XC9502 Series

2ch. Step-Up/Down DC/DC Controller ICs

GENERAL DESCRIPTION

XC9502 series is PWM controlled, PWM/PFM automatic switching controlled, multi-functional, 2 channel step-up and down DC/DC controller ICs. With 0.9V of standard voltage supply internal, and using externally connected components, the output 1 voltage (step-up DC/DC controller) can be set freely within a range of 1.5V to 30V. Since the output 2 (step-down DC/DC controller) has a built-in 0.9V reference voltage (accuracy ±2%), 0.9V to 6.0V can be set using external components. With a 180kHz frequency, the size of the external components can be reduced. Switching frequencies of 300kHz and 500kHz are also available as custom-designed products. The control of the XC9502 series can be switched between PWM control and PWM/PFM automatic switching control using external signals. Control switches from PWM to PFM during light loads when automatic switching is selected and the series is highly efficient from light loads through to large output currents. Noise is easily reduced with PWM control since the frequency is fixed. The series gives freedom of control selection so that control suited to the application can be selected. Soft-start time is internally set to 10msec (Output1) and offers protection against in-rush currents when the power is switched. This also prevents voltage overshoot.

APPLICATIONS

- PDAs
- Palmtop computers
- Portable audio
- Various power supplies

FEATURES

2ch DC/DC Controller
 OUTPUT 1: Step-Up DC/DC Controller
- Output Voltage Range: 1.5V ~ 30V (set by FB1 pin)
- Output Current: More than 300mA (VIN=1.8V, VOUT=3.3V)
- Maximum Duty Cycle: 80% (TYP.)
- High Efficiency: 83% (TYP.)

OUTPUT 2: Step-Down DC/DC Controller
- Output Voltage Range: 0.9V ~ 6.0V (set by FB2 pin)
- Output Current: 1000mA (VIN=3.3V, VOUT=1.8V)
- Maximum Duty Cycle: 100% (TYP.)
- High Efficiency: 92% (TYP.)

COMMON
- Supply Voltage Range: 2.0V ~ 10.0V
- Input Voltage Range: 0.9V ~ 10.0V
- Oscillation Frequency: 180kHz (±15%)
- * 300kHz, 500kHz custom
- Control Method: PWM or PWM/PFM selectable
- Stand-by Function: 3.0μF (MAX.)
- Soft-Start Time: 10ms (internally set)
- Package: MSOP-10, USP-10
- Environmentally Friendly: EU RoHS Compliant, Pb Free

TYPICAL APPLICATION CIRCUIT

TYPICAL PERFORMANCE CHARACTERISTICS

![Typical Application Circuit](image)

![Typical Performance Characteristics](image)
**XC9502 Series**

### PIN CONFIGURATION

- **MSOP-10** (TOP VIEW)
- **USP-10** (BOTTOM VIEW)

### PIN ASSIGNMENT

<table>
<thead>
<tr>
<th>PIN NUMBER</th>
<th>PIN NAME</th>
<th>FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EXT 1</td>
<td>Channel 1: External Transistor Drive Pin &lt;Connected to N-ch Power MOSFET Gate&gt;</td>
</tr>
<tr>
<td>2</td>
<td>VDD</td>
<td>Supply Voltage</td>
</tr>
<tr>
<td>3</td>
<td>FB1</td>
<td>Channel 1: Output Voltage Monitor Feedback Pin &lt;Threshold value: 0.9V. Output voltage can be set freely by connecting split resistors between VOUT1 and Ground.&gt;</td>
</tr>
<tr>
<td>4</td>
<td>PWM1</td>
<td>Channel 1: PWM/PFM Switching Pin &lt;Control Output 1. PWM control when connected to VDD, PWM / PFM auto switching when connected to Ground.&gt;</td>
</tr>
<tr>
<td>5</td>
<td>EN1</td>
<td>Channel 1: Enable Pin &lt;Connected to Ground when Output 1 is in stand-by mode. Connected to VDD when Output 1 is active. EXT1 is low when in stand-by mode.&gt;</td>
</tr>
<tr>
<td>6</td>
<td>EN2</td>
<td>Channel 2: Enable Pin &lt;Connected to Ground when Output 2 is in stand-by mode. Connected to VDD when Output 2 is active. EXT2 is high when in stand-by mode.&gt;</td>
</tr>
<tr>
<td>7</td>
<td>PWM2</td>
<td>Channel 2: PWM/PFM Switching Pin &lt;Control Output 2. PWM control when connected to VDD, PWM / PFM auto switching when connected to Ground.&gt;</td>
</tr>
<tr>
<td>8</td>
<td>FB2</td>
<td>Channel 2: Output Voltage Monitor Feedback Pin &lt;Threshold value: 0.9V. Output voltage can be set freely by connecting split resistors between VOUT2 and Ground.&gt;</td>
</tr>
<tr>
<td>9</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>10</td>
<td>EXT2/</td>
<td>Channel 2: External Transistor Drive Pin &lt;Connected to P-ch Power MOSFET Gate&gt;</td>
</tr>
</tbody>
</table>

### PRODUCT CLASSIFICATION

#### Ordering Information

**XC9502**

<table>
<thead>
<tr>
<th>DESIGNATOR</th>
<th>ITEM</th>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>Type of DC/DC Controller</td>
<td>B</td>
<td>Standard type (10 pin)</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Output Voltage</td>
<td>09</td>
<td>FB products ☐ ☐ =0, ☐ =9 fixed</td>
</tr>
<tr>
<td>☐</td>
<td>Oscillation Frequency</td>
<td>2</td>
<td>180kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>300kHz (custom)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>500kHz (custom)</td>
</tr>
<tr>
<td>☐ ☐- ☐ (*1)</td>
<td>Packages (Order Unit)</td>
<td>AR</td>
<td>MSOP-10 (1,000/Reel)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AR-G</td>
<td>MSOP-10 (3,000/Reel)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DR</td>
<td>USP-10 (3,000/Reel)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DR-G</td>
<td>USP-10 (3,000/Reel)</td>
</tr>
</tbody>
</table>

(*1) The "-G" suffix indicates that the products are Halogen and Antimony free as well as being fully RoHS compliant.
**BLOCK DIAGRAM**

![Block Diagram](image)

**ABSOLUTE MAXIMUM RATINGS**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>RATINGS</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vdd Pin Voltage</td>
<td>VDD</td>
<td>- 0.3 ~ 12.0</td>
<td>V</td>
</tr>
<tr>
<td>FB1, 2 Pin Voltage</td>
<td>VFB</td>
<td>- 0.3 ~ 12.0</td>
<td>V</td>
</tr>
<tr>
<td>EN1, 2 Pin Voltage</td>
<td>VEN</td>
<td>- 0.3 ~ 12.0</td>
<td>V</td>
</tr>
<tr>
<td>PWM1, 2 Pin Voltage</td>
<td>VPWIM</td>
<td>- 0.3 ~ 12.0</td>
<td>V</td>
</tr>
<tr>
<td>EXT1, 2 Pin Voltage</td>
<td>VEXT</td>
<td>- 0.3 ~ Vdd + 0.3</td>
<td>V</td>
</tr>
<tr>
<td>EXT1, 2 Pin Current</td>
<td>IEXT</td>
<td>± 100</td>
<td>mA</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>Pd</td>
<td>150</td>
<td>mW</td>
</tr>
<tr>
<td>(MSOP-10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(USP-10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>Topr</td>
<td>- 40 ~ + 85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>Tstg</td>
<td>- 55 ~ + 125</td>
<td>°C</td>
</tr>
</tbody>
</table>

