OUTLINE

The R1280D002x Series are CMOS-based 2-channel PWM Step-up (as Channel 1)/Inverting (as Channel 2) DC/DC converter controllers.

Each of the R1280D002x Series consists of an oscillator, a PWM control circuit, a reference voltage unit, an error amplifier, a reference current unit, a protection circuit, and an under voltage lockout (UVLO) circuit. A high efficiency Step-up/Inverting DC/DC converter can be composed of this IC with inductors, diodes, power MOSFETs, resisters, and capacitors. Each Output Voltage can be adjustable with external resistors, while soft-start time can be adjustable with external capacitors.

Maximum Duty Cycle of R1280D002A and C series can be also adjustable with external resistors.

Maximum Duty Cycle of R1280D002B is built-in as 90%(Typ.).

When CE pin of R1280D002B is set at GND level, this IC turns off external power MOSFETs of Step-up/Inverting as Standby-mode.

Standby current is typically 0μA.

As for a protection circuit, if Maximum duty cycle of either Step-up DC/DC converter side or Inverting DC/DC converter side is continued for a certain time, the R1280D Series latch both external drivers with their off state by its Latch-type protection circuit. Delay time for protection is internally fixed typically at 100ms. To release the protection circuit, restart with power-on (Voltage supplier is equal or less than UVLO detector threshold level), or as for R1280D002B, once after making the circuit be stand-by with chip enable pin and enable the circuit again.

FEATURES

- Input Voltage Range .........................................2.5V to 5.5V
- Built-in Latch-type Protection Function by monitoring duty cycle (Fixed Delay Time Typ. 100ms)
- Oscillator Frequency .........................................700kHz (R1280D002A,B)/200kHz (R1280D002C)
- Maximum Duty Cycle ........................................Typ. 90% (Only applied to R1280D002B Series)
- High Reference Voltage Accuracy ............................±1.5%
- U.V.L.O. Threshold ...........................................Typ. 2.2V (Hysteresis: Typ. 0.1V)
- Small Package ..................................................thin SON-10 (package thickness Max. 0.9mm)

APPLICATIONS

- Constant Voltage Power Source for Portable Equipment.
- Constant Voltage Power Source for LCD and CCD.
BLOCK DIAGRAM

• R1280D002A/C

• R1280D002B
**SELECTION GUIDE**

The mask option for the ICs can be selected at the user's request. The selection can be made with designating the part number as shown below;

\[
\text{R1280D002x-TR} \leftrightarrow \text{Part Number}
\]

\[
\text{a b}
\]

<table>
<thead>
<tr>
<th>Code</th>
<th>Contents</th>
</tr>
</thead>
</table>
| a    | Designation of Mask Option:  
A version: fosc=700kHz, with External Phase Compensation for Channel 1.  
B version: fosc=700kHz, with Internal Phase Compensation and standby mode.  
C version: fosc=200kHz, with External Phase Compensation for Channel 1 |
| b    | Designation of Taping Type:  
(Refer to Taping Specifications.) |

**PIN CONFIGURATION**

![PIN CONFIGURATION Diagram]
### PIN DESCRIPTION

#### R1280D002A/C

<table>
<thead>
<tr>
<th>Pin No</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EXT1</td>
<td>External Transistor of Channel 1 Drive Pin (CMOS Output)</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground Pin</td>
</tr>
<tr>
<td>3</td>
<td>AMPOUT1</td>
<td>Amplifier Output Pin of Channel 1</td>
</tr>
<tr>
<td>4</td>
<td>DTC1</td>
<td>Maximum Duty Cycle of Channel 1 Setting Pin</td>
</tr>
<tr>
<td>5</td>
<td>VFB1</td>
<td>Feedback pin of Channel 1</td>
</tr>
<tr>
<td>6</td>
<td>VFB2</td>
<td>Feedback pin of Channel 2</td>
</tr>
<tr>
<td>7</td>
<td>DTC2</td>
<td>Maximum Duty Cycle of Channel 2 Setting Pin</td>
</tr>
<tr>
<td>8</td>
<td>Vrefout</td>
<td>Reference Output Pin</td>
</tr>
<tr>
<td>9</td>
<td>VIN</td>
<td>Voltage Supply Pin of the IC</td>
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<tr>
<td>10</td>
<td>EXT2</td>
<td>External Transistor of Channel 2 Drive Pin (CMOS Output)</td>
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#### R1280D002B

<table>
<thead>
<tr>
<th>Pin No</th>
<th>Symbol</th>
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<tbody>
<tr>
<td>1</td>
<td>EXT1</td>
<td>External Transistor of Channel 1 Drive Pin (CMOS Output)</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground Pin</td>
</tr>
<tr>
<td>3</td>
<td>CE</td>
<td>Chip Enable Pin</td>
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<tr>
<td>4</td>
<td>DTC1</td>
<td>Soft-start Time of Channel 1 Setting Pin</td>
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<tr>
<td>5</td>
<td>VFB1</td>
<td>Feedback pin of Channel 1</td>
</tr>
<tr>
<td>6</td>
<td>VFB2</td>
<td>Feedback pin of Channel 2</td>
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<tr>
<td>7</td>
<td>DTC2</td>
<td>Soft-start Time of Channel 2 Setting Pin</td>
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<td>8</td>
<td>Vrefout</td>
<td>Reference Output Pin</td>
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<td>9</td>
<td>VIN</td>
<td>Voltage Supply Pin of the IC</td>
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<td>10</td>
<td>EXT2</td>
<td>External Transistor of Channel 2 Drive Pin (CMOS Output)</td>
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### ABSOLUTE MAXIMUM RATINGS

**• R1280D002A/C**

<table>
<thead>
<tr>
<th>Symbol</th>
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<th>Rating</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>$V_{IN}$</td>
<td>$V_{IN}$ Pin Voltage</td>
<td>6.5</td>
<td>V</td>
</tr>
<tr>
<td>$V_{EXT1,2}$</td>
<td>$V_{EXT1,2}$ Pin Output Voltage</td>
<td>$-0.3 \sim V_{IN} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{AMPOUT1}$</td>
<td>AMPOUT1 Pin Voltage</td>
<td>$-0.3 \sim V_{IN} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{DTC1,2}$</td>
<td>DTC1,2 Pin Voltage</td>
<td>$-0.3 \sim V_{IN} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{ref}out}$</td>
<td>$V_{\text{ref}out}$ Pin Voltage</td>
<td>$-0.3 \sim V_{IN} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{FB1,2}$</td>
<td>$V_{FB1,2}$ Pin Voltage</td>
<td>$-0.3 \sim V_{IN} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$I_{EXT1,2}$</td>
<td>$I_{EXT1,2}$ Pin Output Current</td>
<td>$\pm 50$</td>
<td>mA</td>
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<tr>
<td>$P_D$</td>
<td>Power Dissipation</td>
<td>250</td>
<td>mW</td>
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<tr>
<td>$T_{opt}$</td>
<td>Operating Temperature Range</td>
<td>$-40$ to $+85$</td>
<td>°C</td>
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<tr>
<td>$T_{stg}$</td>
<td>Storage Temperature Range</td>
<td>$-55$ to $+125$</td>
<td>°C</td>
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**• R1280D002B**

