OUTLINE

The R1293K is a multi power supply IC dedicated for mid-size TFT LCD panels. The R1293K consists of a PWM control step-up DC/DC converter, an LDO regulator, a VCOM amplifier and six GAMMA amplifiers. The output noise can be reduced by SEL pin. (SEL pin "H": normal mode, SEL pin "L": low noise mode.) The MOSFET for step-up DC/DC converter is built-in and, low power operation is realized by standby mode. The package is 4mm square QFN(PLP)0404-32.

FEATURES

Step-up DC/DC converter part
- Input Voltage Range ......................................................... 2.2V to 5.5V (Vin_DC pin)
- Adjustable Output Voltage Range with external resistors up to 16V
- Feedback Voltage .......................................................... 1.0V
- Feedback Voltage Accuracy .............................................. ±1.5%
- Adjustable Oscillator Frequency with external resistors for RT pin 300kHz to 1MHz
- Adjustable Phase compensation with external components
- Internal Soft Start Time .................................................. TYP. 10ms
- Adjustable Soft Start Time with external capacitors for DTC pin
- Oscillator Maximum Duty Cycle Set with external resistors for DTC pin (Limit TYP. 90%)
- UVLO detector threshold ................................................ TYP. 1.9V
- Internal 2A/16V capability Nch MOSFET Driver .................. TYP. 0.2Ω
- Built-in Peak Current Limit Circuit
- Short Protection with timer latch function (Adjustable delay time with external capacitors for DELAY pin)

LDO part
- Input Voltage Range ....................................................... 2.2V to 5.5V (Vin_LDO pin)
- Output Voltage Range .................................................. 1.8V to 2.5V (Selectable / 0.1V Step)
- Output Voltage Accuracy ............................................... ±1.0%
- Maximum Output Current .............................................. Min. 350mA guaranteed
- Ripple Rejection ......................................................... TYP. 65db (Frequency = 1kHz)
- Built-in Fold-back Protection Circuit ................................. TYP. 70mA (Current at short mode)

Buffer Amplifier part
- Input Voltage Range for Amplifiers ................................. 5V to 16V (VBUFF pin)
- Output Current Range for VCOM Amplifier ....................... -100mA to 100mA
- Output Current Range for GAMMA Amplifier ................... -10mA to 10mA

Others
- Built-in Thermal Shutdown Circuit
- Stand-by function by ENB pin
- Package ................................................................. QFN(PLP)0404-32

APPLICATIONS
- Power sources of the medium and small sized TFT LCD panels
R1293K Block Diagram
SELECTION GUIDE

The output voltage ($V_{OUT}$) for the ICs is a user-selectable option.

<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>R1293Kxx1A-E2</td>
<td>QFN(PLP)0404-32</td>
<td>2,000 pcs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

xx: Designation of the LDO output voltage ($V_{OUT}$)

$V_{OUT}$ can be set within the range of 1.8 V to 2.5 V in 0.1 V steps.

PIN CONFIGURATION

QFN(PLP)0404-32 Pin Configuration
# PIN DESCRIPTIONS

## R1293K Pin Description

<table>
<thead>
<tr>
<th>Pin No</th>
<th>Symbol</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PGND</td>
<td>Power GND Pin</td>
<td>Make the PGND pin a short-circuit with the GND pin.</td>
</tr>
<tr>
<td>2</td>
<td>PGND</td>
<td>Power GND Pin</td>
<td>Make the PGND pin a short-circuit with the GND pin.</td>
</tr>
<tr>
<td>3</td>
<td>V_LDO</td>
<td>LDO Output Pin</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>V_LDO</td>
<td>LDO Power Input Pin</td>
<td>Input 2.2V to 5.5V to V_LDO. Make V_LDO a short-circuit with the V_DC pin.</td>
</tr>
<tr>
<td>5</td>
<td>IN_GM1</td>
<td>GAMMA1 Input Pin</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>IN_GM2</td>
<td>GAMMA2 Input Pin</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>IN_GM3</td>
<td>GAMMA3 Input Pin</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>IN_GM4</td>
<td>GAMMA4 Input Pin</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>IN_GM5</td>
<td>GAMMA5 Input Pin</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>IN_GM6</td>
<td>GAMMA6 Input Pin</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>V_GM1</td>
<td>GAMMA1 Output Pin</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>V_GM2</td>
<td>GAMMA2 Output Pin</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>V_GM3</td>
<td>GAMMA3 Output Pin</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>V_GM4</td>
<td>GAMMA4 Output Pin</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>V_GM5</td>
<td>GAMMA5 Output Pin</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>V_GM6</td>
<td>GAMMA6 Output Pin</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>GND</td>
<td>GND Pin</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>V_BUFF</td>
<td>Buffer Amplifier Power Source Pin</td>
<td>Connect the V_BUFF pin to Boost Output.</td>
</tr>
<tr>
<td>19</td>
<td>IN_COM</td>
<td>VCOM Input Pin</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>V_COM</td>
<td>VCOM Output Pin</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>GND</td>
<td>GND Pin</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>RT</td>
<td>Oscillator Frequency Setting Pin</td>
<td>Connect a resistor to the RT pin to set the operation frequency.</td>
</tr>
<tr>
<td>23</td>
<td>DTC</td>
<td>Maxduty/ Soft-start Time Setting Pin</td>
<td>By adding a resistor, the Maxduty limit can be set; otherwise the Maxduty limit will be the preset value set inside the ICs. By adding a capacitor, Maxduty can start from 0 which means startup-time can be set longer.</td>
</tr>
<tr>
<td>24</td>
<td>SEL*1</td>
<td>Noise Reduction Level Selection Pin</td>
<td>“L” Input: Low Noise Mode “H” Input: Normal Mode</td>
</tr>
<tr>
<td>Pin No</td>
<td>Symbol</td>
<td>Description</td>
<td>Notes</td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td>-------------</td>
<td>-------</td>
</tr>
<tr>
<td>25</td>
<td>DELAY</td>
<td>Short-circuit Protection Delay Time Setting Pin</td>
<td>By adding a capacitor, the DELAY pin can set a protection delay time.</td>
</tr>
<tr>
<td>26</td>
<td>ENB*1</td>
<td>Chip Enable Pin (DC/DC or Buffer Amplifier)</td>
<td>“L” Input: Active</td>
</tr>
<tr>
<td>27</td>
<td>VFB</td>
<td>DC/DC Feedback Pin</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>AMPOUT</td>
<td>DC/DC Phase Compensation Pin</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>GND</td>
<td>GND Pin</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>VIN_DC</td>
<td>DC/DC Power Source Pin</td>
<td>Input voltage should be 2.2V to 5.5V. Make the VIN_DC pin a short-circuit with the VIN_LDO pin.</td>
</tr>
<tr>
<td>31</td>
<td>Lx</td>
<td>DC/DC Switching Pin</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Lx</td>
<td>DC/DC Switching Pin</td>
<td></td>
</tr>
</tbody>
</table>

