |
$T_{START}$ | Soft-start Time | $V_{IN}=3.6V$ | $V_{OUT1} < 1.5$ | −0.03 | +0.03 | ms |
$R_{ONP}$ | ON Resistance of Pch Transistor | $V_{IN}=3.6V, I_{LX}=-100mA$ | 0.5 | | Ω |
$R_{ONN}$ | ON Resistance of Nch Transistor | $V_{IN}=3.6V, I_{LX}=-100mA$ | 0.5 | | Ω |
$V_{LX}$ | Lx Leakage Current | $V_{IN}=5.5V, V_{CE}=0V, L_{X}=5.5V/0V$ | −1.0 | 1.0 | μA |
$ΔV_{OUT}/ΔT_{opt}$ | Output Voltage Temperature Coefficient | $-40°C ≤ T_{opt} ≤ 85°C$ | ±150 | | ppm/°C |
$I_{MODEH}$ | MODE "H" Input Voltage | | 1.0 | | V |
$I_{MODEL}$ | MODE "L" Input Voltage | | 0 | 0.3 | V |

### VR Part

**Symbol** | **Item** | **Conditions** | **Min.** | **Typ.** | **Max.** | **Unit**
---|---|---|---|---|---|---
$V_{OUT2}$ | Output Voltage | $V_{IN}=V_{OUT}+1.0V, I_{OUT}=10mA$ | $V_{OUT2} ≥ 1.5$ | ×0.98 | ×1.02 | V |
$I_{OUT}$ | Output Current | $V_{IN}=V_{OUT}+1.0V$ | | 50 | | mA |
$ΔV_{OUT2}/ΔI_{OUT}$ | Load Regulation | $V_{IN}=V_{OUT}+1.0V, 10μA ≤ I_{OUT} ≤ 25mA$ | $V_{OUT2} ≥ 2.3$ | 15 | 40 | mV |
$V_{DD}$ | Dropout Voltage | $I_{OUT}=50mA$ | $V_{OUT2} < 1.8$ | 0.7 | | V |
$ΔV_{OUT2}/ΔV_{IN}$ | Line Regulation | $2.8V ≤ V_{IN} ≤ 5.5V, I_{OUT}=25mA$ | $V_{OUT2} < 2.3$ | 0.2 | | %/V |
$RR$ | Ripple Rejection | Refer to Typical Characteristics | | | | dB |
$ΔV_{OUT}/ΔT_{opt}$ | Output Voltage Temperature Coefficient | $I_{OUT}=30mA, −40°C ≤ T_{opt} ≤ 85°C$ | | ±100 | | ppm/°C |
$I_{lim}$ | Short Current Limit | $V_{OUT}=0V$ | | 60 | | mA |
$I_{OC}$ | CE pull-down current | | 0.12 | 0.40 | 0.70 | μA |
$V_{CEH}$ | CE "H" Input Voltage | | 1.0 | | V |
$V_{CEL}$ | CE "L" Input Voltage | | 0 | 0.3 | | V |
### R5220xxxxB

**Symbol** | **Item** | **Conditions** | **Min.** | **Typ.** | **Max.** | **Unit**
--- | --- | --- | --- | --- | --- | ---
VIN | Input Voltage | 2.8 | 5.5 | V

| ISS1 | Supply Current 1 (Standby mode) | \( V_{IN}=V_{OUT}+1.0V, V_{CE}=GND, V_{MODE}=GND \) or \( V_{IN}=V_{OUT} \) | 0.1 | 1.0 | \( \mu A \)

| ISS2 | Supply Current 2 (Power Save mode) | \( V_{IN}=V_{CE}=V_{MODE}=V_{OUT}+1.0V \), \( V_{OUT2}=0mA \) | 5 | 10 | \( \mu A \)

| ISS3 | Supply Current 3 | \( V_{IN}=V_{CE}=3.6V, V_{MODE}=GND \) | 350 | 450 | \( \mu A \)

