The R1283x 2ch DC/DC converter is designed for CCD & OLED Display power source. It contains a step up DC/DC converter and an inverting DC/DC converter to generate two required voltages by CCD & OLED Display.

Step up DC/DC converter generates boosted output voltage up to 20V. Inverting DC/DC converter generates negative voltage up to V_IN voltage minus 20V independently. Start up sequence is internally made. Each of the R1283x series consists of an oscillator, a PWM control circuit, a voltage reference, error amplifiers, over current protection circuits, short protection circuits, an under voltage lockout circuit (UVLO), an Nch driver for boost operation, a Pch driver for inverting. A high efficiency boost and inverting DC/DC converter can be composed with external inductors, diodes, capacitors, and resistors.

**FEATURES**

- Operating Voltage ......................................... 2.5V to 5.5V
- Step Up DC/DC (CH1)
  - Internal Nch MOSFET Driver (R_{ON}=400mΩ Typ.)
  - Adjustable V_{OUT} Up to 20V with external resistor
  - Internal Soft start function (Typ. 4.5ms)
  - Over Current Protection
  - Maximum Duty Cycle: 91%(Typ.)
- Inverting DC/DC (CH2)
  - Internal Pch MOSFET Driver (R_{ON}=400mΩ Typ.)
  - Adjustable V_{OUT} Up to Vdd-20V with external resistor
  - Auto Discharge function for negative output
  - Internal Soft start function (Typ. 4.5ms)
  - Over Current Protection
  - Maximum Duty Cycle: 91%(Typ.)

- Short Protection with timer latch function (Typ. 50ms): Short condition for either or both two outputs makes all output drivers off and latches. If the maximum duty cycle continues for a certain time, these output drivers will be turned off.

  - CE with start up sequence function
  - CH1→CH2 (R1283K001x) / CH2→CH1(R1283K002x) Selectable
  - UVLO function
  - Operating Frequency Selection ..........300kHz / 700kHz / 1400kHz

- Packages ...................................................... DFN(PLP)2730-12, WLCSP-11-P2

**APPLICATION**

- Fixed voltage power supply for portable equipment
- Fixed voltage power supply for CCD, OLED, LCD

* R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.
R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.
SELECTION GUIDE

The start-up sequence, oscillator frequency, and the package 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>R1283Z0x++-E2-F</td>
<td>WLCSP-11-P2</td>
<td>4,000 pcs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>R1283K0x++-TR</td>
<td>DFN(PLP)2730-12</td>
<td>5,000 pcs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

x: The start-up sequence can be designated.
   (1) Step-up → Inverting
   (2) Inverting → Step-up

*: The oscillator frequency is the option as follows.
   (A) 300kHz (A Version for 1283Z packaged in WLCSP-11-P2 is not available)
   (B) 700kHz
   (C) 1400kHz

* R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.
PIN CONFIGURATIONS

• WLCSP-11-P2

Top View

Bottom View

• DFN(PLP)2730-12

Top View

Bottom View

PIN DESCRIPTIONS

• WLCSP-11-P2

<table>
<thead>
<tr>
<th>Pin No</th>
<th>Symbol</th>
<th>Pin Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>PGND</td>
<td>Power GND pin</td>
</tr>
<tr>
<td>A2</td>
<td>VFB1</td>
<td>Feedback pin for Step up DC/DC</td>
</tr>
<tr>
<td>A3</td>
<td>LX1</td>
<td>Switching pin for Step up DC/DC</td>
</tr>
<tr>
<td>B1</td>
<td>PVCC</td>
<td>Power Input pin</td>
</tr>
<tr>
<td>B2</td>
<td>CE</td>
<td>Chip Enable pin for the R1283</td>
</tr>
<tr>
<td>B3</td>
<td>LX2</td>
<td>Switching pin for Inverting DC/DC</td>
</tr>
<tr>
<td>C1</td>
<td>GND</td>
<td>Analog GND pin</td>
</tr>
<tr>
<td>C3</td>
<td>VOUTN</td>
<td>Discharge pin for Negative output</td>
</tr>
<tr>
<td>D1</td>
<td>VCC</td>
<td>Analog power source Input pin</td>
</tr>
<tr>
<td>D2</td>
<td>VREF</td>
<td>Reference Voltage Output pin</td>
</tr>
<tr>
<td>D3</td>
<td>VFB2</td>
<td>Feedback pin for Inverting DC/DC</td>
</tr>
</tbody>
</table>