<table>
<thead>
<tr>
<th>Symbol</th>
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<tr>
<td>$V_{IN}$</td>
<td>$V_{IN}$ Pin Voltage</td>
<td>6.5</td>
<td>V</td>
</tr>
<tr>
<td>$V_{EXT1,2}$</td>
<td>$V_{EXT1,2}$ Pin Output Voltage</td>
<td>$-0.3 \sim V_{IN} + 0.3$</td>
<td>V</td>
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<tr>
<td>$V_{CE}$</td>
<td>$V_{CE}$ Pin Voltage</td>
<td>$-0.3 \sim V_{IN} + 0.3$</td>
<td>V</td>
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<tr>
<td>$V_{DTC1,2}$</td>
<td>DTC1,2 Pin Voltage</td>
<td>$-0.3 \sim V_{IN} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{ref}out}$</td>
<td>$V_{\text{ref}out}$ Pin Voltage</td>
<td>$-0.3 \sim V_{IN} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{FB1,2}$</td>
<td>$V_{FB1,2}$ Pin Voltage</td>
<td>$-0.3 \sim V_{IN} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$I_{EXT1,2}$</td>
<td>$I_{EXT1,2}$ Pin Output Current</td>
<td>$\pm 50$</td>
<td>mA</td>
</tr>
<tr>
<td>$P_D$</td>
<td>Power Dissipation</td>
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<td>$T_{opt}$</td>
<td>Operating Temperature Range</td>
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<td>°C</td>
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<tr>
<td>$T_{stg}$</td>
<td>Storage Temperature Range</td>
<td>$-55$ to $+125$</td>
<td>°C</td>
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</tbody>
</table>
## ELECTRICAL CHARACTERISTICS

- **R1280D002A**

### Symbol | Item | Conditions | Min. | Typ. | Max. | Unit |
---|---|---|---|---|---|---|
VIN | Operating Input Voltage | | 2.5 | 5.5 | | V |
VREFOUT | VREFOUT Voltage Tolerance | VIN=3.3V, IOUT=1mA | 1.478 | 1.500 | 1.522 | V |
IOUT | VREFOUT Output Current | VIN=3.3V | 20 | | | mA |
ΔVREFOUT /ΔVIN | VREFOUT Line Regulation | 2.5V ≤ VIN ≤ 5.5V | 2 | 6 | | mV |
ΔVREFOUT /ΔIOUT | VREFOUT Load Regulation | 1mA ≤ IOUT ≤ 10mA VIN=3.3V | 6 | 12 | | mV |
IILM | VREFOUT Short Current Limit | VIN=3.3V, VREFOUT=0V | | | 25 | mA |
ΔVREFOUT/ΔT | VREFOUT Voltage Temperature Coefficient | −40°C ≤ Topt ≤ 85°C | | ±150 | | ppm/°C |
VFB1 | VFB1 Voltage | VIN=3.3V | 0.985 | 1.000 | 1.015 | V |
ΔVFB1/ΔT | VFB1 Voltage Temperature Coefficient | −40°C ≤ Topt ≤ 85°C | | ±150 | | ppm/°C |
IFB1,2 | IFB1,2 Input Current | VIN=5.5V, VFB1 or VFB2=0V or 5.5V | −0.1 | 0.1 | | µA |
fosc | Oscillator Frequency | EXT1,2 Pins at no load, VIN=3.3V | 595 | 700 | 805 | kHz |
IDD1 | Supply Current | VIN=5.5V, EXT1,2 pins at no load | | 1.4 | 3.0 | | mA |
REXT1H | EXT1 "H" ON Resistance | VIN=3.3V, IEXT=−20mA | 4.0 | 8.0 | | Ω |
REXT1L | EXT1 "L" ON Resistance | VIN=3.3V, IEXT=20mA | 2.7 | 5.0 | | Ω |
REXT2H | EXT2 "H" ON Resistance | VIN=3.3V, IEXT=−20mA | 4.0 | 8.0 | | Ω |
REXT2L | EXT2 "L" ON Resistance | VIN=3.3V, IEXT=20mA | 3.7 | 8.0 | | Ω |
T Daly | Delay Time for Protection | VIN=3.3V, VFB1=1.1V→0V | 60 | 100 | 140 | ms |
VUVLOD | UVLO Detector Threshold | VIN=3.3V, | 2.10 | 2.20 | 2.35 | V |
VUVLO | UVLO Released Voltage | | | | | V |
VDC10 | CH1 Duty=0% | VIN=3.3V | 0.1 | 0.2 | 0.3 | V |
VDC1100 | CH1 Duty=100% | VIN=3.3V | 1.1 | 1.2 | 1.3 | V |
VDC20 | CH2 Duty=0% | VIN=3.3V | 0.1 | 0.2 | 0.3 | V |
VDC2100 | CH2 Duty=100% | VIN=3.3V | 1.1 | 1.2 | 1.3 | V |
AV1 | CH1 Open Loop Gain | VIN=3.3V | 1.9 | | | dB |
FT1 | CH1 Single Loop Gain Frequency Band | VIN=3.3V, AV1=0dB | | | | MHz |
VCR1 | CH1 Input Voltage Range | VIN=3.3V | 0.7 to VIN | | | V |
IAMPL | CH1 Sink Current | VIN=3.3V, VAMP=1.0V, VFB1=VFB1+0.1V | 70 | 115 | | µA |
IAMPH | CH1 Source Current | VIN=3.3V, VAMP=1.0V, VFB1=VFB1−0.1V | −1.4 | −0.7 | | mA |
AV2 | CH2 Open Loop Gain | VIN=3.3V | 60 | | | dB |
FT2 | CH2 Single Loop Gain Frequency Band | VIN=3.3V, AV2=0−dB | 3 | | | MHz |
VCR2 | CH2 Input Voltage Range | VIN=3.3V | | −0.2 to VIN=1.3 | | V |
VFB2 | CH2 Input Offset Voltage | VIN=3.3V | −12 | 12 | | mV |
### R1280D002B

