**GENERAL DESCRIPTION**

The XC6604 series is a low voltage input (0.5V) operation and provides high accuracy ±15mV / ±20mV and can supply large current efficiently due to its ultra low on-resistance even at low output voltages.

The series is ideally suited to the applications which require high current in low input/output voltages and consists of a N-ch driver transistor, a voltage reference, an error amplifier, a current limiter, a fold-back circuit, a thermal shutdown (TSD) circuit, an under voltage lock out (UVLO) circuit, a soft-start circuit and a phase compensation circuit.

Output voltage is selectable in 0.1V increments within a range of 0.5V to 1.8V using laser trimming technology and ceramic capacitors can be used for the output stabilization capacitor (C<sub>L</sub>). When the output current reaches the current limit, the output voltage drops as well as the output current is decreased as a function of the foldback circuit. The current limit can be adjustable with connecting a resistor to the I<sub>LIM</sub> pin.

The CE function enables the output to be turned off and the series to be put in stand-by mode resulting in greatly reduced power consumption. At the time of entering the stand-by mode, the series enables the electric charge at the output capacitor (C<sub>L</sub>) to be discharged via the internal switch. As a result the V<sub>OUT</sub> pin quickly returns to the V<sub>SS</sub> level.

The CE pull-down function keeps the IC to be in stand-by mode even if the CE pin is left open.

**APPLICATIONS**

- Smart phones / Mobile phones
- Digital still cameras / Camcorders
- Note PCs / Tablet PCs
- E-book Readers / Electronic dictionaries
- Wireless LAN

**FEATURES**

- **Maximum Output Current**: 1A (1.3A Limit)
- **ON Resistance**: 0.15Ω @V<sub>BIAS</sub>=3.6V, V<sub>OUT</sub>=1.2V
- **Bias Voltage Range**: 2.5V~6.0V
- **Input Voltage Range**: 0.5V~3.0V
- **Output Voltage Range**: 0.5V~1.8V (0.1V increments)
- **Output Voltage Accuracy**: ±0.015V @V<sub>OUT</sub> < 1.2V
- **Ripple Rejection**: 60dB @f=1kHz (V<sub>BIAS_PSRR</sub>)
- **Low Power Consumption**: 100 μA (V<sub>BIAS</sub>), 6.5 μA (V<sub>IN</sub>) @V<sub>OUT</sub>=1.2V
- **Stand-by Current**: 0.01 μA (V<sub>BIAS</sub>), 0.01 μA (V<sub>IN</sub>)
- **Under-voltage Lockout**: 1.8V (V<sub>BIAS</sub>), 0.4V (V<sub>IN</sub>)
- **Thermal Shutdown**: 150°C @detect, 125°C @release
- **Protection Circuit**: Foldback Current Limit, TSD, UVLO
- **Function**: Soft-start, CE Pull-Down (Active High)
- **Operating Ambient Temperature**: -40°C ~ +85°C
- **Output Capacitor**: Ceramic Capacitor Compatible (2.2 μF)
- **Packages**: USP-6C, SOT-26W
- **Environmentally Friendly**: EU RoHS Compliant, Pb Free

**TYPICAL APPLICATION CIRCUIT**

**TYPICAL PERFORMANCE CHARACTERISTICS**

![Typical Application Circuit Diagram](image)

![Typical Performance Characteristics Graph](image)
**BLOCK DIAGRAMS**

Type A

![Type A Diagram](image)

Type B

![Type B Diagram](image)

**PRODUCT CLASSIFICATION**

**Ordering Information**

<table>
<thead>
<tr>
<th>DESIGNATOR</th>
<th>ITEM</th>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>Type</td>
<td>A</td>
<td>Refer to Selection Guide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>②③</td>
<td>Output Voltage</td>
<td>05~18</td>
<td>e.g. 1.2V → ②=1, ③=2</td>
</tr>
<tr>
<td>④</td>
<td>Output Voltage Accuracy</td>
<td>1</td>
<td>±0.015V ($V_{OUT}$&lt;1.2V), ±0.020V ($V_{OUT}$≧1.2V)</td>
</tr>
<tr>
<td>⑤⑥⑦(*)</td>
<td>Packages (Order Unit)</td>
<td>ER-G</td>
<td>USP-6C (3,000/Reel)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MR-G</td>
<td>SOT-26W (3,000/Reel)</td>
</tr>
</tbody>
</table>

(*) The “-G” suffix denotes Halogen and Antimony free as well as being fully EU RoHS compliant.

**Selection Guide**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SOFT-START</th>
<th>CURRENT LIMITTER</th>
<th>THERMAL SHUTDOWN</th>
<th>UVLO</th>
<th>CE PULL-DOWN RESISTOR</th>
<th>CL AUTO DISCHARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Yes</td>
<td>Adjustable</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>B</td>
<td>No</td>
<td>Adjustable</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
■ PIN CONFIGURATION

*The dissipation pad for the USP-6C package should be solder-plated in recommended mount pattern and metal masking so as to enhance mounting strength and heat release. If the pad needs to be connected to other pins, it should be connected to the VSS (No. 2) pin.