• DFN(PLP)2730-12

<table>
<thead>
<tr>
<th>Pin No</th>
<th>Symbol</th>
<th>Pin Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NC</td>
<td>No Connect</td>
</tr>
<tr>
<td>2</td>
<td>LX1</td>
<td>Switching pin for Step up DC/DC</td>
</tr>
<tr>
<td>3</td>
<td>LX2</td>
<td>Switching pin for Inverting DC/DC</td>
</tr>
<tr>
<td>4</td>
<td>VOUTN</td>
<td>Discharge pin for Negative Output</td>
</tr>
<tr>
<td>5</td>
<td>CE</td>
<td>Chip Enable pin for the R1283</td>
</tr>
<tr>
<td>6</td>
<td>VFB2</td>
<td>Feedback pin for Inverting DC/DC</td>
</tr>
<tr>
<td>7</td>
<td>VREF</td>
<td>Reference Voltage Output pin</td>
</tr>
<tr>
<td>8</td>
<td>VCC</td>
<td>Analog power source Input pin</td>
</tr>
<tr>
<td>9</td>
<td>VFB1</td>
<td>Feedback pin for Step up DC/DC</td>
</tr>
<tr>
<td>10</td>
<td>GND</td>
<td>Analog GND pin</td>
</tr>
<tr>
<td>11</td>
<td>PVCC</td>
<td>Power Input pin</td>
</tr>
<tr>
<td>12</td>
<td>PGND</td>
<td>Power GND pin</td>
</tr>
</tbody>
</table>

*) 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.

* R1283Z (WLCSP-11-P2) is the limited 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>VCC</td>
<td>VCC / PVCC pin Voltage</td>
<td>6.5</td>
<td>V</td>
</tr>
<tr>
<td>VDTC</td>
<td>VFB1 pin Voltage</td>
<td>-0.3 to VCC+0.3</td>
<td>V</td>
</tr>
<tr>
<td>VFBD</td>
<td>VFB2 pin Voltage</td>
<td>-0.7(×1) to VCC+0.3</td>
<td>V</td>
</tr>
<tr>
<td>VCE</td>
<td>CE pin Voltage</td>
<td>-0.3 to VCC+0.3</td>
<td>V</td>
</tr>
<tr>
<td>VREF</td>
<td>VREF pin Voltage</td>
<td>-0.7(×1) to VCC+0.3</td>
<td>V</td>
</tr>
<tr>
<td>VLX1</td>
<td>LX1 pin Voltage</td>
<td>-0.3 to 24</td>
<td>V</td>
</tr>
<tr>
<td>IILX1</td>
<td>LX1 pin Current</td>
<td>Internally Limited</td>
<td>A</td>
</tr>
<tr>
<td>VLX2</td>
<td>LX2 pin Voltage</td>
<td>VCC–24 to VCC+0.3</td>
<td>V</td>
</tr>
<tr>
<td>IILX2</td>
<td>LX2 pin Current</td>
<td>Internally Limited</td>
<td>A</td>
</tr>
<tr>
<td>VOUTN</td>
<td>VOUTN pin Voltage</td>
<td>VCC–24 to VCC+0.3</td>
<td>V</td>
</tr>
<tr>
<td>PD</td>
<td>Power Dissipation (WLCSP-11-P2) (×2)</td>
<td>1000</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>Power Dissipation (DFN(PLP)2730-12) (×2)</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>TOPT</td>
<td>Operating Temperature Range</td>
<td>-40 to 85</td>
<td>°C</td>
</tr>
<tr>
<td>TSTG</td>
<td>Storage Temperature Range</td>
<td>-55 to 125</td>
<td>°C</td>
</tr>
</tbody>
</table>

*1) In case the voltage range is from −0.7V to −0.3V, permissible current is 10mA or less.

*2) 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.