<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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<tr>
<td>VIN</td>
<td>Operating Input Voltage</td>
<td></td>
<td>2.5</td>
<td>5.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VREFOUT</td>
<td>VREFOUT Voltage Tolerance</td>
<td>VIN=3.3V, IOUT=1mA</td>
<td>1.478</td>
<td>1.500</td>
<td>1.522</td>
<td>V</td>
</tr>
<tr>
<td>IOUT</td>
<td>VREFOUT Output Current</td>
<td>VIN=3.3V</td>
<td>20</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>ΔVREFOUT/ΔVin</td>
<td>VREFOUT Line Regulation</td>
<td>2.5V ≤ VIN ≤ 5.5V</td>
<td>2</td>
<td>6</td>
<td>mV</td>
<td></td>
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<tr>
<td>ΔVREFOUT/ΔIOUT</td>
<td>VREFOUT Load Regulation</td>
<td>IOUT=1mA</td>
<td>6</td>
<td>12</td>
<td>mV</td>
<td></td>
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<tr>
<td>IILM</td>
<td>VREFOUT Short Current Limit</td>
<td>VIN=3.3V, VREFOUT=0V</td>
<td>25</td>
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<td>mA</td>
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<tr>
<td>ΔVREFOUT/ΔT</td>
<td>VREFOUT Voltage Temperature Coefficient</td>
<td>−40°C ≤ Topt ≤ 85°C</td>
<td>±150</td>
<td>ppm/°C</td>
<td></td>
<td></td>
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<tr>
<td>VFB1</td>
<td>VFB1 Voltage</td>
<td>VIN=3.3V</td>
<td>0.985</td>
<td>1.000</td>
<td>1.015</td>
<td>V</td>
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<tr>
<td>ΔVFB1/ΔT</td>
<td>VFB1 Voltage Temperature Coefficient</td>
<td>−40°C ≤ Topt ≤ 85°C</td>
<td>±150</td>
<td>ppm/°C</td>
<td></td>
<td></td>
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<tr>
<td>IIFB1,2</td>
<td>IIFB1,2 Input Current</td>
<td>VIN=5.5V, VFB1 or VFB2=0V or 5.5V</td>
<td>−0.1</td>
<td>0.1</td>
<td>μA</td>
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<td>fosc</td>
<td>Oscillator Frequency</td>
<td>EXT1,2 Pins at no load, VIN=3.3V</td>
<td>595</td>
<td>700</td>
<td>805</td>
<td>kHz</td>
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<td>IDDl</td>
<td>Supply Current</td>
<td>VIN=5.5V, EXT1,2 pins at no load</td>
<td>1.4</td>
<td>3.0</td>
<td>mA</td>
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<td>MaxDly</td>
<td>Maximum Duty Cycle</td>
<td>VIN=3.3V, CDTC1,2=1000pF</td>
<td>84</td>
<td>90</td>
<td>95</td>
<td>%</td>
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<tr>
<td>REXTH1</td>
<td>EXT1 &quot;H&quot; ON Resistance</td>
<td>VIN=3.3V, IEXT=−20mA</td>
<td>4.0</td>
<td>8.0</td>
<td>Ω</td>
<td></td>
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<tr>
<td>REXTL1</td>
<td>EXT1 &quot;L&quot; ON Resistance</td>
<td>VIN=3.3V, IEXT=20mA</td>
<td>2.7</td>
<td>5.0</td>
<td>Ω</td>
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<tr>
<td>REXTH2</td>
<td>EXT2 &quot;H&quot; ON Resistance</td>
<td>VIN=3.3V, IEXT=−20mA</td>
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<td>8.0</td>
<td>Ω</td>
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<td>REXTL2</td>
<td>EXT2 &quot;L&quot; ON Resistance</td>
<td>VIN=3.3V, IEXT=20mA</td>
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<td>8.0</td>
<td>Ω</td>
<td></td>
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<td>TDLY</td>
<td>Delay Time for Protection</td>
<td>VIN=3.3V, VFB1=1.1V→0V</td>
<td>60</td>
<td>100</td>
<td>140</td>
<td>ms</td>
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<tr>
<td>TSS1</td>
<td>Soft Start Time1 for Ch1</td>
<td>VIN=3.3V, CDTC1=0.33μF</td>
<td>10</td>
<td></td>
<td></td>
<td>ms</td>
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<td>TSS2</td>
<td>Soft Start Time2 for Ch2</td>
<td>VIN=3.3V, CDTC2=0.33μF</td>
<td>15</td>
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<td>ms</td>
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<td>VCEH</td>
<td>CE &quot;H&quot; Input Voltage</td>
<td>VIN=5.5V</td>
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<td></td>
<td>V</td>
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<td>VCEL</td>
<td>CE &quot;L&quot; Input Voltage</td>
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<td>V</td>
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<td>UVLO</td>
<td>UVLO Detector Threshold</td>
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<td>2.20</td>
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<td>V</td>
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<td>UVLO+0.10</td>
<td>UVLO Released Voltage</td>
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<td>2.45</td>
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<td>V</td>
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<td>ICEH</td>
<td>CE &quot;H&quot; Input Current</td>
<td>VIN= VCE=5.5V</td>
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<td>ICSEL</td>
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<td>VIN=5.5V, VCE=0.0V</td>
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<td>0.1</td>
<td>μA</td>
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<tr>
<td>ISTB</td>
<td>Standby Current</td>
<td>VIN=5.5V, VCE=0.0V</td>
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<td>2</td>
<td>μA</td>
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<tr>
<td>VOFF2</td>
<td>Input Offset Voltage of Ch2.</td>
<td>VIN=3.3V</td>
<td>−12</td>
<td>12</td>
<td>mV</td>
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*Limited Product*
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<tr>
<th>Symbol</th>
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<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
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<tr>
<td>V&lt;sub&gt;In&lt;/sub&gt;</td>
<td>Operating Input Voltage</td>
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<td>2.5</td>
<td>5.5</td>
<td></td>
<td>V</td>
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<tr>
<td>V&lt;sub&gt;VREFOUT&lt;/sub&gt;</td>
<td>VREFOUT Voltage Tolerance</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V, I&lt;sub&gt;OUT&lt;/sub&gt;=1mA</td>
<td>1.478</td>
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<td>1.522</td>
<td>V</td>
</tr>
<tr>
<td>I&lt;sub&gt;OUT&lt;/sub&gt;</td>
<td>VREFOUT Output Current</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>20</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>ΔV&lt;sub&gt;VREFOUT&lt;/sub&gt;/ΔV&lt;sub&gt;In&lt;/sub&gt;</td>
<td>VREFOUT Line Regulation</td>
<td>2.5V ≤ V&lt;sub&gt;In&lt;/sub&gt; ≤ 5.5V</td>
<td>2</td>