* Voltage is all ground standardized.*
### ELECTRICAL CHARACTERISTICS

#### XC9502B092 Common Characteristics

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
<th>CIRCUIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage (*1)</td>
<td>Vdc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Input Voltage</td>
<td>Vin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage Range (*3)</td>
<td>Voutset</td>
<td>Vdc ≥ 2.0V, Iout1, 2=1mA Vout1</td>
<td>0.9</td>
<td></td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vdc ≥ Vout1 Vout2</td>
<td>0.9</td>
<td></td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vin ≥ 0.9V, Iout1, 2=1mA Vout1</td>
<td>2.0</td>
<td></td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vdc ≥ Vout1 Vout2</td>
<td>0.9</td>
<td></td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Supply Current 1</td>
<td>Idd1</td>
<td>FB1, 2=0V</td>
<td>-</td>
<td>70</td>
<td>160</td>
<td>mA</td>
<td>A</td>
</tr>
<tr>
<td>Supply Current 1-1</td>
<td>Idd1-1</td>
<td>EN1=3.0V, EN2=0V, FB1=0V</td>
<td>-</td>
<td>60</td>
<td>120</td>
<td>mA</td>
<td>A</td>
</tr>
<tr>
<td>Supply Current 1-2</td>
<td>Idd1-2</td>
<td>EN2=3.0V, EN1=0V, FB2=0V</td>
<td>-</td>
<td>50</td>
<td>110</td>
<td>mA</td>
<td>A</td>
</tr>
<tr>
<td>Supply Current 1-3</td>
<td>Idd1-3</td>
<td>FB1=0V, FB2=1.0V</td>
<td>-</td>
<td>70</td>
<td>160</td>
<td>mA</td>
<td>A</td>
</tr>
<tr>
<td>Supply Current 1-4</td>
<td>Idd1-4</td>
<td>FB1=1.0V, FB2=0V</td>
<td>-</td>
<td>60</td>
<td>130</td>
<td>mA</td>
<td>A</td>
</tr>
<tr>
<td>Supply Current 2</td>
<td>Idd2</td>
<td>FB1, 2=1.0V</td>
<td>-</td>
<td>60</td>
<td>130</td>
<td>mA</td>
<td>A</td>
</tr>
<tr>
<td>Stand-by Current</td>
<td>Istb</td>
<td>Same as Idd1, EN1=EN2=0V</td>
<td>-</td>
<td>1.0</td>
<td>3.0</td>
<td>mA</td>
<td>A</td>
</tr>
<tr>
<td>Oscillation Frequency</td>
<td>Fosc</td>
<td>Same as Idd1</td>
<td>153</td>
<td>180</td>
<td>207</td>
<td>kHz</td>
<td></td>
</tr>
<tr>
<td>EN1, 2 &quot;High&quot; Voltage</td>
<td>Venh</td>
<td>FB1, 2=0V</td>
<td>0.65</td>
<td></td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>EN1, 2 &quot;Low&quot; Voltage</td>
<td>Venl</td>
<td>FB1, 2=0V</td>
<td>-</td>
<td></td>
<td>0.20</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>EN1, 2 &quot;High&quot; Current</td>
<td>Ienh</td>
<td>EN1, 2=3.0V</td>
<td>-</td>
<td></td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>EN1, 2 &quot;Low&quot; Current</td>
<td>Ienl</td>
<td>EN1, 2=3.0V</td>
<td>-</td>
<td></td>
<td>-0.50</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>PWM1, 2 &quot;High&quot; Current</td>
<td>IPWMH</td>
<td>FB1, 2=3.0V, PWM=3.0V</td>
<td>-</td>
<td></td>
<td>-0.50</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>PWM1, 2 &quot;Low&quot; Current</td>
<td>IPWML</td>
<td>FB1, 2=3.0V, PWM=0V</td>
<td>-</td>
<td></td>
<td>-0.50</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>PWM1, 2 &quot;High&quot; Voltage</td>
<td>VPWMH</td>
<td>FB1, 2=3.0V</td>
<td>-</td>
<td></td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>PWM1, 2 &quot;Low&quot; Voltage</td>
<td>VPWMH</td>
<td>FB1, 2=3.0V</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>FB1, 2 &quot;High&quot; Current</td>
<td>IFBH</td>
<td>FB1, 2=3.0V</td>
<td>-</td>
<td></td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>FB1, 2 &quot;Low&quot; Current</td>
<td>IFBL</td>
<td>FB1, 2=1.0V</td>
<td>-</td>
<td></td>
<td>-0.50</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

Unless otherwise stated, Vdc=3.0V, PWM1, 2=3.0V, EN1, 2 =3.0V

#### Output 1 Characteristics: Step-Up Controller

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
<th>CIRCUIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>FB1 Voltage</td>
<td>Vfb1</td>
<td>Vdc=3.0V, Vin=1.5V, Iout1=10mA</td>
<td>0.882</td>
<td>0.900</td>
<td>0.918</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Operation Start Voltage1 (*2)</td>
<td>Vst1-1</td>
<td>Using Tr. 2SD1628 Iout1=1.0mA, Rfb1=200kΩ, Rfb2=75kΩ</td>
<td>-</td>
<td>0.9</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vdc ≥ Vout1 Iout1=1mA</td>
<td>-</td>
<td></td>
<td>-0.50</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Oscillation Start-up Voltage1</td>
<td>Vst2-1</td>
<td>FB1=0V</td>
<td>-</td>
<td></td>
<td>-0.8</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Maximum Duty Ratio1</td>
<td>MAXDTY1</td>
<td>Same as Idd1</td>
<td>75</td>
<td>80</td>
<td>85</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Minimum Duty Ratio1</td>
<td>MINDTY1</td>
<td>Same as Idd2</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>PFM Duty Ratio1</td>
<td>PFMDTY1</td>
<td>No Load, VPWM=0V</td>
<td>22</td>
<td>30</td>
<td>38</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Efficiency 1 (*4)</td>
<td>EFF11</td>
<td>Iout1=30mA, N-ch MOSFET: XP161A1355P</td>
<td>-</td>
<td>85</td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Soft-Start Time1</td>
<td>Tss1</td>
<td>Vout1 ≥ 0.95V, EN1=0V, 0.65V</td>
<td>5.0</td>
<td>10.0</td>
<td>20.0</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>EXT1 &quot;High&quot; ON Resistance</td>
<td>Rextbh</td>
<td>FB1=0, EXT1=Vdc-0.4V</td>
<td>-</td>
<td>28</td>
<td>47</td>
<td>Ω</td>
<td></td>
</tr>
<tr>
<td>EXT1 &quot;Low&quot; ON Resistance</td>
<td>Rextbl</td>
<td>EN1=FB2=0V, EXT1=0.4V</td>
<td>-</td>
<td>22</td>
<td>30</td>
<td>Ω</td>
<td></td>
</tr>
<tr>
<td>PWM1 &quot;High&quot; Voltage</td>
<td>VPWMH</td>
<td>No Load</td>
<td>0.65</td>
<td>-</td>
<td>-</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>PWM1 &quot;Low&quot; Voltage</td>
<td>VPWMH</td>
<td>No Load</td>
<td>-</td>
<td>0.20</td>
<td></td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

Unless otherwise stated, Vdc=EN1=VPWM1=3.0V, EN2=PWM2=GND, EXT2=OPEN, FB2=OPEN, Vin=1.8V

#### Output 2 Characteristics: Step-Down Controller

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
<th>CIRCUIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>FB2 Voltage</td>
<td>Vfb2</td>
<td>Vin=3.0V, Iout2=10mA</td>
<td>0.882</td>
<td>0.900</td>
<td>0.918</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Minimum Operating Voltage</td>
<td>Vomin</td>
<td>-</td>
<td>-</td>
<td>2.0</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Maximum Duty Ratio 2</td>
<td>MAXDTY2</td>
<td>Same as Idd1</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Minimum Duty Ratio 2</td>
<td>MINDTY2</td>
<td>Same as Idd2</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>PFM Duty Ratio 2</td>
<td>PFMDTY2</td>
<td>No Load, VPWM=0V</td>
<td>22</td>
<td>30</td>
<td>38</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Efficiency 2 (*4)</td>
<td>EFF12</td>
<td>Iout2=250mA, P-ch MOSFET: XP162A126AP</td>
<td>-</td>
<td>92</td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Soft-Start Time2</td>
<td>Tss2</td>
<td>Vout2 ≥ 0.95V, EN2=0V, 0.65V</td>
<td>5.0</td>
<td>10.0</td>
<td>20.0</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>EXT2 &quot;High&quot; ON Resistance</td>
<td>Rexth2</td>
<td>EN2=0, EXT2=Vdc-0.4V</td>
<td>-</td>
<td>28</td>
<td>47</td>
<td>Ω</td>
<td></td>
</tr>
<tr>
<td>EXT2 &quot;Low&quot; ON Resistance</td>
<td>Rextl2</td>
<td>FB2=0V, EXT2=0.4V</td>
<td>-</td>
<td>22</td>
<td>30</td>
<td>Ω</td>
<td></td>
</tr>
<tr>
<td>PWM2 &quot;High&quot; Voltage</td>
<td>VPWMH</td>
<td>No Load</td>
<td>0.65</td>
<td>-</td>
<td>-</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>PWM2 &quot;Low&quot; Voltage</td>
<td>VPWMH</td>
<td>No Load</td>
<td>-</td>
<td>0.20</td>
<td></td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

Unless otherwise stated, Vdc=EN2=VPWM=3.0V, PWM1=EN1=GND, EXT1=OPEN, FB1=OPEN, Vin=5.0V

**NOTE:**

1. *: Although the IC's step-up operations start from a Vdc of 0.8V, the output voltage and switching frequency are stabilized at Vdc ≥ 2.0V. Therefore, a value of more than 2.0V is recommended when Vdc is supplied from Vin or other power sources.

2. #: Although the IC's switching operations start from a Vin of 0.9V, the IC's power supply pin (Vdc) and output voltage monitor pin (FB1) should be connected to Vout1. With operations from Vin=0.9V, the 2nd channel's (output 2) EN2 pin should be set to chip disable. Once output voltage Vout1 is more than 2.0V, the EN2 pin should be set to chip enable.

3. #: Please be careful not to exceed the breakdown voltage level of the external components.