The exposed tab on the bottom of the package enhances thermal performance and is electrically connected to GND (substrate level). It is recommended that the exposed tab be connected to the ground plane on the board otherwise be left open.

*1 Do not leave the IN_GM1 to IN_GM6, IN_COM, SEL and ENB pins open.
# ABSOLUTE MAXIMUM RATINGS

## Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{VIN}_\text{DC}$</td>
<td>$\text{VIN}_\text{DC}$ Pin Voltage</td>
<td>-0.3 to 6.5</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VIN}_\text{LDO}$</td>
<td>$\text{VIN}_\text{LDO}$ Pin Voltage</td>
<td>-0.3 to 6.5</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VBUFF}$</td>
<td>$\text{VBUFF}$ Pin Voltage</td>
<td>-0.3 to 24</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VRT}$</td>
<td>RT Pin Voltage</td>
<td>-0.3 to 4.0</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VDT}$</td>
<td>DTC Pin Voltage</td>
<td>-0.3 to 4.0</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VFB}$</td>
<td>$\text{VFB}$ Pin Voltage</td>
<td>-0.3 to 4.0</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VAMP}$</td>
<td>AMPOUT Pin Voltage</td>
<td>-0.3 to 4.0</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VDELAY}$</td>
<td>DELAY Pin Voltage</td>
<td>-0.3 to 4.0</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VSEL}$</td>
<td>SEL Pin Voltage</td>
<td>-0.3 to 6.5</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VENB}$</td>
<td>ENB Pin Voltage</td>
<td>-0.3 to 6.5</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VLX}$</td>
<td>Lx Pin Voltage</td>
<td>-0.3 to 24</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VO}_\text{LDO}$</td>
<td>$\text{VO}_\text{LDO}$ Pin Output Voltage</td>
<td>-0.3 to $\text{VIN}_\text{LDO}$+0.3</td>
<td>V</td>
</tr>
<tr>
<td>$\text{IO}_\text{LDO}$</td>
<td>$\text{VO}_\text{LDO}$ Pin Output Current</td>
<td>450</td>
<td>mA</td>
</tr>
<tr>
<td>$\text{VIN}_\text{BUFF}$</td>
<td>Buffer Amplifier Input Voltage</td>
<td>-0.3 to $\text{VBUFF}$+0.3</td>
<td>V</td>
</tr>
<tr>
<td>$\text{VO}_\text{BUFF}$</td>
<td>Buffer Amplifier Output Voltage</td>
<td>-0.3 to $\text{VBUFF}$+0.3</td>
<td>V</td>
</tr>
<tr>
<td>$\text{P}_\text{o}$</td>
<td>Power Dissipation (Standard Land Pattern)$^1$</td>
<td>1500</td>
<td>mW</td>
</tr>
<tr>
<td>$\text{T}_\text{a}$</td>
<td>Operating Temperature Range</td>
<td>-40 to +85</td>
<td>°C</td>
</tr>
<tr>
<td>$\text{T}_{\text{stg}}$</td>
<td>Storage Temperature Range</td>
<td>-55 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>$\text{T}_\text{j}$</td>
<td>Junction Temperature</td>
<td>-40 to +125</td>
<td>°C</td>
</tr>
</tbody>
</table>

$^1$ For more information about the 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.

## 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 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**

\( \text{V}_{\text{IN,DC}} = 3.6 \text{ V}, \ Ta = 25^\circ \text{C} \) unless otherwise noted.

**R1293K Electrical Characteristics**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{VIN} )</td>
<td>Input Voltage</td>
<td>( \text{VIN} = \text{VIN,DC} = \text{VIN,LDO} )</td>
<td>2.2</td>
<td>5.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( \text{IIN} )</td>
<td>Supply Current</td>
<td>( \text{VIN,DC}=5.5\text{V}, \ \text{VFB}=1.1\text{V} )</td>
<td>300</td>
<td>550</td>
<td>( \mu \text{A} )</td>
<td></td>
</tr>
<tr>
<td>( \text{ISTB} )</td>
<td>Standby VIN Current</td>
<td>( \text{VIN,DC}=5.5\text{V} )</td>
<td>60</td>
<td>90</td>
<td>( \mu \text{A} )</td>
<td></td>
</tr>
<tr>
<td>( \text{VUVLO1} )</td>
<td>UVLO Detector Threshold</td>
<td>( \text{VIN,DC}=2.2\text{V} \rightarrow 1.7\text{V} )</td>
<td>1.8</td>
<td>1.9</td>
<td>2.0</td>
<td>V</td>
</tr>
<tr>
<td>( \text{VUVLO2} )</td>
<td>UVLO Release Voltage</td>
<td>( \text{VIN,DC}=1.7\text{V} \rightarrow 2.2\text{V} )</td>
<td>2.05</td>
<td>2.15</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