■ PIN ASSIGNMENT

<table>
<thead>
<tr>
<th>PIN NUMBER</th>
<th>PIN NAME</th>
<th>FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>USP-6C</td>
<td>SOT-26W</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>VBUS</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>VSS</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>VIN</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>VOUT</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>ILM</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>CE</td>
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</table>

■ FUNCTION CHART

<table>
<thead>
<tr>
<th>PIN NAME</th>
<th>SIGNAL</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE</td>
<td>L</td>
<td>Stand-by</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>OPEN</td>
<td>Stand-by</td>
</tr>
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</table>
## ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>RATINGS</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bias Voltage</td>
<td>$V_{BIAS}$</td>
<td>-0.3~+6.5</td>
<td>V</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>$V_{IN}$</td>
<td>-0.3~+6.5</td>
<td>V</td>
</tr>
<tr>
<td>Output Current</td>
<td>$I_{OUT}$</td>
<td>1.65 $^{(*)1}$</td>
<td>A</td>
</tr>
<tr>
<td>Output Voltage $^{(*)2}$</td>
<td>$V_{OUT}$</td>
<td>-0.3~$V_{BIAS}$+0.3 or +6.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.3~$V_{IN}$+0.3 or +6.5</td>
<td></td>
</tr>
<tr>
<td>CE Input Voltage</td>
<td>$V_{CE}$</td>
<td>-0.3~+6.5</td>
<td>V</td>
</tr>
<tr>
<td>$I_{LIM}$ Pin Voltage $^{(*)3}$</td>
<td>$I_{LIM}$</td>
<td>-0.3~$V_{IN}$+0.3 or +6.5</td>
<td>V</td>
</tr>
</tbody>
</table>

| Power Dissipation          | USP-6C | Pd  | 120 | 1000 (PCB mounted) $^{(*)4}$ |
|                            | SOT-26W |     | 250 |                                 |

| Operating Ambient Temperature | Topr | -40~+85 | °C |
| Storage Temperature           | Tstg | -55~+125 | °C |

$^{(*)}$ All voltages are described based on the $V_{SS}$ pin.

$^{(*)1}$ $I_{OUT}$ ≤ $Pd / (V_{IN} \cdot V_{OUT})$

$^{(*)2}$ The maximum value should be either $V_{BIAS}$+0.3, $V_{IN}$+0.3 or +6.5 in the lowest.

$^{(*)3}$ The maximum value should be either $V_{IN}$+0.3 or +6.5 in the lowest.

$^{(*)4}$ The power dissipation measured with the test board condition is listed as reference data.