4. #: EFF1 = [(Output voltage) / (Input voltage)] / [(Output current) / (Input current)] × 100

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**XC9502 Series**

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### ELECTRICAL CHARACTERISTICS (Continued)

#### Parameter Table

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<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
<th>CIRCUIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage (*1)</td>
<td>VDD</td>
<td></td>
<td>2.0</td>
<td>-</td>
<td>10.0</td>
<td>V</td>
<td></td>
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<tr>
<td>Maximum put Voltage</td>
<td>VIN</td>
<td></td>
<td>10.0</td>
<td>-</td>
<td>-</td>
<td>V</td>
<td></td>
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<tr>
<td>Output Voltage Range (*3)</td>
<td>VOUTSET</td>
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<tr>
<td></td>
<td></td>
<td>VDD ≤ 0V, IOUT1, 2=1mA</td>
<td>VOUT1</td>
<td>0.9</td>
<td>-</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VDD ≤ VOUT1</td>
<td>VOUT2</td>
<td>0.9</td>
<td>-</td>
<td>VIN</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VIN ≤ 0.9V, IOUT1, 2=1mA</td>
<td>VOUT1</td>
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<td>-</td>
<td>10.0</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VDD=VOUT1</td>
<td>VOUT2</td>
<td>0.9</td>
<td>-</td>
<td>VIN</td>
<td>V</td>
</tr>
<tr>
<td>Supply Current 1</td>
<td>IOD1</td>
<td>FB1, 2=0V</td>
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<td>100</td>
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<td>µA</td>
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<td>Supply Current 1-1</td>
<td>IOD1-1</td>
<td>EN1=3.0V, EN2=0V, FB1=0V</td>
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<td>80</td>
<td>150</td>
<td>µA</td>
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<tr>
<td>Supply Current 1-2</td>
<td>IOD1-2</td>
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<td>60</td>
<td>120</td>
<td>µA</td>
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<tr>
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<td>100</td>
<td>190</td>
<td>µA</td>
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<tr>
<td>Supply Current 1-4</td>
<td>IOD1-4</td>
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<td>70</td>
<td>150</td>
<td>µA</td>
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<tr>
<td>Supply Current 2</td>
<td>IOD2</td>
<td>FB1, 2=1.0V</td>
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<td>70</td>
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<td>µA</td>
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</tr>
<tr>
<td>Stand-by Current</td>
<td>ISTB</td>
<td>Same as IOD1</td>
<td>-</td>
<td>1.0</td>
<td>3.0</td>
<td>µA</td>
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<tr>
<td>Oscillation Frequency</td>
<td>FOSC</td>
<td>Same as IOD1</td>
<td>255</td>
<td>300</td>
<td>345</td>
<td>kHz</td>
<td></td>
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<tr>
<td>EN1, 2 &quot;High&quot; Voltage</td>
<td>VINH</td>
<td>FB1, 2=0V</td>
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<td>-</td>
<td>-</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>EN1, 2 &quot;Low&quot; Voltage</td>
<td>VINL</td>
<td>FB1, 2=0V</td>
<td>-</td>
<td>0.2</td>
<td>0.2</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>EN1, 2 &quot;High&quot; Current</td>
<td>INH</td>
<td>EN1, 2=3.0V</td>
<td>-</td>
<td>-</td>
<td>0.50</td>
<td>µA</td>
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<tr>
<td>EN1, 2 &quot;Low&quot; Current</td>
<td>INL</td>
<td>EN1, 2=0V, FB1, 2=3.0V</td>
<td>-</td>
<td>-</td>
<td>-0.50</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>PWM1, 2 &quot;High&quot; Current</td>
<td>IPWMH</td>
<td>FB1, 2=3.0V, PWM=3.0V</td>
<td>-</td>
<td>-</td>
<td>-0.50</td>
<td>µA</td>
<td></td>
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<tr>
<td>PWM1, 2 &quot;Low&quot; Current</td>
<td>IPWML</td>
<td>FB1, 2=3.0V, PWM=0V</td>
<td>-</td>
<td>-</td>
<td>-0.50</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>FB1, 2 &quot;High&quot; Current</td>
<td>FBH</td>
<td>FB1, 2=3.0V</td>
<td>-</td>
<td>-</td>
<td>-0.50</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>FB1, 2 &quot;Low&quot; Current</td>
<td>FBL</td>
<td>FB1, 2=1.0V</td>
<td>-</td>
<td>-</td>
<td>-0.50</td>
<td>µA</td>
<td></td>
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</tbody>
</table>

#### Output 1 Characteristics: Step-Up Controller

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
<th>CIRCUIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation Start Voltage (*2)</td>
<td>VST1-1</td>
<td>Using Tr: 2SD1628</td>
<td>IOUT1=1.0mA, RFB1=200k [Ω], RFB2=75k [Ω]</td>
<td>-</td>
<td>0.9</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VDD ≤ VOUT1</td>
<td>IOUT1=1mA</td>
<td>-</td>
<td>2.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Maximum Duty Ratio</td>
<td>MAXDTY1</td>
<td>Same as IOD1</td>
<td>75</td>
<td>80</td>
<td>85</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Minimum Duty Ratio</td>
<td>MINDTY1</td>
<td>Same as IOD2</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>PFM Duty Ratio</td>
<td>PFMDTYP</td>
<td>No Load, VPWM1=0V</td>
<td>22</td>
<td>30</td>
<td>38</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Efficiency (*4)</td>
<td>EFFI1</td>
<td>IOUT=130mA</td>
<td>-</td>
<td>85</td>
<td>-</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Soft-Start Time</td>
<td>TSS1</td>
<td>VOUT1 ≤ 0.95V, EN1=0V</td>
<td>-</td>
<td>5.0</td>
<td>10.0</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>EXT1 &quot;High&quot; ON Resistance</td>
<td>REXTBH1</td>
<td>FB1=0V, EXT1=VDD-0.4V</td>
<td>-</td>
<td>28</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXT1 &quot;Low&quot; ON Resistance</td>
<td>REXTBL1</td>
<td>EN1=FB2=0V, EXT1=0.4V</td>
<td>-</td>
<td>22</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PWM1 &quot;High&quot; Voltage</td>
<td>VPWMHI</td>
<td>No Load</td>
<td>0.65</td>
<td>-</td>
<td>-</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>PWM1 &quot;Low&quot; Voltage</td>
<td>VPWMHL</td>
<td>No Load</td>
<td>-</td>
<td>-0.2</td>
<td>0</td>
<td>V</td>
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</tr>
</tbody>
</table>

#### Output 2 Characteristics: Step-Down Controller

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
<th>CIRCUIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Operating Voltage</td>
<td>VINMIN</td>
<td></td>
<td>-</td>
<td>-</td>
<td>2.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Maximum Duty Ratio 2</td>
<td>MAXDTY2</td>
<td>Same as IOD1</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Minimum Duty Ratio 2</td>
<td>MINDTY2</td>
<td>Same as IOD2</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>PFM Duty Ratio 2</td>
<td>PFMDTYP</td>
<td>No Load, VPWM2=0V</td>
<td>22</td>
<td>30</td>
<td>38</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Efficiency 2 (*4)</td>
<td>EFFI2</td>
<td>IOUT=250mA</td>
<td>-</td>
<td>92</td>
<td>-</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Soft-Start Time 2</td>
<td>TSS2</td>
<td>VOUT2 ≤ 0.95V, EN2=0V</td>
<td>-</td>
<td>5.0</td>
<td>10.0</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>EXT2 &quot;High&quot; ON Resistance</td>
<td>REXTBH2</td>
<td>EN2=0V, EXT2=VDD-0.4V</td>
<td>-</td>
<td>28</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXT2 &quot;Low&quot; ON Resistance</td>
<td>REXTBL2</td>
<td>FB2=0V, EXT2=0.4V</td>
<td>-</td>
<td>22</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PWM2 &quot;High&quot; Voltage</td>
<td>VPWMHI</td>
<td>No Load</td>
<td>0.7</td>
<td>-</td>
<td>-</td>
<td>V</td>
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<tr>
<td>PWM2 &quot;Low&quot; Voltage</td>
<td>VPWMHL</td>
<td>No Load</td>
<td>-</td>
<td>-0.2</td>
<td>0</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:**
- *1: Although the IC's step-up operations start from a VDD of 0.8V, the output voltage and switching frequency are stabilized at VDD ≤ 2.0V. Therefore, a VDD of more than 2.0V is recommended when VDD is supplied from VIN or other power sources.
- *2: Although the IC's switching operations start from a VIN of 0.9V, the IC's power supply pin (VDD) and output voltage monitor pin (FB1) should be connected to VOUT1. With operations from VIN=0.9V, the 2nd channel's (output 2) EN2 pin should be set to chip disable. Once output voltage VOUT1 is more than 2.0V, the EN2 pin should be set to chip enable.
- *3: Please be careful not to exceed the breakdown voltage level of the external components.
- *4: Please be careful not to exceed the breakdown voltage level of the external components.
### ELECTRICAL CHARACTERISTICS (Continued)