### 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.
## ELECTRICAL CHARACTERISTICS

**R1283x**

*Topt=25°C*

<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>VCC</td>
<td>Operating Input Voltage</td>
<td>VCC=5.5V, FREQ=300kHz</td>
<td>2.0</td>
<td>5.5</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=700kHz</td>
<td>4.0</td>
<td></td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=1400kHz</td>
<td>8.0</td>
<td></td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>ICC1</td>
<td>VCC Consumption Current (Switching)</td>
<td>VCC=5.5V, FREQ=300kHz</td>
<td>250</td>
<td>μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=700kHz</td>
<td>300</td>
<td>μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=1400kHz</td>
<td>350</td>
<td>μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICC2</td>
<td>VCC Consumption Current (At no switching)</td>
<td>VCC=5.5V, FREQ=300kHz</td>
<td>5.5</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=700kHz</td>
<td>3.0</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=1400kHz</td>
<td>3.5</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Istandby</td>
<td>Standby Current</td>
<td>VCC=5.5V</td>
<td>0.1</td>
<td>3</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>IVUVLO1</td>
<td>UVLO Detect Voltage (Falling)</td>
<td>VCC=5.5V</td>
<td>2.05</td>
<td>2.15</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>IVUVLO2</td>
<td>UVLO Released Voltage (Rising)</td>
<td>VCC=5.5V</td>
<td>1.172</td>
<td>1.2</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VREF</td>
<td>VREF Voltage Tolerance</td>
<td>VCC=3.3V</td>
<td>1.172</td>
<td>1.2</td>
<td>1.228</td>
<td>V</td>
</tr>
<tr>
<td>ΔVREF/ΔTopt</td>
<td>VREF Voltage Temperature Coefficient</td>
<td>VCC=3.3V, −40°C≤Topt≤85°C</td>
<td>±150</td>
<td>ppm/°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔVREF/ΔVCC</td>
<td>VREF Line Regulation</td>
<td>2.5V≤VCC≤5.5V</td>
<td>5</td>
<td>mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔVREF/ΔIOUT</td>
<td>VREF Load Regulation</td>
<td>VCC=3.3V, 0.1mA≤IOUT≤2mA</td>
<td>5</td>
<td>mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IULREF</td>
<td>VREF Short Current Limit</td>
<td>VCC=3.3V, VREF=0V</td>
<td>15</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VFBI</td>
<td>VFBI Voltage Tolerance</td>
<td>VCC=3.3V</td>
<td>0.985</td>
<td>1.0</td>
<td>1.015</td>
<td>V</td>
</tr>
<tr>
<td>ΔVFBI1/ΔTopt</td>
<td>VFBI Voltage Temperature Coefficient</td>
<td>VCC=3.3V, −40°C≤Topt≤85°C</td>
<td>±150</td>
<td>ppm/°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IFBI1</td>
<td>VFBI1 Input Current</td>
<td>VCC=5.5V, VFBI=0V or 5.5V</td>
<td>−0.1</td>
<td>0.1</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>VFBI2</td>
<td>VFBI2 Voltage Tolerance</td>
<td>VCC=3.3V</td>
<td>−25</td>
<td>0</td>
<td>25</td>
<td>mV</td>
</tr>
<tr>
<td>IFBI2</td>
<td>VFBI2 Input Current</td>
<td>VCC=5.5V, VFBI2=0V or 5.5V</td>
<td>−0.1</td>
<td>0.1</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>fosc</td>
<td>Oscillator Frequency</td>
<td>VCC=3.3V</td>
<td>240</td>
<td>300</td>
<td>360</td>
<td>kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=3.3V</td>
<td>600</td>
<td>700</td>
<td>800</td>
<td>kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=3.3V</td>
<td>1200</td>
<td>1400</td>
<td>1600</td>
<td>kHz</td>
</tr>
<tr>
<td>Maxduty1</td>
<td>CH1 Max. Duty Cycle</td>
<td>VCC=3.3V</td>
<td>86</td>
<td>91</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Maxduty2</td>
<td>CH2 Max. Duty Cycle</td>
<td>VCC=3.3V</td>
<td>86</td>
<td>91</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>tsS1</td>
<td>CH1 Soft-start Time</td>
<td>VCC=3.3V, VFBI=0.9V</td>
<td>4.5</td>
<td>ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tsS2</td>
<td>CH2 Soft-start Time</td>
<td>VCC=3.3V, VFBI=0.12V</td>
<td>4.5</td>
<td>ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tDLY</td>
<td>Delay Time for Protection</td>
<td>VCC=3.3V</td>
<td>20</td>
<td>50</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>RLX1</td>
<td>LX1 ON Resistance</td>
<td>VCC=3.3V</td>
<td>400</td>
<td>mΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iofflx1</td>
<td>LX1 Leakage Current</td>
<td>VCC=5.5V, VLx=20V</td>
<td>5</td>
<td>μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ILMLX1</td>
<td>LX1 Current limit</td>
<td>VCC=3.3V</td>
<td>1.0</td>
<td>1.5</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>RLX2</td>
<td>LX2 ON Resistance</td>
<td>VCC=3.3V</td>
<td>400</td>
<td>mΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iofflx2</td>
<td>LX2 Leakage Current</td>
<td>VCC=5.5V, VLx=−14.5V</td>
<td>5</td>
<td>μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ILMLX2</td>
<td>LX2 Current limit</td>
<td>VCC=3.3V</td>
<td>1.0</td>
<td>1.5</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>RVDOUTN</td>
<td>VOUTN Discharge Resistance</td>
<td>VCC=3.3V, VOUTN=−0.3V</td>
<td>10</td>
<td>25</td>
<td>Ω</td>
<td></td>
</tr>
<tr>
<td>VCEL</td>
<td>CE &quot;L&quot; Input Voltage</td>
<td>VCC=2.5V</td>
<td></td>
<td>0.3</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VCEH</td>
<td>CE &quot;H&quot; Input Voltage</td>
<td>VCC=5.5V</td>
<td>1.5</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>ICEL</td>
<td>CE &quot;L&quot; Input Current</td>
<td>VCC=5.5V</td>
<td>−1.0</td>
<td>1.0</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>ICEH</td>
<td>CE &quot;H&quot; Input Current</td>
<td>VCC=5.5V</td>
<td>−1.0</td>
<td>1.0</td>
<td>μA</td>
<td></td>
</tr>
</tbody>
</table>