**DC/DC CONVERTER**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{VFB} )</td>
<td>( \text{V}_{\text{FB}} ) Voltage</td>
<td>( \text{V}_{\text{FB}}=0\text{dB} )</td>
<td>0.985</td>
<td>1.000</td>
<td>1.015</td>
<td>V</td>
</tr>
<tr>
<td>( \text{A}_{\text{V}} )</td>
<td>Opened-loop Voltage Gain</td>
<td>( \text{A}_{\text{V}}=0\text{dB} )</td>
<td>90</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{f}_{\text{T}} )</td>
<td>Single Gain-bandwidth Range</td>
<td>( \text{A}_{\text{V}}=0\text{dB} )</td>
<td>1.8</td>
<td>MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{IAMPH} )</td>
<td>AMP &quot;H&quot; Output Current</td>
<td>( \text{V}<em>{\text{AMP}}=1\text{V}, \ \text{V}</em>{\text{FB}}=0.9\text{V} )</td>
<td>0.3</td>
<td>1.4</td>
<td>3.5</td>
<td>mA</td>
</tr>
<tr>
<td>( \text{IAMPL} )</td>
<td>AMP &quot;L&quot; Output Current</td>
<td>( \text{V}<em>{\text{AMP}}=1\text{V}, \ \text{V}</em>{\text{FB}}=1.1\text{V} )</td>
<td>50</td>
<td>90</td>
<td>150</td>
<td>( \mu \text{A} )</td>
</tr>
<tr>
<td>( \text{f}_{\text{OSC}} )</td>
<td>Oscillator Frequency</td>
<td>( \text{V}<em>{\text{DELAY}}=\text{V}</em>{\text{FB}}=0\text{V}, \ R6=24\text{k}\Omega )</td>
<td>630</td>
<td>700</td>
<td>770</td>
<td>kHz</td>
</tr>
<tr>
<td>( \text{DTC} )</td>
<td>DTC Maximum Duty Cycle</td>
<td>( \text{R6}=24\text{k}\Omega, \ \text{R5}=100\text{k}\Omega )</td>
<td>62</td>
<td>72</td>
<td>82</td>
<td>%</td>
</tr>
<tr>
<td>( \text{Maxduty} )</td>
<td>Oscillator Maximum Duty Cycle</td>
<td>( \text{V}_{\text{FB}}=0\text{V} )</td>
<td>85</td>
<td>90</td>
<td>95</td>
<td>%</td>
</tr>
<tr>
<td>( \text{tSS} )</td>
<td>Soft-start Time</td>
<td></td>
<td>3.5</td>
<td>10</td>
<td>16</td>
<td>ms</td>
</tr>
<tr>
<td>( \text{tDLY} )</td>
<td>DELAY Pin Charge Current</td>
<td>( \text{V}<em>{\text{DELAY}}=0.8\text{V}, \ \text{V}</em>{\text{FB}}=0\text{V} )</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>( \mu \text{A} )</td>
</tr>
<tr>
<td>( \text{VDLY} )</td>
<td>DELAY Pin Detector Threshold Voltage</td>
<td>( \text{V}_{\text{FB}}=0\text{V} )</td>
<td>0.95</td>
<td>1.0</td>
<td>1.05</td>
<td>V</td>
</tr>
<tr>
<td>( \text{RON} )</td>
<td>LX ON Resistance</td>
<td></td>
<td>0.2</td>
<td></td>
<td>( \Omega )</td>
<td></td>
</tr>
<tr>
<td>( \text{ILXLM} )</td>
<td>LX Limit Current</td>
<td></td>
<td>2.0</td>
<td>3.0</td>
<td>3.7</td>
<td>A</td>
</tr>
<tr>
<td>( \text{V_DVP1} )</td>
<td>OVP Detector Threshold Voltage</td>
<td>( \text{V}_{\text{OUT}} ) rising</td>
<td>21</td>
<td>23</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( \text{V_DVP2} )</td>
<td>OVP Release Voltage</td>
<td>( \text{V}_{\text{OUT}} ) falling</td>
<td>18</td>
<td>( \text{V}_{\text{DVP1}}-1 )</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( \text{V_SELH} )</td>
<td>SEL &quot;H&quot; Input Voltage</td>
<td>( \text{VIN,DC}=2.2\text{V} )</td>
<td>0.4</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{V_SELH} )</td>
<td>SEL &quot;H&quot; Input Voltage</td>
<td>( \text{VIN,DC}=5.5\text{V} )</td>
<td>1.5</td>
<td>V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**LDO**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{V}_{\text{O,LDO}} )</td>
<td>LDO Output Voltage</td>
<td>( \text{VIN,DC}=\text{V}<em>{\text{O,LDO}}+1.0\text{V}, \ \text{I}</em>{\text{O,LDO}}=1\text{mA} \times 0.99 )</td>
<td>x 1.01</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{V}_{\text{DIF}} )</td>
<td>Dropout Voltage</td>
<td>( \text{I}_{\text{O,LDO}}=250\text{mA} )</td>
<td>600</td>
<td>700</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>( \Delta \text{V}_{\text{O,LDO}}/\Delta \text{VIN} )</td>
<td>Line Regulation</td>
<td>( \text{I}<em>{\text{O,LDO}}=30\text{mA}, \ \text{V}</em>{\text{O,LDO}}=0.5\text{V}+\text{V}_{\text{IN,LDO}}\leq5.5\text{V} )</td>
<td>0.2</td>
<td>%/V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \Delta \text{V}<em>{\text{O,LDO}}/\Delta \text{I}</em>{\text{OUT}} )</td>
<td>Load Regulation</td>
<td>( \text{VIN,DC}=\text{V}<em>{\text{O,LDO}}+1.0\text{V}, \ \text{I}</em>{\text{O,LDO}}=\text{I}_{\text{O,LDO}}\leq250\text{mA} )</td>
<td>0.4</td>
<td>mV/( \mu \text{A} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{RR} )</td>
<td>Ripple Rejection</td>
<td>( f=1\text{kHz}, \ \text{Ripple Rejection} \leq 0.2 \text{ Vp-p}, \ \text{I}_{\text{O,LDO}}=30\text{mA} )</td>
<td>65</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{ILIM,LDO} )</td>
<td>LDO Output Current Limit</td>
<td>( \text{VIN,DC}=\text{V}_{\text{O,LDO}}+1.0\text{V} )</td>
<td>350</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{ISC,LDO} )</td>
<td>LDO Short Current</td>
<td>( \text{VIN,DC}=\text{V}_{\text{O,LDO}}+1.0\text{V} )</td>
<td>70</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
R1293K

NO.EA-301-160107

$V_{IN\_DC}=3.6V$, $Ta = 25^\circ C$ unless otherwise noted.