#### XC9502B095

<table>
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<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
<th>CIRCUIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage (*1)</td>
<td>Vdd</td>
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<td>2.0</td>
<td></td>
<td>10.0</td>
<td>V</td>
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</tr>
<tr>
<td>Maximum Input Voltage</td>
<td>Vin</td>
<td></td>
<td>10.0</td>
<td></td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Output Voltage Range (*3)</td>
<td>VOUTSET</td>
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<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Vdd □ 2.0V, IOUT1, 2=1mA</td>
<td>VOUT1</td>
<td>0.9</td>
<td></td>
<td>V</td>
<td></td>
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<td>VOUT2</td>
<td>0.9</td>
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<td>Vin</td>
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<td>Vin □ 0.9V, IOUT1, 2=1mA</td>
<td>VOUT1</td>
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<td>10.0</td>
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<tr>
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<td>VOUT2</td>
<td>0.9</td>
<td></td>
<td>Vin</td>
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<td>Supply Current 1</td>
<td>IOD1</td>
<td>FB1, 2=0V</td>
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<td>130</td>
<td>250</td>
<td>A</td>
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<tr>
<td>Supply Current 1-1</td>
<td>IOD1-1</td>
<td>EN1=3.0V, EN2=0V, FB1=0V</td>
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<tr>
<td>Supply Current 1-2</td>
<td>IOD1-2</td>
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<td>80</td>
<td>150</td>
<td>A</td>
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<tr>
<td>Supply Current 1-3</td>
<td>IOD1-3</td>
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<td>240</td>
<td>A</td>
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<tr>
<td>Supply Current 1-4</td>
<td>IOD1-4</td>
<td>FB1=1.0V, FB2=0V</td>
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<td>190</td>
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<td>Supply Current 2</td>
<td>IOD2</td>
<td>FB1, 2=1.0V</td>
<td>-</td>
<td>90</td>
<td></td>
<td>190</td>
<td>A</td>
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<tr>
<td>Stand-by Current</td>
<td>ISTB</td>
<td>Same as IOD1, EN1=EN2=0V</td>
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<td>3.0</td>
<td>A</td>
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<tr>
<td>Oscillation Frequency</td>
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<td>500</td>
<td>575</td>
<td>kHz</td>
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<td>EN1, 2 &quot;High&quot; Voltage</td>
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<td>V</td>
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<tr>
<td>EN1, 2 &quot;Low&quot; Voltage</td>
<td>VE1L</td>
<td>FB1, 2=0V</td>
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<td>-0.2</td>
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<td>V</td>
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<td>EN1, 2 &quot;High&quot; Current</td>
<td>VE1H</td>
<td>EN1, 2=3.0V</td>
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<tr>
<td>EN1, 2 &quot;Low&quot; Current</td>
<td>VE1L</td>
<td>EN1, 2=0V, FB1, 2=3.0V</td>
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<td>-0.5</td>
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<td>A</td>
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</tr>
<tr>
<td>PWM1, 2 &quot;High&quot; Current</td>
<td>IPWMH</td>
<td>FB1, 2=3.0V, PWM=3.0V</td>
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<td>-0.5</td>
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<tr>
<td>PWM1, 2 &quot;Low&quot; Current</td>
<td>IPWML</td>
<td>FB1, 2=3.0V, PWM=0V</td>
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<td>-0.5</td>
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<tr>
<td>FB1, 2 &quot;High&quot; Current</td>
<td>IFBH</td>
<td>FB1, 2=3.0V</td>
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<td>-0.5</td>
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<tr>
<td>FB1, 2 &quot;Low&quot; Current</td>
<td>IFBL</td>
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<td>-0.5</td>
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<td>A</td>
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</table>

Unless otherwise stated, Vou=3.0V, PWM1, 2=3.0V, EN1, 2 =3.0V

#### Output 1 Characteristics: Step-Up Controller

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
<th>CIRCUIT</th>
</tr>
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<tbody>
<tr>
<td>FB 1 Voltage</td>
<td>Vfb1</td>
<td>VDD=3.0V, VIN=1.5V, IOUT1=10mA</td>
<td>0.882</td>
<td>0.900</td>
<td>0.918</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Operation Start Voltage 1 (*2)</td>
<td>VST1-1</td>
<td>Using Tr. 2SD1628, IOUT1=1.0mA, RFB1=200kΩ, RFB2=75kΩ</td>
<td>-</td>
<td>0.9</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VDD □ VOUT1, IOUT1=1mA</td>
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<td></td>
<td>V</td>
<td></td>
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<td>V</td>
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<tr>
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<td>80</td>
<td>85</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Minimum Duty Ratio 1</td>
<td>MINDTY1</td>
<td>Same as IOD2</td>
<td>-</td>
<td>0</td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>PFM Duty Ratio 1</td>
<td>PFMDTY1</td>
<td>No Load, VPWM1=0V</td>
<td>22</td>
<td>30</td>
<td>38</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Efficiency 1 (*4)</td>
<td>EFFI1</td>
<td>IOUT1=130mA</td>
<td>-</td>
<td>83</td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Soft-Start Time 1</td>
<td>TSS1</td>
<td>VOUT1 □ 0.95V, EN1=0V □ 0.65V</td>
<td>5.0</td>
<td>10.0</td>
<td>20.0</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>EXT1 &quot;High&quot; ON Resistance</td>
<td>REXTBH1</td>
<td>FB1=0V, EXT1=VDD-0.4V</td>
<td>-</td>
<td>28</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXT1 &quot;Low&quot; ON Resistance</td>
<td>REXTBL1</td>
<td>EN1=FB2=0V, EXT1=0.4V</td>
<td>-</td>
<td>22</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PWM1 &quot;High&quot; Voltage</td>
<td>VPWMH1</td>
<td>No Load</td>
<td>0.65</td>
<td>-</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>PWM1 &quot;Low&quot; Voltage</td>
<td>VPWMH1</td>
<td>No Load</td>
<td>-</td>
<td>0.2</td>
<td></td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

Unless otherwise stated, VDD=EN1=EN2=P=3.0V, EN2=P=3.0V, EXT1=OPEN, FB2=OPEN, VIN=1.8V

#### Output 2 Characteristics: Step-Down Controller

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
<th>CIRCUIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>FB 2 Voltage</td>
<td>Vfb2</td>
<td>VIN=3.0V, IOUT2=10mA</td>
<td>0.882</td>
<td>0.900</td>
<td>0.918</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Minimum Operating Voltage</td>
<td>VMIN</td>
<td></td>
<td>-</td>
<td>2.0</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Maximum Duty Ratio 2</td>
<td>MAXDTY2</td>
<td>Same as IOD1</td>
<td>100</td>
<td>-</td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Minimum Duty Ratio 2</td>
<td>MINDTY2</td>
<td>Same as IOD2</td>
<td>-</td>
<td>0</td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>PFM Duty Ratio 2</td>
<td>PFMDTY2</td>
<td>No Load, VPWM2=0V</td>
<td>22</td>
<td>30</td>
<td>38</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Efficiency 2 (*4)</td>
<td>EFFI2</td>
<td>IOUT2=250mA</td>
<td>-</td>
<td>91</td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Soft-Start Time 2</td>
<td>TSS2</td>
<td>VOUT2 □ 0.95V, EN2=0V □ 0.65V</td>
<td>5.0</td>
<td>10.0</td>
<td>20.0</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>EXT2 &quot;High&quot; ON Resistance</td>
<td>REXTBH2</td>
<td>EN2=0V, EXT2=VDD-0.4V</td>
<td>-</td>
<td>28</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXT2 &quot;Low&quot; ON Resistance</td>
<td>REXTBL2</td>
<td>FB2=0V, EXT2=0.4V</td>
<td>-</td>
<td>22</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PWM2 &quot;High&quot; Voltage</td>
<td>VPWMH2</td>
<td>No Load</td>
<td>0.65</td>
<td>-</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>PWM2 &quot;Low&quot; Voltage</td>
<td>VPWMH2</td>
<td>No Load</td>
<td>-</td>
<td>0.2</td>
<td></td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

Unless otherwise stated, VDD=EN2=P=3.0V, EN1=P=3.0V, EXT1=OPEN, FB1=OPEN, VIN=5.0V

**NOTE:**

1: Although the IC's step-up operations start from a Vdd of 0.8V, the output voltage and switching frequency are stabilized at Vdd □ 2.0V. Therefore, a Vdd of more than 2.0V is recommended when Vdd is supplied from Vss or other power sources.

2: Although the IC's switching operations start from a Vss of 0.9V, the IC's power supply pin (Vdd) and output voltage monitor pin (FB1) should be connected to Vout1. With operations from Vss=0.9V, the 2nd channel's (output 2) EN2 pin should be set to chip disable. Once output voltage Vout1 is more than 2.0V, the EN2 pin should be set to chip enable.