<td>6</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>ΔV&lt;sub&gt;VREFOUT&lt;/sub&gt;/ΔI&lt;sub&gt;OUT&lt;/sub&gt;</td>
<td>VREFOUT Load Regulation</td>
<td>1mA ≤ I&lt;sub&gt;OUT&lt;/sub&gt; ≤ 10mA V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>6</td>
<td>12</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>I&lt;sub&gt;LIM&lt;/sub&gt;</td>
<td>VREFOUT Short Current Limit</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V, V&lt;sub&gt;VREFOUT&lt;/sub&gt;=0V</td>
<td>25</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>ΔV&lt;sub&gt;VREFOUT&lt;/sub&gt;/ΔT</td>
<td>VREFOUT Voltage Temperature Coefficient</td>
<td>−40°C ≤ Topt ≤ 85°C</td>
<td>±150</td>
<td></td>
<td></td>
<td>ppm/°C</td>
</tr>
<tr>
<td>V&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;&lt;/sub&gt;</td>
<td>VFB1 Voltage</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>0.985</td>
<td>1.000</td>
<td>1.015</td>
<td>V</td>
</tr>
<tr>
<td>ΔV&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;&lt;/sub&gt;/ΔT</td>
<td>VFB1 Voltage Temperature Coefficient</td>
<td>−40°C ≤ Topt ≤ 85°C</td>
<td>±150</td>
<td></td>
<td></td>
<td>ppm/°C</td>
</tr>
<tr>
<td>I&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;&lt;/sub&gt;</td>
<td>I&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;1&lt;/sub&gt; Input Current</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=5.5V, V&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;&lt;/sub&gt; or V&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;2&lt;/sub&gt;=0V or 5.5V</td>
<td>−0.1</td>
<td>0.1</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>f&lt;sub&gt;OSC&lt;/sub&gt;</td>
<td>Oscillator Frequency</td>
<td>EXT1,2 Pins at no load, V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>160</td>
<td>200</td>
<td>240</td>
<td>kHz</td>
</tr>
<tr>
<td>I&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>Supply Current</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=5.5V, EXT1,2 pins at no load</td>
<td>0.7</td>
<td>1.2</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>R&lt;sub&gt;EXT&lt;/sub&gt;H1</td>
<td>EXT1 &quot;H&quot; ON Resistance</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V, I&lt;sub&gt;EXT&lt;/sub&gt;=−20mA</td>
<td>4.0</td>
<td>8.0</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>R&lt;sub&gt;EXT&lt;/sub&gt;L1</td>
<td>EXT1 &quot;L&quot; ON Resistance</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V, I&lt;sub&gt;EXT&lt;/sub&gt;=20mA</td>
<td>2.7</td>
<td>5.0</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>R&lt;sub&gt;EXT&lt;/sub&gt;H2</td>
<td>EXT2 &quot;H&quot; ON Resistance</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V, I&lt;sub&gt;EXT&lt;/sub&gt;=−20mA</td>
<td>4.0</td>
<td>8.0</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>R&lt;sub&gt;EXT&lt;/sub&gt;L2</td>
<td>EXT2 &quot;L&quot; ON Resistance</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V, I&lt;sub&gt;EXT&lt;/sub&gt;=20mA</td>
<td>3.7</td>
<td>8.0</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>T&lt;sub&gt;DLY&lt;/sub&gt;</td>
<td>Delay Time for Protection</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V, V&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;&lt;/sub&gt;=1.1V→0V</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>ms</td>
</tr>
<tr>
<td>V&lt;sub&gt;UVLO&lt;/sub&gt;</td>
<td>UVLO Detector Threshold</td>
<td></td>
<td>2.10</td>
<td>2.20</td>
<td>2.35</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;UVLO&lt;/sub&gt;</td>
<td>UVLO Released Voltage</td>
<td>V&lt;sub&gt;UVLO&lt;/sub&gt;+0.10</td>
<td>2.45</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;DTC1&lt;/sub&gt;0</td>
<td>CH1 Duty 0%</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>0.15</td>
<td>0.25</td>
<td>0.35</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;DTC1&lt;/sub&gt;100</td>
<td>CH1 Duty 100%</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;DTC2&lt;/sub&gt;0</td>
<td>CH2 Duty 0%</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>0.15</td>
<td>0.25</td>
<td>0.35</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;DTC2&lt;/sub&gt;100</td>
<td>CH2 Duty 100%</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
<td>V</td>
</tr>
<tr>
<td>A&lt;sub&gt;V1&lt;/sub&gt;</td>
<td>CH1 Open Loop Gain</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>110</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F&lt;sub&gt;T1&lt;/sub&gt;</td>
<td>CH1 Single Gain Frequency Band</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V, A&lt;sub&gt;V1&lt;/sub&gt;=0dB</td>
<td>1.9</td>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>V&lt;sub&gt;ICR1&lt;/sub&gt;</td>
<td>CH1 Input Voltage Range</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>0.7 to V&lt;sub&gt;In&lt;/sub&gt;</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>I&lt;sub&gt;AMPL&lt;/sub&gt;</td>
<td>CH1 Sink Current</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V, V&lt;sub&gt;AMPOUT&lt;/sub&gt;=1.0V, V&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;&lt;/sub&gt;=V&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;1&lt;/sub&gt;+0.1V</td>
<td>70</td>
<td>115</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>I&lt;sub&gt;AMPH&lt;/sub&gt;</td>
<td>CH1 Source Current</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V, V&lt;sub&gt;AMPOUT&lt;/sub&gt;=1.0V, V&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;&lt;/sub&gt;=V&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;1&lt;/sub&gt;−0.1V</td>
<td>−1.4</td>
<td>−0.7</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>A&lt;sub&gt;V2&lt;/sub&gt;</td>
<td>CH2 Open Loop Gain</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>60</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>F&lt;sub&gt;T1&lt;/sub&gt;</td>
<td>CH2 Single Gain Frequency Band</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V, A&lt;sub&gt;V2&lt;/sub&gt;=0dB</td>
<td>3</td>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>V&lt;sub&gt;ICR2&lt;/sub&gt;</td>
<td>CH2 Input Voltage Range</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>−0.2 to V&lt;sub&gt;In&lt;/sub&gt;−1.3</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;F&lt;sub&gt;B&lt;/sub&gt;&lt;/sub&gt;2</td>
<td>CH2 Input Offset Voltage</td>
<td>V&lt;sub&gt;In&lt;/sub&gt;=3.3V</td>
<td>−12</td>
<td>12</td>
<td></td>
<td>mV</td>
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</tbody>
</table>
Operation of Step-up DC/DC Converter and Output Current