*R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.*
TYPICAL APPLICATION

- **Step-up DC/DC converter output voltage setting**
  The output voltage $V_{OUT1}$ of the step-up DC/DC converter is controlled with maintaining the $V_{FB1}$ as 1.0V. $V_{OUT1}$ can be set with adjusting the values of $R1$ and $R2$ as in the next formula. $V_{OUT1}$ can be set equal or less than 20V.
  $$V_{OUT1} = V_{FB1} \times \frac{R1+R2}{R1}$$

- **Inverting DC/DC converter output voltage setting**
  The output voltage $V_{OUT2}$ of the inverting DC/DC converter is controlled with maintaining the $V_{FB2}$ as 0V. $V_{OUT2}$ can be set with adjusting the values of $R4$ and $R5$ as in the next formula.
  $$V_{OUT2} = V_{FB2} - (V_{REF}-V_{FB2}) \times \frac{R5}{R4}$$

- **Auto Discharge Function**
  When CE level turns from "H" to "L" level, the R1283x goes into standby mode and switching of the outputs of LX1 and LX2 will stop. Then discharge Tr. between $V_{OUT2}$ and $V_{CC}$ turns on and discharges the negative output voltage. When the negative output voltage is discharged to 0V, the Tr. turns off and the negative output will be Hi-Z.
  When the Auto discharge function is unnecessary, $V_{OUTN}$ connect to $V_{CC}$ or make be Hi-Z.

* R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.
• **Start up Sequence (R1283x001x)**

  When CE level turns from "L" to "H" level, the softstart of CH1 starts the operation. After detecting output voltage of CH1(V\textsubscript{OUT1}) as the nominal level, the soft start of CH2 starts the operation.

  

  

<table>
<thead>
<tr>
<th>CE</th>
<th>CH1 (V\textsubscript{OUT1})</th>
<th>CH2 (V\textsubscript{OUT2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0V</td>
<td>Soft start CH1</td>
<td>Soft Start CH2</td>
</tr>
</tbody>
</table>

• **Start up Sequence (R1283x002x)**

  When CE level turns from "L" to "H" level, the softstart of CH2 starts the operation. After detecting output voltage of CH2(V\textsubscript{OUT2}) as the nominal level, the soft start of CH1 starts the operation.