3: Please be careful not to exceed the breakdown voltage level of the external components.

4: EFF=[[(output voltage) □ (output current)] / [input voltage □ (input current)]] □ 100
OPERATIONAL EXPLANATION

The XC9502 series are multi-functional, 2 channel step-up and down DC/DC converter controller ICs with built-in high speed, low ON resistance drivers.

<Error Amp.>
The error amplifier is designed to monitor the output voltage and it compares the feedback voltage (FB) with the reference voltage. In response to feedback of a voltage lower than the reference voltage, the output voltage of the error amp. decreases.

<OSC Generator>
This circuit generates the switching frequency, which in turn generates the reference clock.

<Ramp Wave Generator 1, 2>
The ramp wave generator generates a saw-tooth waveform based on outputs from the Phase Shift Generator.

<PWM Comparator 1, 2>
The PWM comparator compares outputs from the error amp. and saw-tooth waveform. When the voltage from the error amp's output is low, the external switch will be set to ON.

<PWM/PFM Controller 1, 2>
This circuit generates PFM pulses. Control can be switched between PWM control and PWM/PFM automatic switching control using external signals. The PWM/PFM automatic switching mode is selected when the voltage of the PWM1 (2) pin is less than 0.2V, and the control switches between PWM and PFM automatically depending on the load. As the PFM circuit generates pulses based on outputs from the PWM comparator, shifting between modes occurs smoothly. PWM control mode is selected when the voltage of the PWM1 (2) pin is more than 0.65V. Noise is easily reduced with PWM control since the switching frequency is fixed. Control suited to the application can easily be selected which is useful in audio applications, for example, where traditionally, efficiencies have been sacrificed during stand-by as a result of using PWM control (due to the noise problems associated with the PFM mode in stand-by).

<Vref with Soft Start 1, 2>
The reference voltage, Vref (FB pin voltage)=0.9V, is adjusted and fixed by laser trimming (for output voltage settings, please refer to the notes on next page). To protect against inrush current, when the power is switched on, and also to protect against voltage overshoot, soft-start time is set internally to 10ms. It should be noted, however, that this circuit does not protect the load capacitor (CL) from inrush current. With the Vref voltage limited and depending upon the input to the error amps, the operation maintains a balance between the two inputs of the error amps and controls the EXT pin's ON time so that it doesn't increase more than is necessary.

<Chip Enable Function>
This function controls the operation and shutdown of the IC. When the voltage of the EN1 or EN2 pins is 0.2V or less, the mode will be chip disable, the channel's operations will stop and the EXT1 pin will be kept at a low level (the external N-ch MOSFET will be OFF) and the EXT2 pin will be kept at a high level (the external P-type MOSFET will be OFF). When both EN1 and EN2 are in a state of chip disable, current consumption will be no more than 3.0 mA. When the EN1 or EN2 pin's voltage is 0.65V or more, the mode will be chip enable and operations will recommence. With soft-start, 95% of the set output voltage will be reached within 10mS (TYP.) from the moment of chip enable. Although IC starts oscillation from a VIN of 0.9V, the IC's power supply pin (Vdd) and the output voltage monitor pin (FB1) should be connected to VOUT1. The start-up sequence for EN1 and EN2 is required when operations begin with a power supply voltage of Vdd=0.9V, and channel two's (output 2) EN2 pin should be set to chip disable and turn it to enable when VOUT1 is more than 2.0V. For power supply voltages of Vdd<2.0V, oscillation may occur irrespective of the FB pin voltage. Should this happen, you may find that output voltage will be higher than the set voltage. The FB pin voltage and the reference voltage Vref will be compared and output voltage will be controlled when the power supply voltage is Vdd>2.0V or more. With power supply voltages of Vdd>2.0V, the start-up sequence for EN1 and EN2 will not be required.
OPERATIONAL EXPLANATION (Continued)

<Setting of Output Voltage>
Output voltage can be set by adding external split resistors. Output voltage is determined by the following equation, based on the values of RFB11 (RFB21) and RFB12 (RFB22). The sum of RFB11 (RFB21) and RFB12 (RFB22) should normally be 1MΩ or less.

\[ V_{OUT} = 0.9 \frac{(RFB11+RFB12)}{RFB12} \]

The value of CFB1 (CFB2), speed-up capacitor for phase compensation, should be \( f_{zfB} = \frac{1}{(2 \pi RFB1\times CFB1)} \) which is equal to 12kHz. Adjustments are required from 1kHz to 50kHz depending on the application, value of inductance (L), and value of load capacity (CL).

[Example of Calculation]
\[ V_{OUT1} = 0.9 \times \frac{(200k+75k)}{75k} = 3.3V. \]

[Typical Example]

<table>
<thead>
<tr>
<th>VOUT (V)</th>
<th>RFB11 (kΩ)</th>
<th>RFB12 (kΩ)</th>
<th>CFB1 (pF)</th>
<th>VOUT (V)</th>
<th>RFB11 (kΩ)</th>
<th>RFB12 (kΩ)</th>
<th>CFB1 (pF)</th>
<th>VOUT (V)</th>
<th>RFB11 (kΩ)</th>
<th>RFB12 (kΩ)</th>
<th>CFB1 (pF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>30</td>
<td>270</td>
<td>430</td>
<td>2.5</td>
<td>390</td>
<td>220</td>
<td>33</td>
<td>8.0</td>
<td>120</td>
<td>15</td>
<td>100</td>
</tr>
<tr>
<td>1.5</td>
<td>220</td>
<td>330</td>
<td>62</td>
<td>2.7</td>
<td>360</td>
<td>180</td>
<td>33</td>
<td>12.0</td>
<td>160</td>
<td>13</td>
<td>82</td>
</tr>
<tr>
<td>1.8</td>
<td>220</td>
<td>220</td>
<td>62</td>
<td>3.0</td>
<td>240</td>
<td>24</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2.0</td>
<td>330</td>
<td>270</td>
<td>39</td>
<td>3.3</td>
<td>200</td>
<td>75</td>
<td>62</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2.2</td>
<td>390</td>
<td>270</td>
<td>33</td>
<td>5.0</td>
<td>82</td>
<td>18</td>
<td>160</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

The same method can also be adopted for channel two (output 2).

[External Components]

Output 1 (Step-Up DC/DC controller)
Tr 1 : * MOSFET
XP161A1355PR (N-ch Power MOSFET, TOREX)
Note: Vgs Breakdown Voltage of this Tr. is 8V so please be careful with the power supply voltage.
For 6V power supply voltage, XP161A1265PR which Vgs breakdown voltage is 12V is recommended. Vst1 of XP161A1355PR is 1.2V (MAX.) and that of XP161A1265PR is 1.5V (MAX.)

SD 1: MA2Q737 (Schottky, MATSUSHITA)
CMS02 (Schottky, TOSHIBA)
L 1: 10 µH (CDRH5D28, SUMIDA, FOSC = 500kHz)
15 µH (CDRH5D28, SUMIDA, FOSC = 300kHz)
22 µH (CDRH5D28, SUMIDA, FOSC = 180kHz)
CL1: 16V, 47µF (Tantalum)

Increase capacity according to the equation below when the step-up voltage ratio is large and output current is high.

\[ C = (CL \text{ standard value}) \times \frac{I_{OUT1} (mA)}{300mA / V_{OUT1/VIN}} \]

Tr : * NPN MOSFET 2SD1628 (SANYO)
Rb1 : 500Ω (Adjust in accordance with load & Tr.’s HFE.)
Set according to the equation below:
\[ Rb1 \times (Vin+0.7) \times hFE / IC-Rextth \]
Cb1 : 2200pF (Ceramic)

Output 2 (Step-Down DC/DC controller)
Tr 2 : * MOSFET
XP162A12A6P (P-ch Power MOSFET, TOREX)
Note: Vgs Breakdown Voltage of this Tr. is 12V so please be careful with the power supply voltage.