**DC/DC Part**

**Symbol** | **Item** | **Conditions** | **Min.** | **Typ.** | **Max.** | **Unit**
--- | --- | --- | --- | --- | --- | ---
VOUT1 | Output Voltage | \( V_{IN}=3.6V \), \( I_{OUT}=50mA \) | \( V_{OUT1} \geq 1.5 \) | \( <1.02 \) | V

| fosc | Oscillator Frequency | \( V_{IN}=V_{SET}+1.5V \) | 0.96 | 1.20 | 1.44 | MHz

| TSTART | Soft-start Time | \( V_{IN}=3.6V \) | \( V_{OUT1} \leq 1.5 \) | 0.15 | 0.30 | ms

| RONP | ON Resistance of Pch Transistor | \( V_{IN}=3.6V, I_{LX}=100mA \) | 0.5 | | \( \Omega \)

| RONN | ON Resistance of Nch Transistor | \( V_{IN}=3.6V, I_{LX}=100mA \) | 0.5 | | \( \Omega \)

| ILXLEAK | Lx Leakage Current | \( V_{IN}=5.5V, V_{CE}=0V, L_{X}=5.5V/0V \) | 1.0 | 1.0 | \( \mu A \)

| \( \Delta V_{OUT}/\Delta T_{OPT} \) | Output Voltage Temperature Coefficient | \( -40^\circ C \leq T_{OPT} \leq 85^\circ C \) | 100 | 150 | ppm/\(^\circ C\)

Maxduty | Oscillator Maximum Duty Cycle | \( V_{OUT}=0V \) | | | %

| IILIM | Lx Current Limit | \( V_{IN}=3.6V \) | 500 | 800 | mA

| Tprot | Protection Delay Circuit | \( V_{IN}=3.6V \) | 1.0 | 3.0 | 7.0 | ms

| VUVLO1 | UVLO Threshold Voltage | \( V_{CE}=V_{IN}, V_{MODE}=GND, V_{OUT}=0V \) | 2.00 | 2.35 | 2.75 | V

| VUVLO2 | UVLO Released Voltage | \( V_{CE}=V_{IN}, V_{MODE}=GND, V_{OUT}=0V \) | 2.05 | 2.45 | 2.80 | V

| VMODEH | MODE "H" Input Voltage | | 1.0 | | V

| VMODEL | MODE "L" Input Voltage | | 0 | 0.3 | V

**VR Part**

**Symbol** | **Item** | **Conditions** | **Min.** | **Typ.** | **Max.** | **Unit**
--- | --- | --- | --- | --- | --- | ---
VOUT2 | Output Voltage | \( V_{IN}=V_{OUT}+1.0V \), \( I_{OUT}=10mA \) | \( V_{OUT2} \geq 1.5 \) | \( <1.02 \) | V

| IOUT | Output Current | \( V_{IN}=V_{OUT}+1.0V \) | 50 | | mA

| \( \Delta V_{OUT}/\Delta I_{OUT} \) | Load Regulation | \( V_{IN}=V_{OUT}+1.0V \), \( 10\mu A \leq I_{OUT} \leq 25mA \) | \( V_{OUT2} \leq 2.3 \) | 15 | 40 | mV

| VDIFF | Dropout Voltage | \( I_{OUT}=50mA \) | \( V_{OUT2} \leq 1.8V \) | 0.7 | | V

| \( \Delta V_{OUT2}/\Delta V_{IN} \) | Line Regulation | \( 2.8V \leq V_{IN} \leq 5.5V \), \( I_{OUT}=25mA \) | \( V_{OUT2} \leq 2.3V \) | | 0.2 | %/V

| RR | Ripple Rejection | | | | | dB

| \( \Delta V_{OUT}/\Delta T_{OPT} \) | Output Voltage Temperature Coefficient | \( I_{OUT}=30mA, -40^\circ C \leq T_{OPT} \leq 85^\circ C \) | | ±100 | ppm/\(^\circ C\)

| IILIM | Short Current Limit | \( V_{OUT}=0V \) | | 60 | | mA

| IILIM | CE pull-down current | | 12 | 0.40 | 70 | \( \mu A \)

| VCEH | CE "H" Input Voltage | | 1.0 | | V

| VCEL | CE "L" Input Voltage | | 0 | 0.3 | V

---

* R5220D (SON-6) is the non-promotion product. As of March in 2014.
External Components

- Set external components such as an inductor, \( C_{\text{IN}} \), \( C_{\text{OUT}} \) as close as possible to the IC, in particular, minimize the wiring to \( V_{\text{IN}} \) pin and GND pin. If \( V_{\text{DD}} \) line or GND line's impedance is high, the internal voltage level of the IC may fluctuate and the operation may be unstable. Make GND line and \( V_{\text{DD}} \) line sufficient. Through the \( V_{\text{DD}} \) line, the GND line, the inductor, \( L_x \) pin, and \( V_{\text{OUT}} \) line, a large current caused by switching may flow, therefore, those lines should be sufficient and avoid the cross talk with other sensitive lines. Use the individual line from the \( V_{\text{OUT}} \) pin of the IC for the inductor and the capacitor and load.