  

<table>
<thead>
<tr>
<th>CE</th>
<th>CH1 (V\textsubscript{OUT1})</th>
<th>CH2 (V\textsubscript{OUT2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0V</td>
<td>Soft Start CH2</td>
<td>Soft start CH1</td>
</tr>
</tbody>
</table>

• **Short protection circuit timer**

  In case that the voltage of V\textsubscript{FB1} drops, the error amplifier of CH1 outputs "H". In case that the voltage of V\textsubscript{FB2} rises, the error amplifier of CH2 outputs "L". The built-in short protection circuit makes the internal timer operate with detecting the output of the error amplifier of CH1 as "H", or the output of the error amplifier of CH2 as "L". After the setting time will pass, the switching of LX1 and LX2 will stop.

  To release the latch operation, make the V\textsubscript{CC} set equal or less than UVLO level and restart or set the CE pin as "L" and make it "H" again.

  During the softstart operation of CH1 and CH2, the timer operates independently from the outputs of the error amplifiers. Therefore, even if the softstart cannot finish correctly because of the short circuit, the protection timer function will be able to work correctly.

• **Phase Compensation**

  DC/DC converter's phase may lose 180 degree by external components of L and C and load current. Because of this, the phase margin of the system will be less and the stability will be worse. Therefore, the phase must be gained.

  A pole will be formed by external components, L and C.

  \[ F_{\text{pole}} \approx \frac{1}{2\pi \sqrt{L_1 \times C_2}} \]  \hspace{1cm} (CH1)
  \[ F_{\text{pole}} \approx \frac{1}{2\pi \sqrt{L_2 \times C_3}} \]  \hspace{1cm} (CH2)

  Zero will be formed with R2, C5, R5, and C6.
\[ F_{\text{zero}} \approx \frac{1}{2 \times \pi \times R_2 \times C_5} \quad \text{(CH1)} \]
\[ F_{\text{zero}} \approx \frac{1}{2 \times \pi \times R_5 \times C_6} \quad \text{(CH2)} \]

Set the cut-off frequency of the Zero close to the cut-off frequency of the pole by L and C.

**To reduce the noise of Feedback voltage**

If the noise of the system is large, the output noise affects the feedback and the operation may be unstable. In that case, resistor values, R1, R2, R4, and R5 should be set lower and make the noise into the feedback pin reduce. Another method is set R3 and R6. The appropriate value range is from 1kΩ to 5kΩ.

- Set a ceramic 1μF or more capacitor as C1B between Vcc pin and GND. Set another 4.7μF or more capacitor between PVcc and GND as C1.
- Set a ceramic 1μF or more capacitor between VOUT1 and GND, and between VOUT2 and GND for each as C2 and C3. Recommendation value range is from 4.7μF to 22μF.
- Set a ceramic capacitor between VREF and GND as C4. Recommendation value range is from 0.1μF to 2.2μF.

**Operation of Step-up DC/DC Converter and Output Current**
There are two operation modes for the PWM control step-up switching regulator, that is the continuous mode and the discontinuous mode.

When the Lx Tr. is on, the voltage for the inductor L will be $V_{IN}$. The inductor current (IL1) will be:

$$IL1 = \frac{V_{IN} \times t_{on}}{L}$$  

Formula 1

When the Lx transistor turns off, power will supply continuously. The inductor current at off (IL2) will be:

$$IL2 = \frac{(V_{OUT} - V_{IN}) \times t_{f}}{L}$$  

Formula 2

In terms of the PWM control, when the $t_f = t_{off}$, the inductor current will be continuous, the operation of the switching regulator will be continuous mode.

In the continuous mode, the current variation of IL1 and IL2 are same, therefore

$$V_{IN} \times t_{on} / L = \frac{(V_{OUT} - V_{IN}) \times t_{off}}{L}$$  

Formula 3

In the continuous mode, the duty cycle will be

$$DUTY = \frac{t_{on}}{t_{on} + t_{off}} = \frac{(V_{OUT} - V_{IN})}{V_{OUT}}$$  

Formula 4

If the input power equals to output power,

$$I_{OUT} = \frac{V_{IN}^2 \times t_{on}}{(2 \times L \times V_{OUT})}$$  

Formula 5

When $I_{OUT}$ becomes more then Formula5, it will be continuous mode.