Please refer to page 26~27 for details.
## ELECTRICAL 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>Bias Voltage</td>
<td>V_{bas}</td>
<td></td>
<td>2.5</td>
<td>-</td>
<td>6.0</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>V_{in}</td>
<td></td>
<td>0.5</td>
<td>-</td>
<td>3.0</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>V_{out}(\text{ typ.})</td>
<td>i_{out}=100mA,</td>
<td>V_{out}\leq0.1V</td>
<td>-0.015</td>
<td>+0.015</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>Maximum Output Current (\textsuperscript{3})</td>
<td>i_{out}\text{ \text{typ.}}=1.2V, V_{bas}=V_{ce}=2.5V</td>
<td>V_{out}\leq0.1V</td>
<td>-0.020</td>
<td>+0.020</td>
<td>V</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Load Regulation</td>
<td>ΔV_{out}</td>
<td>1mA, ICE input goes over the CE H threshold and the output reaches V_{out} \times 0.9V</td>
<td>-</td>
<td>0.15</td>
<td>37</td>
<td>mV</td>
<td>1</td>
</tr>
<tr>
<td>Dropout Voltage</td>
<td>V_{dif}(\textsuperscript{4})</td>
<td>i_{out}=1A</td>
<td>-</td>
<td>E-1(\textsuperscript{2})</td>
<td>mV</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Supply Current 1 (\textsuperscript{3})</td>
<td>i_{bas}</td>
<td>i_{out}=0A</td>
<td>V_{out}\leq1.2V</td>
<td>0.1</td>
<td>-</td>
<td>8.7</td>
<td>μA</td>
</tr>
<tr>
<td>Supply Current 2</td>
<td>i_{bas}</td>
<td>i_{out}=0A</td>
<td>V_{out}\leq1.2V</td>
<td>3.9</td>
<td>-</td>
<td>14.2</td>
<td>μA</td>
</tr>
<tr>
<td>Stand-by Current 1</td>
<td>i_{bas-STB}</td>
<td>V_{bas}=6.0V, V_{in}=3.0V, V_{ce}=V_{ss}</td>
<td>-</td>
<td>0.01</td>
<td>0.10</td>
<td>μA</td>
<td>2</td>
</tr>
<tr>
<td>Stand-by Current 2</td>
<td>i_{bas-STB}</td>
<td>V_{bas}=6.0V, V_{in}=3.0V, V_{ce}=V_{ss}</td>
<td>-</td>
<td>0.01</td>
<td>0.15</td>
<td>μA</td>
<td>2</td>
</tr>
<tr>
<td>Bias Line Regulation</td>
<td>ΔV_{out}/(ΔV_{bas}/V_{out})</td>
<td>V_{out}\leq1.2V, V_{ce}=V_{ss}, 2.5\leq V_{bas}\leq6.0V</td>
<td>-</td>
<td>0.01</td>
<td>1.0</td>
<td>%/V</td>
<td>1</td>
</tr>
<tr>
<td>Bias UVLO Voltage</td>
<td>V_{bas-UVLO}</td>
<td>V_{ss}</td>
<td>-</td>
<td>1.28</td>
<td>V</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Bias UVLO Release Voltage</td>
<td>V_{bas-UVLO}</td>
<td>V_{ss}</td>
<td>-</td>
<td>6.0</td>
<td>V</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Input UVLO Voltage</td>
<td>V_{in-UVLO}</td>
<td>V_{ss}</td>
<td>-</td>
<td>0.23</td>
<td>V</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Input UVLO Release Voltage</td>
<td>V_{in-UVLO}</td>
<td>V_{ss}</td>
<td>-</td>
<td>3.0</td>
<td>V</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Output Voltage Temperature</td>
<td>V_{out}(\text{ typ.})</td>
<td>i_{out}=100mA</td>
<td>-</td>
<td>±30</td>
<td>-</td>
<td>ppm/°C</td>
<td>1</td>
</tr>
<tr>
<td>Bias Ripple Rejection Ratio</td>
<td>V_{bas-PSSR}</td>
<td>V_{bas}=V_{ce}=3.6V, V_{out}=0.2V,</td>
<td>60</td>
<td>-</td>
<td>dB</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Input Ripple Rejection Ratio</td>
<td>V_{in-PSSR}</td>
<td>V_{in}=0.3V, V_{out}=0.2V,</td>
<td>75</td>
<td>-</td>
<td>dB</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Current Limit (\textsuperscript{3})</td>
<td>i_{lim}</td>
<td>V_{out}/(V_{out}=1A)\times0.95</td>
<td>1.0</td>
<td>1.3</td>
<td>-</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>Adjustable Current Limit Accuracy (\textsuperscript{3})</td>
<td>i_{lim-adj}</td>
<td>(-35)</td>
<td>-</td>
<td>(35)</td>
<td>-</td>
<td>%</td>
<td>1</td>
</tr>
<tr>
<td>Short - Circuit Current</td>
<td>i_{short}</td>
<td>V_{out}=V_{ss}</td>
<td>-</td>
<td>90</td>
<td>-</td>
<td>mA</td>
<td>1</td>
</tr>
<tr>
<td>Thermal Shutdown Detect Temperature</td>
<td>T_{tsd}</td>
<td>Junction Temperature</td>
<td>-</td>
<td>150</td>
<td>-</td>
<td>°C</td>
<td>1</td>
</tr>
<tr>
<td>Thermal Shutdown Release Temperature</td>
<td>T_{tsr}</td>
<td>Junction Temperature</td>
<td>-</td>
<td>125</td>
<td>-</td>
<td>°C</td>
<td>1</td>
</tr>
<tr>
<td>Thermal Shutdown Hysteresis Width</td>
<td>T_{tsd-tsr}</td>
<td>Junction Temperature</td>
<td>-</td>
<td>25</td>
<td>-</td>
<td>°C</td>
<td>1</td>
</tr>
<tr>
<td>C Auto-Discharge Resistance</td>
<td>R_{oc}</td>
<td>V_{oc}=V_{ss}, V_{out}=V_{out} \textsuperscript{(1)}</td>
<td>130</td>
<td>190</td>
<td>255</td>
<td>Ω</td>
<td>1</td>
</tr>
<tr>
<td>CE &quot;H&quot; Level Voltage</td>
<td>V_{ceh}</td>
<td>V_{oc}=6.0V</td>
<td>0.65</td>
<td>6.00</td>
<td>V</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>CE &quot;L&quot; Level Voltage</td>
<td>V_{cel}</td>
<td>V_{oc}=6.0V</td>
<td>0.41</td>
<td>V</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE &quot;H&quot; Level Current</td>
<td>i_{ceh}</td>
<td>V_{bas}=V_{ce}=6.0V</td>
<td>3.2</td>
<td>6.0</td>
<td>16.5</td>
<td>mA</td>
<td>4</td>
</tr>
<tr>
<td>CE &quot;L&quot; Level Current</td>
<td>i_{cel}</td>
<td>V_{bas}=V_{ce}=6.0V,</td>
<td>-0.1</td>
<td>-</td>
<td>0.1</td>
<td>μA</td>
<td>4</td>
</tr>
<tr>
<td>Soft-Start Time (\textsuperscript{(3)} Type A)</td>
<td>t_{ss}</td>
<td>V_{out}=0V, V_{in}=1A</td>
<td>225</td>
<td>430</td>
<td>600</td>
<td>μs</td>
<td>5</td>
</tr>
<tr>
<td>Output Rise Time (\textsuperscript{3)} Type B)</td>
<td>t_{on}</td>
<td>V_{out}=0V, V_{ce}=3.6V,</td>
<td>-</td>
<td>110</td>
<td>-</td>
<td>μs</td>
<td>5</td>
</tr>
<tr>
<td>Inrush Current (Type A)</td>
<td>i_{rush}</td>
<td>C_L=2.2μF,</td>
<td>V_{out}=1.2V</td>
<td>-</td>
<td>110</td>
<td>mA</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C_L=2.2μF</td>
<td>V_{out}&gt;1.2V</td>
<td>-</td>
<td>85</td>
<td>mA</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C_L=10μF</td>
<td>V_{out}=1.2V</td>
<td>-</td>
<td>155</td>
<td>mA</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C_L=10μF</td>
<td>V_{out}&gt;1.2V</td>
<td>-</td>
<td>215</td>
<td>mA</td>
<td>5</td>
</tr>
</tbody>
</table>

### NOTE:

- Unless otherwise stated, V_{bas}=V_{ce}=3.6V, V_{in}=V_{out}\geq0.3V, i_{out}=1mA, C_{bas}=C_{ce}=1.0μF, C_L=2.2μF, f_{in-adj}=V_{pin}.

\textsuperscript{(1)} V_{out}\textsuperscript{(1)} = Effective output voltage

\textsuperscript{(2)} V_{out}\textsuperscript{(2)} = Nominal output voltage

\textsuperscript{(3)} Mount conditions affect heat dissipation. Maximum output current is not guaranteed when TSD starts to operate earlier.