- Use a low ESR ceramic capacitor \( C_{\text{OUT}}/C_{\text{IN}} \) with a capacity of 10\( \mu \)F or more.

- Select an inductor with an inductance range from 4.7\( \mu \)H to 10\( \mu \)H. The internal phase compensation is secured with these inductance values and \( C_{\text{OUT}} \) value. Choose the inductor with a low DC resistance and enough permissible current and hard to reach magnetic saturation. In terms of inductance value, choose the appropriate value with considering the conditions of the input voltage range and the output voltage, and load current. If the inductance value is too small and the load current is large, the peak current of \( L_x \) may reach the \( L_x \) current limit, and the protection against over-current may work.

- The protection circuit against over-current is affected by the self-heating and the heat radiation environment. Therefore evaluate under the considerable environment of the application.

The performance of power source circuits using these ICs extremely depends upon the peripheral circuits. Pay attention in the selection of the peripheral circuits. In particular, design the peripheral circuits in a way that the values such as voltage, current, and power of each component, PCB patterns and the IC do not exceed their respected rated values.
**OPERATION of step-down DC/DC converter and Output Current**

The step-down DC/DC converter charges energy in the inductor when L_x transistor is ON, and discharges the energy from the inductor when L_x 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:

**Step 1**: P-channel Tr. turns on and current \( i_1 \) flows, and energy is charged into \( CL \). At this moment, \( IL \) increases from \( IL_{\text{min}} (=0) \) to reach \( IL_{\text{max}} \) in proportion to the on-time period (\( ton \)) of P-channel Tr.

**Step 2**: When P-channel Tr. turns off, Synchronous rectifier N-channel Tr. turns on in order that L maintains \( IL \) at \( IL_{\text{max}} \), and current \( i_2 \) flows.

**Step 3**: \( IL (=i_2) \) decreases gradually and reaches \( IL = IL_{\text{min}} = 0 \) after a time period of \( topen \), and N-channel Tr. Turns off. Provided that in the continuous mode, next cycle starts before \( IL \) becomes to 0 because \( toff \) time is not enough. In this case, \( IL \) value increases from this \( IL_{\text{min}} (>0) \).

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

The maximum value (\( IL_{\text{max}} \)) and the minimum value (\( IL_{\text{min}} \)) of the current flowing through the inductor are the same as those when P-channel Tr. turns on and off.

The difference between \( IL_{\text{max}} \) and \( IL_{\text{min}} \), which is represented by \( \Delta IL \);

\[
\Delta IL = IL_{\text{max}} - IL_{\text{min}} = V_{OUT} \times topen / L = (V_{IN} - V_{OUT}) \times ton / L 
\]

wherein, \( T = 1 / f_{osc} = ton + toff \)

\[
\text{duty} (%) = \frac{ton}{T} \times 100 = \frac{ton \times f_{osc}}{100} 
\]

\( topen \leq toff \)

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

---

\* R5220D (SON-6) is the non-promotion product. As of March in 2014.
OUTPUT CURRENT AND SELECTION OF EXTERNAL COMPONENTS

When P-channel Tr. of Lx is ON:

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

$$V_{IN} = V_{OUT} + (R_{ONP} + R_L) \times I_{OUT} + L \times \frac{I_{RP}}{ton}$$ ................................................................. Equation 2

When P-channel Tr. of Lx is "OFF" (N-channel Tr. is "ON"):

$$L \times \frac{I_{RP}}{toff} = R_{ONN} \times I_{OUT} + V_{OUT} + R_L \times I_{OUT}$$ ................................................................. Equation 3

Put Equation 3 to Equation 2 and solve for ON duty of P-channel transistor, $ton / (toff + ton) = D_{ON}$,

$$D_{ON} = \frac{(V_{OUT} - R_{ONN} \times I_{OUT} + R_L \times I_{OUT})}{(V_{IN} + R_{ONN} \times I_{OUT} - R_{ONP} \times I_{OUT})}$$ .................................................. Equation 4

Ripple Current is as follows;

$$I_{RP} = \frac{(V_{IN} - V_{OUT} - R_{ONP} \times I_{OUT} - R_L \times I_{OUT}) \times D_{ON}}{fosc / L}$$ ................................................................. Equation 5

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

$$I_{Lmax} = I_{OUT} + \frac{I_{RP}}{2}$$ .................................................................................................. Equation 6

Consider $I_{Lmax}$, condition of input and output and select external components.

