OUTLINE

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 ($R_{ON}=400m\Omega$ 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 ($R_{ON}=400m\Omega$ 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**
* 1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.

R1283x

**BLOCK DIAGRAM**

Diagram showing connections and control blocks for a circuit, including:
- **VCC**
- **VREF**
- **VFB2**
- **VFB1**
- **GND**
- **CE**
- **PVCC**
- **LX2**
- **VOUTN**
- **LX1**
- **PGND**

Connections and control points highlighted:
- UVLO
- Maxduty
- PWM Control
- Discharge Control
- Sequence Control

Legend:
- Timer
- Current Limit
- PWM
- Discharge
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>
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</thead>
<tbody>
<tr>
<td>R1283Z00x+-E2-F</td>
<td>WLCSP-11-P2</td>
<td>4,000 pcs</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>R1283K00x+-TR</td>
<td>DFN(PLP)2730-12</td>
<td>5,000 pcs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* : 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
PIN CONFIGURATIONS

- **WLCSP-11-P2**

```
Top View
1 2 3
A B C D

Bottom View
1 2 3
D C B A
```

- **DFN(PLP)2730-12**

```
Top View
7 8 9 10 11 12

Bottom View
1 2 3 4 5 6
```

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>
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<tr>
<td>A2</td>
<td>V_FB1</td>
<td>Feedback pin for Step up DC/DC</td>
</tr>
<tr>
<td>A3</td>
<td>L_X1</td>
<td>Switching pin for Step up DC/DC</td>
</tr>
<tr>
<td>B1</td>
<td>PV_CC</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>L_X2</td>
<td>Switching pin for Inverting DC/DC</td>
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<tr>
<td>C1</td>
<td>GND</td>
<td>Analog GND pin</td>
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<tr>
<td>C3</td>
<td>V_DUTN</td>
<td>Discharge pin for Negative output</td>
</tr>
<tr>
<td>D1</td>
<td>V_CC</td>
<td>Analog power source Input pin</td>
</tr>
<tr>
<td>D2</td>
<td>V_REF</td>
<td>Reference Voltage Output pin</td>
</tr>
<tr>
<td>D3</td>
<td>V_FB2</td>
<td>Feedback pin for Inverting DC/DC</td>
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</table>

- **DFN(PLP)2730-12**

<table>
<thead>
<tr>
<th>Pin No</th>
<th>Symbol</th>
<th>Pin Description</th>
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<tr>
<td>1</td>
<td>NC</td>
<td>No Connect</td>
</tr>
<tr>
<td>2</td>
<td>L_X1</td>
<td>Switching pin for Step up DC/DC</td>
</tr>
<tr>
<td>3</td>
<td>L_X2</td>
<td>Switching pin for Inverting DC/DC</td>
</tr>
<tr>
<td>4</td>
<td>V_DUTN</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>V_FB2</td>
<td>Feedback pin for Inverting DC/DC</td>
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<tr>
<td>7</td>
<td>V_REF</td>
<td>Reference Voltage Output pin</td>
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<tr>
<td>8</td>
<td>V_CC</td>
<td>Analog power source Input pin</td>
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<tr>
<td>9</td>
<td>V_FB1</td>
<td>Feedback pin for Step up DC/DC</td>
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<tr>
<td>10</td>
<td>GND</td>
<td>Analog GND pin</td>
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<tr>
<td>11</td>
<td>PV_CC</td>
<td>Power Input pin</td>
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<tr>
<td>12</td>
<td>PGND</td>
<td>Power GND pin</td>
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*) Tab is GND level. (They are connected to the reverse side of this IC.) The tab is better to be connected to the GND, but leaving it open is also acceptable.
### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Rating</th>
<th>Unit</th>
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</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>VFB</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>ILX1</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>ILX2</td>
<td>LX2 pin Current</td>
<td>Internally Limited</td>
<td>A</td>
</tr>
<tr>
<td>VNFN</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>mW</td>
</tr>
<tr>
<td>T_{opt}</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>

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.