\textsuperscript{(4)} V_{dif}=V_{in-adj}\

\textsuperscript{(5)} Please refer to the table E-1 named DROPOUT VOLTAGE CHART

\textsuperscript{(6)} A time between the CE input goes over the CE H threshold and the output reaches V_{out}\times0.9V.

\textsuperscript{(7)} Design value
## ELECTRICAL CHARACTERISTICS (Continued)

### Dropout Voltage Chart

<table>
<thead>
<tr>
<th>NOMINAL OUTPUT VOLTAGE</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$V_{GS}$ (V)</td>
<td>$V_{diff}$ (mV)</td>
<td>$V_{GS}$ (V)</td>
<td>$V_{diff}$ (mV)</td>
<td>$V_{GS}$ (V)</td>
<td>$V_{diff}$ (mV)</td>
<td>$V_{GS}$ (V)</td>
<td>$V_{diff}$ (mV)</td>
<td>$V_{GS}$ (V)</td>
<td>$V_{diff}$ (mV)</td>
</tr>
<tr>
<td>$V_{OUT(T)}$ (V)</td>
<td>TYP.</td>
<td>MAX.</td>
<td>TYP.</td>
<td>MAX.</td>
<td>TYP.</td>
<td>MAX.</td>
<td>TYP.</td>
<td>MAX.</td>
<td>TYP.</td>
<td>MAX.</td>
</tr>
<tr>
<td>0.5</td>
<td>2.5</td>
<td>152</td>
<td>218</td>
<td>2.8</td>
<td>3.1</td>
<td>213</td>
<td>146</td>
<td>2.9</td>
<td>3.6</td>
<td>2.9</td>
</tr>
<tr>
<td>0.6</td>
<td>2.4</td>
<td>155</td>
<td>223</td>
<td>2.7</td>
<td>3.0</td>
<td>213</td>
<td>146</td>
<td>2.9</td>
<td>3.5</td>
<td>2.9</td>
</tr>
<tr>
<td>0.7</td>
<td>2.3</td>
<td>2.6</td>
<td>152</td>
<td>218</td>
<td>2.8</td>
<td>3.4</td>
<td>2.8</td>
<td>3.4</td>
<td>2.8</td>
<td></td>
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<tr>
<td>0.8</td>
<td>2.2</td>
<td>158</td>
<td>228</td>
<td>2.5</td>
<td>3.4</td>
<td>2.8</td>
<td>3.4</td>
<td>2.8</td>
<td>3.4</td>
<td>2.8</td>
</tr>
<tr>
<td>0.9</td>
<td>2.1</td>
<td>162</td>
<td>233</td>
<td>2.4</td>
<td>3.3</td>
<td>2.7</td>
<td>3.3</td>
<td>2.7</td>
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<td>303</td>
<td>1.8</td>
<td>169</td>
<td>253</td>
<td>3.2</td>
</tr>
</tbody>
</table>

* Dropout voltage is defined as the $V_{GS} = V_{BIAS} - V_{OUT(E)}$ of the driver transistor.
■ TEST CIRCUITS (Continued)

XC6604 Series, Type A

XC6604 Series, Type B
OPERATIONAL DESCRIPTION

The voltage divided by resistors R1 and R2 is compared with the internal reference voltage by the error amplifier. The V_OUT pin is then driven by the subsequent output signal. The output voltage at the V_OUT pin is controlled and stabilized by a system of negative feedback. V_BIAS pin is power supply pin for output voltage control circuit, protection circuit and CE circuit. Also, the V_BIAS pin supplies some current as output current. V_IN pin is connected to a driver transistor and provides output current.

In order to obtain high efficient output current through low on-resistance, please take enough V_GS (V_BIAS – V_OUT) of the driver transistor.

Figure 1: XC6604 Series, Type A

<Current Limiter, Short-Circuit Protection>
The XC6604 series includes a combination of a fixed current limiter circuit and a foldback short-circuit protection. When the output current reaches the current limit, the output voltage drops and this operation makes the output current foldback to be decreased.

The current limit can be set freely with connecting a resistor to the I_LIM pin.

Please note about the foldback circuit characteristics below;

- Output voltage may not rise when the output voltage is lower than 0V at the IC operation start.
- Current over the foldback current limit will not flow at the IC operation start.
- Please use type A (with soft-start time) to prevent from inrush current, because the circuit may not response to a drastic current change such as the inrush current.

When the I_LIM pin is left open, driver transistor will be forced off.

Current Limit is calculated by the following formulas.

\[
I_{LM} = \frac{V_{OUT(T)}}{R_{LIM1} + R_{LIM2}} \times \frac{79645.7}{[A]} \]

\[
R_{LIM1} = \frac{V_{OUT(T)}}{16.3 \times 10^3} \quad [\Omega] \]

I_LIM: Current Limit
V_OUT(T): Nominal Output Voltage
R_LIM1: Internal Current Limit Resistance
R_LIM2: External Current Limit Resistance

Figure 2: XC6604 Series, Range of adjustable current limit

<table>
<thead>
<tr>
<th>OUTPUT VOLTAGE RANGE</th>
<th>ADJUSTABLE CURRENT LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_OUT(T)</td>
<td>I_LIM</td>
</tr>
<tr>
<td>0.5V~1.8V</td>
<td>0.5A~1.3A</td>
</tr>
</tbody>
</table>

XC6604 Series, R_LIM2 Connecting
OPERATIONAL DESCRIPTION (Continued)

<Soft-Start Function>
With the XC6604 (Type A), the inrush current ($I_{RUSH}$) from $V_{IN}$ to $V_{OUT}$ for charging $C_L$ at start-up can be reduced and makes the $V_{IN}$ stable. As for the XC6604, the soft-start time in the type A is optimized internally. On the other hand, the type B of the XC6604 does not have the soft-start time function.