In this moment, the peak current, $I_{Lx_{max}}$ flowing through the inductor is described as follows:

$$I_{Lx_{max}} = \frac{I_{OUT} \times V_{OUT}}{V_{IN} + V_{IN} \times t_{on} / (2 \times L)}$$  

Formula 6

$$I_{Lx_{max}} = \frac{I_{OUT} \times V_{OUT}}{V_{IN} + V_{IN} \times T \times (V_{OUT} - V_{IN}) / (2 \times L \times V_{OUT})}$$  

Formula 7

Therefore, peak current is more than $I_{OUT}$. Considering the value of $I_{Lx_{max}}$, the condition of input and output, and external components should be selected.

The explanation above is based on the ideal calculation, and the loss caused by Lx switch and external components is not included.

The actual maximum output current is between 50% and 80% of the calculation.

Especially, when the IL is large, or $V_{IN}$ is low, the loss of $V_{IN}$ is generated with on resistance of the switch. As for $V_{OUT}$, $V_F$ (as much as 0.3V) of the diode should be considered.
Operation of Inverting DC/DC Converter and Output Current

There are also two operation modes for the PWM control inverting switching regulator, that is the continuous mode and the discontinuous mode.

When the LX Tr. is on, the voltage for the inductor L will be VIN. The inductor current (IL1) will be:

\[
IL1 = \frac{VIN \times ton}{L} \tag{Formula8}
\]

Inverting circuit saves energy during on time of LX Tr, and supplies the energy to output during off time, output voltage opposed to input voltage is obtained. The inductor current at off (IL2) will be:

\[
IL2 = \frac{VOUT \times tf}{L} \tag{Formula9}
\]

(The above formula and after, the absolute value of the negative output voltage is assumed to be VOUT. :Output voltage= -10V, VOUT=10 )

In terms of the PWM control, when the \( t=toff \), the inductor current will be continuous, the operation of the switching regulator will be continuous mode.

In the continuous mode, the current variation of IL1 and IL2 are same, therefore
\[ V_{IN} \times t_{on} / L = V_{OUT} \times t_{off} / L \] .................................................................Formula10

In the continuous mode, the duty cycle will be:

\[ DUTY = t_{on} / (t_{on} + t_{off}) = V_{OUT} / (V_{OUT} + V_{IN}) \] .................................................................Formula11

If the input power equals to output power,

\[ I_{OUT} = V_{IN}^2 \times t_{on} / (2 \times L \times V_{OUT}) \] .................................................................Formula12

When \( I_{OUT} \) becomes more then Formula12, it will be continuous mode.

In this moment, the peak current, \( I_{L\text{max}} \), flowing through the inductor is described as follows:

\[ I_{L\text{max}} = I_{OUT} \times V_{OUT} / (V_{IN} + V_{IN} \times t_{on} / (2 \times L)) \] .................................................................Formula13

\[ I_{L\text{max}} = I_{OUT} \times V_{OUT} / (V_{IN} + V_{IN} \times V_{OUT} \times T / (2 \times L \times (V_{OUT} + V_{IN})) \} \] ..............................................Formula14

Therefore, peak current is more than \( I_{OUT} \). Considering the value of \( I_{L\text{max}} \), the condition of input and output, and external components should be selected.

The explanation above is based on the ideal calculation, and the loss caused by Lx switch and external components is not included.

The actual maximum output current is between 50% and 80% of the calculation.

Especially, when the \( I_L \) is large, or \( V_{IN} \) is low, the loss of \( V_{IN} \) is generated with on resistance of the switch. As for \( V_{OUT} \), \( V_F \) (as much as 0.3V) of the diode should be considered.

* R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.
TYPICAL CHARACTERISTICS

1) Output Voltage VS. Output Current

R1283x001A

Topt=25°C

Vout1 [V]

0 25 50 75 100 125 150

Iout1 [mA]

VIN=2.8V
VIN=3.6V
VIN=4.2V
VIN=5.0V

R1283x001A

Topt=25°C

Vout2 [V]

0 25 50 75 100 125 150

Iout2 [mA]

VIN=2.8V
VIN=3.6V
VIN=4.2V
VIN=5.0V
R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.
2) Efficiency vs. Output Current