SD 2: MA2Q737 (Schottky, MATSUSHITA)
CMS02 (Schottky, TOSHIBA)
L 2: 10 µH (CDRH5D28, SUMIDA, FOSC = 500kHz)
22 µH (CDRH5D28, SUMIDA, FOSC = 300kHz)
47 µH (CDRH5D28, SUMIDA, FOSC = 180kHz)
CL1: 16V, 47µF (Tantalum)

Increase capacity according to the equation below when the step-up voltage ratio is large and output current is high.

\[ C = (CL \text{ standard value}) \times \frac{I_{OUT2} (mA)}{500mA / V_{OUT2/VIN}} \]

Tr : * PNP MOSFET 2SA1213 (SANYO)
Rb2 : 500Ω (Adjust in accordance with load & Tr.’s HFE.)
Set according to the equation below:
\[ Rb2 \times (Vin+0.7) \times hFE / IC-Rextth \]
Cb2 : 2200pF (Ceramic)

Set according to the equation below:
\[ Cb2 \times (2 \times Rb2 x FOSC x 0.7) \]
TEST CIRCUITS

Circuit 1

Circuit 2

Circuit 3

Circuit 4

Circuit 5

Circuit 6

Circuit 7

Circuit 8
EXTERNAL COMPONENTS USED FOR TEST CIRCUITS

Circuit □, □

L1, L2:
22 ㎸ H (CDRH5D28, SUMIDA) : XC9502B092A
15 ㎸ H (CDRH5D28, SUMIDA) : XC9502B093A
10 ㎸ H (CDRH5D28, SUMIDA) : XC9502B095A
SD1, SD2:
CRS02 (Schottky diode, TOSHIBA)
EC10QS06 (Schottky diode, NIHON INTER)
CL1, CL2:
16MCE476MD2 (Tantalum, NIHON CHEMICON)
35MCE335MB2 x 3 (Tantalum, NIHON CHEMICON)
CIN:
16MCE476MD2 (Tantalum, NIHON CHEMICON)
NPN Tr1:
2SD1628 (SANYO)
PNP Tr1:
2SA1213 (TOSHIBA)
RFB:
Please use by the conditions as below:
\[ \frac{RFB11}{RFB12} = (\text{Setting output voltage} / 0.9) - 1 \]
\[ VOUT2 = (0.9 - VOUT1) \times \left( \frac{RFB21}{RFB22} \right) + 0.9V \]
CFB:
Please adjust as below:
\[ f_{xfb} = \frac{1}{2 \pi x CFB1 \times RFB11} = 1kHz \sim 50kHz \text{ (12kHz usual)} \]
\[ f_{xfb} = \frac{1}{2 \pi x CFB2 \times RFB21} = 1kHz \sim 50kHz \text{ (12kHz usual)} \]

Circuit □

L1:
22 ㎸ H (CDRH5D28, SUMIDA)
SD1:
MA2Q737 (Schottky diode, MATSUSHITA)
CL1:
16MCE476MD2 (Tantalum, NIHON CHEMICON)
CIN:
16MCE476MD2 (Tantalum, NIHON CHEMICON)
N-ch MOSFET1:
XP161A1355P (TOREX)

Circuit □

L1:
22 ㎸ H (CDRH5D28, SUMIDA)
SD1:
MA2Q737 (Schottky diode, MATSUSHITA)
CL1:
16MCE476MD2 (Tantalum, NIHON CHEMICON)
CIN:
16MCE476MD2 (Tantalum, NIHON CHEMICON)
N-ch MOSFET1:
XP161A1355P (TOREX)

Circuit □

L1:
22 ㎸ H (CDRH5D28, SUMIDA)
SD1:
MA2Q737 (Schottky diode, MATSUSHITA)
CL1:
16MCE476MD2 (Tantalum, NIHON CHEMICON)
CIN:
16MCE476MD2 (Tantalum, NIHON CHEMICON)
P-ch MOSFET2:
XP162A12A6P (TOREX)

Circuit □

L2:
22 ㎸ H (CDRH5D28, SUMIDA)
15 ㎸ H (CDRH5D28, SUMIDA)
10 ㎸ H (CDRH5D28, SUMIDA)
SD2:
MA2Q737 (Schottky diode, MATSUSHITA)
CL2:
16MCE476MD2 (Tantalum, NIHON CHEMICON)
CIN:
16MCE476MD2 (Tantalum, NIHON CHEMICON)
P-ch MOSFET2:
XP162A12A6P (TOREX)
NOTES ON USE

1. Checking for Intermittent Oscillation
   The XC9502 series is subject to intermittent oscillation in the proximity of the maximum duty if the step-down ratio is low (e.g., from 4.2 V to 3.3 V) or a heavy load is applied where the duty ratio becomes high. Check waveforms at EXT under your operating conditions. A remedy for this problem is to raise the inductance of coil L or increase the load capacitance CL.

2. PWM/PFM Automatic Switching
   If PWM/PFM automatic switching control is selected and the step-up ratio is low (e.g., from 4.5V to 5.0V) or the step-down ratio is high (e.g., from 10.0V to 1.0 V), the control mode remains in PFM setting in the whole load range, since the duty ratio under continuous-duty condition is smaller than the PFM duty ratio of the XC9502 series. The output voltage's ripple voltage becomes substantially high under heavy load conditions, with the XC9502 series appearing to be producing an abnormal oscillation. If this operation becomes a concern, set pins PWM1 and PWM2 to High to set the control mode to PWM setting. For use under the above-mentioned condition, measured data of PWM/PFM automatic switching control shown on the data sheets are available up to IOUT = 100 mA.

3. Ratings
   Use the XC9502 series and external components within the limits of their ratings.
TYPICAL PERFORMANCE CHARACTERISTICS

< 1ch Step-Up DC/DC Controller >

(1) Output Voltage vs. Output Current

FOSC=180kHz, VOUT1= 1.5V

```
Output Voltage (V) vs. Output Current (mA)
```

FOSC=180kHz, VOUT1= 2.5V

```
Output Voltage (V) vs. Output Current (mA)
```

FOSC=180kHz, VOUT1= 3.3V

```
Output Voltage (V) vs. Output Current (mA)
```

FOSC=180kHz, VOUT1= 5.0V

```
Output Voltage (V) vs. Output Current (mA)
```

FOSC=180kHz, VOUT1= 8.0V

```
Output Voltage (V) vs. Output Current (mA)
```

Dotted Arrowhead -----> PWM/PFM Switching Control
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 1ch Step-Up DC/DC Controller >
(1) Output Voltage vs. Output Current (Continued)

FOSC=300kHz, VOUT1 = 2.5V

L1=15μH(CDRH5D28), CL1=94μF(Tantalum)
SD1:CMS02, Tr1:XP161A1355P

Output Voltage vs. Output Current

FOSC=300kHz, VOUT1 = 3.3V

L1=15μH(CDRH5D28), CL1=94μF(Tantalum)
SD1:CMS02, Tr1:XP161A1355P

Output Voltage vs. Output Current

FOSC=300kHz, VOUT1 = 5.0V

L1=15μH(CDRH5D28), CL1=94μF(Tantalum)
SD1:CMS02, Tr1:XP161A1355P

Output Voltage vs. Output Current

FOSC=500kHz, VOUT1 = 2.5V

L1=10μH(CDRH5D28), CL1=94μF(Tantalum)
SD1:CMS02, Tr1:XP161A1355P

Output Voltage vs. Output Current

FOSC=500kHz, VOUT1 = 3.3V

L1=10μH(CDRH5D28), CL1=94μF(Tantalum)
SD1:CMS02, Tr1:XP161A1355P

Output Voltage vs. Output Current

FOSC=500kHz, VOUT1 = 5.0V

L1=10μH(CDRH5D28), CL1=94μF(Tantalum)
SD1:CMS02, Tr1:XP161A1355P

Output Voltage vs. Output Current

Dotted Arrowhead ----> PWM/PMF Switching Control
XC9502 Series

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 1ch Step-Up DC/DC Controller >

(2) Efficiency vs. Output Current

![Efficiency vs. Output Current Graphs](image-url)

Dotted Arrowhead ———> PWM/PFM Switching Control
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 1ch Step-Up DC/DC Controller >

(2) Efficiency vs. Output Current (Continued)

FOSC=300kHz, VOUT1= 2.5V

\[ L_1=15 \mu H (\text{CDRH5D28}), \quad C_{L1}=94 \mu F (\text{Tantalum}) \]

\[ \text{SD1:CMS02, Tr1:XP161A1355P} \]

PWM/PFM Switching Control

P WM  Control

Efficiency vs. Output Current (m A)

Dotted Arrowhead ----- PWM/PFM Switching Control

FOSC=300kHz, VOUT1= 3.3V

\[ L_1=15 \mu H (\text{CDRH5D28}), \quad C_{L1}=94 \mu F (\text{Tantalum}) \]

\[ \text{SD1:CMS02, Tr1:XP161A1355P} \]

PWM/PFM Switching Control

P WM  Control

Efficiency vs. Output Current (m A)

Dotted Arrowhead ----- PWM/PFM Switching Control

FOSC=300kHz, VOUT1= 5.0V

\[ L_1=15 \mu H (\text{CDRH5D28}), \quad C_{L1}=94 \mu F (\text{Tantalum}) \]

\[ \text{SD1:CMS02, Tr1:XP161A1355P} \]

PWM/PFM Switching Control

P WM  Control

Efficiency vs. Output Current (m A)

Dotted Arrowhead ----- PWM/PFM Switching Control

FOSC=500kHz, VOUT1= 2.5V

\[ L_1=15 \mu H (\text{CDRH5D28}), \quad C_{L1}=94 \mu F (\text{Tantalum}) \]

\[ \text{SD1:CMS02, Tr1:XP161A1355P} \]

PWM/PFM Switching Control

P WM  Control

Efficiency vs. Output Current (m A)