<Thermal Shutdown Circuit (TSD)>
When the junction temperature of the built-in driver transistor reaches the temperature limit, the thermal shutdown circuit operates and the driver transistor will be set to OFF. The IC resumes its operation when the thermal shutdown function is released and the IC’s operation is automatically restored because the junction temperature drops to the level of the thermal shutdown release temperature.

<Under Voltage Lock Out (UVLO)>
When the $V_{BIAS}$ and $V_{IN}$ pin voltage drops, the output driver transistor is set to OFF by UVLO function to prevent false output caused by unstable operation of the internal circuitry. When the $V_{BIAS}$ pin voltage and the $V_{IN}$ pin voltage rises at release voltage, the UVLO function is released. The driver transistor is turned ON and start to operate voltage regulation.

<CE Pin>
The XC6604 internal circuitry can be shutdown via the signal to the CE pin. In shutdown mode with CE low level voltage, the $V_{OUT}$ pin will be pulled down to the $V_{ES}$ level via $C_L$ discharge resistance ($R_{DCHG}$) placed in parallel to R1 and R2. The CE pin has pull-down circuitry so that CE input current flows during IC operation. If the CE pin voltage is taken from $V_{BIAS}$ pin or $V_{SS}$ pin then logic is fixed and the IC will operate normally. However, supply current may increase as a result of through current in the IC’s internal circuitry when medium voltage is input.

<C_L High Speed Auto-Discharge>
XC6604 series can quickly discharge the electric charge at the output capacitor ($C_L$) via the internal transistor located between the $V_{OUT}$ pin and the $V_{SS}$ pin when a low signal to the CE pin which enables a whole IC circuit put into OFF state. When the IC is disabled, electric charge at the output capacitor ($C_L$) is quickly discharged so that it could avoids malfunction. Discharge time of the output capacitor ($C_L$) is set by the $C_L$ auto-discharge resistance ($R_{DCHG}$) and the output capacitor ($C_L$). By setting time constant of a $C_L$ auto-discharge resistance value ($R_{DCHG}$) and an output capacitor value ($C_L$) as $\tau$ ($\tau = C_L \times R_{DCHG}$), the output voltage after discharge via the internal transistor is calculated by the following formula. Please also note $R_{DCHG}$ is depended on $V_{BIAS}$. When $V_{BIAS}$ is larger, $R_{DCHG}$ is smaller.

$$V = V_{OUT(E)} \times e^{-t/\tau} \text{ or } t = \tau \ln \left( V_{OUT(E)} / V \right)$$

V: Output voltage during discharge
$V_{OUT(E)}$: Initial Output voltage
$t$: Discharge time
$\tau$: $C_L \times R_{DCHG}$

<Low ESR Capacitor>
With the XC6604 series, a stable output voltage is achievable even if used with low ESR capacitors, as a phase compensation circuit is built-in. The output capacitor ($C_L$) should be connected as close to $V_{OUT}$ pin and $V_{SS}$ pin to obtain stable phase compensation. Values required for the phase compensation are as the table below.

For a stable power input, please connect a bias capacitor ($C_{BIAS}$) between the $V_{BIAS}$ pin and the $V_{SS}$ pin. Also, please connect an input capacitor ($C_{IN}$) between the $V_{IN}$ pin and the $V_{SS}$ pin. In order to ensure the stable phase compensation while avoiding run-out of values, please use the capacitor ($C_{BIAS}$, $C_{IN}$ and $C_L$) which does not depend on bias or temperature too much. The table below (Figure 3) shows recommended values of $C_{BIAS}$, $C_{IN}$ and $C_L$.

Figure 3: Recommended Values of $C_{BIAS}$, $C_{IN}$ and $C_L$ (MIN.)

<table>
<thead>
<tr>
<th>OUTPUT VOLTAGE RANGE</th>
<th>BIAS CAPACITOR</th>
<th>INPUT CAPACITOR</th>
<th>OUTPUT CAPACITOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{OUT(T)}$</td>
<td>$C_{BIAS}$</td>
<td>$C_{IN}$</td>
<td>$C_L$</td>
</tr>
<tr>
<td>0.5V~1.8V</td>
<td>1.0 $\mu$F</td>
<td>1.0 $\mu$F</td>
<td>2.2 $\mu$F</td>
</tr>
</tbody>
</table>
NOTES ON USE

1. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded.

2. Where wiring impedance is high, operations may become unstable due to noise and/or phase lag depending on output current. Please keep the resistance low for the V_{BIAS}, V_{IN} and V_{SS} wiring in particular.

3. Please wire the C_{BIAS}, C_{IN} and C_{L} as close to the IC as possible.

4. Capacitances of these capacitors (C_{BIAS}, C_{IN}, C_{L}) are decreased by the influences of bias voltage and ambient temperature. Care shall be taken for capacitor selection to ensure stability of phase compensation from the point of ESR influence.

5. When it is used in a quite small input / output dropout voltage, output may go into unstable operation. Please test it thoroughly before using it in production.