$\ast$ The above explanation is directed to the calculation in an ideal case in continuous mode.
TIMING CHART

1) IC start-up

The timing chart as shown in the next describes the operation starting the IC is enabled with CE. When the CE pin voltage becomes higher than the threshold voltage, the IC’s operations starts. At first, only the voltage regulator (VR) starts. The threshold level of the CE pin is between CE “H” input voltage and CE “L” input voltage. After starting the operation, the output capacitor (C_OUT) is charged with the output current of the VR, and the output level becomes the set VR output voltage. At this moment, the output of Lx is “off”, (“Hi-Z”), the pin voltage, V_Lx = V_OUT through the external inductor L.

Secondly, the Mode pin voltage is higher than the threshold voltage, internal operation of DC/DC starts. The threshold level is between Mode “H” input voltage and Mode “L” input voltage. The soft-start circuit inside the DC/DC converter’s operation is as follows:

(Case 1) DC/DC output voltage < VR output voltage
After the soft-start time, while the output voltage level is down from the VR output voltage to DC/DC output voltage, the circuit is waiting for the start of DC/DC operation. When the output voltage reaches so set DC/DC output voltage level, the actual DC/DC operation starts.

(Case 2) DC/DC output voltage > VR output voltage
The soft-start circuit of DC/DC converter makes the voltage reference unit of the IC rise gradually and be constant. After the voltage reference unit reaches the constant level which the output voltage of DC/DC converter can balance becomes the output voltage of VR, the set output voltage of DC/DC converter may be realized.

Therefore, the soft-start time means the time range of starting to the time when the voltage reference unit reaches the constant level, and the soft-start time is different from turning on speed in some cases. The operation starting time depends on the ability of the power supply, the load current, the inductance value, the capacitance value, and the voltage difference between the set VR output and the set DC/DC output.

If CE and Mode are on at once, the same operation as above is happened except the VR start-up and Soft-start operation start at the same time.

If Mode signal is forced earlier than CE signal, this IC is stand-by until CE signal comes. Therefore when the CE signal is set, the IC operation starts as above.

• V_OUT voltage rising speed at start-up with power supply is affected by the next conditions:
  1. The turning on speed of V_IN voltage limited by the power supply to the IC and the input capacitor C_IN.
  2. The output capacitor, C_OUT value and load current.

• DC/DC operation starting time
  1. If the VR output ≥ DC/DC output, the operation starting time of the DC/DC converter is approximately equal to the next formula.

\[
T_{DDC\_ACT} = T_{SS} + \left( V_{OUT\_VR} - V_{OUT\_DC/DC} + 15mV \right) \times \frac{C_{OUT}}{(load\ current\ at\ mode\ change + 1\ \mu A)}
\]

T_{SS}: Soft-start time
V_{OUT\_VR}: VR output voltage
V_{OUT\_DC/DC}: DC/DC Output Voltage

*1 \mu A is the supply current of the IC itself for the output.

2. If the VR output < DC/DC output, the operation starting time is the soft-start time + starting operation time which depends on the power supply, the load current, and the external components.
If CE pin input signal is forced earlier than the supply voltage, the voltage difference between the input and the output which is according to the input voltage to \( V_{\text{IN}} \), is maintained and the \( V_{\text{OUT}} \) is rising up.

