NCP5603

High Efficiency Charge Pump Converter / White LED Driver

The NCP5603 is an integrated circuit dedicated to the medium power White LED applications. The power conversion is achieved by means of a charge pump structure, using two external ceramic capacitors, making the system extremely tiny. The device supplies a constant voltage to the load from a low battery voltage source. It is particularly suited for the High Efficiency LED used in low cost, low power applications, with high extended battery life.

Features

• Wide Battery Supply Voltage Range: 2.7 < VCC < 5.5 V
• Automatic Operating Mode 1X, 1.5X and 2X Improves Efficiency
• Dimmable Output Current
• Up to 350 mA Output Pulsed Current
• Selectable Output Voltage
• High Efficiency Up To 90%
• Supports 2.5 kV ESD, Human Body Model
• Supports 200 V Machine Model ESD
• Low 40 mA Short Circuit Current
• Pb-Free Package is Available

Applications

• High Power LED
• Back Light Display
• High Power Flash

MARKING DIAGRAM

DFN10, 3x3
MN SUFFIX
CASE 485C

5603 = Specific Device Code
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
* = Pb-Free Package
(Note: Microdot may be in either location)

PIN CONNECTIONS

Vout 1 10 C2P
C1P 2 9 C1N
Vbat 3 8 GND
Fsel 4 7 C2N
Vsel 5 6 EN

(Top View)

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Shipping†</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP5603MNR2</td>
<td>DFN10</td>
<td>3000/ Tape &amp; Reel</td>
</tr>
<tr>
<td>NCP5603MNR2G</td>
<td>DFN10 (Pb-Free)</td>
<td>3000/ Tape &amp; Reel</td>
</tr>
</tbody>
</table>

† For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.
Figure 1. Typical Application
Figure 2. Block Diagram
## PIN FUNCTION DESCRIPTION

<table>
<thead>
<tr>
<th>Pin</th>
<th>Symbol</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vout</td>
<td>OUTPUT, PWR</td>
<td>This pin supplies the regulated voltage to the external LED. Since high current transients are present in this pin, care must be observed to avoid voltage spikes in the system. Good high frequency layout technique must be observed.</td>
</tr>
<tr>
<td>2</td>
<td>C1N</td>
<td>POWER</td>
<td>One side of the external charge pump capacitor (CFLY) is connected to this pin, associated with C1P, pin 9. Using low ESR ceramic capacitor is recommended to optimize the Charge Pump efficiency.</td>
</tr>
<tr>
<td>3</td>
<td>Vbat</td>
<td>POWER</td>
<td>This pin shall be connected to the power source, and must be decoupled to Ground by a low ESR capacitor (2.2 μF/6.3 V ceramic or better (see Note 1)).</td>
</tr>
</tbody>
</table>
| 4   | Fsel   | INPUT, Digital  | This pin is used to program the operating frequency:  
Fsel = 0 → \(F_{op} = 262\text{ kHz}\)  
Fsel = 1 → \(F_{op} = 650\text{ kHz}\) |
| 5   | Vsel   | INPUT, Digital  | This pin setup the output voltage:  
Vsel = 0 → \(V_{out} = 4.5\text{ V}\)  
Vsel = 1 → \(V_{out} = 5.0\text{ V}\) |
| 6   | EN/PWM | INPUT, Digital  | This pin controls the activity of the NCP5603 chip:  
EN/PWM = Low → the chip is deactivated, the load is disconnected  
EN/PWM = High → the chip is activated and the load is connected to the regulated output current.  
The NCP5603 can operate either in a continuous mode (EN/PWM = High), or can be controlled by a PWM pulse applied to EN/PWM to dim the output light. When EN/PWM is Low, the external load is disconnected from the converter, providing a very low standby current. The pull down built-in resistance makes sure the chip is deactivated even if the EN/PWM pin is disconnected (see Note 2). |
| 7   | C2N    | POWER           | One side of the external charge pump capacitor (CFLY) is connected to this pin, associated with C2P, pin 10. Using low ESR ceramic capacitor is recommended to optimize the Charge Pump efficiency. |
| 8   | GND    | GROUND          | This pin combines the Signal ground and the Power ground and must be connected to the system ground. Using good quality ground plane is mandatory to avoid spikes on the logic signal lines. |
| 9   | C1P    | POWER           | One side of the external charge pump capacitor (CFLY) is connected to this pin, associated with C1N, pin 2. Using low ESR ceramic capacitor is recommended to optimize the Charge Pump efficiency. |
| 10  | C2P    | POWER           | One side of the external charge pump capacitor is connected to this pin, associated with C2N, pin 7. Using low ESR ceramic capacitor is recommended to optimize the Charge Pump efficiency. |

1. Using ceramic 16 V working voltage capacitors is recommended to compensate the DC bias effect encountered with such type of capacitors.  
2. Any external impedance connected to pin 6 shall be 10 kΩ or higher.
### MAXIMUM RATINGS