**R1293K Electrical Characteristics**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BUFFER AMP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{BUFF}$</td>
<td>Amplifier Power Source Voltage</td>
<td></td>
<td>5</td>
<td>16</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$I_{DD_BUFF}$</td>
<td>Amplifier Supply Current</td>
<td>$V_{BUFF}=16V, V_i=8V, VCOM 1ch + GAMMA 1 to 6ch</td>
<td>0.6</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{OS}$</td>
<td>Offset Voltage</td>
<td>$V_i=V_{BUFF}/2$</td>
<td>1</td>
<td>mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{CM_COM}$</td>
<td>VCOM Common-mode Input Voltage Range</td>
<td>VCOM ch</td>
<td>1.5</td>
<td>$V_{BUFF}$</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{CM_GM}$</td>
<td>GAMMA Common-mode Input Voltage Range</td>
<td>GAMMA ch</td>
<td>0</td>
<td>$V_{BUFF}$</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$I_{O_COM}$</td>
<td>VCOM Output Current</td>
<td>$V_{BUFF}=10V, V_i=5V$</td>
<td>-100</td>
<td>100</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>$I_{O_GM}$</td>
<td>GAMMA Output Current</td>
<td>$V_{BUFF}=10V, V_i=5V$</td>
<td>-10</td>
<td>10</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>$\Delta V_{O_COM}/\Delta I_{OUT}$</td>
<td>VCOM Load Regulation</td>
<td>$V_{BUFF}=10V, V_i=5V, -50mA \leq I_{OUT} \leq +50mA$</td>
<td>0.5</td>
<td>1</td>
<td>mV/mA</td>
<td></td>
</tr>
<tr>
<td>$\Delta V_{O_GM}/\Delta I_{OUT}$</td>
<td>GAMMA Load Regulation</td>
<td>$V_{BUFF}=10V, V_i=5V, -10mA \leq I_{OUT} \leq +10mA$</td>
<td>0.5</td>
<td>1</td>
<td>mV/mA</td>
<td></td>
</tr>
<tr>
<td>CMRR</td>
<td>Input Voltage Ripple Rejection</td>
<td>$f=0.1kHz, V_{BUFF}=10V, V_i=5V, $ Ripple Rejection 50mVp-p</td>
<td>75</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSRR</td>
<td>Power Source Ripple Rejection</td>
<td>$f=0.1kHz, V_{BUFF}=10V, V_i=5V, $ Ripple Rejection 0.2Vp-p</td>
<td>70</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{OL_COM}$</td>
<td>VCOM &quot;L&quot; Output Voltage</td>
<td>$V_{BUFF}=10V, V_i=1.5V, I_{O}=+50mA$</td>
<td>1.5</td>
<td>1.55</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{OL_GM}$</td>
<td>GAMMA &quot;L&quot; Output Voltage</td>
<td>$V_{BUFF}=10V, V_i=0V, I_{O}=+5mA$</td>
<td>0.1</td>
<td>0.2</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{OH_COM}$</td>
<td>VCOM &quot;H&quot; Output Voltage</td>
<td>$V_{BUFF}=10V, V_i=8.5V, I_{O}=-50mA$</td>
<td>8.45</td>
<td>8.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{OH_GM}$</td>
<td>GAMMA &quot;H&quot; Output Voltage</td>
<td>$V_{BUFF}=10V, V_i=9.8V, I_{O}=-10mA$</td>
<td>9.8</td>
<td>9.9</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

**CONTROL**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{ENBL}$</td>
<td>ENB &quot;L&quot; Input Voltage</td>
<td>$V_{IN_DC}=2.2V$</td>
<td>0.4</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{ENBH}$</td>
<td>ENB &quot;H&quot; Input Voltage</td>
<td>$V_{IN_DC}=5.5V$</td>
<td>1.5</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_{TSD}$</td>
<td>Thermal Shutdown Temperature</td>
<td>Junction Temperature</td>
<td>150</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_{TSR}$</td>
<td>Thermal Shutdown Released Temperature</td>
<td>Junction Temperature</td>
<td>100</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All test items listed under Electrical Characteristics are done under the pulse load condition ($T_j=Ta=25^\circ C$) except
Opened-loop Voltage Gain (DC/ DC), Single Gain-bandwidth Range (DC/ DC), Ripple Rejection (LDO), Input Voltage Ripple Rejection (Buffer AMP) and Power Source Ripple Rejection (Buffer AMP).