Step-up DC/DC Converter makes higher output voltage than input voltage by releasing the energy accumulated during on time of Lx Transistor on input voltage.

Step 1. Lx Tr. is on, then the current $I_L=i_1$ flows, and the energy is charged in L. In proportion to the on time of Lx Tr. ($T_{on}$), $I_L=i_1$ increases from $I_L=I_{Lx\min}=0$ and reaches $I_{Lx\max}$.

Step 2. When the Lx Tr. is off, L turns on Schottky Diode (SD), and $I_L=i_2$ flows to maintain $I_L=I_{Lx\max}$.

Step 3. $I_L=i_2$ gradually decreases, and after $T_f$ passes, $I_L=I_{Lx\min}=0$ is true, then SD turns off. Note that in the case of the continuous mode, before $I_L=I_{Lx\min}=0$ is true, $T_{off}$ passes, and the next cycle starts, then Lx Tr. turns on again.

In this case, $I_{Lx\min}>0$, therefore $I_L=I_{Lx\min}>0$ is another starting point and $I_{Lx\max}$ increases.

With the PWM controller, switching times during the time unit are fixed. By controlling $T_{on}$, output voltage is maintained.
Output Current and Selection of External Components

Output Current of Step-up Circuit and External Components

There are two modes, or discontinuous mode and continuous mode for the PWM step-up switching regulator depending on the continuous characteristic of inductor current.

During on time of the transistor, when the voltage added on to the inductor is described as $V_{IN}$, the current is $V_{IN} \times t/L$.

Therefore, the electric power, $P_{ON}$, which is supplied with input side, can be described as in next formula.

$$P_{ON} = \int_{0}^{Ton} V_{IN}^2 \times t/L \, dt$$

............................................................................................................ Formula 1

With the step-up circuit, electric power is supplied from power source also during off time. In this case, input current is described as $(V_{OUT} - V_{IN}) \times t/L$, therefore electric power, $P_{OFF}$ is described as in next formula.

$$P_{OFF} = \int_{0}^{Tf} V_{IN} \times (V_{OUT} - V_{IN}) t/L \, dt$$

....................................................................................... Formula 2

In this formula, $Tf$ means the time of which the energy saved in the inductance is being emitted. Thus average electric power, $P_{AV}$ is described as in the next formula.

$$P_{AV} = \frac{1}{(Ton + Toff)} \times \left\{ \int_{0}^{Ton} V_{IN}^2 \times t/L \, dt + \int_{0}^{Tf} V_{IN} \times (V_{OUT} - V_{IN}) t/L \, dt \right\}$$

.................................................................................... Formula 3

In PWM control, when $Tf = Toff$ is true, the inductor current becomes continuous, then the operation of switching regulator becomes continuous mode.

In the continuous mode, the deviation of the current is equal between on time and off time.

$$V_{IN} \times Ton/L = (V_{OUT} - V_{IN}) \times Toff/L$$

............................................................................................. Formula 4

Further, the electric power, $P_{AV}$ is equal to output electric power, $V_{OUT} \times I_{OUT}$, thus,

$$I_{OUT} = \frac{f_{OSC} \times V_{IN}^2 \times Ton^2 / (2 \times L \times (V_{OUT} - V_{IN})) \times V_{IN} \times Toff / (V_{OUT})}{2 \times L \times V_{OUT}}$$

............................................................................. Formula 5

When $I_{OUT}$ becomes more than $V_{IN} \times Ton \times Toff / (2 \times L \times (Ton + Toff))$, the current flows through the inductor, then the mode becomes continuous. The continuous current through the inductor is described as $I_{const}$, then,

$$I_{OUT} = \frac{f_{OSC} \times V_{IN}^2 \times Ton^2 / (2 \times L \times (V_{OUT} - V_{IN})) + V_{IN} \times I_{const} / V_{OUT}}{2 \times L \times V_{OUT}}$$

............................................................................. Formula 6
In this moment, the peak current, $I_{L\text{Xmax}}$ flowing through the inductor and the driver $T_r$ is described as follows:

$$I_{L\text{Xmax}} = I_{\text{const}} + V_{IN} \times T_{on}/L \quad \text{.................................Formula 7}$$

With the formula 4, 6, and $I_{L\text{Xmax}}$ is,

$$I_{L\text{Xmax}} = V_{OUT}/V_{IN} \times I_{OUT} + V_{IN} \times T_{on}/(2 \times L) \quad \text{.................................Formula 8}$$

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

In the formula 7, peak current $I_{L\text{Xmax}}$ at discontinuous mode can be calculated. Put $I_{\text{const}} = 0$ in the formula.

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 $I_{LX}$ is large, or $V_{IN}$ is low, the loss of $V_{IN}$ is generated with the 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

Inverting DC/DC converter saves energy during on time of Lx transistor, and supplies the energy to output during off time, output voltage opposed to input voltage is obtained.

Step 1. Lx Tr. turns on, current, IL=i1 flows, energy is charged in L. In proportion to the on time, Ton, of Lx Tr. IL=i1 increases from IL=ILxmin=0 and reaches ILxmax.

Step 2. When the Lx Tr. turns off, L turns on Shottky diode (SD) and flow IL=i2 to maintain IL = ILxmax.

Step 3. IL=i2 decreases gradually, after Tf passes, IL=ILxmin=0 is true, then SD turns off. Note that in the case of continuous mode, before IL=ILxmin=0 is true, Toff passes and next cycle starts, then Lx Tr. turns on. In this case, ILxmin>0, therefore IL increases from IL=ILxmin>0.

With the PWM controller, switching time (fosc) in the time unit is fixed, and by controlling Ton, output voltage is maintained.
Output Current and Selection of External Components

There are also two modes, or discontinuous mode and continuous mode for the PWM inverting switching regulator depending on the continuous characteristic of inductor current.