<table>
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<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply Voltage</td>
<td>V_{bat}</td>
<td>7.0</td>
<td>V</td>
</tr>
<tr>
<td>Power Supply Current</td>
<td>I_{bat}</td>
<td>800</td>
<td>mA</td>
</tr>
<tr>
<td>Digital Input Pins</td>
<td>V_{in}</td>
<td>-0.5 &lt; V_{bat} &lt; V_{bat} +0.5 &lt; 6.0</td>
<td>V</td>
</tr>
<tr>
<td>Digital Input Pins</td>
<td>I_{in}</td>
<td>± 5.0</td>
<td>mA</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>V_{out}</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>ESD Capability (Note 3)</td>
<td>V_{ESD}</td>
<td>2.5</td>
<td>kV</td>
</tr>
<tr>
<td>Human Body Model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine Model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFN10, 3x3 Package</td>
<td>P_{DS}</td>
<td>580</td>
<td>mW</td>
</tr>
<tr>
<td>Power Dissipation @ Tamb = +85°C</td>
<td>R_{lJA}</td>
<td>68.5</td>
<td>°C/W</td>
</tr>
<tr>
<td>Thermal Resistance, Junction-to-Air (R_{lJA})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Ambient Temperature Range</td>
<td>T_{A}</td>
<td>-40 to +85</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Junction Temperature Range</td>
<td>T_{J}</td>
<td>-40 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>T_{Jmax}</td>
<td>+150</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>T_{stg}</td>
<td>-65 to +150</td>
<td>°C</td>
</tr>
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<td>Latchup Current Maximum Rating</td>
<td></td>
<td>100 mA per JEDEC standard, JESD78</td>
<td></td>
</tr>
<tr>
<td>Moisture Sensitivity Level (MSL)</td>
<td></td>
<td>1 per IPC/JEDEC standard, J-STD-020A</td>
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</tbody>
</table>

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

3. This device series contains ESD protection and exceeds the following tests:
   - Human Body Model (HBM) ± 2.5 kV per JEDEC Standard: JESD22-A114

4. The maximum package power dissipation limit must not be exceeded.
### ELECTRICAL CHARACTERISTICS

@ 2.85 V < Vbat < 5.5 V (~-40°C to +85°C ambient temperature, unless otherwise noted).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pin</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power Supply</strong></td>
<td>3</td>
<td>Vbat</td>
<td>2.85</td>
<td>-</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Quiescent Current @ Vbat = 3.7 V, Iout = 0 µA</td>
<td>3</td>
<td>Iqsc</td>
<td>-</td>
<td>-</td>
<td>0.8</td>
<td>mA</td>
</tr>
<tr>
<td>@ Pulsed Clock Fop = 262 kHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>@ Pulsed Clock Fop = 650 kHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>@ Continuous Clock Fop = 262 kHz</td>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>@ Continuous Clock Fop = 650 kHz</td>
<td></td>
<td></td>
<td></td>
<td>2.1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Shutdown Current @ Iout = 0 mA, EN/PWM = L</td>
<td>3</td>
<td>Isubb</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
<td>µA</td>
</tr>
<tr>
<td>@ 2.85 &lt; Vbat &lt; 4.2 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>@ Vbat = 5.5 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Output Voltage Regulation</td>
<td>3</td>
<td>Vout</td>
<td>4.75</td>
<td>5.0</td>
<td>5.25</td>
<td>V</td>
</tr>
<tr>
<td>@ Vsel = 1, 2.85 V &lt; Vbat &lt; 4.3 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>@ Vsel = 0, 2.85 V &lt; Vbat &lt; 4.3 V</td>
<td></td>
<td></td>
<td>4.275</td>
<td>4.5</td>
<td>4.725</td>
<td></td>
</tr>
<tr>
<td>Continuous DC Load Current (Note 7)</td>
<td>3</td>
<td>Iout</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td>Cin = 1.0 µF, CFLY = 1.0 µF, Cout = 1.0 µF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>@ Vsel = 1, 3.2 V &lt; Vbat &lt; 4.3 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>@ Vsel = 0, 3.2 V &lt; Vbat &lt; 4.3 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>@ Vsel = 1, 2.85 V &lt; Vbat &lt; 4.3 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>@ Vsel = 2.85 V &lt; Vbat &lt; 4.3 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Pulsed Output Current</td>
<td>3</td>
<td>IFPLH</td>
<td>-</td>
<td>350</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td>Cin = 10 µF, CFLY = 1.0 µF, Cout = 10 µF, Vbat = 3.6 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fop = 500 ms, -40°C &lt; TA &lt; +65°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Continuous Short Circuit Current, Vout = 0 V</td>
<td>3</td>
<td>Isch</td>
<td>-</td>
<td>40</td>
<td>100</td>
<td>mA</td>
</tr>
<tr>
<td>Operating Frequency (Note 5)</td>
<td>Fop</td>
<td></td>
<td>210</td>
<td>262</td>
<td>320</td>
<td>kHz</td>
</tr>
<tr>
<td>Fop = 262 kHz, Iout = 60 mA (Note 7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage Ripple (Note 6)</td>
<td>3</td>
<td>Vpp</td>
<td>-</td>
<td>150</td>
<td>-</td>
<td>mV</td>
</tr>
<tr>
<td>Fop = 262 kHz, Iout = 60 mA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Input High Level</td>
<td>4, 5, 6</td>
<td>VIL</td>
<td>1.3</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Digital Input Low level</td>
<td>4, 5, 6</td>
<td>VIL</td>
<td>-</td>
<td>-</td>
<td>0.4</td>
<td>V</td>
</tr>
<tr>
<td>Output Power Efficiency</td>
<td></td>
<td></td>
<td>P_I</td>
<td>75</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>@ Vbat = 3.3 V, Vout = 5.0 V, Iout = 60 mA, Fop = 262 kHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Shut Down Protection</td>
<td></td>
<td></td>
<td>160</td>
<td>-</td>
<td>-</td>
<td>°C</td>
</tr>
<tr>
<td>Hysteresis</td>
<td></td>
<td></td>
<td>20</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