*1 $V_{SET}=Set$ Output Voltage
TYPICAL APPLICATION

R1293K Typical Application

R1293K

NO.EA-301-160107

RICOH
### External Parts Example

<table>
<thead>
<tr>
<th>Vout [V]</th>
<th>Frequency [kHz]</th>
<th>L1</th>
<th>CIN2</th>
<th>CO1</th>
<th>VO_GM [pF]</th>
</tr>
</thead>
<tbody>
<tr>
<td>8~10</td>
<td>300</td>
<td>VLF5014S-4R7M1R7</td>
<td>C1608JB0J106M</td>
<td>GRM21BB31E475KA75B</td>
<td>1000</td>
</tr>
<tr>
<td>10~12</td>
<td>300</td>
<td>VLF5014S-4R7M1R7</td>
<td>C1608JB0J106M</td>
<td>GRM21BB31E475KA75B * 2</td>
<td>1000</td>
</tr>
<tr>
<td>12~16</td>
<td>300</td>
<td>NR6020T4R7N</td>
<td>C1608JB0J106M</td>
<td>GRM21BB31E475KA75B</td>
<td>1000</td>
</tr>
<tr>
<td>8~10</td>
<td>700</td>
<td>NR4018T4R7M</td>
<td>GRM21BB31E475KA75B</td>
<td>GRM21BB31E475KA75B * 2</td>
<td>1000</td>
</tr>
<tr>
<td>10~12</td>
<td>700</td>
<td>NR4018T4R7M</td>
<td>GRM21BB31E475KA75B</td>
<td>GRM21BB31E475KA75B * 2</td>
<td>1000</td>
</tr>
<tr>
<td>12~16</td>
<td>700</td>
<td>VLF5014S-4R7M1R7</td>
<td>GRM21BB31E475KA75B</td>
<td>GRM21BB31E475KA75B * 2</td>
<td>1000</td>
</tr>
<tr>
<td>8~10</td>
<td>1000</td>
<td>NR4018T4R7M</td>
<td>GRM21BB31E475KA75B</td>
<td>GRM21BB31E475KA75B * 2</td>
<td>1000</td>
</tr>
<tr>
<td>10~12</td>
<td>1000</td>
<td>NR4018T4R7M</td>
<td>GRM21BB31E475KA75B</td>
<td>GRM21BB31E475KA75B * 2</td>
<td>1000</td>
</tr>
<tr>
<td>12~16</td>
<td>1000</td>
<td>VLF5014S-4R7M1R7</td>
<td>GRM21BB31E475KA75B</td>
<td>GRM21BB31E475KA75B * 2</td>
<td>1000</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Vout [V]</th>
<th>Frequency [kHz]</th>
<th>CO3</th>
<th>CIN3</th>
<th>CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>8~10</td>
<td>300</td>
<td>TMK316BJ106MD-TD</td>
<td>CM105B105K10AT</td>
<td>CM105B105K10AT</td>
</tr>
<tr>
<td>10~12</td>
<td>300</td>
<td>TMK316BJ106MD-TD</td>
<td>CM105B105K10AT</td>
<td>CM105B105K10AT</td>
</tr>
<tr>
<td>12~16</td>
<td>300</td>
<td>TMK316BJ106MD-TD</td>
<td>CM105B105K10AT</td>
<td>CM105B105K10AT</td>
</tr>
<tr>
<td>8~10</td>
<td>700</td>
<td>TMK316BJ106MD-TD</td>
<td>CM105B105K10AT</td>
<td>CM105B105K10AT</td>
</tr>
<tr>
<td>10~12</td>
<td>700</td>
<td>TMK316BJ106MD-TD</td>
<td>CM105B105K10AT</td>
<td>CM105B105K10AT</td>
</tr>
<tr>
<td>12~16</td>
<td>700</td>
<td>TMK316BJ106MD-TD</td>
<td>CM105B105K10AT</td>
<td>CM105B105K10AT</td>
</tr>
<tr>
<td>8~10</td>
<td>1000</td>
<td>TMK316BJ106MD-TD</td>
<td>CM105B105K10AT</td>
<td>CM105B105K10AT</td>
</tr>
<tr>
<td>10~12</td>
<td>1000</td>
<td>TMK316BJ106MD-TD</td>
<td>CM105B105K10AT</td>
<td>CM105B105K10AT</td>
</tr>
<tr>
<td>12~16</td>
<td>1000</td>
<td>TMK316BJ106MD-TD</td>
<td>CM105B105K10AT</td>
<td>CM105B105K10AT</td>
</tr>
</tbody>
</table>

The table shows various components and their specifications for different voltage ranges and frequencies, including values for R1293K and R1293N.
**TECHNICAL NOTES**

**Output Voltage Setting (DC/DC)**

$V_{OUT}$ controls the $V_{FB}$ pin voltage to maintain $V_{FB}=1.0V$. $V_{OUT}$ can be set using $R1$ and $R2$ in the following equation. $V_{OUT}$ voltage should be set between 5V to 16V. Also, the sum of $R1$ and $R2$ should be equal or less than 500kΩ.

$$V_{OUT} = V_{FB} \times \frac{R1 + R2}{R2}$$

**Phase Compensation Setting (DC/DC)**

A 180 degree phase shift may be caused by the inductor ($L1$) and the capacitor ($C01$). The phase shift reduces phase margin and stability of the system. Thus, it is necessary to keep a leading phase margin. In the following equation, the pole is made by $L1$ and $C01$.

$$F_{pole} \sim \frac{1}{2 \pi \sqrt{L1 \times C01}}$$

The phase compensation and the system gain can be set by using $R4$, $C3$ and $C2$. Please refer to *Typical Application* (P.10,11) for positioning and setting value examples. In the following equation, the zero is made by $R4$ and $C3$.

$$F_{zero} \sim \frac{1}{2 \pi R4 \times C3}$$

When selecting the values for $R4$ and $C3$, please consider that the cutoff frequency of zero should be approximately equal to the cutoff frequency of pole.

For example, if $L1=10\mu H$ and $C01=10\mu F$, the cutoff frequency of pole is approximately 16kHz.

The gain can be set by the resistance ratio of $R4$ and $RT$ which is the combined resistance of $R1$ and $R2$ ($RT=R1\times R2/(R1+R2)$). If $R4$ is larger than $RT$, the gain becomes high. The high gain improves the response characteristic; however, the extremely high gain decreases stability of the operation. It is important to select an appropriate value for $R4$. In the following equation, zero is made by $R1$ and $C2$.

$$F_{zero} \sim \frac{1}{2 \pi R1 \times C2}$$

Set the cutoff frequency of zero lower than the cutoff frequency of pole.

**Reduction of Feedback Voltage Noise (DC/DC)**

If the system noise is large, it may wrap around the $V_{FB}$ pin and causes unstable operation. In this case, set $R1$ and $R2$ resistance values lower to reduce the noise entering the $V_{FB}$ pin. Or, place $R3$ with 1kΩ to 5kΩ to reduce the noise entering the $V_{FB}$ pin as shown in *Typical Application* (P.10,11).