During on time of the transistor, when the voltage added on to the inductor is described as $V_{IN}$, the current is $V_{IN} \times t/L$.

Therefore, the electric power, $P$, which is supplied with input side, can be described as in next formula.

$$ P = \int_0^{Ton} V_{IN}^2 \times t/L \, dt \quad \text{...................................................Formula 9} $$

Thus average electric power in one cycle, $P_{AV}$ is described as in the next formula.

$$ P_{AV} = \frac{1}{(Ton + Toff)} \times \int_0^{Ton} V_{IN}^2 \times t/L \, dt = \frac{V_{IN}^2 \times Ton^2}{(2 \times L \times (Ton + Toff))} \quad \text{........................Formula 10} $$

This electric power $P_{AV}$ equals to output electric power $V_{OUT} \times I_{OUT}$, thus,

$$ I_{OUT} = f_{OSC} \times \frac{V_{IN}^2 \times Ton^2}{(2 \times L \times V_{OUT})} \quad \text{...................................................Formula 11} $$

When $I_{OUT}$ becomes more than $V_{IN} \times Ton \times Toff/(2 \times L \times (Ton + Toff))$, the current flows through the inductor continuously, then the mode becomes continuous. In the continuous mode, the deviation of the current equals between $Ton$ and $Toff$, therefore,

$$ V_{IN} \times Ton/L = V_{OUT} \times Toff/L \quad \text{...................................................Formula 12} $$

In this moment, the current flowing continuously through $L$, is assumed as $I_{const}$, $I_{OUT}$ is described as in the next formula:

$$ I_{OUT} = f_{OSC} \times \frac{V_{IN}^2 \times Ton^2}{(2 \times L \times V_{OUT})} + \frac{Ton/(Ton + Toff)}{V_{IN} \times I_{const} / V_{OUT}} \quad \text{........................................Formula 13} $$

In this moment, the peak current, $IL_{x\text{max}}$ flowing through the inductor and the driver $Tr.$ is described as follows:

$$ IL_{x\text{max}} = I_{const} + V_{IN} \times Ton/L \quad \text{...................................................Formula 14} $$

With the formula 12,13, $IL_{x\text{max}}$ is,

$$ IL_{x\text{max}} = (Ton + Toff)/Toff \times I_{OUT} + V_{IN} \times Ton/(2 \times L) \quad \text{...................................................Formula 15} $$

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

In the formula 14, peak current $IL_{x\text{max}}$ at discontinuous mode can be calculated. Put $I_{const}=0$ in the formula.

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 $IL_{x}$ is large, or $V_{IN}$ is low, the loss of $V_{IN}$ is generated with the on resistance of the switch. As for $V_{OUT}$, $Vf$ (as much as 0.3V) of the diode should be considered.
TEST CIRCUITS

Test Circuit 1

Test Circuit 2

Test Circuit 3

Test Circuit 4

Test Circuit 5

Test Circuit 6
Typical Characteristics shown in the following pages are obtained with test circuits shown above.

- **R1280D002A/C**
  - Test Circuit 1,2 : Typical Characteristic 4)
  - Test Circuit 3 : Typical Characteristic 6)
  - Test Circuit 4 : Typical Characteristic 7)
  - Test Circuit 5 : Typical Characteristic 8)
  - Test Circuit 6 : Typical Characteristics 9) 10)
  - Test Circuit 7 : Typical Characteristic 11)
  - Test Circuit 8 : Typical Characteristic 12)
  - Test Circuit 9 : Typical Characteristics 13) 14)

- **R1280D002B**
  - Test Circuit 10,11 : Typical Characteristics 4) 5)
  - Test Circuit 12 : Typical Characteristic 6)
  - Test Circuit 13 : Typical Characteristic 7)
  - Test Circuit 14 : Typical Characteristic 8)
  - Test Circuit 15 : Typical Characteristics 9) 10)
  - Test Circuit 16 : Typical Characteristic 11)
  - Test Circuit 17 : Typical Characteristics 15) 16)
  - Test Circuit 18 : Typical Characteristics 17) 18)

  Standard Circuit Example: Typical Characteristics 1) 2) 3) 19) 20)

Note) Capacitors' values of test circuits

  Capacitors: Ceramic Type:
  - C1=4.7µF, C2=1.0µF, C3=C4=1000pF

Efficiency η(%) can be calculated with the next formula:

\[
\eta = \frac{(V_{OUT1} \times I_{OUT1} + V_{OUT2} \times I_{OUT2})}{(V_{IN} \times I_{IN})} \times 100
\]
TYPICAL CHARACTERISTICS

1) Output Voltage vs. Output Current

- **R1280D002A**
  - $T_{opt}=25^\circ C$, $L_1=6.8\mu H$, $C_1=10\mu F$
  - $V_{OUT2}=-10V$, $I_{OUT2}=0mA$

- **R1280D002B**
  - $T_{opt}=25^\circ C$, $L_2=6.8\mu H$, $C_2=10\mu F$
  - $V_{OUT2}=-10V$, $I_{OUT2}=0mA$

- **R1280D002C**
  - $L_1=22\mu H$, $C_1=10\mu F$
  - $V_{OUT2}=-10V$, $I_{OUT2}=0mA$

- **R1280D002A**
  - $T_{opt}=25^\circ C$, $L_2=6.8\mu H$, $C_2=10\mu F$
  - $V_{OUT1}=10V$, $I_{OUT1}=0mA$

- **R1280D002B**
  - $T_{opt}=25^\circ C$, $L_2=6.8\mu H$, $C_2=10\mu F$
  - $V_{OUT1}=10V$, $I_{OUT1}=0mA$

- **R1280D002C**
  - $L_2=22\mu H$, $C_2=10\mu F$
  - $V_{OUT1}=10V$, $I_{OUT1}=0mA$

Limited Product
2) Efficiency vs. Output Current

**R1280D002A**

- **VIN=3.3V, Topt=25 C, L1=6.8μH**
- **C1=10μF, VOUT2=-VOUT1, IOUT2=0mA**

**R1280D002B**

- **VIN=3.3V, Topt=25 C, L1=6.8μH**
- **C1=10μF, VOUT2=-VOUT1, IOUT2=0mA**

**R1280D002C**

- **VIN=3.3V, Topt=25 C, L1=22μH**
- **C1=10μF, VOUT2=-VOUT1, IOUT2=0mA**
3) Output Voltage vs. Temperature