6. Torex places an importance on improving our products and their reliability. We request that users incorporate fail-safe designs and post-aging protection treatment when using Torex products in their systems.
TYPICAL PERFORMANCE CHARACTERISTICS

* Unless otherwise stated, $V_{BB}=V_{CE}=3.6V$, $V_{IN}=V_{OUT}=+0.3V$, $I_{OUT}=1mA$, $I_{IN}=1mA$, $P_{IN}=V_{BB}$. $C_{BIAS}=C_{IN}=1.0\mu F$, $C_{C}=2.2\mu F$, $Ta=25^\circ C$

(1) Output Voltage vs. Output Current

* Mount conditions affect heat dissipation. Thermal shutdown may start to operate before reaching the current limit.

* If start-up current is required over the current limit, IC operation will not start. Please use the current within the range of use.
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

* Unless otherwise stated, $V_{\text{BIAS}}=V_{\text{CE}}=3.6\text{V}$, $V_{\text{IN}}=V_{\text{OUT}}=0.3\text{V}$, $I_{\text{OUT}}=1\text{mA}$, $I_{\text{LM}}$ Pin = $V_{\text{SS}}$, $C_{\text{BIAS}}=C_{\text{IN}}=1.0\mu\text{F}$, $C_{\text{L}}=2.2\mu\text{F}$, $Ta=25\degree\text{C}$

(2) Limit Current vs. Adjustable Resistance

![Graph showing Limit Current vs. Adjustable Resistance](image1)

(3) Output Voltage vs. Bias Voltage

![Graph showing Output Voltage vs. Bias Voltage](image2)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

* Unless otherwise stated, V_{\text{BIAS}}=V_{\text{CE}}=3.6V, V_{\text{IN}}=V_{\text{OUT}}=0.3V, I_{\text{OUT}}=1mA, \text{ Pin}=V_{\text{SS}}, C_{\text{BIAS}}=C_{\text{N}}=1.0 \mu F, C_{\text{L}}=2.2 \mu F, \text{ Ta}=25^\circ C

(4) Output Voltage vs. Input Voltage

(5) Dropout Voltage vs. Output Current

\( V_{\text{GS}} \) is a Gate–Source voltage of the driver transistor that is defined as the value of \( V_{\text{BIAS}} - V_{\text{OUT(E)}} \). A value of the dropout voltage is determined by the value of the \( V_{\text{GS}} \).
(6) Supply Bias Current vs. Bias Voltage

XC6604x051xR-G

(7) Supply Input Current vs. Input Voltage

XC6604x051xR-G

* Unless otherwise stated, \( V_{\text{BIAS}} = V_{\text{CE}} = 3.6 \text{V}, \ V_{\text{IN}} = V_{\text{OUT}} = 0.3 \text{V}, \ I_{\text{OUT}} = 1 \text{mA}, \ I_{\text{IM}} \) \( \text{Pin} = V_{\text{ES}}, \ C_{\text{BIAS}} = C_{\text{N}} = 1.0 \mu \text{F}, \ C_{\text{L}} = 2.2 \mu \text{F}, \ T_a = 25^\circ \text{C} \)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

* Unless otherwise stated, \( V_{BCs} = V_{CE} = 3.6\, \text{V}, V_{IN} = V_{OUT} = 0.3\, \text{V}, I_{OUT} = 1\, \text{mA}, I_{LM} = P_{IN} = V_{BO}, C_{BIAS} = C_{B} = 1.0\, \mu\text{F}, C_{L} = 2.2\, \mu\text{F}, Ta = 25^\circ\text{C} \)

(8) Output Voltage vs. Ambient Temperature

\[ \text{Output Voltage: } V_{OUT}(\text{V}) \]

- \( I_{OUT} = 1\, \text{mA} \)
- \( I_{OUT} = 100\, \text{mA} \)

Ambient Temperature: \( Ta(\degree\text{C}) \)

(9) Supply Bias Current vs. Ambient Temperature

\[ \text{Supply Bias Current: } I_{BIAS}(\mu\text{A}) \]

- \( C_{IN} = C_{BIAS} = C_{L} = \text{OPEN} \)
- \( I_{OUT} = 0\, \text{mA} \)

Ambient Temperature: \( Ta(\degree\text{C}) \)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

* Unless otherwise stated, \( V_{\text{BIAS}} = V_{\text{CE}} = 3.6 \text{V}, V_{\text{IN}} = V_{\text{OUT(T)}} = 0.3 \text{V}, I_{\text{OUT}} = 1 \text{mA}, I_{\text{LM}} \text{ Pin} = V_{\text{SS}}, C_{\text{BIAS}} = C_{\text{N}} = 1.0 \mu \text{F}, C_{\text{L}} = 2.2 \mu \text{F}, T_{a} = 25^\circ \text{C} \)

(10) Supply Input Current vs. Ambient Temperature

**XC6604x051xR-G**

![Graph](image1)

**XC6604x121xR-G**

![Graph](image2)

**XC6604x181xR-G**

![Graph](image3)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

* Unless otherwise stated, $V_{BBIAS}=V_{CE}=3.6V$, $V_{IN}=V_{OUT}(H)+0.3V$, $I_{OUT}=1mA$, $I_{LM}=V_{SS}$, $C_{BIAS}=C_{IN}=1\mu F$, $C_{L}=2.2\mu F$, $T_{a}=25^\circ C$

(11) Bias Transient Response

(12) Input Transient Response

![Graph 1](image1)

![Graph 2](image2)

![Graph 3](image3)

![Graph 4](image4)

![Graph 5](image5)

![Graph 6](image6)
(13) Load Transient Response

XC6604x051xR-G

Output Current: I_{OUT}(A)

Output Voltage: V_{OUT}(V)

Time (200 μs/div)