Dotted Arrowhead ----- PWM/PFM Switching Control

FOSC=500kHz, VOUT1= 3.3V

\[ L_1=15 \mu H (\text{CDRH5D28}), \quad C_{L1}=94 \mu F (\text{Tantalum}) \]

\[ \text{SD1:CMS02, Tr1:XP161A1355P} \]

PWM/PFM Switching Control

P WM  Control

Efficiency vs. Output Current (m A)

Dotted Arrowhead ----- PWM/PFM Switching Control

FOSC=500kHz, VOUT1= 5.0V

\[ L_1=15 \mu H (\text{CDRH5D28}), \quad C_{L1}=94 \mu F (\text{Tantalum}) \]

\[ \text{SD1:CMS02, Tr1:XP161A1355P} \]

PWM/PFM Switching Control

P WM  Control

Efficiency vs. Output Current (m A)

Dotted Arrowhead ----- PWM/PFM Switching Control
(3) Ripple Voltage vs. Output Current

- **FOSC=180kHz, VOUT= 1.5V**
  - L1=22H(CDRH5D28), CL1=94F(Tantalum)
  - SD1:CMS02, Tr1:XP161A1355P

- **FOSC=180kHz, VOUT= 2.5V**
  - L1=22H(CDRH5D28), CL1=94F(Tantalum)
  - SD1:CMS02, Tr1:XP161A1355P

- **FOSC=180kHz, VOUT= 3.3V**
  - L1=22H(CDRH5D28), CL1=94F(Tantalum)
  - SD1:CMS02, Tr1:XP161A1355P

- **FOSC=180kHz, VOUT= 5.0V**
  - L1=22H(CDRH5D28), CL1=94F(Tantalum)
  - SD1:CMS02, Tr1:XP161A1355P

- **FOSC=180kHz, VOUT= 8.0V**
  - L1=22H(CDRH5D28), CL1=94F(Tantalum)
  - SD1:CMS02, Tr1:XP161A1265P

Dotted Arrowhead ----> PWM/PFM Switching Control
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 1ch Step-Up DC/DC Controller >

(3) Ripple Voltage vs. Output Current (Continued)

![Diagram of Ripple Voltage vs. Output Current for different output voltages and frequencies](image)

Dotted Arrowhead ----> PWM/PFM Switching Control
**TYPICAL PERFORMANCE CHARACTERISTICS (Continued)**

< 2ch Step-Down DC/DC Controller >

(4) Output Voltage vs. Output Current

**FOSC=180kHz, VOUT2=1.0V**

- L2=47μH(CDRH6D38), CL2=94μF(Tantalum)
- SD2:CMS92, Ti2:XP162A12A6P

- **VIN=2.7V 3.3V 4.2V 5.0V 6.0V 8.0V**

**FOSC=180kHz, VOUT2=3.3V**

- L2=47μH(CDRH6D38), CL2=94μF(Tantalum)
- SD2:CMS92, Ti2:XP162A12A6P

- **VIN=4.2V 5.0V 6.0V 8.0V 10V**

**FOSC=180kHz, VOUT2=5.0V**

- L2=47μH(CDRH6D38), CL2=94μF(Tantalum)
- SD2:CMS92, Ti2:XP162A12A6P

- **VIN=6.0V 8.0V 10V**

**FOSC=300kHz, VOUT2=1.0V**

- L2=22μH(CDRH5D28), CL2=94μF(Tantalum)
- SD2:CMS92, Ti2:XP162A12A6P

- **VIN=2.7V 3.3V 4.2V 5.0V 6.0V 8.0V 10V**

**FOSC=300kHz, VOUT2=1.0V**

- L2=22μH(CDRH5D28), CL2=94μF(Tantalum)
- SD2:CMS92, Ti2:XP162A12A6P

- **VIN=2.7V 3.3V 5.0V**

---

*When setting VOUT = 1.0V, VIN = 8.0V, 10.0V
CL should be 94μF (Tantalum) + 100μF (OS capacitor)*
< 2ch Step-Down DC/DC Controller >
(4) Output Voltage vs. Output Current (Continued)

\[ \text{FOSC}=300kHz, \text{VOUT2}=1.8V \]

\[ \text{FOSC}=300kHz, \text{VOUT2}=2.5V \]

\[ \text{FOSC}=300kHz, \text{VOUT2}=3.3V \]

\[ \text{FOSC}=300kHz, \text{VOUT2}=1.8V \]

\[ \text{FOSC}=300kHz, \text{VOUT2}=2.5V \]

\[ \text{FOSC}=300kHz, \text{VOUT2}=3.3V \]
XC9502 Series

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2ch Step-Down DC/DC Controller >

(4) Output Voltage vs. Output Current (Continued)

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

FOSC=300kHz, VOUT=5.0V

FOSC=300kHz, VOUT=5.0V

0.1 1 10 100 1000
Output Current2 IOUT2 (mA)

Output Voltage2 VOUT2 (V)

PWM Control

L2=22 H(CDRH5D28), CL2=94 μF (Tantalum)
SD2:CM902, T2:XP162A12A6P

VIN= 6.0V, 8.0V

*When setting VOUT = 1.0V, VIN = 8.0V, 10.0V
Cl should be 94 μF (Tantalum) + 100 μF (OS capacitor)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2ch Step-Down DC/DC Controller >

(4) Output Voltage vs. Output Current (Continued)

*When setting $V_{OUT} = 1.0V$, $V_{IN} = 8.0V$, 10.0V

$C_L$ should be $94 \mu F$ (Tantalum) + $100 \mu F$ (OS capacitor)
XC9502 Series

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2ch Step-Down DC/DC Controller >

(5) Efficiency vs. Output Current

FOSC=180kHz, VOUT=1.0V
L2=47 \mu F (CDRH6D28), CL2=94 \mu F (Tantalum)
SD2: CMS02, T2: XP162A12A6P

FOSC=180kHz, VOUT=3.3V
L2=47 \mu F (CDRH6D28), CL2=94 \mu F (Tantalum)
SD2: CMS02, T2: XP162A12A6P

FOSC=180kHz, VOUT=5.0V
L2=47 \mu F (CDRH6D28), CL2=94 \mu F (Tantalum)
SD2: CMS02, T2: XP162A12A6P

FOSC=300kHz, VOUT=1.0V
L2=22 \mu F (CDRH5D28), CL2=94 \mu F (Tantalum)
SD2: CMS02, T2: XP162A12A6P

*When setting VOUT = 1.0V, VIN = 8.0V, 10.0V
CL should be 94 \mu F (Tantalum) + 100 \mu F (OS capacitor)
"TYPICAL PERFORMANCE CHARACTERISTICS (Continued)"

< 2ch Step-Down DC/DC Controller >

(5) Efficiency vs. Output Current (Continued)

\[
\text{FOSC}=300kHz, \text{VOUT}=1.8V
\]

\[
\text{FOSC}=300kHz, \text{VOUT}=2.5V
\]

\[
\text{FOSC}=300kHz, \text{VOUT}=3.3V
\]

\[
\text{FOSC}=300kHz, \text{VOUT}=5.0V
\]

*When setting VOUT = 1.0V, VIN = 8.0V, 10.0V
CL should be 94 \( \xi \) F (Tantalum) + 100 \( \xi \) F (OS capacitor)
< 2ch Step-Down DC/DC Controller >

(5) Efficiency vs. Output Current (Continued)

*When setting $V_{OUT} = 1.0V, V_{IN} = 8.0V, 10.0V$

$Cl$ should be $94\ \mu F$ (Tantalum) + $100\ \mu F$ (OS capacitor)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2ch Step-Down DC/DC Controller >

(6) Ripple Voltage vs. Output Current

* When setting VOUT = 1.0V, VIN = 8.0V, 10.0V
CL should be 94μF (Tantalum) + 100μF (OS capacitor)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2ch Step-Down DC/DC Controller >

(6) Ripple Voltage vs. Output Current (Continued)

FOSC=300kHz, VOUT=1.0V
L2=22μH(CDRH5D28), CL=94μF(Tantalum)
SD2:CMS02, Tr2:XP162A12A6P

FOSC=300kHz, VOUT=1.8V
L2=22μH(CDRH5D28), CL=94μF(Tantalum)
SD2:CMS02, Tr2:XP162A12A6P

FOSC=300kHz, VOUT=2.5V
L2=22μH(CDRH5D28), CL=94μF(Tantalum)
SD2:CMS02, Tr2:XP162A12A6P

*When setting VOUT = 1.0V, VIN = 8.0V, 10.0V
CL should be 94μF (Tantalum) + 100μF (OS capacitor)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2ch Step-Down DC/DC Controller >

(6) Ripple Voltage vs. Output Current (Continued)

* When setting $V_{OUT} = 1.0\,\text{V}$, $V_{IN} = 8.0\,\text{V},\ 10.0\,\text{V}$
  Cl. should be 94 $\mu\text{F}$ (Tantalum) + 100 $\mu\text{F}$ (OS capacitor)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

< 2ch Step-Down DC/DC Controller >

(6) Ripple Voltage vs. Output Current (Continued)