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

**Symbol**: 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>
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<tbody>
<tr>
<td>VCC</td>
<td>Operating Input Voltage</td>
<td>VCC=5.5V, FREQ=300kHz</td>
<td>2.5</td>
<td>2.0</td>
<td>5.5</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=700kHz</td>
<td></td>
<td>4.0</td>
<td></td>
<td>mA</td>
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<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=1400kHz</td>
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<td>8.0</td>
<td></td>
<td>mA</td>
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<tr>
<td>ICC1</td>
<td>VCC Consumption Current (Switching)</td>
<td>VCC=5.5V, FREQ=300kHz</td>
<td>250</td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=700kHz</td>
<td>300</td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=1400kHz</td>
<td>350</td>
<td></td>
<td></td>
<td>μA</td>
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<tr>
<td>ICC2</td>
<td>VCC Consumption Current (At no switching)</td>
<td>VCC=5.5V, FREQ=300kHz</td>
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<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=700kHz</td>
<td></td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC=5.5V, FREQ=1400kHz</td>
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<td></td>
<td></td>
<td>μA</td>
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<tr>
<td>Istandby</td>
<td>Standby Current</td>
<td>VCC=5.5V</td>
<td>0.1</td>
<td>2.05</td>
<td>2.25</td>
<td>μA</td>
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<td>VUVLO1</td>
<td>UVLO Detect Voltage</td>
<td>Failing</td>
<td></td>
<td>2.15</td>
<td></td>
<td>V</td>
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<tr>
<td>VUVLO2</td>
<td>UVLO Released Voltage</td>
<td>Rising</td>
<td>VUVLO1+0.16</td>
<td>1.72</td>
<td>1.2</td>
<td>2.48</td>
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<tr>
<td>VREF</td>
<td>VREF Voltage Tolerance</td>
<td>VCC=3.3V</td>
<td></td>
<td>1.172</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+VFB2</td>
<td></td>
<td>1.2</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+VFB2</td>
<td></td>
<td>1.228</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>∆VREF/∆Topt</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>∆VREF/∆VCC</td>
<td>VREF Line Regulation</td>
<td>2.5V≤VCC≤5.5V</td>
<td>5</td>
<td>mV</td>
<td></td>
<td></td>
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<tr>
<td>∆VREF/∆IOUT</td>
<td>VREF Load Regulation</td>
<td>VCC=3.3V, 0.1mA≤IOUT≤2mA</td>
<td>5</td>
<td>mV</td>
<td></td>
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<tr>
<td>IREF</td>
<td>VREF Short Current Limit</td>
<td>VCC=3.3V, VREF=0V</td>
<td>15</td>
<td>mA</td>
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<td>VFB1</td>
<td>VFB1 Voltage Tolerance</td>
<td>VCC=3.3V</td>
<td>0.985</td>
<td>1.0</td>
<td>1.015</td>
<td>V</td>
</tr>
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<td>∆VFB1/∆Topt</td>
<td>VFB1 Voltage Temperature Coefficient</td>
<td>VCC=3.3V, −40°C≤Topt≤85°C</td>
<td>±150</td>
<td>ppm/°C</td>
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<tr>
<td>IFB1</td>
<td>VFB1 Input Current</td>
<td>VCC=5.5V, VFB1=0V or 5.5V</td>
<td>−0.1</td>
<td>0.1</td>
<td></td>
<td>μA</td>
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<td>VFB2</td>
<td>VFB2 Voltage Tolerance</td>
<td>VCC=3.3V</td>
<td>−25</td>
<td>0</td>
<td>25</td>
<td>mV</td>
</tr>
<tr>
<td>IFB2</td>
<td>VFB2 Input Current</td>
<td>VCC=5.5V, VFB2=0V or 5.5V</td>
<td>−0.1</td>
<td>0.1</td>
<td></td>
<td>μA</td>
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<td>fosc</td>
<td>Oscillator Frequency</td>
<td>VCC=3.3V</td>
<td>240</td>
<td>300</td>
<td>360</td>
<td>kHz</td>
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<td></td>
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<td>VCC=3.3V</td>
<td>600</td>
<td>700</td>
<td>800</td>
<td>kHz</td>
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<tr>
<td></td>
<td></td>
<td>VCC=3.3V</td>
<td>1200</td>
<td>1400</td>
<td>1600</td>
<td>kHz</td>
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<td>Maxduty1</td>
<td>CH1 Max. Duty Cycle</td>
<td>VCC=3.3V</td>
<td>86</td>
<td>91</td>
<td></td>
<td>%</td>
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<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>
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<td>tSS1</td>
<td>CH1 Soft-start Time</td>
<td>VCC=3.3V, VFB1=0.9V</td>
<td>4.5</td>
<td>ms</td>
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<tr>
<td>tSS2</td>
<td>CH2 Soft-start Time</td>
<td>VCC=3.3V, VFB2=0.12V</td>
<td>4.5</td>
<td>ms</td>
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<td>tDLY</td>
<td>Delay Time for Protection</td>
<td>VCC=3.3V</td>
<td>20</td>
<td>50</td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>RLX1</td>
<td>Lx1 ON Resistance</td>
<td>VCC=3.3V</td>
<td>400</td>
<td>mΩ</td>
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<tr>
<td>IloffLX1</td>
<td>Lx1 Leakage Current</td>
<td>VCC=5.5V, Vlx=20V</td>
<td>5</td>
<td>μA</td>
<td></td>
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<tr>
<td>LMLX1</td>
<td>Lx1 Current limit</td>
<td>VCC=3.3V</td>
<td>1.0</td>
<td>1.5</td>
<td>A</td>
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<td>RLX2</td>
<td>Lx2 ON Resistance</td>
<td>VCC=3.3V</td>
<td>400</td>
<td>mΩ</td>
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<td>IloffLX2</td>
<td>Lx2 Leakage Current</td>
<td>VCC=5.5V, Vlx=−14.5V</td>
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<td>μA</td>
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<td>LMLX2</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>RVOUTN</td>
<td>VOUTN Discharge Resistance</td>
<td>VCC=3.3V, VOUTN=−0.3V</td>
<td>10</td>
<td>25</td>
<td></td>
<td>Ω</td>
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<tr>
<td>VCEL</td>
<td>CE &quot;L&quot; Input Voltage</td>
<td>VCC=2.5V</td>
<td>0.3</td>
<td>V</td>
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<tr>
<td>VCEH</td>
<td>CE &quot;H&quot; Input Voltage</td>
<td>VCC=5.5V</td>
<td>1.5</td>
<td>V</td>
<td></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>
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<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 discontinued product as of June, 2016.
**TYPICAL APPLICATION**