5. Temperature range guaranteed by design, not production tested.
6. Smaller footprint associated to lower working voltages (10 V or 6.3 V, size 0805 or 0602) can be used, but care must be observed to prevent DC bias effect on the capacitance final value. See capacitor manufacturer data sheets.
7. Ceramic X7R, ESR < 100 mΩ, SMD type capacitors are mandatory to achieve the Iout specifications. Depending upon the PCB layout, it might be necessary to use two 2.2 µF/6.3 V ceramic capacitors in parallel, yielding an improved Vout noise over the temperature range. On the other hand, care must be observed to take into account the DC bias impact on the capacitance value. See ceramic capacitor manufacturer data sheets.
8. Digital inputs undershoot < -0.30 V to ground, Digital inputs overshoot < 0.30 V to Vbat.
TYPICAL CHARACTERISTICS

Figure 3. Operating Modes Transitions and Output Power Efficiency @ Vout = 4.5 V/262 kHz

Figure 4. Operating Modes Transitions and Output Power Efficiency @ Vout = 4.5 V/650 kHz

Figure 5. Operating Modes Transitions and Output Power Efficiency @ Vout = 5.0 V/650 kHz

Figure 6. Typical Output Voltage Ripple

Test conditions: Vbat = 3.6 V, Vout = 5 V, Load = 4*LW87S, ILED = 25mA

Figure 7. Typical Output Voltage Line Regulation

Figure 8. Output Voltage Startup from Scratch
TYPICAL CHARACTERISTICS

Figure 9. Typical PWM Dimming

Test conditions: $V_{bat} = 3.6$ V, $V_{out} = 5$ V, Load = 4*LW87S, $I_{LED} = 25$ mA

Figure 10. Typical High Power Flash Circuit

OSRAM: LWW5SG
GOLDEN DRAGON
Figure 11. NCP5603 Output Current

Table 1. Ceramic Preferred Capacitors

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Type/Series</th>
<th>Format</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDK</td>
<td>C3216X5R1C475MT</td>
<td>1206</td>
<td>4.7 μF / 16 V</td>
</tr>
<tr>
<td>TDK</td>
<td>C2012X5R1C225MT</td>
<td>0805</td>
<td>2.2 μF / 16 V</td>
</tr>
<tr>
<td>TDK</td>
<td>C2012X5R1C105MT</td>
<td>0805</td>
<td>1.0 μF / 16 V</td>
</tr>
</tbody>
</table>
Figure 12. Evaluation Board Schematic Diagram
Figure 13. Evaluation Board: Silk View (Top View)
NOTES:
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.25 AND 0.30 MM FROM TERMINAL.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
5. TERMINAL b MAY HAVE MOLD COMPOUND MATERIAL ALONG SIDE EDGE. MOLD FLASHING MAY NOT EXCEED 30 MICRONS ONTO BOTTOM SURFACE OF TERMINAL b.
6. FOR DEVICE OPN CONTAINING W OPTION, DETAIL A AND B ALTERNATE CONSTRUCTION ARE NOT APPLICABLE. WET-TABLE FLANK CONSTRUCTION IS DETAIL B AS SHOWN ON SIDE VIEW OF PACKAGE.

DETAIL B WETTABLE FLANK OPTION CONSTRUCTION

DETAIL A ALTERNATE TERMINAL CONSTRUCTIONS

DETAIL B ALTERNATE CONSTRUCTIONS

EXPOSED Cu MOLD CMPD

DIMENSIONS: MILLIMETERS

PACKAGING OUTLINE

SOLDERING FOOTPRINT

NOTE 3

NOTE 2

NOTE 1

NOTE 0

NOTE A1

NOTE A3

NOTE A

NOTE B

NOTE L

NOTE E

NOTE D

NOTE C

NOTE A1

NOTE A3

NOTE A

NOTE B

NOTE L

NOTE E

NOTE D

NOTE C

NOTE A1

NOTE A3

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NOTE B

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