* When setting $V_{OUT} = 1.0V$, $V_{IN} = 8.0V$, 10.0V
  $C_L$ should be 94 $\mu$F (Tantalum) + 100 $\mu$F (OS capacitor)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(7) Supply Current vs. Supply Voltage

![Graph of Supply Current vs. Supply Voltage for XC9502B092 (180kHz)]

(8) Supply Current 1-1 vs. Supply Voltage

![Graph of Supply Current 1-1 vs. Supply Voltage for XC9502B092 (180kHz)]

(9) Supply Current 1-2 vs. Supply Voltage

![Graph of Supply Current 1-2 vs. Supply Voltage for XC9502B092 (180kHz)]

(10) Supply Current 1-3 vs. Supply Voltage

![Graph of Supply Current 1-3 vs. Supply Voltage for XC9502B092 (180kHz)]

(11) Supply Current 1-4 vs. Supply Voltage

![Graph of Supply Current 1-4 vs. Supply Voltage for XC9502B092 (180kHz)]

(12) Supply Current 2 vs. Supply Voltage

![Graph of Supply Current 2 vs. Supply Voltage for XC9502B092 (180kHz)]
XC9502 Series

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(13) Oscillation Frequency vs. Supply Voltage

**XC9502B092 (180kHz)**

![Oscillation Frequency vs. Supply Voltage Graph](#)

(14) Stand-by Current vs. Supply Voltage

**XC9502B092 (180kHz)**

![Stand-by Current vs. Supply Voltage Graph](#)

(15) PWM1, 2 'H' 'L' Voltage vs. Supply Voltage

**XC9502B092 (180kHz)**

![PWM1, 2 'H' 'L' Voltage vs. Supply Voltage Graph](#)

(16) EN1, 2 'H' 'L' Voltage vs. Supply Voltage

**XC9502B092 (180kHz)**

![EN1, 2 'H' 'L' Voltage vs. Supply Voltage Graph](#)

(17) Maximum Duty Ratio 1 vs. Supply Voltage

**XC9502B092 (180kHz)**

![Maximum Duty Ratio 1 vs. Supply Voltage Graph](#)

(18) PFM Duty Ratio 1, 2 vs. Supply Voltage

**XC9502B092 (180kHz)**

![PFM Duty Ratio 1, 2 vs. Supply Voltage Graph](#)
Ⅲ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(19) EXT 1, 2 High ON Resistance vs. Supply Voltage

XC9502B092 (180kHz)

(20) EXT 1, 2 Low ON Resistance vs. Supply Voltage

XC9502B092 (180kHz)

(21) Output Voltage vs. Ambient Temperature

XC9502B093(300kHz)

L=22μH (CDR15028), CL=94μF (Tantalum)
Tr=10μA/1000μA, SD=CM502

(22) Oscillation Start-Up Voltage vs. Ambient Temperature

XC9502B092 (180kHz,VOUT=2.0V)

(23) Operation Retention Voltage vs. Ambient Temperature

XC9502B092(180kHz,VOUT=3.3V)

L=22μH (CDR15028), CL=47μF (Tantalum)
SD=MA20373, Tr=2SD168G

(24) Operation Start-Up Voltage vs. Ambient Temperature

XC9502B092(180kHz,VOUT=3.3V)

L=22μH (CDR15028), CL=47μF (Tantalum)
SD=MA20373, Tr=2SD168G
(25) Soft-Start Time 1, 2 vs. Supply Voltage

XC9502B092 (180kHz)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(26) Load Transient Response

[1 channel: Step-Up DC/DC Controller]

\(< \text{VOUT}_1 = 3.3V, \text{VIN} = 2.0V, \text{IOUT}_1, 2 = 100 mA \leftrightarrow 100mA >\)

- PWM Control

\[\text{FOSC}=180kHz, \text{VOUT}_1=3.3V, \text{VIN}=2.0V, \text{IOUT}_1=100mA \leftrightarrow 100mA\]

\[\text{CH1: VOUT}_1, \text{AC-COUPLED, 50mV/div, CH2: IOUT}_1, 50mA/div\]

\[200 \mu\text{sec/div} \]

\[10\text{msec/div} \]

- PWM/PFM Switching Control

\[\text{FOSC}=180kHz, \text{VOUT}_1=3.3V, \text{VIN}=2.0V, \text{IOUT}_1=100mA \leftrightarrow 100mA\]

\[\text{CH1: VOUT}_1, \text{AC-COUPLED, 50mV/div, CH2: IOUT}_1, 50mA/div\]

\[200 \mu\text{sec/div} \]

\[10\text{msec/div} \]
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(26) Load Transient Response (Continued)

< VOUT1 = 3.3V, VIN = 2.0V, IOUT1, 2 =10mA ↔ 100mA >

PWM Control

PWM/PWM Switching Control

FOSC=180kHz, VOUT1=3.3V
VIN=2.0V, IOUT1=10mA ↔ 100mA

CH1: VOUT1, AC-COUPLED, 50mV/div
CH2: IOUT1, 50mA/div

200 µsec/div

FOSC=180kHz, VOUT1=3.3V
VIN=2.0V, IOUT1=100mA ↔ 10mA

CH1: VOUT1, AC-COUPLED, 50mV/div
CH2: IOUT1, 50mA/div

200 µsec/div
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(26) Load Transient Response (Continued)

<PWM Control □ PWM/PFM Switching Control>

<FOSC=180kHz, VOUT1=3.3V
VIN=2.0V, IOUT1=1mA, PWM1 'L' □ 'H'>

CH1: VOUT1, AC-COUPLED, 10mV/div
CH2: PWM1, 0.5V/div

1msec/div

CH1
3.3V
0.65V
0V

CH2

FOSC=180kHz, VOUT1=3.3V
VIN=2.0V, IOUT1=1mA, PWM1 'H' □ 'L'

CH1: VOUT1, AC-COUPLED, 10mV/div
CH2: PWM1, 0.5V/div

1msec/div

CH1
3.3V
0.65V
0V

CH2

<Soft Start Wave Form>

<FOSC=180kHz, VOUT1=3.3V
VIN=2.0V, IOUT1=100mA, EN1 'L' □ 'H'
CIN=47 □ F>

CH1: VOUT1, 1.0V/div
CH2: IIN1, 100mA/div
CH3: EN1, 0.5V/div

4ms/div

* EN2=GND
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(26) Load Transient Response (Continued)

\(< V_{out2}=3.3\,V, \, V_{in}=5.0\,V, \, I_{out2}=100\,\mu A \leftrightarrow 300\,mA >

- PWM Control

![PWM Control Graph]

- PWM/PFM Switching Control

![PWM/PFM Switching Control Graph]
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(26) Load Transient Response (Continued)

< Vout2=3.3V, Vin=5.0V, Iout2=10mA ↔ 300mA >

- PWM Control

![PWM Control Graph](image1)

- PWM/PFM Switching Control

![PWM/PFM Switching Control Graph](image2)
(26) Load Transient Response (Continued)

< VOUT2=0.9V, VIN=3.3V, IOUT2=100mA ↔ 300mA >

- PWM Control

- PWM/PFM Switching Control
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(26) Load Transient Response (Continued)

< VOUT2=0.9V, VIN=3.3V, IOUT2=10mA ↔ 300mA>

PWM Control

PWM/PFM Switching Control
XC9502 Series

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(26) Load Transient Response (Continued)

< PWM Control   □ PWM/PFM Switching Control>

FOSC=300kHz, VOUT2=3.3V
VIN=5.0V, IOUT2=5mA, PWM2 'L' □ 'H'

CH1: VOUT2, AC-COUPLED, 10mV/div
CH2: PWM2, 0.5V/div

FOSC=300kHz, VOUT2=3.3V
VIN=5.0V, IOUT2=5mA, PWM2 'H' □ 'L'

CH1: VOUT2, AC-COUPLED, 20mV/div
CH2: PWM2, 0.5V/div

<Soft Start Wave Form>

FOSC=300kHz, VOUT2=3.3V
VIN=5.0V, IOUT2=300mA, EN2 'L' □ 'H'
CIN=47 µF

CH1: VOUT2, 2.0V/div
CH2: IIN2, 100mA/div
CH3: EN2, 0.5V/div

FOSC=300kHz, VOUT2=3.3V
VIN=5.0V, IOUT2=100mA, EN2 'L' □ 'H'
CIN=47 µF

CH1: VOUT2, 2.0V/div
CH2: IIN2, 50mA/div
CH3: EN2, 0.5V/div

* EN1=GND
PACKAGING INFORMATION

MSOP-10

USP-10

USP-10 Recommended Pattern Layout

USP-10 Recommended Metal Mask Design
маркering Rule

- MSOP-10, USP-10

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- represents product series

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- represents type of DC/DC converter

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- , ,  represents FB voltage

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- represents oscillation frequency

- represents production lot number
  0 to 9, A to Z repeated (G, I, J, O, Q, W excluded)

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