- **Pin Connection**
  Externally short VCC pin to PVCC pin. Externally short GND pin to PGND pin.

- **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 VCC 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 VCC or make be Hi-Z.

CE

0V

Negative output

Discharge

Hi-Z
* 1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.

**Start up Sequence (R1283x001x)**

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

![Diagram 1](image1.png)

**Start up Sequence (R1283x002x)**

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

![Diagram 2](image2.png)

**Short protection circuit timer**

In case that the voltage of V_{FB1} drops, the error amplifier of CH1 outputs "H". In case that the voltage of V_{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_{CC} set equal or less than UVLO level and restart or set the CE pin as "L" and make it "H" again.

During the soft start operation of CH1 and CH2, the timer operates independently from the outputs of the error amplifiers. Therefore, even if the soft start 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.

\[
F_{pole} \approx \frac{1}{2\pi \sqrt{L_1C_2}} \quad (CH1)
\]

\[
F_{pole} \approx \frac{1}{2\pi \sqrt{L_2C_3}} \quad (CH2)
\]

Zero will be formed with R2, C5, R5, and C6.
**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**

Discontinuous Mode

\[ \text{IL}_{\text{xmin}} \leq \text{IL} \leq \text{IL}_{\text{xmax}} \]

\[ \text{ton} \leq t \leq \text{toff} \]

\[ T = \frac{1}{\text{fosc}} \]

Continuous Mode

\[ \text{IL}_{\text{xmin}} \leq \text{IL} \leq \text{IL}_{\text{xmax}} \]

\[ \text{ton} \leq t \leq \text{toff} \]

\[ T = \frac{1}{\text{fosc}} \]
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:

$$IL1 = \frac{V_{IN} \times t_{on}}{L}$$  ............................................................................................................ Formula1

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

$$IL2 = \frac{(V_{OUT} - V_{IN}) \times t_f}{L}$$ .................................................................................................. Formula2

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

$$V_{IN} \times t_{on} / L = (V_{OUT} - V_{IN}) \times t_{off} / L$$ .................................................................................. Formula3

In the continuous mode, the duty cycle will be

$$DUTY = \frac{t_{on}}{t_{on} + t_{off}} = \frac{(V_{OUT} - V_{IN})}{V_{OUT}}$$ .................................................................... Formula4

If the input power equals to output power,

$$I_{OUT} = \frac{V_{IN}^2 \times t_{on}}{(2 \times L \times V_{OUT})}$$ ....................................................................................... Formula5