**Input Voltage Setting (DC/DC and LDO)**

The input voltage ranges of the $V_{IN_{DC}}$ and $V_{IN_{LDO}}$ pins are from 2.2V to 5.5V. Place a bypass capacitor between $V_{IN}$ and GND. Use Boost Output as the input voltage for the $V_{BUFF}$ pin.
Oscillator Frequency Setting (DC/ DC)
By connecting R6 to the the RT pin, fosc can be set in the range of 300kHz to 1MHz. R6 can be calculated by inserting a desired oscillator frequency value into fosc in the following equation.
\[
R6 = \frac{19.128 \times 10^9}{Fosc} - 3443
\]
Example: Oscillator Frequency 700kHz
R6 = \frac{19.128 \times 10^9}{(700 \times 10^3)} - 3443 = 23883 \approx 24k\Omega

Maxduty and Maxduty Soft-start Adjustment (DC/ DC)
Maxduty is preset to 90% (Typ.); however, it can be set lower by adding R5 to the DTC pin. Maxduty is determined by R6 and R5 as shown in the equation below. The preset Maxduty is compared with the Maxduty set by the DTC pin, and the lower Maxduty will be selected.
\[
Maxduty_{(DC)} = \frac{0.3267 \times R5 - 0.6285 \times R6 + 2367}{R6 + 3550}
\]
Example: R6=24kΩ, R5=110kΩ
Maxduty = \frac{(0.3267 \times 110000 - 0.6285 \times 24000 + 2367)}{24000 + 3550}
\approx 0.843 \rightarrow 84.3%

By adding C_{DTC} to the DTC pin, Maxduty can increase gradually and the inrush current can be controlled. (Maxduty Soft-start). After start-up, Maxduty after t-time (Maxduty_{(t)}) can be calculated by the following equation.
\[
Maxduty_{(t)} = \frac{0.3267 \times R5 \times \left[1 - \exp\left(-\frac{t}{C_{DTC} \times R5}\right)\right] - 0.6285 \times R6 + 2367}{R6 + 3550}
\]
Example: R6=24kΩ, R5=110kΩ, C_{DTC}=0.047\mu F to 0.47\mu F

Typical Application with RT Pin/ DTC Pin

When using Maxduty soft-start, it is recommended that latch protection delay time (t_{DLV}) be set t_{DLV} > 6 \times (R5 \times C_{DTC}). t_{DLV} should be longer than the soft-start time.
Overcurrent Protection (DC/DC)
The overcurrent protection circuit monitors the Nch-switch current and immediately turns off if the Nch-switch current reaches the current limit. Nch-switch turns on every internal reference clock cycle and turns off if the Nch-switch current reaches the current limit again.

Short Current Protection/ Protection Delay Time Setting (DC/DC)
If Boost Output drops and causes the VFB voltage drop to 85% of the preset value, the IC recognizes a short-circuit and starts to charge C1. If the short-circuit condition persists for a certain period of time and the DELAY pin voltage reaches V\text{DLY}, the latch-type protection circuit shuts down Boost Output. t\text{DLY} can be set by C1 shown in the following equations.
\[ t_{\text{DLY}} = C \times V_{\text{DLY}} / I_{\text{DLY}} \]
To release latch state, make V_{\text{IN,DC}} voltage below the UVLO detector threshold and then restart, or set ENB "H" once and then set it back to "L".

Undervoltage Lock Out (DC/DC)
If the V_{\text{IN,DC}} pin voltage becomes equal or lower than UVLO detector threshold, the UVLO circuit immediately disables the switching output.

Thermal Shutdown (LDO and Buffer AMP)
Thermal shutdown circuit detects overheating of the IC and turns off VCOM Output, GAMMA Output, and LDO Outputs to reset the IC if the junction temperature becomes more than the detector threshold. If the causes of overheating are removed and the junction temperature decreases to the release temperature, the IC restarts.

Standby Mode (DC/DC and Buffer AMP)
By setting the ENB pin “H”, DC/DC and Buffer AMP go into Standby mode and the output shuts down. LDO is always-on and outputs voltage.

SEL Pin Mode Switching (DC/DC)
By setting the SEL pin voltage “L”, the switching speed of a built-in MOSFET shifts to moderate mode to reduce the influences of noise to external parts. The SEL pin voltage operates in normal mode when “H”.

Diode, Inductor and Capacitor Selections (DC/DC, LDO and Buffer AMP)
Efficiency and stability of system can be affected by the following conditions. Spike voltage may be generated by the influence of an inductor when Nch MOSFET turns off. Therefore, diodes, inductors and capacitors should not exceed the voltage tolerance of the capacitor connected to V_{\text{OUT}} or their respected rated values (voltage, current and power). Please refer to Operation of DC/DC Converter and Output Current (P.15). Choose the diode with low forward voltage (schottky diode), small reverse current and fast switching speed.
Operation of DC/DC Converter and Output Current

Figure 1. Basic Circuit

Figure 2. The inductor current (IL) flowing through the inductor (L)

Discontinuous Mode

There are two operation modes in the PWM step-up DC/DC converter: continuous mode and discontinuous mode. When a transistor is in the On-state, the voltage to be applied to L is described as $V_{IN}$. An increase in the inductor current ($i_1$) can be written as follows:

$$\Delta i_1 = V_{IN} \times \frac{ton}{L} \quad \text{Formula 1}$$

In the step-up circuit, the energy accumulated during the On-state is transferred into the capacitor even in the Off-state. A decrease in the inductor current ($i_2$) can be written as follows:

$$\Delta i_2 = (V_{OUT} - V_{IN}) \times \frac{topen}{L} \quad \text{Formula 2}$$
In the PWM switching control, i1 and i2 become continuous when topen=toff, which is called continuous mode.

When the IC is in the continuous mode and operates in steady-state conditions, the variations of i1 and i2 are same:

\[ \frac{V_{IN} \times \text{ton}}{L} = \frac{(V_{OUT} - V_{IN}) \times \text{toff}}{L} \]  \hspace{1cm} \text{Formula 3}

Therefore, the duty cycle in the continuous mode is:

\[ \text{Duty} = \frac{\text{ton}}{(\text{ton} + \text{toff})} = \frac{(V_{OUT} - V_{IN})}{V_{OUT}} \]  \hspace{1cm} \text{Formula 4}

When topen=toff, the average of IL is:

\[ IL (\text{Ave.}) = \frac{V_{IN} \times \text{ton}}{(2 \times L)} \]  \hspace{1cm} \text{Formula 5}

If the input voltage (V_{IN}) is equal to V_{OUT}, the output current (I_{OUT}) is:

\[ I_{OUT} = \frac{V_{IN}^2 \times \text{ton}}{(2 \times L \times V_{OUT})} \]  \hspace{1cm} \text{Formula 6}

If I_{OUT} is larger than Formula 6, the IC switches to the continuous mode.

ILmax flowing through L is:

\[ IL_{max} = I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times \text{ton} / (2 \times L) \]  \hspace{1cm} \text{Formula 7}

\[ IL_{max} = I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times T \times (V_{OUT} - V_{IN}) / (2 \times L \times V_{OUT}) \]  \hspace{1cm} \text{Formula 8}

As a result, ILmax becomes larger compared to I_{OUT}.