**R1280D002A**

- **VIN=3.3V, L1=6.8μH, C1=10μF**
- Output Voltage VOUT1(V)
- Temperature Topt(°C)

<table>
<thead>
<tr>
<th>Temperature Topt(°C)</th>
<th>Output Voltage VOUT1(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-60</td>
<td>11.0</td>
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<tr>
<td>-40</td>
<td>10.5</td>
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<tr>
<td>20</td>
<td>10.0</td>
</tr>
<tr>
<td>60</td>
<td>9.5</td>
</tr>
<tr>
<td>100</td>
<td>9.0</td>
</tr>
</tbody>
</table>

- IOUT=10mA
- IOUT=100mA

**R1280D002A**

- **VIN=3.3V, L2=6.8μH, C2=10μF**
- Output Voltage VOUT2(V)
- Temperature Topt(°C)

<table>
<thead>
<tr>
<th>Temperature Topt(°C)</th>
<th>Output Voltage VOUT2(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-60</td>
<td>10.0</td>
</tr>
<tr>
<td>-40</td>
<td>9.5</td>
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<tr>
<td>20</td>
<td>9.0</td>
</tr>
<tr>
<td>60</td>
<td>8.5</td>
</tr>
<tr>
<td>100</td>
<td>8.0</td>
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</table>

- IOUT=-10mA

**R1280D002B**

- **VIN=3.3V, L1=6.8μH, C1=10μF**
- Output Voltage VOUT1(V)
- Temperature Topt(°C)

<table>
<thead>
<tr>
<th>Temperature Topt(°C)</th>
<th>Output Voltage VOUT1(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-60</td>
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<tr>
<td>-40</td>
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<td>20</td>
<td>10.0</td>
</tr>
<tr>
<td>60</td>
<td>9.5</td>
</tr>
<tr>
<td>100</td>
<td>9.0</td>
</tr>
</tbody>
</table>

- IOUT=10mA
- IOUT=100mA

**R1280D002B**

- **VIN=3.3V, L2=6.8μH, C2=10μF**
- Output Voltage VOUT2(V)
- Temperature Topt(°C)

<table>
<thead>
<tr>
<th>Temperature Topt(°C)</th>
<th>Output Voltage VOUT2(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-60</td>
<td>10.0</td>
</tr>
<tr>
<td>-40</td>
<td>9.5</td>
</tr>
<tr>
<td>20</td>
<td>9.0</td>
</tr>
<tr>
<td>60</td>
<td>8.5</td>
</tr>
<tr>
<td>100</td>
<td>8.0</td>
</tr>
</tbody>
</table>

- IOUT=-10mA

**R1280D002C**

- **VIN=3.3V, L1=22μH, C1=10μF**
- Output Voltage VOUT1(V)
- Temperature Topt(°C)

<table>
<thead>
<tr>
<th>Temperature Topt(°C)</th>
<th>Output Voltage VOUT1(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-60</td>
<td>11.0</td>
</tr>
<tr>
<td>-40</td>
<td>10.5</td>
</tr>
<tr>
<td>20</td>
<td>10.0</td>
</tr>
<tr>
<td>60</td>
<td>9.5</td>
</tr>
<tr>
<td>100</td>
<td>9.0</td>
</tr>
</tbody>
</table>

- IOUT=10mA
- IOUT=100mA

**R1280D002C**

- **VIN=3.3V, L2=22μH, C2=10μF**
- Output Voltage VOUT2(V)
- Temperature Topt(°C)

<table>
<thead>
<tr>
<th>Temperature Topt(°C)</th>
<th>Output Voltage VOUT2(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-60</td>
<td>10.0</td>
</tr>
<tr>
<td>-40</td>
<td>9.5</td>
</tr>
<tr>
<td>20</td>
<td>9.0</td>
</tr>
<tr>
<td>60</td>
<td>8.5</td>
</tr>
<tr>
<td>100</td>
<td>8.0</td>
</tr>
</tbody>
</table>

- IOUT=-10mA
4) Frequency vs. Temperature

5) Maximum Duty Cycle vs. Temperature
6) Feedback Voltage vs. Temperature

R1280D002A/B/C

7) Input Offset Voltage vs. Temperature

R1280D002A/B/C

8) Vrefout Output Voltage vs. Temperature

R1280D002A/B/C

9) Vrefout Output Voltage vs. Output Current

R1280D002A/B/C

10) Vrefout Output Voltage vs. Output Current

R1280D002A/B/C

11) Protection Circuit Delay Time vs. Temperature

R1280D002A/B/C
12) Duty Cycle vs. DTC Voltage

\begin{align*}
\text{R1280D002A} & \quad \text{VIN=3.3V, EXT=1000pF} \\
\text{R1280D002C} & \quad \text{VIN=3.3V, EXT=1000pF}
\end{align*}

13) Output Sink Current vs. Temperature

\begin{align*}
\text{R1280D002A/C} & \quad \text{VIN=3.3V} \\
\text{R1280D002A/C} & \quad \text{VIN=3.3V}
\end{align*}

14) Output Source Current vs. Temperature

\begin{align*}
\text{R1280D002A/C} & \quad \text{VIN=3.3V} \\
\text{R1280D002A/C} & \quad \text{VIN=3.3V}
\end{align*}

15) CE "H" Input Voltage vs. Temperature

\begin{align*}
\text{R1280D002B} & \quad \text{VIN=5.5V} \\
\text{R1280D002B} & \quad \text{VIN=2.5V}
\end{align*}

16) CE "L" Input Voltage vs. Temperature
17) Soft Starting Time vs. Capacitance value

18) Soft Starting Time vs. Temperature

19) Load Transient Response (Step-up Side)
20) Load Transient Response (Inverting Side)
TYPICAL APPLICATION AND TECHNICAL NOTES

- R1280D002A/C

External Components
Inductor L1,2: 6.8μH, LDR655312T (TDK) for A type, 22μH for C type
Diode: FS1J3 (Origin Electronics)
NMOS: IRF7601 (International Rectifier)
PMOS: Si3443DV (Siliconix)
Resistors: R1, R2, R3, and R4 are for Setting Output Voltage. Recommendation values are
R1+R2≤100kΩ or R3+R4≤100kΩ
R5=43kΩ, R6=10kΩ, R7=R9=22kΩ, R8=R10=43kΩ, R11=220kΩ
Capacitors: Ceramic Capacitor