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

In this moment, the peak current, ILxmax flowing through the inductor is described as follows:

$$IL_{xmax} = \frac{I_{OUT} \times V_{OUT}}{V_{IN} + V_{IN} \times t_{on}} / (2 \times L)$$ ............................................................................................................ Formula6

$$IL_{xmax} = \frac{I_{OUT} \times V_{OUT} / V_{IN} + V_{IN} \times T \times (V_{OUT} - V_{IN})}{(2 \times L \times V_{OUT})}$$ .................................................................................................. Formula7

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

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**

*1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.*

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

When the \( L_x \) Tr. is on, the voltage for the inductor \( L \) will be \( V_{IN} \). The inductor current (\( IL_1 \)) will be:

\[
IL_1 = \frac{V_{IN} \times t_{on}}{L} \tag{Formula 8}
\]

Inverting circuit saves energy during on time of \( L_x \) Tr, and supplies the energy to output during off time, output voltage opposed to input voltage is obtained. The inductor current at off (\( IL_2 \)) will be:

\[
IL_2 = |V_{OUT}| \times \frac{t_f}{L} \tag{Formula 9}
\]

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 \( IL_1 \) and \( IL_2 \) are same, therefore
* 1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.

\[ V_{IN} \times t_{on} / L = |V_{OUT}| \times t_{off} / L \] ......................................................................................... Formula10

In the continuous mode, the duty cycle will be:

\[ \text{DUTY} = t_{on} / (t_{on} + t_{off}) = |V_{OUT}| / (|V_{OUT}| + V_{IN}) \] ......................................................................................... 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 than Formula12, it will be continuous mode.

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

\[ I_{L\text{max}} = I_{OUT} \times |V_{OUT}| / V_{IN} + V_{IN} \times t_{on} / (2 \times L) \] ......................................................................................... 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 \( L_x \) switch and external components is not included.

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

Especially, when the \( L \) 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.
TYPICAL CHARACTERISTICS

1) Output Voltage VS. Output Current

**R1283x001A**

```
0 50 100 150 200
IOUT1 [mA]

VOUT1 [V]

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

Topt=25°C
```

**R1283x001A**

```
0 50 100 150 200
IOUT2 [mA]

VOUT2 [V]

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

Topt=25°C
```

**R1283x001A**

```
0 25 50 75 100 125 150
IOUT1 [mA]

VOUT1 [V]

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

Topt=25°C
```

**R1283x001A**

```
0 50 100 150 200
IOUT2 [mA]

VOUT2 [V]

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

Topt=25°C
```

**R1283x001B**

```
0 50 100 150 200
IOUT1 [mA]

VOUT1 [V]

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

Topt=25°C
```

**R1283x001B**

```
0 50 100 150 200
IOUT2 [mA]

VOUT2 [V]

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

Topt=25°C
```
* 1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.

R1283x

**R1283x001B**

![Graph showing Vout1 vs Iout1 for different VIN values at Topt=25°C](image1)

**R1283x001B**

![Graph showing Vout2 vs Iout2 for different VIN values at Topt=25°C](image2)

**R1283x001B**

![Graph showing Vout1 vs Iout1 for different VIN values at Topt=25°C](image3)

**R1283x001B**

![Graph showing Vout2 vs Iout2 for different VIN values at Topt=25°C](image4)
2) Efficiency vs. Output Current

R1283x001A

Topt=25°C, Vout1=4.6V, Vout2=4.4V, Iout1=0mA, Iout2=0mA

R1283x001A

Topt=25°C, Vout1=4.6V, Vout2=4.4V, Iout1=0mA, Iout2=0mA

R1283x001A

Topt=25°C, Vout1=12V, Vout2=7.5V, Iout1=0mA, Iout2=0mA

R1283x001A

Topt=25°C, Vout1=12V, Vout2=7.5V, Iout1=0mA, Iout2=0mA

R1283x001B

Topt=25°C, Vout1=4.6V, Vout2=5.4V, Iout1=0mA, Iout2=0mA

R1283x001B

Topt=25°C, Vout1=4.6V, Vout2=5.4V, Iout1=0mA, Iout2=0mA

*1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.*
*1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.