XC6604x121xR-G

Output Current: I_{OUT}(A)

Output Voltage: V_{OUT}(V)

Time (200 μs/div)

XC6604x181xR-G

Output Current: I_{OUT}(A)

Output Voltage: V_{OUT}(V)

Time (200 μs/div)

* Unless otherwise stated, V_{BIAS}=V_{CE}=3.6V, V_{IN}=V_{OUT}=0.3V, I_{OUT}=1mA, I_{LM} Pin=V_{SS}, C_{BIAS}=C_{IN}=1.0 μF, C_{L}=2.2 μF, Ta=25°C
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

* Unless otherwise stated, $V_{\text{BAS}}=V_{\text{CE}}=3.6\,\text{V}$, $V_{\text{IN}}=V_{\text{OUT}}=0.3\,\text{V}$, $I_{\text{OUT}}=1\,\text{mA}$, $I_{\text{LM}}$ Pin $= V_{\text{SS}}$, $C_{\text{BAS}}=C_{\text{AN}}=1.0\,\mu\text{F}$, $C_{\text{C}}=2.2\,\mu\text{F}$, $Ta=25\,^\circ\text{C}$

(14) CE Input Response

**XC6604A051xR-G**

$V_{\text{IN}}=0\,\text{V} \rightarrow 3.6\,\text{V} (t_r=5\,\mu\text{s})$

$I_{\text{OUT}}=100\,\text{mA}$

**XC6604A121xR-G**

$V_{\text{IN}}=0\,\text{V} \rightarrow 3.6\,\text{V} (t_r=5\,\mu\text{s})$

$I_{\text{OUT}}=100\,\text{mA}$

**XC6604A181xR-G**

$V_{\text{IN}}=0\,\text{V} \rightarrow 3.6\,\text{V} (t_r=5\,\mu\text{s})$

$I_{\text{OUT}}=100\,\text{mA}$
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

* Unless otherwise stated, $V_{BIAS}=V_{CE}=3.6V$, $V_{IN}=V_{OUT}=0.3V$, $I_{OUT}=1mA$, $I_{LM}=P_{IN}=V_{SSS}$. $C_{BIAS}=C_{IN}=1.0 \mu F$, $C_{L}=2.2 \mu F$, $T_a=25^\circ C$

(14) CE Input Response (Continued)

**XC6604A051xR-G**

$C_L=10 \mu F$

$V_{CE}=0V \rightarrow 3.6V$, $t_{rise}=100mA$

**XC6604A121xR-G**

$C_L=10 \mu F$

$V_{CE}=0V \rightarrow 3.6V$, $t_{rise}=100mA$

**XC6604A181xR-G**

$C_L=10 \mu F$

$V_{CE}=0V \rightarrow 3.6V$, $t_{rise}=100mA$

**XC6604A051xR-G**

$C_L=10 \mu F$

$V_{CE}=0V \rightarrow 3.6V$, $t_{rise}=100mA$

**XC6604A121xR-G**

$C_L=10 \mu F$

$V_{CE}=0V \rightarrow 3.6V$, $t_{rise}=100mA$

**XC6604A181xR-G**

$C_L=10 \mu F$

$V_{CE}=0V \rightarrow 3.6V$, $t_{rise}=100mA$
(15) CE Rising Response Time
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

* Unless otherwise stated, $V_{BAS}=V_{CE}=3.6V$, $V_{IN}=V_{OUT}=0.3V$, $I_{OUT}=1mA$, $I_{MM}$ Pin=$V_{SSI}$, $C_{SS}=C_{SS}=1.0 \mu F$, $C_{c}=2.2 \mu F$, $T_{a}=25^\circ C$

(16) Rising Response Time

**XC6604A051xR−G**

$C_{in}=OPEN$

$V_{P}=0V \rightarrow 0.8V (t=5 \mu s), I_{OUT}=100mA$

**XC6604A121xR−G**

$C_{in}=OPEN$

$V_{P}=0V \rightarrow 1.5V (t=5 \mu s), I_{OUT}=100mA$

**XC6604A181xR−G**

$C_{in}=OPEN$

$V_{P}=0V \rightarrow 2.1V (t=5 \mu s), I_{OUT}=100mA$
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

* Unless otherwise stated, $V_{\text{BIAS}}=V_{CE}=3.6 \text{V, } V_{\text{IN}}=V_{\text{OUT(T)}}=0.3 \text{V, } I_{\text{OUT}}=1 \text{mA, } I_{\text{LIN}} \text{ Pin}=V_{SS}, C_{\text{BIAS}}=C_{\text{IN}}=1.0 \mu \text{F, } C_{L}=2.2 \mu \text{F, } T_a=25^\circ \text{C}

(17) Bias Voltage Ripple Rejection Rate

- **XC6604x051xR-G**
  - $V_{\text{BIAS}}=3.6 \text{V, } V_{\text{OUT}}=0.2 \text{Vp-p AC, } I_{\text{OUT}}=100 \text{mA}$
  - $V_{\text{IN}}$=OPEN

- **XC6604x121xR-G**
  - $V_{\text{BIAS}}=3.6 \text{V, } V_{\text{OUT}}=0.2 \text{Vp-p AC, } I_{\text{OUT}}=100 \text{mA}$
  - $V_{\text{IN}}$=OPEN

- **XC6604x181xR-G**
  - $V_{\text{BIAS}}=3.6 \text{V, } V_{\text{OUT}}=0.2 \text{Vp-p AC, } I_{\text{OUT}}=100 \text{mA}$
  - $V_{\text{IN}}$=OPEN