When considering the input and output conditions or selecting the external parts, please pay attention to IL_{max}.

The above calculations are based on the ideal operation of the ICs in the continuous mode. They do not include the losses caused by the external parts or Lx switch. The actual maximum output current will be 50% to 80% of the above calculation results. Especially, if IL is large or V_{IN} is low, it may cause the switching losses. As for V_{OUT}, please consider V_{F} of the diode (approximately 0.8V).
TYPICAL CHARACTERISTICS

Vin = Vin_DC = Vin_LDO, unless otherwise noted.

1) Output Voltage vs. Output Current (DCDC)

- R1293KxxxA
  - fosc=700kHz, Vout=8V, SEL=3.0V
  - fosc=700kHz, Vout=16V, SEL=3.0V

2) Efficiency vs. Output Current (DCDC)

- R1293KxxxA
  - Vin=3.0V, Vout=10V, SEL=3.0V
  - Vin=5.5V, Vout=10V, SEL=5.5V
3) Output Voltage Waveform (DCDC)

**R1293KxxxA**

- **fosc=700kHz, VIN=3.0V, Vout=10V, Ta=25°C**
  - SEL=0V, Iout=80mA
  - SEL=3.0V

**R1293KxxxA**

- **fosc=700kHz, VIN=3.0V, Vout=10V, Ta=25°C**
  - SEL=0V, Iout=80mA
  - SEL=3.0V
4) VFB Voltage vs. Temperature

\[ f_{osc} = 300 \text{kHz}, \ V_{IN} = 3.6 \text{V}, \ V_{DELAY} = V_{FB} = 0 \text{V} \]

\[ f_{osc} = 700 \text{kHz}, \ V_{IN} = 3.6 \text{V}, \ V_{DELAY} = V_{FB} = 0 \text{V} \]

\[ f_{osc} = 1 \text{MHz}, \ V_{IN} = 3.6 \text{V}, \ V_{DELAY} = V_{FB} = 0 \text{V} \]
6) Oscillator Frequency vs. VIN Voltage

- **R1293KxxxA**
  - $f_{osc}=300\,\text{kHz}$, $V_{IN}=3.6\,\text{V}$, $V_{DELAY}=V_{FB}=0\,\text{V}$, $T_a=25\,\text{°C}$

- **R1293KxxxA**
  - $f_{osc}=700\,\text{kHz}$, $V_{IN}=3.6\,\text{V}$, $V_{DELAY}=V_{FB}=0\,\text{V}$, $T_a=25\,\text{°C}$

7) Oscillator Frequency vs. R6 Resistance

- **R1293KxxxA**
  - $f_{osc}=1\,\text{MHz}$, $V_{IN}=3.6\,\text{V}$, $V_{DELAY}=V_{FB}=0\,\text{V}$, $T_a=25\,\text{°C}$

- **R1293KxxxA**
  - $V_{IN}=3.6\,\text{V}$, $V_{DELAY}=V_{FB}=0\,\text{V}$, $T_a=25\,\text{°C}$

8) Standby VIN Current vs. Temperature

- **R1293KxxxA**
  - $V_{IN}=ENB=5.5\,\text{V}$

9) Supply VIN Current vs. Temperature

- **R1293KxxxA**
  - $V_{IN}=5.5\,\text{V}$, $ENB=0\,\text{V}$, $SEL=0\,\text{V}$, $V_{FB}=1.1\,\text{V}$
10) UVLO Detector Threshold vs. Temperature

R1293KxxxxA

VIN=2.2V → 1.7V

11) UVLO Released Voltage vs. Temperature

R1293KxxxxA

VIN=1.7V → 2.2V

12) Oscillator Maximum Duty Cycle vs. Temperature

R1293KxxxxA

VIN=3.6V, VFB=0V

13) LX Limit Current vs. VIN Voltage

R1293KxxxxA

Ta=25℃
14) DELAY Pin Charge Current vs. Temperature

R1293KxxxA
VIN=3.6V, VDELAY=0.8V, VFB=0V

15) DELAY Pin Discharge Current vs. Temperature

R1293KxxxA
VIN=3.6V, VDELAY=0.1V

16) DELAY Pin Detector Threshold Voltage vs. Temperature

R1293KxxxA
VIN=3.6V, VFB=0V

17) ENB "L" Input Voltage vs. Temperature

R1293KxxxA
VIN=2.2V

18) ENB "H" Input Voltage vs. Temperature

R1293KxxxA
VIN=5.5V
19) DTC Maximum Duty Cycle vs. Temperature
   R1293KxxxA
   R6=24kΩ, R5=100kΩ

20) DTC Maximum Duty Cycle vs. R5/R6
   R1293KxxxA
   VIN=3.6V, R6=24kΩ, Ta=25°C

21) Soft Start Time vs. Temperature
   R1293KxxxA
   VIN=3.6V

22) OVP Detector Threshold Voltage vs. Temperature
   R1293KxxxA
   VIN=3.6V

23) OVP Release Voltage vs Temperature
   R1293KxxxA
   VIN=3.6V
24) SEL "L" Input Voltage vs. Temperature
R1293K181A
VIN=2.2V

25) SEL "H" Input Voltage vs. Temperature
R1293K251A
VIN=5.5V

26) Output Voltage vs Output Current (LDO)
R1293K181A
Ta=25℃

R1293K251A
Ta=25℃
27) Output Voltage vs. Temperature (LDO)

R1293K181A
\( I_{O\_LDO}=1\text{mA} \)

R1293K251A
\( I_{O\_LDO}=1\text{mA} \)

28) Output Voltage vs. \( V_{IN} \) Voltage (LDO)

R1293K181A
\( T_a=25^\circ\text{C} \)

R1293K251A
\( T_a=25^\circ\text{C} \)

29) LDO Ripple Rejection vs. Frequency

R1293K181A
\( V_{IN}=2.8\text{V}, \text{Ripple 0.2V}_{P-P}, T_a=25^\circ\text{C} \)