R1283x

---

R1283x001B

Topt=25°C, VOUT1=12V
VOUT2=-7.5V, IOUT2=0mA

---

R1283x001B

Topt=25°C, VOUT2=-7.5V
VOUT1=12V, IOUT1=0mA

---

R1283x001C

Topt=25°C, VOUT1=4.6V
VOUT2=-4.4V, IOUT2=0mA

---

R1283x001C

Topt=25°C, VOUT2=-4.4V
VOUT1=4.6V, IOUT1=0mA

---

R1283x001C

Topt=25°C, VOUT1=12V
VOUT2=-7.5V, IOUT2=0mA

---

R1283x001C

Topt=25°C, VOUT2=-7.5V
VOUT1=12V, IOUT1=0mA
* 1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.

3) CE "L" Input Voltage vs. Temperature
   \textbf{R1283x00xx}

4) CE "H" Input Voltage vs. Temperature
   \textbf{R1283x00xx}

5) VFB1 Voltage vs. Temperature
   \textbf{R1283x00xx}

6) VFB2 Voltage vs. Temperature
   \textbf{R1283x00xx}

7) VREF Voltage vs. Temperature
   \textbf{R1283x00xx}

8) UVLO Voltage vs. Temperature
   \textbf{R1283x00xx}
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

---

* 1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.
* 1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.

14) Maxduty1 vs. Temperature

15) Maxduty2 vs. Temperature
* R1283x (WLCSP-11-P2) is the discontinued product as of June, 2016.

16) CH1 Soft-start Time vs. Temperature
R1283x00xx

17) CH2 Soft-start Time vs. Temperature
R1283x00xx

18) Timer Latch Delay Time vs. Temperature
R1283x00xx

19) VOUTN Discharge Current vs. Temperature
R1283x00xx
* 1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.

### 20) Startup Response

**R1283x001x**

Topt=25°C, V_{IN}=3.6V  
V_{OUT1}=12V, V_{OUT2}=-7.5V  

**R1283x002x**

Topt=25°C, V_{IN}=3.6V  
V_{OUT1}=12V, V_{OUT2}=-7.5V  

### 21) Shut down Response

**R1283x001x**

Topt=25°C, V_{IN}=3.6V  
V_{OUT1}=12V, V_{OUT2}=-7.5V  
I_{OUT1}=10mA  

**R1283x002x**

Topt=25°C, V_{IN}=3.6V  
V_{OUT1}=12V, V_{OUT2}=-7.5V  
I_{OUT1}=10mA  

**R1283x001x (VOUTN=Open)**

Topt=25°C, V_{IN}=3.6V  
V_{OUT1}=12V, V_{OUT2}=-7.5V  
I_{OUT1}=10mA  

**R1283x002x (VOUTN=Open)**

Topt=25°C, V_{IN}=3.6V  
V_{OUT1}=12V, V_{OUT2}=-7.5V  
I_{OUT1}=10mA
R1283x

22) Load Transient Response

**R1283x00xA**

Topt=25°C, VIN=3.6V

**R1283x00xB**

Topt=25°C, VIN=3.6V

**R1283x00xC**

Topt=25°C, VIN=3.6V

* R1283Z (WLCSP-11-P2) is the discontinued product as of June, 2016.*
**APPLIED CIRCUIT**

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

![Circuit Diagram]

<table>
<thead>
<tr>
<th>L1</th>
<th>L2</th>
<th>C5</th>
<th>C6</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1283x00xA</td>
<td>15µH</td>
<td>10µH</td>
<td>220pF</td>
</tr>
<tr>
<td>R1283x00xB</td>
<td>6.8µH</td>
<td>6.8µH</td>
<td>150pF</td>
</tr>
<tr>
<td>R1283x00xC</td>
<td>4.7µH</td>
<td>4.7µH</td>
<td>120pF</td>
</tr>
</tbody>
</table>

Inductor: VLF3010 (TDK)

SBD: CRS10I30A (TOSHIBA)

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

![Circuit Diagram]

<table>
<thead>
<tr>
<th>L1</th>
<th>L2</th>
<th>C5</th>
<th>C6</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1283x00xA</td>
<td>15µH</td>
<td>10µH</td>
<td>100pF</td>
</tr>
<tr>
<td>R1283x00xB</td>
<td>4.7µH</td>
<td>4.7µH</td>
<td>47pF</td>
</tr>
<tr>
<td>R1283x00xC</td>
<td>4.7µH</td>
<td>4.7µH</td>
<td>68pF</td>
</tr>
</tbody>
</table>

Inductor: VLF3010 (TDK)

SBD: CRS10I30A (TOSHIBA)
3) Application with output disconnect and discharge.

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