(18) Input Voltage Ripple Rejection Rate

- **XC6604x051xR-G**
  - $V_{\text{BIAS}}=3.6 \text{V, } V_{\text{OUT}}=0.2 \text{Vp-p AC, } I_{\text{OUT}}=100 \text{mA}$
  - $V_{\text{IN}}$=OPEN

- **XC6604x121xR-G**
  - $V_{\text{BIAS}}=3.6 \text{V, } V_{\text{OUT}}=0.2 \text{Vp-p AC, } I_{\text{OUT}}=100 \text{mA}$
  - $V_{\text{IN}}$=OPEN

- **XC6604x181xR-G**
  - $V_{\text{BIAS}}=3.6 \text{V, } V_{\text{OUT}}=0.2 \text{Vp-p AC, } I_{\text{OUT}}=100 \text{mA}$
  - $V_{\text{IN}}$=OPEN
## PACKAGING INFORMATION

**USP-6C**  
(unit: mm)

- 1.9 ± 0.2
- 2.0 ± 0.05
- 0.6 MAX
- 0.2 ± 0.05

**SOT-26W**  
(unit: mm)

- 2.9 ± 0.2
- 0.4 ± 0.2
- 1.9 ± 0.2
- 0.15 MAX

---

**USP-6C Reference Pattern Layout (unit: mm)**

---

**USP-6C Reference Metal Mask Design (unit: mm)**
PACKAGING INFORMATION (Continued)

- **USP-6C Power Dissipation**

Power dissipation data for the USP-6C is shown in this page. The value of power dissipation varies with the mount board conditions. Please use this data as one of reference data taken in the described condition.

1. **Measurement Condition (Reference data)**
   - Condition: Mount on a board
   - Ambient: Natural convection
   - Soldering: Lead (Pb) free
   - Board: Dimensions 40 x 40 mm (1600 mm² in one side)
   - Copper (Cu) traces occupy 50% of the board area
   - In top and back faces
   - Package heat-sink is tied to the copper traces
   - Material: Glass Epoxy (FR-4)
   - Thickness: 1.6 mm
   - Through-hole: 4 x 0.8 Diameter

2. **Power Dissipation vs. Ambient temperature**

   Board Mount (Tj max = 125°C)

<table>
<thead>
<tr>
<th>Ambient Temperature (°C)</th>
<th>Power Dissipation Pd (mW)</th>
<th>Thermal Resistance (°C/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>400</td>
<td>100.00</td>
</tr>
</tbody>
</table>

![Pd vs. Ta](image_url)
PACKAGING INFORMATION (Continued)

- SOT-26W Power Dissipation

Power dissipation data for the SOT-26W is shown in this page. The value of power dissipation varies with the mount board conditions. Please use this data as one of reference data taken in the described condition.

1. Measurement Condition (Reference data)
   - Condition: Mount on a board
   - Ambient: Natural convection
   - Soldering: Lead (Pb) free
   - Board: Dimensions 40 x 40 mm (1600 mm² in one side)
     - Copper (Cu) traces occupy 50% of the board area
     - In top and back faces
     - Package heat-sink is tied to the copper traces
     (Board of SOT-26 is used.)
   - Material: Glass Epoxy (FR-4)
   - Thickness: 1.6 mm
   - Through-hole: 4 x 0.8 Diameter

2. Power Dissipation vs. Ambient temperature

Board Mount (Tj max = 125°C)

<table>
<thead>
<tr>
<th>Ambient Temperature (°C)</th>
<th>Power Dissipation Pd (mW)</th>
<th>Thermal Resistance (°C/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>600</td>
<td>166.67</td>
</tr>
<tr>
<td>85</td>
<td>240</td>
<td></td>
</tr>
</tbody>
</table>

Evaluation Board (Unit: mm)
MARKING RULE

① represents product series

<table>
<thead>
<tr>
<th>MARK</th>
<th>PRODUCT SERIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>XC6604A*****-G</td>
</tr>
<tr>
<td>U</td>
<td>XC6604B*****-G</td>
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</tbody>
</table>

② represents output voltage

<table>
<thead>
<tr>
<th>MARK</th>
<th>OUTPUT VOLTAGE (V)</th>
<th>MARK</th>
<th>OUTPUT VOLTAGE (V)</th>
</tr>
</thead>
<tbody>
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<td>B</td>
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<td>L</td>
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<td>M</td>
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<tr>
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<td>P</td>
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<td>F</td>
<td>1.0</td>
<td>R</td>
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</tr>
<tr>
<td>H</td>
<td>1.1</td>
<td>S</td>
<td>1.8</td>
</tr>
</tbody>
</table>

③④ represents production lot number
01 to 09, 0A to 0Z, 11 to 9Z, A1 to A9, AA to Z9, B1 to ZZ in order.
(G, I, J, O, Q, W excluded)
*No character inversion used.
### MARKING RULE (Continued)

1. **represents product series**

<table>
<thead>
<tr>
<th>MARK</th>
<th>PRODUCT SERIES</th>
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</table>

2. **represents regulator type**

<table>
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<td>B</td>
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</table>

3. **represents output voltage**

<table>
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<th>MARK</th>
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<th>MARK</th>
<th>OUTPUT VOLTAGE (V)</th>
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<tbody>
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<td>K</td>
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<tr>
<td>B</td>
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</tr>
</tbody>
</table>

4. **represents production lot number**

   01 to 09, 0A to 0Z, 11 to 9Z, A1 to A9, AA to Z9, B1 to ZZ in order. (G, I, J, O, Q, W excluded)

   *No character inversion used.*
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