* R5220D (SON-6) is the non-promotion product. As of March in 2014.
TEST CIRCUITS

Supply Current 1,2,3

Output Voltage (DC/DC)

Oscillator Frequency

Soft-start Time

Lx Leakage Current

Lx Current Limit, Output Delay for Protection
Lx Pch transistor ON resistance
Nch transistor ON resistance

*R5220D (SON-6) is the non-promotion product. As of March in 2014.*
UVLO Detector Threshold
UVLO Release Voltage

MODE Input Voltage "H","L" Input Current

Output Voltage (VR), Load Regulation
Line Regulation, Dropout Voltage

(J) Ripple Rejection

Short Current Limit
CE="H"/"L" Input Voltage/ Input Current

* R5220D (SON-6) is the non-promotion product. As of March in 2014.
**TYPICAL CHARACTERISTICS**

1) DC/DC Converter

1-1) DC/DC Output Voltage vs. Output Current

<table>
<thead>
<tr>
<th>Output Voltage (V)</th>
<th>2.8V</th>
<th>3.6V</th>
<th>5.5V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Current (mA)</td>
<td>1mA</td>
<td>50mA</td>
<td>250mA</td>
</tr>
</tbody>
</table>

![Graph showing DC/DC Output Voltage vs. Output Current](image)

1-2) DC/DC Output Voltage vs. Input Voltage

<table>
<thead>
<tr>
<th>Input Voltage (V)</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
<th>5.0</th>
<th>5.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage (V)</td>
<td>1.76</td>
<td>1.77</td>
<td>1.78</td>
<td>1.79</td>
<td>1.80</td>
<td>1.82</td>
<td>1.83</td>
</tr>
</tbody>
</table>

![Graph showing DC/DC Output Voltage vs. Input Voltage](image)

1-3) DC/DC Efficiency vs. Output Current

<table>
<thead>
<tr>
<th>Output Current (mA)</th>
<th>0.1</th>
<th>1</th>
<th>100</th>
<th>10</th>
<th>1000</th>
<th>200</th>
<th>240</th>
<th>220</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency (%)</td>
<td>0.1</td>
<td>1</td>
<td>100</td>
<td>10</td>
<td>1000</td>
<td>200</td>
<td>240</td>
<td>220</td>
<td>400</td>
</tr>
</tbody>
</table>

![Graph showing DC/DC Efficiency vs. Output Current](image)

1-4) DC/DC Supply Current vs. Temperature

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>-50</th>
<th>75</th>
<th>25</th>
<th>-25</th>
<th>50</th>
<th>0</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Current (μA)</td>
<td>200</td>
<td>220</td>
<td>240</td>
<td>260</td>
<td>280</td>
<td>320</td>
<td>360</td>
</tr>
</tbody>
</table>

![Graph showing DC/DC Supply Current vs. Temperature](image)

1-5) DC/DC Supply Current vs. Input Voltage

<table>
<thead>
<tr>
<th>Input Voltage (V)</th>
<th>-50</th>
<th>75</th>
<th>25</th>
<th>-25</th>
<th>50</th>
<th>0</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Current (μA)</td>
<td>1.14</td>
<td>1.26</td>
<td>1.24</td>
<td>1.16</td>
<td>1.20</td>
<td>1.18</td>
<td>1.22</td>
</tr>
</tbody>
</table>

![Graph showing DC/DC Supply Current vs. Input Voltage](image)

1-6) DC/DC Output Waveform

![Graph showing DC/DC Output Waveform](image)

---

* R5220D (SON-6) is the non-promotion product. As of March in 2014.
1-7) DC/DC Output Voltage vs. Temperature

1-8) DC/DC Oscillator Frequency vs. Temperature

1-9) DC/DC Oscillator Frequency vs. Input Voltage

1-10) Soft-start time vs. Temperature

1-11) UVLO Detector Threshold/Released Voltage vs. Temperature

* R5220D (SON-6) is the non-promotion product. As of March in 2014.
1-12) MODE Input Voltage vs. temperature

1-13) Pch Transistor On Resistance vs. Temperature

1-14) Nch Transistor On Resistance vs. Temperature

1-15) DC/DC Lx Current Limit vs. Temperature

2) VR

2-1) VR Output Voltage vs. Output Current
2-2) VR Output Voltage vs. Input Voltage

2-3) VR Supply Current vs. Input Voltage

2-4) VR Output Voltage vs. Temperature

* R5220D (SON-6) is the non-promotion product. As of March in 2014.
2-5) VR Supply Current vs. Temperature

![VR Supply Current vs. Temperature](image1)

2-6) Dropout Voltage vs. Output Current

![Dropout Voltage vs. Output Current](image2)

2-7) Ripple Rejection vs. Input Voltage

![Ripple Rejection vs. Input Voltage](image3)

*R5220D (SON-6) is the non-promotion product. As of March in 2014.*
2-8) VR Ripple Rejection vs. Frequency