**R1283x001A**

Topt=25°C, Vout1=4.6V, Vout2=-4.4V, Iout1=0mA

**R1283x001A**

Topt=25°C, Vout1=12V, Vout2=-7.5V, Iout1=0mA

**R1283x001B**

Topt=25°C, Vout1=4.6V, Vout2=-5.4V, Iout1=0mA

**R1283x001B**

Topt=25°C, Vout1=4.6V, Vout2=-5.4V, Iout1=0mA

* R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.
* R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.
3) CE "L" Input Voltage vs. Temperature

4) CE "H" Input Voltage vs. Temperature

5) VFB1 Voltage vs. Temperature

6) VFB2 Voltage vs. Temperature

7) VREF Voltage vs. Temperature

8) UVLO Voltage vs. Temperature

*R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.*
9) LX1 ON Resistance vs. Temperature
R1283x00xx

10) LX2 ON Resistance vs. Temperature
R1283x00xx

11) LX1 Limit Current vs. Temperature
R1283x00xx

12) LX2 Limit Current vs. Temperature
R1283x00xx

13) Oscillator Frequency vs. Temperature
R1283x00xA

R1283x00xB

* R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.
14) Maxduty1 vs. Temperature

15) Maxduty2 vs. Temperature
*R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.
20) Startup Response

![Graph of Startup Response for R1283x001x and R1283x002x]

- **R1283x001x**
  - Topt=25°C, Vref=3.6V
  - Vout1=12V, Vout2=-7.5V

- **R1283x002x**
  - Topt=25°C, Vref=3.6V
  - Vout1=12V, Vout2=-7.5V

21) Shut down Response

![Graph of Shut down Response for R1283x001x and R1283x002x]

- **R1283x001x**
  - Topt=25°C, Vref=3.6V
  - Vout1=12V, Vout2=-7.5V
  - Iout1=10mA
  - VOUT1: discharge

- **R1283x001x (VOUTN=Open)**
  - Topt=25°C, Vref=3.6V
  - Vout1=12V, Vout2=-7.5V
  - Iout1=10mA
  - VOUT2: not discharge

- **R1283x002x**
  - Topt=25°C, Vref=3.6V
  - Vout1=12V, Vout2=-7.5V
  - Iout1=10mA
  - VOUT1: discharge

- **R1283x002x (VOUTN=Open)**
  - Topt=25°C, Vref=3.6V
  - Vout1=12V, Vout2=-7.5V
  - Iout1=10mA
  - VOUT2: not discharge
22) Load Transient Response

**R1283x00xA**

- **Topt=25°C , VIN=3.6V**

**R1283x00xA**

- **Topt=25°C , VIN=3.6V**

**R1283x00xB**

- **Topt=25°C , VIN=3.6V**

**R1283x00xB**

- **Topt=25°C , VIN=3.6V**

**R1283x00xC**

- **Topt=25°C , VIN=3.6V**

**R1283x00xC**

- **Topt=25°C , VIN=3.6V**

---

*R1283Z (WLCSP-11-P2) is the limited product. As of March in 2014.*
APPLIED CIRCUIT

1) Application with outputting power supply (+12V/-7.5V) for CCD from Li battery

```
L1  L2  C5  C6
R1283x00xA  15μH  10μH  220pF  220pF
R1283x00xB  6.8μH  6.8μH  150pF  150pF
R1283x00xC  4.7μH  4.7μH  120pF  120pF

Inductor | VLF3010 (TDK)
---------|-----------------
SBD      | CRS02 (TOSHIBA)
```

2) Application with outputting power supply (+4.6V/-4.4V) for AMOLED from Li battery

```
L1  L2  C5  C6
R1283x00xA  15μH  10μH  100pF  100pF
R1283x00xB  4.7μH  4.7μH  47pF  33pF
R1283x00xC  4.7μH  4.7μH  68pF  47pF

Inductor | VLF3010 (TDK)
---------|-----------------
SBD      | CRS02 (TOSHIBA)
```
3) Application with output disconnect and discharge.

R1283x (WLCSP-11-P2) is the limited 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, 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, firecontainment 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.

For the conservation of the global environment, Ricoh is advancing the decrease of the negative environmental impact material. 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. Basically after Apr. 1, 2012, we will ship out the Power Management ICs of the Halogen Free products only. (Ricoh Halogen Free products are also Antimony Free.)