R1293K251A
\( V_{IN}=3.5\text{V}, \text{Ripple 0.2V}_{P-P}, T_a=25^\circ\text{C} \)
30) Amplifier Supply Current vs. Temperature (BUFFER AMP)

R1293KxxxA
VIN=3.6V, VBUFF=16V, IN_COM=8V, IN_GM*=8V

31) VCOM Offset Voltage vs. Temperature

R1293KxxxA
VIN=3.6V, VBUFF=7V, IN_COM=3.5V, IO_COM=0mA

32) GAMMA Offset Voltage vs. Temperature

R1293KxxxA
VIN=3.6V, VBUFF=7V, IN_GM*=3.5V, IO_GM*=0mA

33) VCOM Output Voltage vs. Temperature

R1293KxxxA
VIN=3.6V, VBUFF=10V, IN_COM=1.5V, IO_COM=+50mA

R1293KxxxA
VIN=3.6V, VBUFF=10V, IN_COM=8.5V, IO_COM=-50mA
34) GAMMA Output Voltage vs. Temperature

R1293KxxxA

VIN=3.6V, VBUFF=10V, IN_GM*=1.5V, IO_GM*=+10mA

VIN=3.6V, VBUFF=10V, IN_GM*=8.5V, IO_GM*=-10mA

35) VCOM Output Voltage vs. Output Current

R1293KxxxA

VIN=3.6V, VBUFF=10V, IN_COM=5V, Ta=25°C
36) GAMMA Output Voltage vs. Output Current

R1293KxxxA

\[ V_{IN} = 3.6V, \quad V_{BUFF} = 10V, \quad I_{N\_GM}\ast = 0.2V, \quad T = 25^\circ\text{C} \]

![Graph 1](image1)

\[ V_{IN} = 3.6V, \quad V_{BUFF} = 10V, \quad I_{N\_GM}\ast = 5V, \quad T = 25^\circ\text{C} \]

![Graph 2](image2)

\[ V_{IN} = 3.6V, \quad V_{BUFF} = 10V, \quad I_{N\_GM}\ast = 9.8V, \quad T = 25^\circ\text{C} \]

![Graph 3](image3)
37) DCDC Turn-on/Turn-off WaveForm by ENB
R1293KxxxA
VIN=3.6V, Vout=V BUFF =10V, fosc=700kHz, SEL=0V, Ta=25℃
Iout=0mA

38) DCDC Turn-on/Turn-off WaveForm (DTC Soft Start) by VIN
R1293KxxxA
VIN=3.6V, Vout=V BUFF =10V, fosc=700kHz, SEL=0V, Ta=25℃
Rs=130kΩ, CDTC=0.22uF, Iout=0mA

39) LDO Turn-on/Turn-off WaveForm by VIN
VIN=3.6V, V0 LDO=2.4V, Ta=25℃
I0 LDO=0mA
40) VCOM Turn-on/Turn-off WaveForm by ENB
\[ V_{IN} = 3.6V, V_{OUT} = V_{BUFF} = 10V, \text{IN\_COM} = V_{BUFF}/2 V, \text{SEL} = 0V, Ta = 25^\circ C \]
\[ I_{OUT} = 1mA \]

41) GAMMA Turn-on/Turn-off WaveForm by ENB
\[ V_{IN} = 3.6V, V_{OUT} = V_{BUFF} = 10V, \text{IN\_GM} = V_{BUFF}/2 V, \text{SEL} = 0V, Ta = 25^\circ C \]
\[ I_{OUT} = 1mA \]

42) DCDC Load Transient Response
\[ V_{IN} = 3.3V, V_{OUT} = V_{BUFF} = 10V, f_{osc} = 700kHz, \]
\[ I_{OUT} = 10mA \leftrightarrow 100mA, \text{SEL} = 0V, Ta = 25^\circ C \]

\[ V_{IN} = 5.0V, V_{OUT} = V_{BUFF} = 10V, f_{osc} = 700kHz, \]
\[ I_{OUT} = 10mA \leftrightarrow 100mA, \text{SEL} = 0V, Ta = 25^\circ C \]
43) LDO Load Transient Response

\[ V_{IN} = 2.9V, \ V_{O_LDO} = 2.4V \]
\[ I_{O_LDO} = 1mA \rightarrow 150mA, \ T_a=25^\circ C \]

\[ V_{IN} = 5.5V, \ V_{O_LDO} = 2.4V \]
\[ I_{O_LDO} = 1mA \rightarrow 150mA, \ T_a=25^\circ C \]

\[ V_{IN} = 2.9V, \ V_{O_LDO} = 2.4V \]
\[ I_{O_LDO} = 150mA \rightarrow 1mA, \ T_a=25^\circ C \]

\[ V_{IN} = 5.5V, \ V_{O_LDO} = 2.4V \]
\[ I_{O_LDO} = 150mA \rightarrow 1mA, \ T_a=25^\circ C \]

44) VCOM Load Transient Response

\[ V_{IN} = 3.6V, \ V_{BUFF} = 10V, \ I_{O_COM} = V_{BUFF}/2 \ V, \]
\[ I_{O_COM} = 10mA \rightarrow 10mA, \ T_a=25^\circ C \]

\[ V_{IN} = 3.6V, \ V_{BUFF} = 10V, \ I_{O_GM*} = V_{BUFF}/2 \ V, \]
\[ I_{O_GM*} = -5mA \rightarrow -5mA, \ T_a=25^\circ C \]

45) GAMMA Load Transient Response

\[ V_{IN} = 3.6V, \ V_{BUFF} = 10V, \ I_{O_GM*} = V_{BUFF}/2 \ V, \]
\[ I_{O_GM*} = -5mA \rightarrow -5mA, \ T_a=25^\circ C \]
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 Ricoh 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, space vehicle, 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. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.

9. WL CSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.

10. There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact Ricoh sales or our distributor before attempting to use AOI.

11. Please contact Ricoh sales representatives should you have any questions or comments concerning the products or the technical information.

Ricoh is committed to reducing the environmental loading materials in electrical devices with a view to contributing to the protection of human health and the environment.

Ricoh has been providing RoHS compliant products since April 1, 2006 and Halogen-free products since April 1, 2012.

https://www.e-devices.ricoh.co.jp/en/