Example:
R1280D002A: C1=C2=10μF, C3=4.7 F, C4=0.22μF, C5=0.47μF, C6=120pF, C7=50pF,
C8=1μF, C9=1000pF
R1280D002C: C1=C2=10 F, C3=4.7μF, C4=0.22μF, C5=0.47μF, C6=220pF, C7=330pF,
C8=1μF, C9=1000pF

Note: Maximum voltage tolerance of each component should be considered. With the transistor
shown above is appropriate to set up to ±15V as output voltage.
External Components

Inductor L1,2: 6.8μH, LDR655312T (TDK)
Diode: FS1J3 (Origin Electronics)
NMOS: IRF7601 (International Rectifier)
PMOS: Si3443DV (Siliconix)
Resistors: R1, R2, R3, and R4 are for Setting Output Voltage. Recommendation values are R1+R2≤100kΩ or R3+R4≤100kΩ
R5=43kΩ, R6=10kΩ
Capacitors: Ceramic Capacitor
(Example)
C1=C2=10μF, C3=4.7μF, C4=0.33μF, C5=0.33μF, C6=120pF, C7=50pF, C8=1μF

Note: Maximum voltage tolerance of each component should be considered. With the transistor shown above is appropriate to set up to ±15V as output voltage.
APPLICATION EXAMPLE

• R1280D002A/C

External Components
- Inductor L1,2: 6.8μH, LDR655312T (TDK) for A version, 22μH for R1280D002C
- Diode: FS1J3 (Origin Electronics)
- NMOS: IRF7601 (International Rectifier)
- PMOS: Si3443DV (Siliconix)
- Resistors: R1, R2, R3, and R4 are for Setting Output Voltage. Recommendation values are R1+R2≤100kΩ or R3+R4≤100kΩ, R5=43kΩ, R6=10kΩ, R7=R9=22kΩ, R8=R10=43kΩ, R11=220kΩ
- Capacitors: Ceramic Capacitor

R1280D002A: C1=C2=10μF, C3=4.7μF, C4=0.22μF, C5=0.47μF, C6=120pF, C7=50pF, C8=C10=C11=1μF, C9=1000pF
R1280D002C: C1=C2=10μF, C3=4.7μF, C4=0.22μF, C5=0.47μF, C6=220pF, C7=330pF, C8=C10=C11=1μF, C9=1000pF

This IC can be used 3 Output TFT Bias Circuit as shown above. \( V_{OUT3} = 2 \times V_{OUT1} - V_F \)

Note: Maximum voltage tolerance of each component should be considered. With the transistor shown above is appropriate to set up to +15V as \( V_{OUT1} \), -15V as \( V_{OUT2} \), 30V as \( V_{OUT3} \).
R1280D002B

External Components
- Inductor L1,2: 6.8μH, LDR655312T (TDK)
- Diode: FS1J3 (Origin Electronics)
- NMOS: IRF7601 (International Rectifier)
- PMOS: Si3443DV (Siliconix)
- Resistors: R1, R2, R3, and R4 are for Setting Output Voltage. Recommendation values are R1+R2 100kΩ or R3+R4 100kΩ, R5=43kΩ, R6=10kΩ.
- Capacitors: Ceramic Capacitor

R1280D002B: C1=C2=10μF, C3=4.7μF, C4=0.22μF, C5=0.33μF, C6=120pF, C7=50pF, C8=C10=C11=1μF

This IC can be used 3 Output TFT Bias Circuit as shown above. VOUT3=2xVOUT1-Vf

Note: Maximum voltage tolerance of each component should be considered. The transistor shown above is appropriate to set up to +15V as VOUT1, -15V as VOUT2, 30V as VOUT3
Components examples
Inductor L: 6.8μH LDR655312T (TDK) (R1280D002C: 22μH)
Diode: FS1J3 (Origin Electronics)
PMOS: SI3443DV (Siliconix)
Resistance: As setting resistors total value for the output voltage, R1+R2 should be 100kΩ or less.
R1=10kΩ R2=68kΩ R3=10kΩ R4=22kΩ
R5=43kΩ R6=1kΩ
*In the circuit above, output, V_{OUT}=-10V
Capacitors Ceramic Type
R1280D002A Ex.)
C1=4.7μF C2=10μF C3=1μF C4=0.47μF C5=50pF
R1280D002C Ex.)
C1=4.7μF C2=10μF C3=1μF C4=0.47μF C5=330pF
As for R1280D002B, when DTC1 is OPEN and V_{FB1}=V_{DD}, then the R1280D002B can be used as an inverting controller without step-up channel.

Note: Consider the ratings of external components including voltage tolerance. With the transistor in the circuit above, V_{OUT}=-15V is the voltage setting limit.

If this IC is used as an inverting controller without step-up channel, V_{refout} pin and V_{FB1}, DTC1 pin should not connect one another. Both the direct connection and via resistor are not permitted.
EXTERNAL COMPONENTS

1. How to set the output voltages

As for step-up side, feedback (VFB1) pin voltage is controlled to maintain 1V, therefore,

\[ V_{OUT1} = R1 + R2 = V_{FB1} \times R2 \]

Thus, \[ V_{OUT1} = V_{FB1} \times (R1 + R2)/R2 \]

Output Voltage is adjustable with R1 and R2.

As for inverting side, Feedback (VFB2) pin voltage is controlled to maintain 0V, therefore,

\[ V_{refout} = R3 = |V_{OUT2}| \times R4 \]

Thus, \[ |V_{OUT2}| = V_{refout} \times R4/R3 \]

Output Voltage is adjustable with R3 and R4.

2. How to set Soft-Start Time

As for R1280D002B, soft-start time is adjustable with connecting a capacitor to DTC pin.

Soft starting time, TSS1 and TSS2 are adjustable. Soft-start time can be set with the time constant of RC.

Soft-start time can be described as in next formula. (Topt=25°C)

\[ T_{SS1} = R_S1 \times C_4, \ T_{SS2} = R_S2 \times C_5 \]

In the above formulas, RS1 value is Typ. 32kΩ, while RS2 value is Typ. 45kΩ. Tolerance of these values is ±25% caused by dispersion of wafer process parameters.

On the other hand, as for R1280D002A/C, each soft-start time is set with the time constant of each external resistor and capacitor shown as in the next formula.

\[ T_{SS1} = R_O1 \times C_4, \ T_{SS2} = R_O2 \times C_5 \]

In the above formula, \[ R_O1 = (R7 \times R8)/(R7 + R8), \ R_O2 = (R9 \times R10)/(R9 + R10) \]
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