- **R5220x121A**
  - $V_{IN}=2.2V+0.2V_{p-p}$
  - $C_{IN}=\text{none}$  $C_{OUT}=\text{Ceramic10}\mu\text{F}$
  - $I_{OUT}=50mA$, $I_{OUT}=25mA$, $I_{OUT}=1mA$

- **R5220x181A**
  - $V_{IN}=2.8V+0.2V_{p-p}$
  - $C_{IN}=\text{none}$  $C_{OUT}=\text{Ceramic10}\mu\text{F}$
  - $I_{OUT}=50mA$, $I_{OUT}=25mA$, $I_{OUT}=1mA$

2-9) Input Transient Response

- **R5220x121A**
  - $I_{OUT}=10mA$
  - $C_{IN}=\text{none}$,  $C_{OUT}=\text{Ceramic10}\mu\text{F}$

- **R5220x181A**
  - $I_{OUT}=10mA$
  - $C_{IN}=\text{none}$,  $C_{OUT}=\text{Ceramic10}\mu\text{F}$

2-10) Load Transient Response

- **R5220x121A**
  - $V_{IN}=3.6V$, $C_{IN}=C_{OUT}=\text{Ceramic10}\mu\text{F}$

- **R5220x121A**
  - $V_{IN}=3.6V$, $C_{IN}=C_{OUT}=\text{Ceramic10}\mu\text{F}$

---

* R5220D (SON-6) is the non-promotion product. As of March in 2014.
3) Mode Transient Response between VR and DC/DC

3-1) VR to DC/DC Mode Transient Response

R5220x151A

V_{IN}=3.6V, I_{OUT}=0.5mA
C_{IN}=C_{OUT}=Ceramic10\mu F

3-2) DC/DC to VR Mode Transient Response

R5220x151A

V_{IN}=3.6V, I_{OUT}=0.5mA
C_{IN}=C_{OUT}=Ceramic10\mu F

* R5220D (SON-6) is the non-promotion product. As of March in 2014.
1. The products and the product specifications described in this document are subject to change or discontinuation of production without notice for reasons such as improvement. Therefore, before deciding to use the products, please refer to Ricoh sales representatives for the latest information thereon.
2. The materials in this document may not be copied or otherwise reproduced in whole or in part without prior written consent of Ricoh.
3. Please be sure to take any necessary formalities under relevant laws or regulations before exporting or otherwise taking out of your country the products or the technical information described herein.
4. The technical information described in this document shows typical characteristics of and example application circuits for the products. The release of such information is not to be construed as a warranty of or a grant of license under Ricoh’s or any third party’s intellectual property rights or any other rights.
5. The products listed in this document are intended and designed for use as general electronic components in standard applications (office equipment, telecommunication equipment, measuring instruments, consumer electronic products, amusement equipment etc.). Those customers intending to use a product in an application requiring extreme quality and reliability, for example, in a highly specific application where the failure or misoperation of the product could result in human injury or death (aircraft, spacevehicle, nuclear reactor control system, traffic control system, automotive and transportation equipment, combustion equipment, safety devices, life support system etc.) should first contact us.
6. We are making our continuous effort to improve the quality and reliability of our products, but semiconductor products are likely to fail with certain probability. In order to prevent any injury to persons or damages to property resulting from such failure, customers should be careful enough to incorporate safety measures in their design, such as redundancy feature, fire containment feature and fail-safe feature. We do not assume any liability or responsibility for any loss or damage arising from misuse or inappropriate use of the products.
7. Anti-radiation design is not implemented in the products described in this document.
8. Please contact Ricoh sales representatives should you have any questions or comments concerning the products or the technical information.

RICOH COMPANY, LTD. Electronic Devices Company

Ricoh presented with the Japan Management Quality Award for 1999.
Ricoh continually strives to promote customer satisfaction, and shares the achievements of its management quality improvement program with people and society.

http://www.ricoh.com/LSI/

Ricoh awarded ISO 14001 certification.
The Ricoh Group was awarded ISO 14001 certification, which is an international standard for environmental management systems, at both its domestic and overseas production facilities. Our current aim is to obtain ISO 14001 certification for all of our business offices.

Ricoh completed the organization of the Lead-free production for all of our products. After Apr. 1, 2006, we will ship out the lead free products only. Thus, all products that will be shipped from now on comply with RoHS Directive.